Chapter 14

CIRCULATION AND BLOOD VESSELS

Objectives

- Trace the path of cardiopulmonary circulation.
- Name and describe the specialized circulatory systems.
- Trace the blood in fetal circulation.
- List the types of blood vessels.
- Identify the principal arteries and veins of the body.
- Describe some disorders of the circulation and blood vessels.
- Define the key words that relate to this chapter.

Key Words

aneurysm
aphasia
arterioles
arteriosclerosis
artery
atherosclerosis
brachial artery
capillaries
cardiopulmonary circulation
carotid artery
cerebral hemorrhage
cerebral vascular accident (CVA)
common carotid artery
coronary artery
coronary circulation
cyanosis
diastolic blood pressure
dorsalis pedis artery
ductus arteriosus
ductus venosus
dysphasia
embolism
femoral artery
fetal circulation
foramen ovale
gangrene
hemiplegia
hemorrhoids
hepatic vein
hypertension
hypoperfusion
hypotension
peripheral vascular disease (PVD)
phlebitis
popliteal artery
portal circulation
portal vein
pulse
pulse pressure
radial artery
shock
stroke
systemic circulation
systolic blood pressure
temporal artery
transient ischemic attacks (TIAs)
tunica adventitia (externa)
tunica intima
tunica media
valves
varicose veins
veins
venipuncture
venules
white-coat hypertension

Blood vessels circulate blood through two major circulatory systems (*Figure 14-1*):

1. *Cardiopulmonary circulation*—blood from the heart to the lungs and back to the heart
2. *Systemic circulation*—blood from the heart to the tissues and cells and back to the heart

Specialized systemic routes are as follows:

a. *Coronary circulation*—brings blood from the heart to the myocardium
b. *Portal circulation*—takes blood from the organs of digestion to the liver through the portal vein
c. *Fetal circulation*—occurs in the pregnant female. The fetus obtains oxygen and nutrients from the mother's blood.

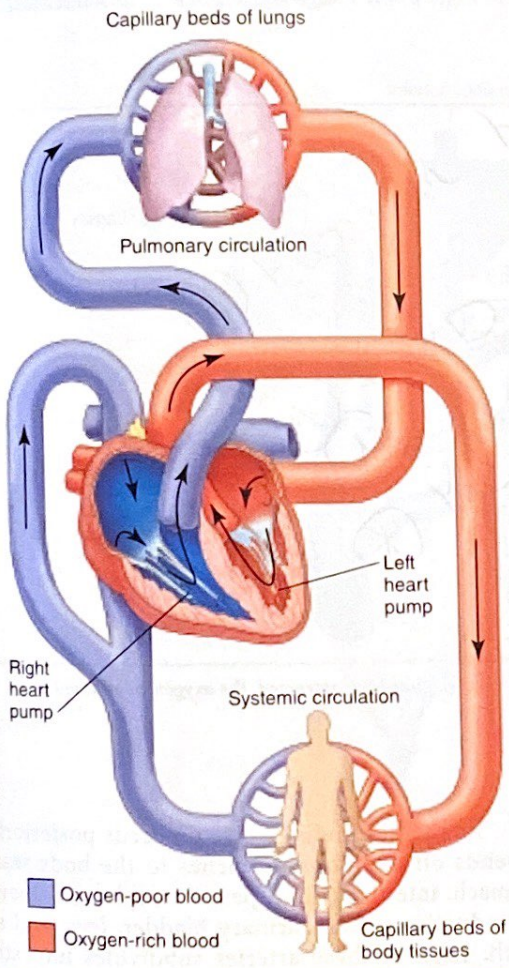

Figure 14-1 *Systemic and pulmonary circulations*

Cardiopulmonary Circulation

Cardiopulmonary circulation takes deoxygenated blood from the heart to the lungs, where carbon dioxide is exchanged for oxygen. The oxygenated blood returns to the heart. As stated in Chapter 13, blood enters the right atrium, which contracts, forcing the blood through the tricuspid valve into the right ventricle.

The right ventricle contracts to push the blood through the pulmonary valve into the main pulmonary artery. The main pulmonary artery bifurcates (divides in two). It branches into the right pulmonary artery, bringing blood to the right lung, and into the left pulmonary artery, bringing blood to the left lung (*Figure 14-2*).

Inside the lungs, the pulmonary arteries branch into countless small arteries called **arterioles** (ar-**TEE**-ree-ohlz). The arterioles connect to dense beds of capillaries lying in the alveoli lung tissue. Here, gaseous exchange takes place by the process of diffusion. Carbon dioxide leaves the red blood cells and is discharged into the air in the alveoli, to be excreted from the lungs. Oxygen from air in the alveoli combines with hemoglobin in the red blood cells. From these capillaries the blood travels into small veins or **venules** (**VEN**-youls) (*Figure 14-3*). Venules from the right and left lungs form large pulmonary veins. These veins carry oxygenated blood from the lungs back to the heart and into the left atrium.

The left atrium contracts, sending blood through the bicuspid, or mitral valve, into the left ventricle. This chamber then acts as a pump for newly oxygenated blood. When the left ventricle contracts, it sends oxygenated blood through the aortic semilunar valve into the aorta.

Systemic Circulation

The function of the general circulation (or **systemic circulation**) is fourfold: it circulates nutrients, oxygen, water, and secretions to the tissues and back to the heart; it carries products such as carbon dioxide and other dissolved wastes away from the tissues; it helps equalize body temperature; and it aids in protecting the body from harmful bacteria.

The aorta is the largest artery in the body. The first branch of the aorta is the **coronary artery,** which takes blood to the myocardium (cardiac muscle). As the aorta emerges (ascending aorta) from the anterior (upper) portion of the heart, it forms an arch. This arch is known as the aortic arch. Three branches come from this arch: the *brachiocephalic artery* (**bray**-kee-oh-seh-**FAL**-ick), the **common carotid artery**

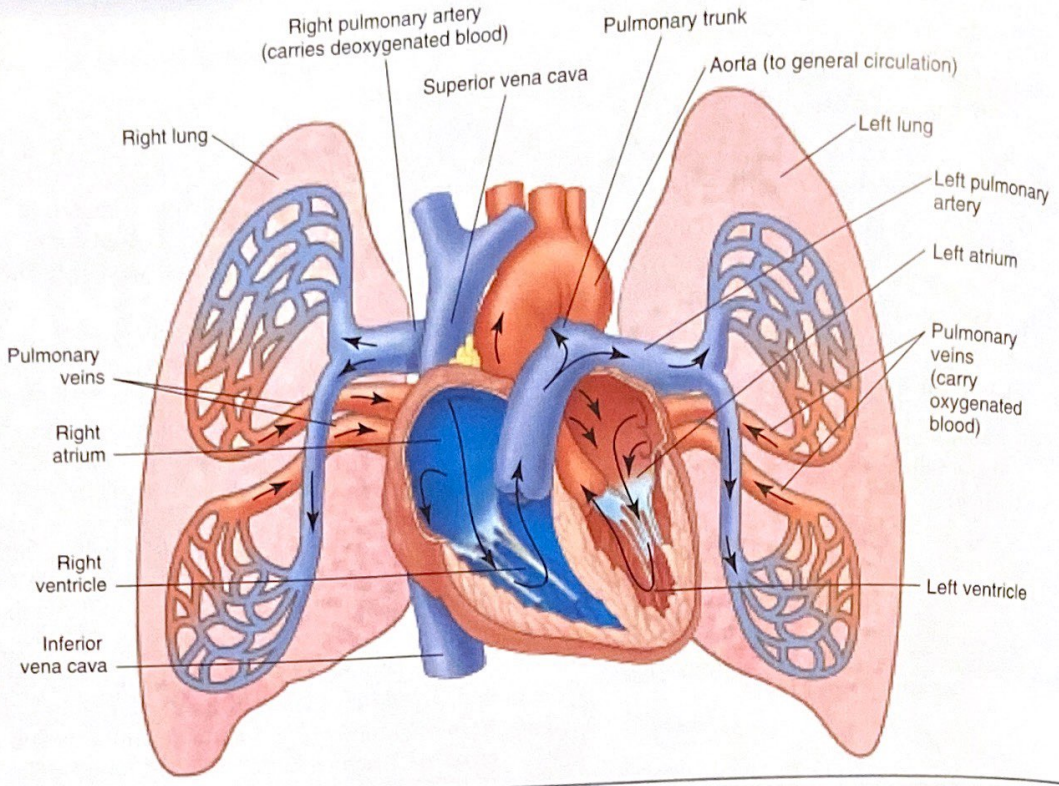

Figure 14-2 *Cardiopulmonary circulation*

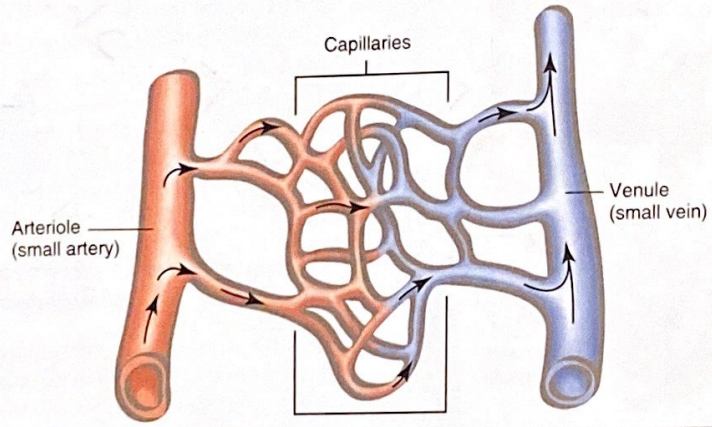

Figure 14-3 *Arterioles deliver oxygenated blood to the capillaries. After the oxygen has been extracted, the oxygen-poor blood is returned to circulation as venous blood.*

(kah-**ROT**-id), and the left *subclavian arteries*. These arteries and their branches carry blood to the arms, neck, and head.

From the aortic arch, the aorta descends along the middorsal wall of the thorax and abdomen. Many arteries branch off from the descending aorta, carrying oxygenated blood throughout the body.

As the descending aorta proceeds posteriorly, it sends off additional branches to the body wall, stomach, intestines, liver, pancreas, spleen, kidneys, reproductive organs, urinary bladder, legs, and so forth. Each of these arteries subdivides into still smaller arteries, then into arterioles, and finally into numerous capillaries embedded in the tissues. This is

where hormones, nutrients, oxygen, and other materials are transferred from the blood into the tissue.

In turn, metabolic waste products, such as carbon dioxide and nitrogenous wastes, are picked up by the blood capillaries. Hormones and nutrients from the small intestines and liver are also absorbed by the blood capillaries. Blood goes from the capillaries first into tiny veins, through increasingly larger veins, and finally into one (or more) of the veins that exit from the organ. Eventually the blood empties into one of the two largest veins in the body.

Deoxygenated (venous) blood, returning from the lower parts of the body, empties into the inferior vena cava. Venous blood from the upper body parts (arms, neck, and head) passes into the superior vena cava. Both the inferior and superior vena cava empty their deoxygenated blood into the right atrium.

Coronary Circulation

Coronary circulation brings oxygenated blood to the heart muscle. The coronary artery has a right and left branch. These branches encircle the heart muscle, with many tiny branches going to all parts of the heart muscle. The blood circulates to the capillaries, where the exchange of gases takes place, and then goes to the veins. Deoxygenated blood returns through the coronary veins to the **coronary sinus.** This is a trough in the posterior wall of the right atrium.

Portal Circulation

Portal circulation is a branch of general circulation. Veins from the pancreas, stomach, small intestine (superior mesenteric vein), colon (inferior mesenteric vein), and spleen empty their blood into the hepatic **portal vein,** which goes to the liver (*Figure 14-4*).

After meals, blood reaching the liver contains a higher than normal concentration of glucose. The liver removes the excess glucose, converting it to glycogen. In the event of vigorous exercise, work, or prolonged periods without nourishment, glycogen reserves will be changed back into glucose for

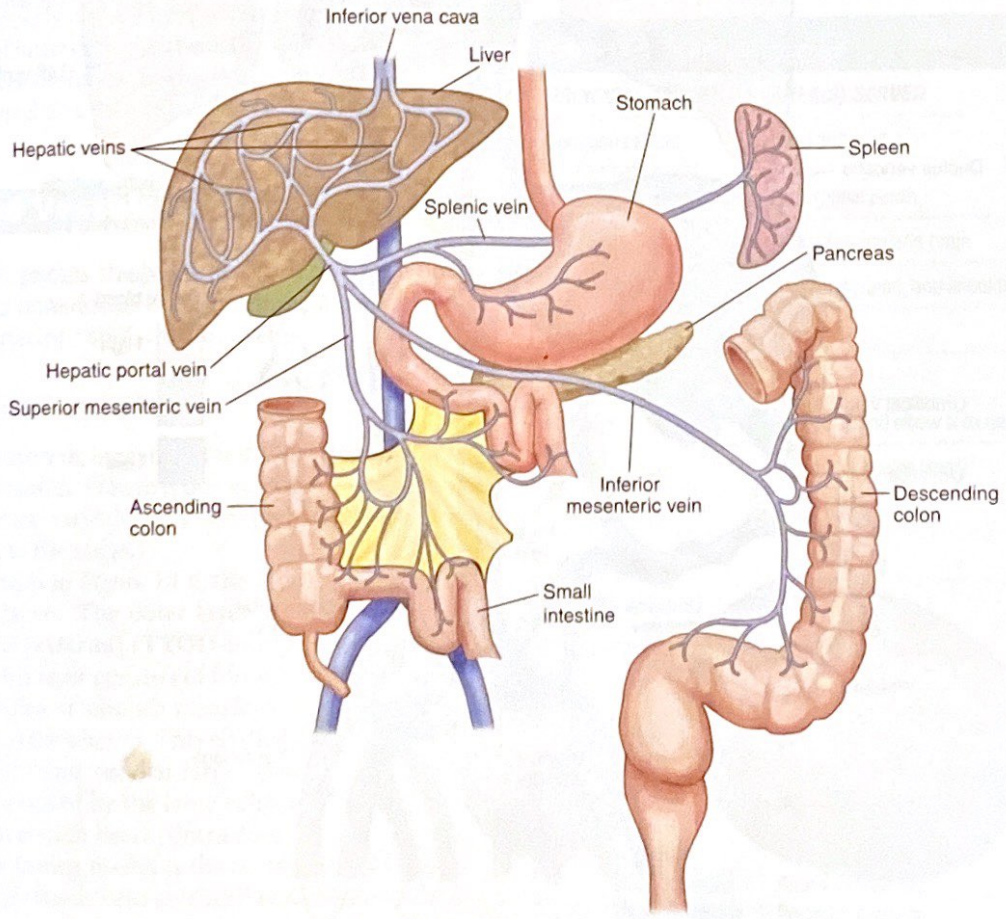

Figure 14-4 *Hepatic portal system*

energy. The liver ensures that the blood's glucose concentration is kept within a relatively narrow range.

Deoxygenated venous blood leaves the liver through the **hepatic vein** (heh-PAT-ick), which carries it to the inferior vena cava. From the inferior vena cava, blood enters the right atrium (*Figure 14-4*).

Fetal Circulation

Fetal circulation occurs in the fetus. Instead of using it own lungs and digestive system, the fetus obtains oxyger and nutrients from the mother's blood. Fetal and mater nal bloods do not mix. The exchange of gases, food, an waste takes place in the structure known as the placenta located in the pregnant uterus (*Figure 14-5*).

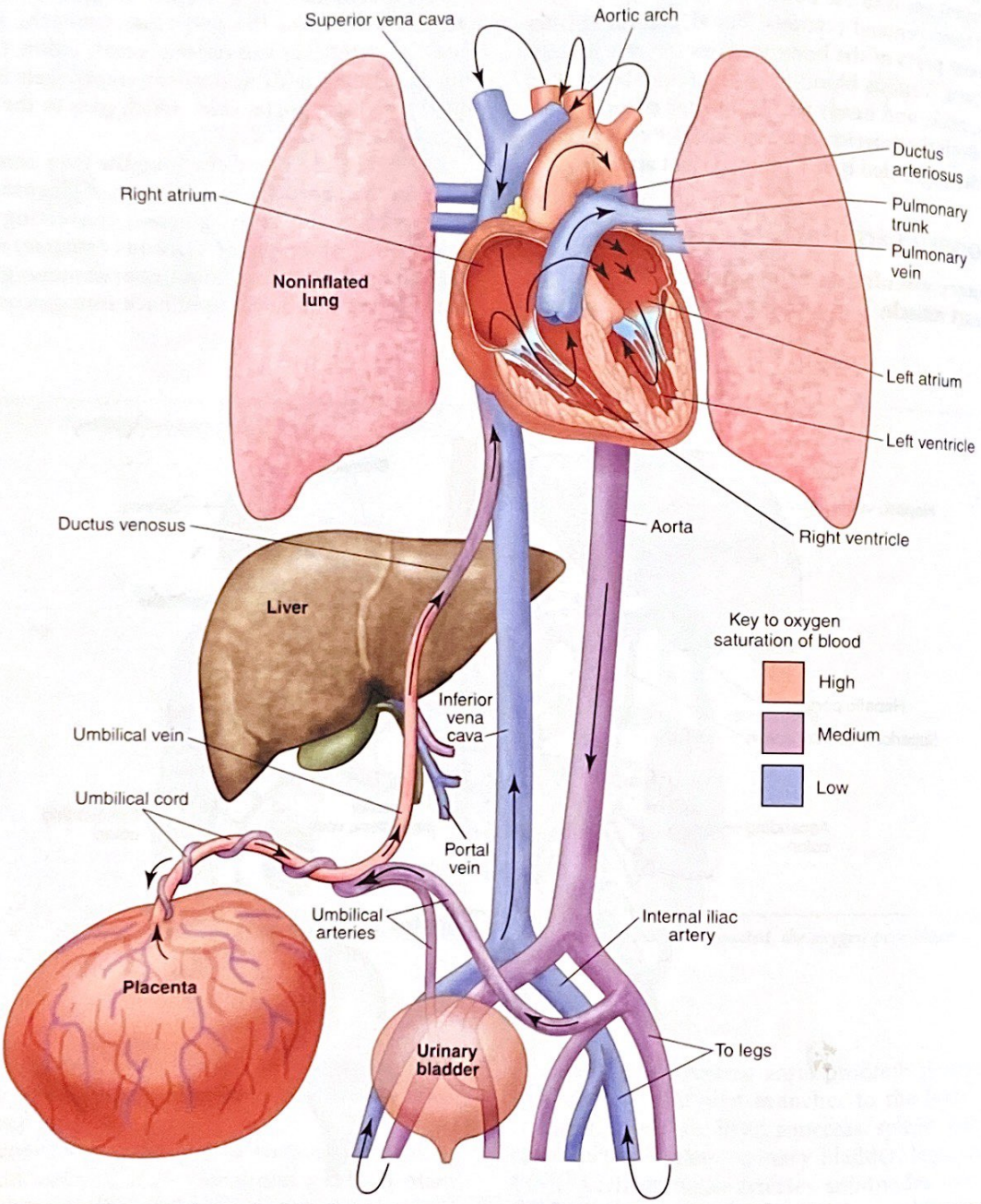

Figure 14-5 *Fetal circulation*

In fetal circulation, oxygenated blood comes through the placenta of the mother to the fetus via the umbilical vein. Most of the blood joins the inferior vena cava by way of a small vessel called the **ductus venosus** (**DUK**-tus vee-**NO**-sus) and goes to the right atrium. The remaining blood goes to the liver. The blood in the right atrium goes through an opening in the atrial septum called the **foramen ovale** (for-**AY**-men oh-**VAL**-ee) and then goes into the left atrium. The blood bypasses the right ventricle and the pulmonary circuit. Some blood goes into the right ventricle and is pumped into the pulmonary artery. The purpose of the blood circulating through the heart is to give the heart and blood vessels oxygen and nutrients to grow. However, most of this blood shunts directly into the systemic circulation through the **ductus arteriosus** (**DUK**-tus ar-tier-ee-**OH**-sis), which connects the main pulmonary artery to the aorta. Blood returns to the placenta through the umbilical arteries. At birth, these adaptations, which include the ductus venosus and the ductus arteriosus, close within 30 minutes, and the foramen ovale completely closes within 1 year. Normal cardiopulmonary circulation begins at birth. Congenital heart defects may occur if these structures do not properly close. The most common symptom of congenital heart defect is **cyanosis** (sigh-ah-**NOH**-sis), a bluish discoloration to the skin and mucous membrane caused by a lack of oxygen in the blood.

Blood Vessels

The heart pumps the blood to all parts of the body through a remarkable system of three types of blood vessels: arteries, capillaries, and veins.

Arteries

Arteries carry oxygenated blood away from the heart to the capillaries. (There is one exception—the pulmonary arteries—which carry deoxygenated blood from the heart to the lungs.)

As seen in *Figure 14-6*, the arterial walls consist of three layers. The outer layer is called the **tunica adventitia (externa)** (**TYOO**-nih-kah ad-ven-**TISH**-ee-ah). This layer consists of fibrous connective tissue with bundles of smooth muscle cells that lend great elasticity to the arteries. This elasticity allows the arteries to withstand sudden large increases in internal pressure, created by the large volume of blood forced into them at each heart contraction.

The **tunica media** is the middle arterial layer. It consists of muscle cells arranged in a circular pattern. This layer controls the artery's diameter by dilation and constriction, which regulates the flow of blood through the artery. This keeps the blood flow steady and even and reduces the heart's work.

An inner layer, the **tunica intima** (**IN**-tih-mah), consists of three smaller layers of endothelium that give the artery a smooth lining to allow for the free flow of blood.

The arteries transport blood under very high pressure; they are elastic, muscular, and thick walled. The thickness of the arteries makes them the strongest of the three types of blood vessels.

The aorta leads away from the heart and branches into smaller arteries. These smaller arteries, in turn, branch into arterioles, which still have some smooth muscle in the walls. Arterioles give rise to the capillaries.

Table 14-1 lists and *Figure 14-7* illustrates the principal arteries and the areas they serve.

Capillaries

Capillaries (**KAP**-ih-lay-reez) are the smallest blood vessels and can only be seen through a compound microscope. Capillaries connect the arterioles with

Table 14-1 *Principal Arteries*

PRINCIPAL ARTERY	*AREA(S) SERVED*
Common carotid	Head and face
Internal carotid	Brain
External carotid	Face (*pulse point*)
Vertebral	Spinal column and brain
Brachiocephalic	Right arm, head, and shoulder
Subclavian	Shoulder
Axillary	Axilla
Brachial	Upper arm and elbow area (*pulse point*)
Radial	Arm, wrist (*pulse point*)
Thoracic aorta	Chest cavity
Splenic	Spleen
Hepatic	Liver
Superior mesenteric	Small intestines and colon
Renal	Kidney
Common iliac	Lower abdomen
Internal iliac	Pelvis and bladder
External iliac	Groin and lower leg
Femoral	Groin (*pulse point*)
Popliteal	Knee area (*pulse point*)
Anterior tibialis	Anterior lower leg
Posterior tibialis	Posterior lower leg
Dorsalis pedis	Ankle (*pulse point*)

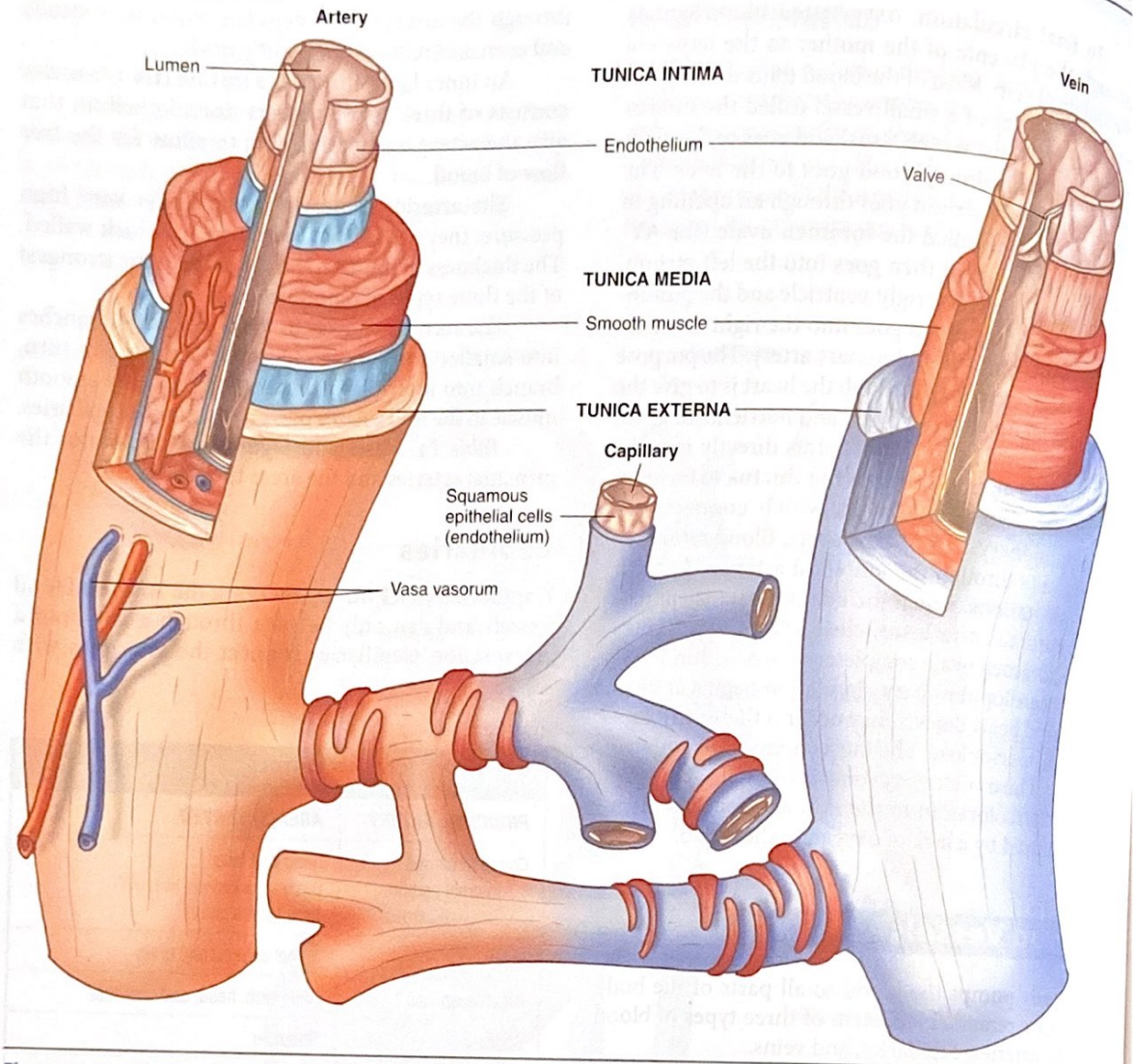

Figure 14-6 *The three layers of the walls of the arteries and veins: tunica intima, tunica media, and tunica adventitia*

venules. Capillaries are branches of the finest arteriole divisions, known as metarterioles. The metarterioles lose most of their connective tissue and muscle layers until they disappear. There remains only a simple endothelial cell layer; this endothelial cell layer constitutes the capillaries.

The capillary walls are extremely thin to allow for the selective permeability of various cells and substances. Nutrient molecules and oxygen pass out of the capillaries and into the surrounding cells and tissues by diffusion. Metabolic waste products such as carbon dioxide and nitrogenous wastes pass back from the cells and tissues into the bloodstream for excretion at their proper sites (i.e., lungs and kidneys).

Tiny openings in the capillary walls allow white blood cells to leave the bloodstream and enter the tissue spaces to help destroy invading bacteria. In the capillaries, some of the plasma diffuses out of the bloodstream and into the tissue spaces. This fluid is called interstitial fluid and is returned to the bloodstream in the form of lymph via the lymphatic vessels.

Blood flow through the capillaries is influenced by hydrostatic pressure. Hydrostatic pressure is the force exerted by a fluid pressing against a wall. In capillaries, hydrostatic pressure is the same as capillary blood pressure—the pressure exerted by blood on the capillary wall. This pressure tends to force fluid through the capillary walls, leaving behind cells and most proteins.

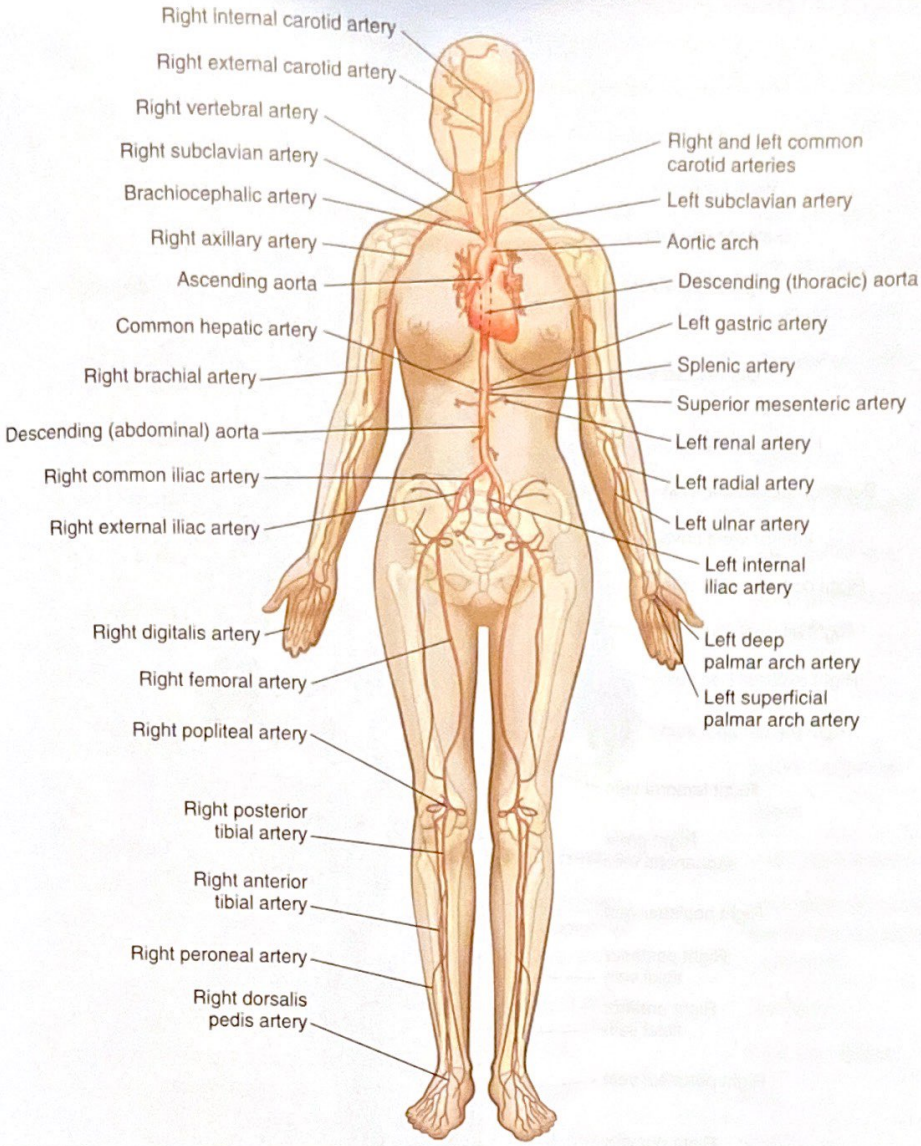

Figure 14-7 *The major arteries of the systemic circulation*

Capillaries are ultimately responsible for transporting blood to all tissues. Not all capillaries are open simultaneously. This system allows for regulation of blood flow to so-called active tissues. For example, if you are running, the skeletal muscles need more oxygen, while the digestive organs need less oxygen. This may explain why, if you run after a heavy meal, you get indigestion or have abdominal cramps.

Veins

The **veins** carry deoxygenated blood away from the capillaries to the heart. The smallest vein (venule) is hardly larger than a capillary, but it contains a muscular layer that is not present within capillaries. *Table 14-2* lists and *Figure 14-8* illustrates the principal veins and the areas they serve.

The veins are composed of three layers: the tunica adventia (externa), tunica media, and tunica intima. Veins are considerably less elastic and muscular than arteries are. The walls of the veins are much thinner than those of the arteries because they do not have to withstand such high internal pressures. The pressure from the heart's contraction is greatly diminished by the time the blood reaches the veins for its return journey. Thus, the thinner walled veins can collapse easily when not filled with blood. Finally, veins have **valves** along their length. These valves allow blood to

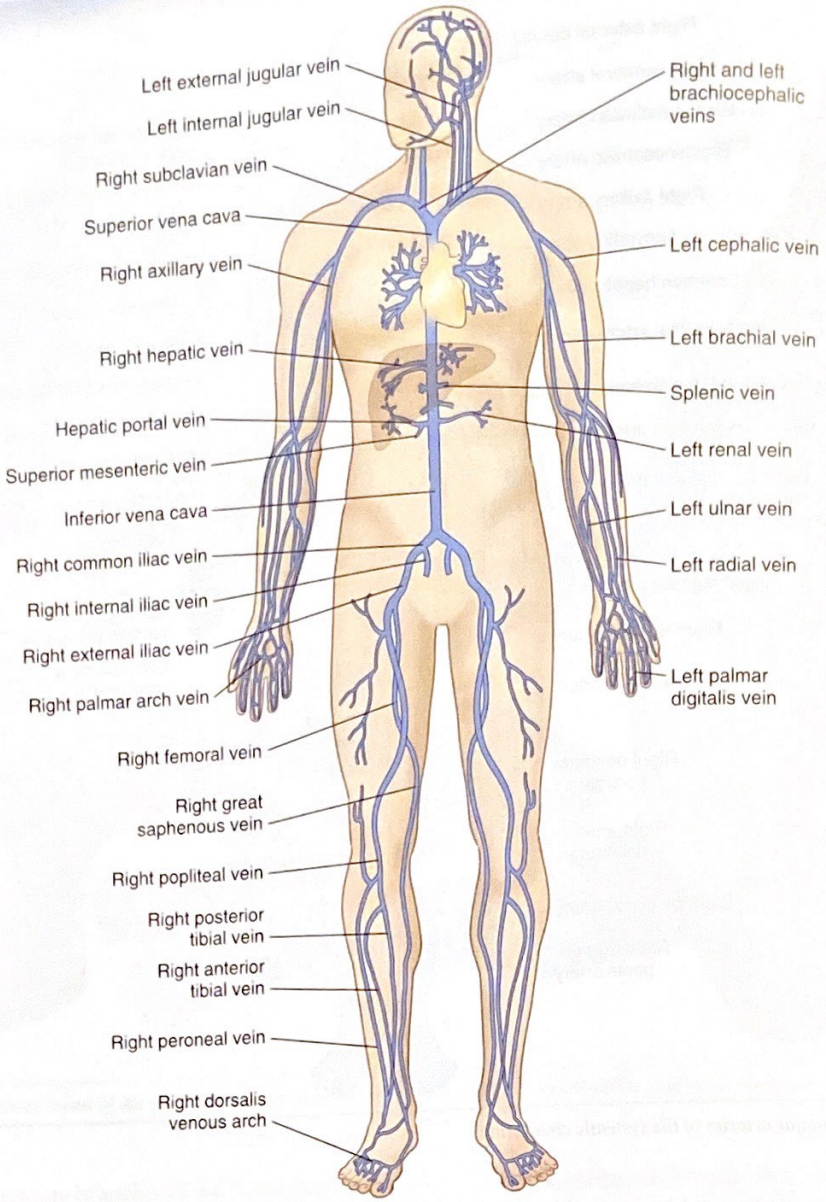

Figure 14-8 *The major veins of the body*

flow in only one direction—toward the heart. This prevents reflux (backflow) of blood toward the capillaries (*Figure 14-9*). Valves are found in abundance in veins where there is a greater chance of reflux. There are many valves in the lower extremities where blood has to oppose the force of gravity.

Eventually, all of the venules converge to make up larger veins, which ultimately form the body's largest veins, the vena cavae. Venous blood from the upper part of the body returns to the right atrium via the superior vena cava; blood from the lower body parts is conducted to the heart via the inferior vena cava.

Venous Return

In addition to valves, the skeletal muscles contract to help push the blood along its path. In the abdominal and thoracic cavity, pressure changes occur when you breathe; this also helps bring the venous blood back to the heart. Think about sitting for a long period of time, especially on a car ride. Think how sleepy you start to get. The reason may be that blood is not getting back to the heart for oxygen. To reduce the drowsiness, you should pull over, stop the car, and get out and walk around for a while. This will improve circulation and the drowsiness should pass.

The Effects of Aging on the Circulation and Blood Vessels

The arteries that are pliable and elastic when young become less elastic, dilated, and elongated with age. These physiological changes mean the heart has to work harder to push blood through the less elastic arteries. Overall, arterial changes appear to be widespread and result in diminished circulation to all organs and tissues.

A frequent cardiovascular measure is blood pressure (BP). It is debatable how aging affects this measure of cardiovascular status. Some researchers believe normal BP for older persons is typically 140 mm Hg systolic and 90 diastolic (140/90).

Some researchers think that systolic increases are due to reduced aortic elasticity, whereas others believe that peripheral resistance in the vessels causes an increase in both systolic and diastolic pressures.

The baroreceptors in the carotid arteries (neural receptors sensitive to blood pressure) become rigid and less sensitive to pressure changes with aging. This results in a slow response to postural changes. Changes in position may cause dizziness and fainting. This hypotensive response is called orthostatic hypotension. Under normal circumstances, the heart continues to adequately supply blood to all parts of the body. However, an aging heart may be slightly less able to increase workloads from effects such as illness, stress, infections, and/or extreme physical exertion. ■

Table 14-2 *Principal Veins*

PRINCIPAL VEIN	AREA(S) SERVED
External jugular	Face
Internal jugular	Head and neck
Subclavian	Shoulder and upper limbs
Brachiocephalic	Head and shoulder
Cephalic	Shoulder and axilla
Axillary	Axilla
Brachial	Upper arm
Radial	Lower arm and wrist
Superior vena cava	Upper part of body
Inferior vena cava	Lower part of body and abdomen area
Hepatic	Liver
Renal	Kidney
Hepatic portal	Organs of digestion
Splenic	Spleen
Superior mesenteric	Small intestine and colon
Common iliac Internal iliac External iliac	Lower abdomen and pelvis Bladder and reproductive organs Lower limbs
Great saphenous	Upper leg
Femoral	Upper leg and groin
Popliteal	Knee
Posterior tibialis	Posterior leg
Dorsal venous arch	Foot

Did You Know?

There are about 62,000 miles of blood vessels and if you lay them end to end, they would encircle the world at least two and one-half times.

Venipuncture

Venipuncture (phlebotomy) is a method of drawing blood using a needle to access a vein for intravenous therapy, or a sampling of venous blood for testing. The major sites for venipuncture are the cephalic, basilic, and the median cubital veins (*Figure 14-10*).

Blood Pressure

When the heart pumps blood into the arteries, the surge of blood filling the vessels creates pressure against their walls. The pressure measured at the moment of contraction is the **systolic blood pressure** (sis-**TOL**-ick). The lessened force of the blood

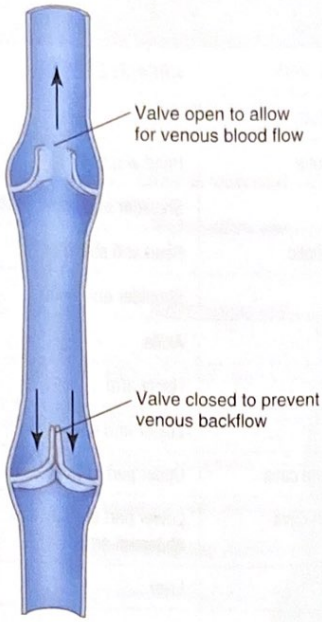

Figure 14-9 *Valves in the veins*

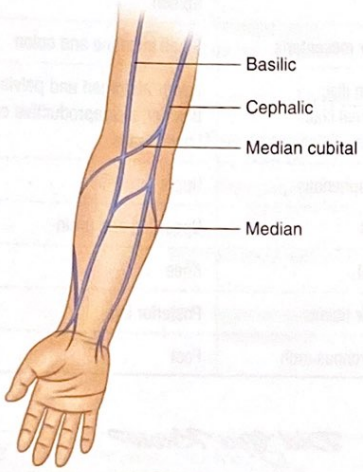

Figure 14-10 *The major sites for venipuncture*

measured when the ventricles relax called the **diastolic blood pressure** (dye-ah-**STOL**-ick). This force is measured using a sphygmomanometer (**sfig**-moh-mah-**NOM**-eh-ter), a blood pressure device. When using a manual style sphygmomanometer, a stethoscope is used to listen to the sounds. The systolic pressure is the first sound heard and the diastolic is the last sound heard (*Figure 14-11*).

The average systolic pressure measured in the upper arm is 120 mm Hg. The average diastolic pressure

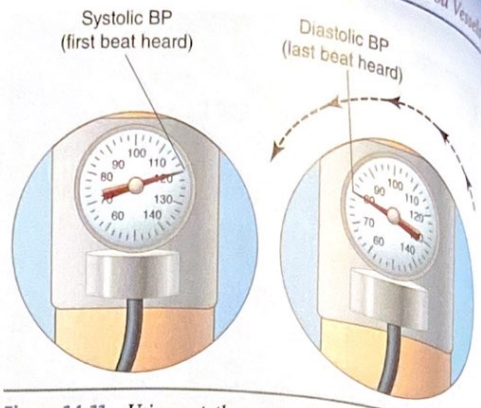

Figure 14-11 *Using a stethoscope to measure blood pressure, the systolic pressure is the first sound heard and the diastolic pressure is the last sound heard.*

in an adult is 80 mm Hg. The blood pressure is recorded as a ratio with the systolic over the diastolic, such as 120/80. Factors that influence blood pressure include:

- Volume of the blood—changes in the volume, such as loss of blood, mean there will be less blood for the heart to pump
- Blood viscosity—the thicker the blood, the harder the heart has to pump
- Total peripheral resistance—if the area through which the blood has to pump is reduced, such as in atherosclerosis, the heart has to pump harder
- Stressors—these cause the muscles around the blood vessels to constrict, making the heart pump harder, thereby increasing blood pressure

Pulse pressure is the difference between the systolic and diastolic. For example, if the blood pressure is 120/80, the pulse pressure is 40. A pulse pressure of more than 60 mm Hg, especially in older adults, indicates a higher risk of cardiac problems.

Pulse

If you touch certain areas (pulse points) of the body, such as the radial artery at the wrist, you will feel alternating, beating throbs. These throbs represent your body's pulse. A **pulse** is the alternating expansion and contraction of an artery as blood flows through it. The pulse rate usually is the same as the heart rate. The pulse provides information about heart rate as well as strength and rhythm of the heart.

Try this simple demonstration: Place your fingertips (excluding the thumb, which has its own pulse point) over an artery that is near the surface of the skin and over a bone. The seven paired locations where you can conveniently feel your pulse are as follows (*Figure 14-12*):

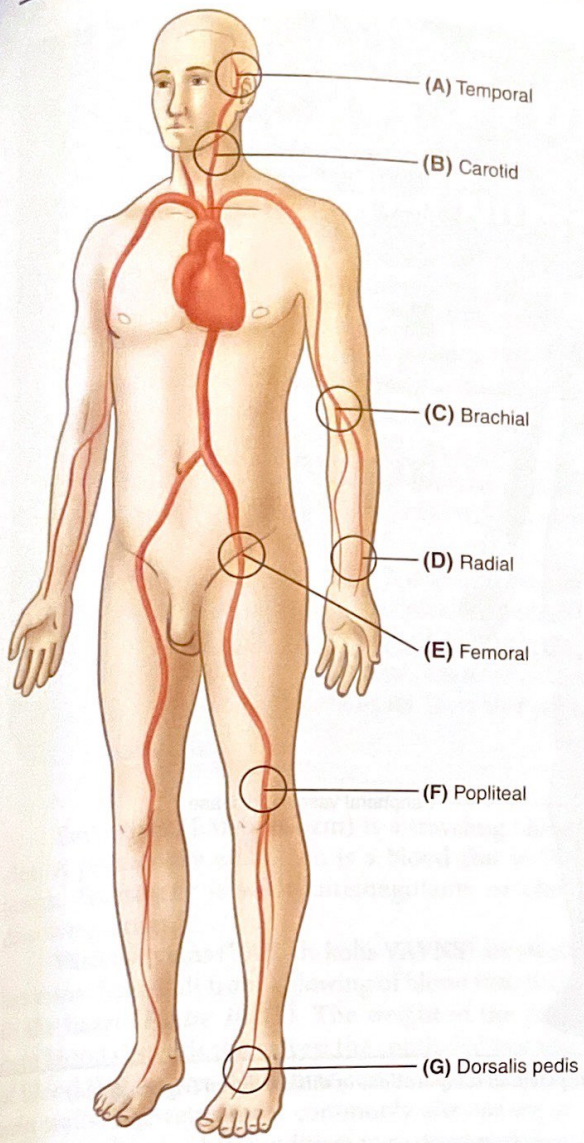

Figure 14-12 *Pulse points of the body*

1. **Temporal artery**—slightly above the outer edge of the eye
2. **Carotid artery** (kah-**ROT**-id)—in the neck, along the front margin of the sternocleidomastoid muscle, near the lower edge of the thyroid cartilage
3. **Brachial artery** (**BRAY**-kee-al)—at the crook of the elbow, along the inner border of the biceps muscle
4. **Radial artery** (**RAY**-dee-al)—at the wrist, on the same side as the thumb (most common site for taking pulse)
5. **Femoral artery** (**FEM**-or-al)—in the inguinal or groin area
6. **Popliteal artery** (pop-lit-**EE**-al)—behind the knee; may be hard to palpate
7. **Dorsalis pedis artery** (dor-**SAY**-lis **PED**-is)—on the anterior surface of the foot, below the ankle joint

A pressure point is where the main artery lies near the skin surface over a bone. The seven locations where you can feel your pulse may also serve as pressure points. If direct pressure cannot be applied to a wound to stop bleeding, pressure should be applied to the closest pulse point.

Media Link
View the **Blood Pressure and Pulse** video on the Online Resources.

Disorders of Circulation and Blood Vessels

Aneurysm (**AN**-you-rizm) is the ballooning out of an artery, accompanied by a thinning arterial wall, caused by a weakening of the blood vessel (almost like having a bubble on a tire). The aneurysm pulsates with each systolic beat. The symptoms are pain and pressure, but sometimes there are no symptoms. For treatment of a brain aneurysm, physicians may use interventional radiology (IR). MRI and CT scans take three-dimensional color pictures, which reveal the anatomy of the brain in minute detail. Physicians then use IR to reach the aneurysm. They insert a wire catheter into the groin, guide it to the brain aneurysm, and then release tiny coils that provide scaffolding to reinforce the artery and prevent the aneurysm from bursting.

Arteriosclerosis (ar-**tee**-ree-oh-skleh-**ROH**-sis) occurs when the arterial walls thicken because of a loss of elasticity as aging occurs. Sometimes it is referred to as hardening of the arteries.

Atherosclerosis (**ath**-er-oh-skleh-**ROH**-sis) occurs when deposits of fat form along the walls of the arteries (see Chapter 13). Exercise, a low-fat diet, and cholesterol-lowering drugs are recommended to prevent atherosclerosis.

In both arteriosclerosis and atherosclerosis, there is a narrowing of the blood vessel opening. This interferes with the blood supply to the body parts and causes hypertension. Symptoms develop where circulation is impaired (numbness and tingling of the lower extremities or loss of memory indicates interference with circulation) (*Figure 14-13*).

Gangrene (**GANG**-green) is death of body tissue due to an insufficient blood supply caused by disease or injury. Symptoms depend on the location and cause of gangrene. Treatment requires that the

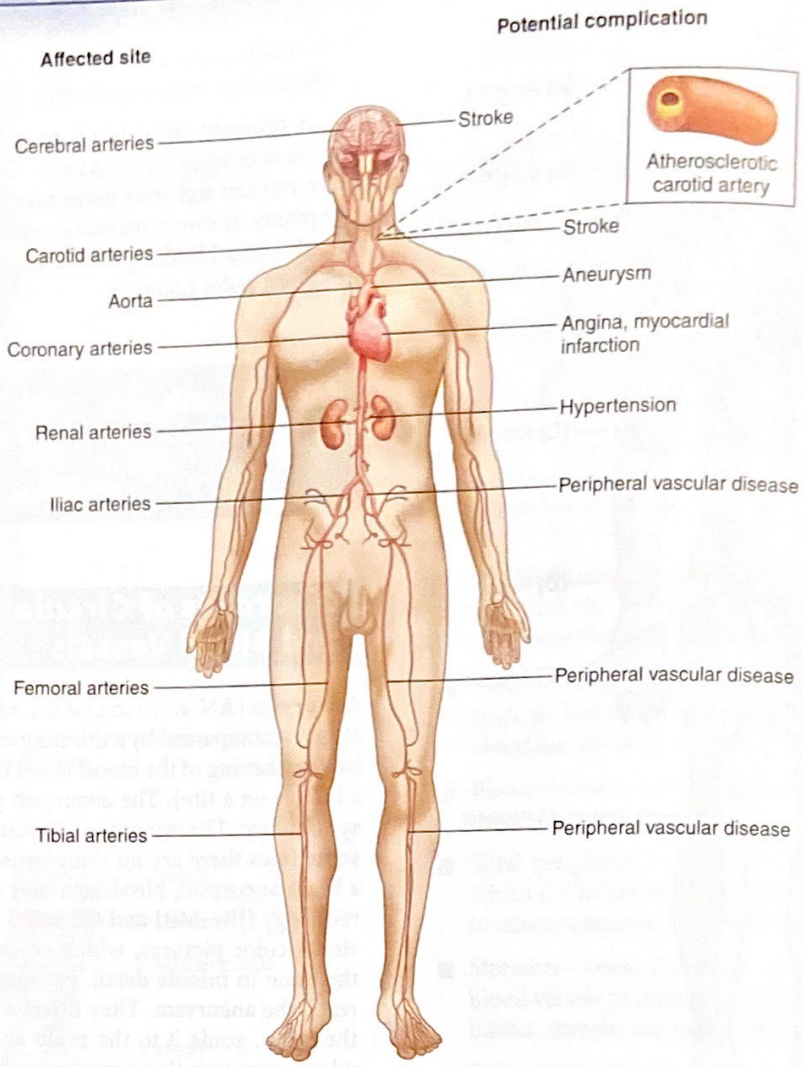

Figure 14-13 *Arteries affected by atherosclerosis (left column) and the potential complications of this condition (right column)*

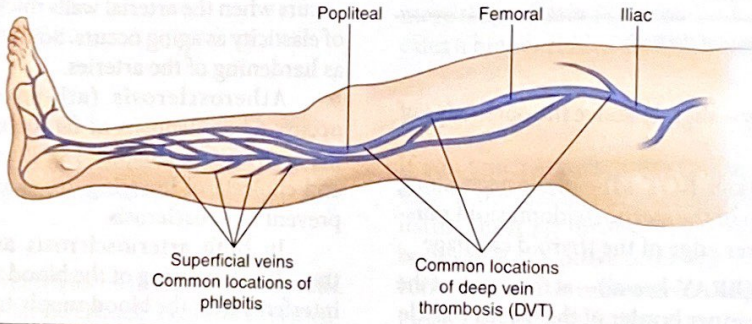

Figure 14-14 *Common locations for the development of phlebitis and deep vein thrombosis*

dead tissue be removed (in some cases this may be an amputation) to allow healing and to prevent further infection.

Phlebitis (fleh-**BYE**-tis) or thrombophlebitis is an inflammation of the lining of a vein, accompanied by clotting of blood in the vein. Symptoms include edema (swelling) of the affected area, pain, and redness along the length of the vein. Treatment may be with warm compresses to the affected area and anti-inflammatory medication (*Figure 14-14*).

Career Profile 14-1

Registered Nurse and Nurse Practitioner

Registered nurses (RNs) provide for the physical, mental, and emotional needs of their patients. They observe, assess, and record symptoms, reactions, and progress; they also assist physicians during treatments and examinations, administer medications, and assist in convalescence and rehabilitation. RNs develop nursing care plans, instruct patients and their families in proper care, and help individuals and groups improve and maintain their health.

Registered nurses work in hospitals, the home, offices, nursing homes, public health services, and industries.

In all states, students must graduate from an accredited school of nursing and pass a national licensing examination to become an RN. There are three major educational paths to nursing: associate degree in nursing (ADN) programs take 2 years, bachelor of science in nursing (BSN) degree programs take 4 years, and diploma programs given in hospitals last 2 to 3 years.

The employment outlook is expected to be above average in the coming years. The job outlook is best for the nurse with a BSN.

A nurse practitioner or nurse clinician is an RN with a master's degree and clinical experience in a particular branch of nursing. The nurse practitioner has acquired expert knowledge in a specific medical specialty. Nurse practitioners are employed by physicians in private practice or clinics, or they sometimes practice independently, especially in rural areas. ■

Embolism (EM-boh-lizm) is a traveling blood clot. A pulmonary embolism is a blood clot in the lungs. Treatment is with anticoagulants or clot-dissolving drugs.

Varicose veins (VAR-ih-kohs VAYNS) are swollen veins that result from a slowing of blood flow back to the heart (*Figure 14-15*). The weight of the stagnant blood distends the valves; the continued pooling of blood then causes distention and inelasticity of the vein walls. The veins most commonly affected are in the legs and feet. This condition may develop due to hereditary weakness or as a result of prolonged periods of standing. Age and pregnancy are other factors responsible for varicose veins. Treatment includes avoiding excess standing, exercise, elevating the legs when sleeping, and wearing support hose. Women need to avoid high heels and tight clothing, especially around the waist. A procedure known as *sclerotherapy* (**skler**-oh-**THAIR**-ah-pee) may be done, in which a sclerosing solution is injected into the vein. The solution causes the vein to scar and close. Other options include laser therapy or vein stripping.

Hemorrhoids (HEM-oh-royds) are varicose veins in the walls of the lower rectum and the tissues around the anus. Conservative treatment for hemorrhoids includes sitz baths (warm baths for buttocks) and over-the-counter topical ointments. In more severe cases, rubber band ligation or hemorrhoidectomy may be done.

Figure 14-15 *Varicose veins*

Cerebral hemorrhage (SER-eh-bral HEM-eh-rij) refers to bleeding from blood vessels within the brain. It can be caused by arteriosclerosis, disease, or injury such as a blow to the head.

Career Profile

Licensed Practical Nurse

Licensed practical nurses (LPNs) or licensed vocational nurses (LVNs) (as they are called in Texas and California) care for people who are sick, injured, convalescing, and handicapped, under the direction of a physician or registered nurse.

Most LPNs provide basic bedside care. They take vital signs, treat bedsores, prepare and give injections, and administer some treatments. They collect laboratory specimens, observe patients, and report any adverse reactions. They help patients with activities of daily living, keep them comfortable, and care for their emotional needs. In states where the law allows, they may administer prescribed medicines.

LPNs in nursing homes also evaluate residents' needs, develop care plans, and supervise nursing aides.

All states require LPNs to graduate from an accredited practical nursing program and pass a national licensing examination.

The job outlook for the practical nurse is good and is expected to increase faster than the average during the next few years. ■

Peripheral vascular disease (PVD) (per-**IF**-er-al) is caused by blockage of the arteries, usually in the legs. Symptoms are pain or cramping in the legs or buttocks while walking. Such cramping subsides when the person stands still. This is called *intermittent claudication* (klaw-dih-**KAY**-shun). As the condition worsens, symptoms may include pain in the toes or feet while at rest, numbness, paleness, and cyanosis in the foot or leg. The condition must be treated or amputation may be necessary. Treatments include medication to reduce cholesterol, improved and/or modified diet, and other treatments to improve circulation.

Hypertension, or high blood pressure, is frequently called the "silent killer," because there are usually no symptoms of the disease. Hypertension is classified as either essential hypertension or secondary. About 90% to 95% of cases are essential, which means high blood pressure with no obvious cause. The remaining 5% are secondary and are caused by conditions that affect the kidneys, arteries, heart, or endocrine system. Hypertension leads to strokes, heart attacks, and kidney failure. Most people discover that they have the condition during a routine physical. There are several categories of hypertension, including

- Normal: Less than 120/80
- Prehypertension: 120–130/80–89
- Stage 1 hypertension: 140–159/90–99
- Stage 2 hypertension: 160 and above/100 and above

One in three adult Americans has hyperter sion. Hypertension was a primary contributing caus of death for more than 348,000 Americans in 200 Risk factors for hypertension are stress, smoking, over weight, diets high in fat and/or sodium, and a famil history of the disease. Having prehypertension or dia betes are also risk factors. Treatment consists of relax ation techniques, reducing fat and sodium in the die exercise, weight loss, and medication to control bloo pressure. In the treatment of hypertension, patient often do not understand the disease and its risks. The frequently stop taking their medication because o costs and side effects. Health care professionals mus realize that better education and communication wil lead to more effective treatment and a higher level o compliance by patients.

White-coat hypertension is so called because i is an increase in a patient's blood pressure that occur only when a medical professional (the "white coat" takes the blood pressure. The thought is that the stres of a medical examination causes the BP to rise, result ing in an inaccurate diagnosis of hypertension. Bloo pressure medication does not help the problem. Th best way to differentiate between white-coat hyperten sion and true hypertension is to ask the patient to wea a device that measures the BP over a 24-hour period.

Hypotension is low blood pressure. The readin is usually less than 90/60. Chronic low blood pressur is almost never serious. Health problems may occur i blood pressure drops suddenly and the brain is deprive of an adequate blood supply, leading to dizziness. I

most commonly occurs when rising from a prone or sitting position to a standing position. This is known as postural hypotension or orthostatic hypotension.

Transient ischemic attacks (TIAs) (iss-**KEE**-mick) are temporary interruptions of the blood flow (ischemia) to the brain. The cause is usually a narrowing of the carotid artery due to an accumulation of fat. Patients may experience strokelike symptoms such as dizziness, weakness, or temporary paralysis that lasts only a few minutes. Most symptoms of a TIA disappear within 1 hour, although they may persist for up to 24 hours. About one-third of people who have had a TIA will have an acute stroke sometime in the future. Many strokes can be prevented by heeding the warning signs given by a TIA and treating the underlying risk factors.

Cerebral vascular accident (CVA) (**ser**-eh-bro-**VAS**-kyou-lar) or **stroke** is the sudden interruption of the blood supply to the brain. This results in a loss of oxygen to brain cells, causing impairment of the brain tissue and/or death (*Figure 14-16*). Stroke is the third leading cause of death in the United States. Based on statistics from the American Heart Association, about 730,000 Americans are affected by stroke per year, with about 160,000 cases resulting in death. Stroke is the number one cause of disability in the United States.

Risk factors include smoking, hypertension, heart disease, and family history. About 90% of strokes are caused by fat deposits accumulating in the carotid arteries, or blood clots becoming lodged in the carotid arteries, choking the blood supply to the brain. The remaining 10% of strokes, called hemorrhagic strokes, are caused when blood vessels within the brain rupture. See *Figures 14-17* and *14-18*.

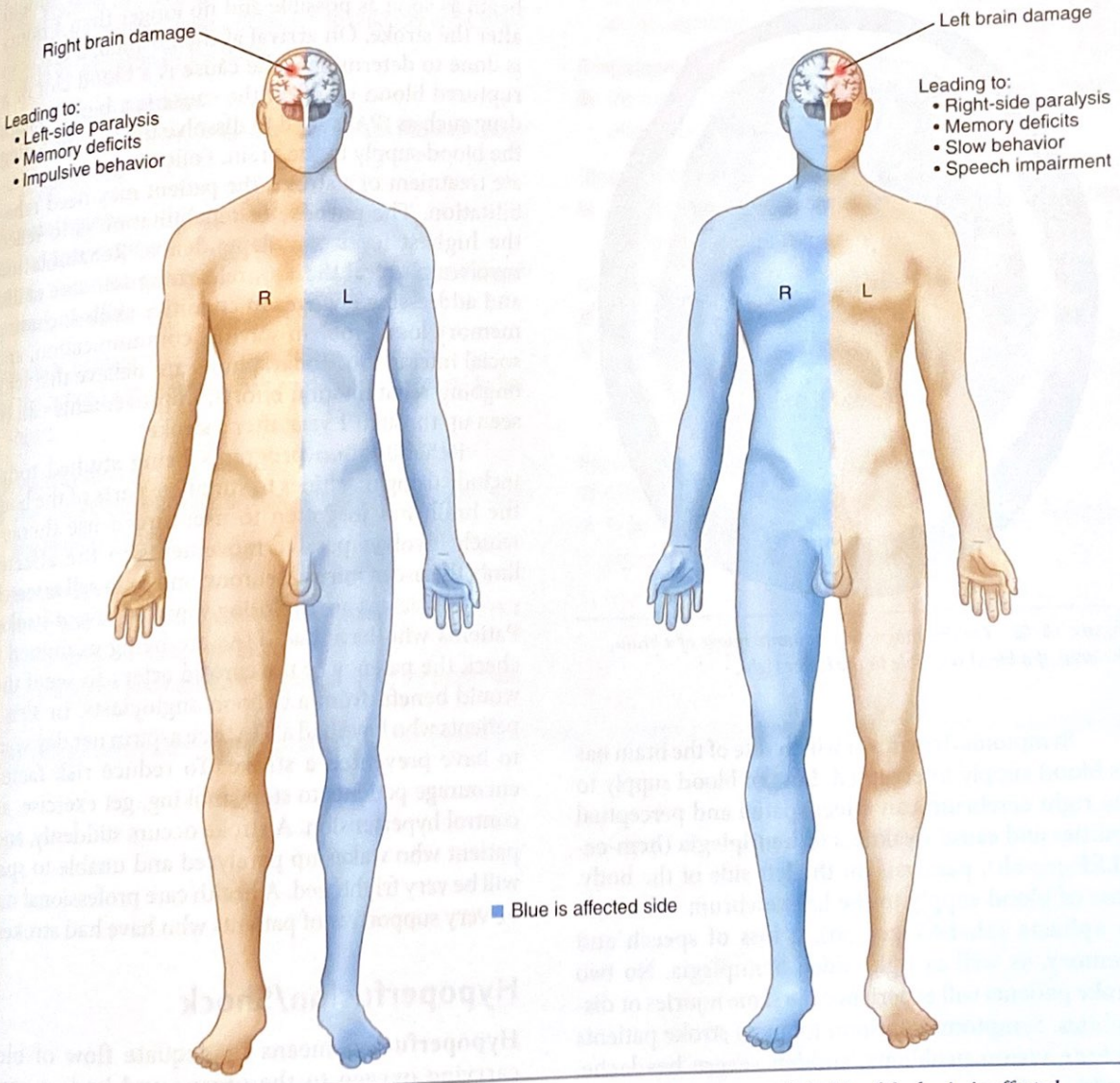

Figure 14-16 *The location of the damage caused by a cerebral vascular accident depends on which side of the brain is affected.*

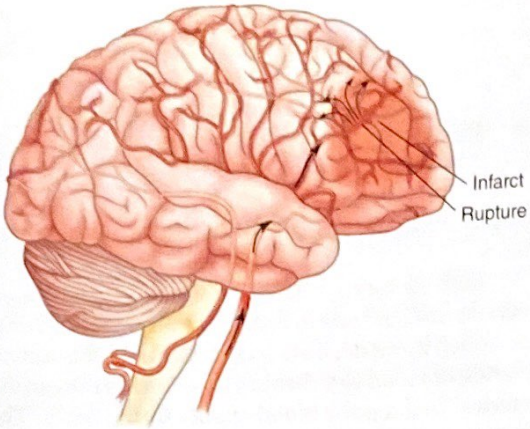

Figure 14-17 *In a hemorrhagic stroke, the rupture of a blood vessel results in decreased blood flow to an area of the brain tissue.*

Figure 14-18 *On this magnetic resonance image of a brain, the area of a bleed is visible in the lower right.*

Symptoms depend on which side of the brain has its blood supply interrupted. Loss of blood supply to the right cerebrum can affect spatial and perceptual abilities and cause weakness or **hemiplegia** (**hem**-ee-**PLEE**-jee-ah), paralysis on the left side of the body. Loss of blood supply to the left cerebrum will result in **aphasia** (ah-**FAY**-zee-ah), a loss of speech and memory, as well as right-sided hemiplegia. No two stroke patients will experience the same injuries or disabilities. Symptoms common to many stroke patients include vision problems, sudden severe headache, trouble walking or staying balanced, communication difficulties, **dysphasia** (dis-**FAY**-zee-ah) (inability to say what one wishes to say), emotional lability (uncontrolled, unexplained displays of crying, anger, or laughter), depression, coma, and possible death.

An acronym to help assess whether someone is having a stroke is F-A-S-T:

1. Face—Ask the person to smile and see if one side of the face droops down.
2. Arms—Ask the person to raise both arms; watch to see if one arm drifts down.
3. Speech—Ask the person to repeat a simple sentence; check for slurred speech or if the sentence is repeated back correctly.
4. Time—If any symptoms are present, call for emergency help immediately.

For treatment to be most effective, it should begin as soon as possible and no longer than 4 hours after the stroke. On arrival at the hospital, a CT scan is done to determine if the cause is a blood clot or a ruptured blood vessel. If the cause is a blood clot, a drug such as tPA is used to dissolve the clot, restoring the blood supply to the brain. Following the immediate treatment of a stroke, the patient may need rehabilitation. The purpose of rehabilitation is to reach the highest level of independence. Rehabilitation involves physical therapy, relearning self-care skills, and addressing changes in cognitive skills including memory loss, problem solving, communication, and social interaction. Today, physicians believe that with ongoing rehabilitation efforts, improvements can be seen up through 1 year after a stroke.

Rehabilitation programs being studied today include using machines to stimulate parts of the body the brain has forgotten to use; forced-use therapy, which involves passive movements to the affected limb; the use of mirror neurons; and stem cell research.

Physicians are exploring ways to prevent strokes. Patients who have had TIAs are being examined to check the patency of the carotid artery to see if they would benefit from a balloon angioplasty. In 39% of patients who have had a TIA, one aspirin per day seems to have prevented a stroke. To reduce risk factors, encourage patients to stop smoking, get exercise, and control hypertension. A stroke occurs suddenly, and a patient who wakes up paralyzed and unable to speak will be very frightened. A health care professional must be very supportive of patients who have had strokes.

Hypoperfusion/Shock

Hypoperfusion means inadequate flow of blood carrying oxygen to the organs and body systems. This can be caused by excessive blood or fluid loss.

Hypoperfused tissue is no longer being given enough oxygen and will stop working optimally. The most sensitive organ to a decrease in blood supply and oxygenation is the brain. After just 4 minutes of decreased blood flow to the brain, brain cells will be irreversibly damaged. Another cause of hypoperfusion is due to a change in the size of the arteries and veins. Blood vessels may become too dilated, and there is not enough pressure to move blood through the blood vessels. The main cause of hypoperfusion is inadequate pumping of the heart. Hypoperfusion leads to **shock**. The body will attempt to compensate for hypoperfusion by increasing the respiratory rate, increasing the heart rate, or sacrificing blood supply to organs to protect blood flow to the brain.

One Body — How the Cardiovascular System Interacts with Other Body Systems

The cardiovascular system plays a role in the maintenance of all body systems by carrying oxygen, nutrients, and hormones to all cells and carrying away cellular waste products and carbon dioxide for excretion by the body.

Integumentary System
- The capillary network in the skin helps maintain body temperature.

Skeletal System
- Red bone marrow produces blood cells.
- The bones of the thoracic cavity protect the heart and major blood vessels.

Muscular System
- The action of the muscles helps return venous blood to the heart.

Nervous System
- The autonomic nervous system influences the heart rate and blood pressure.

Endocrine System
- The blood serves as the transport medium for hormones produced by the endocrine system.
- The hormones adrenaline and thyroxine affect the heart rate.

Lymphatic System
- Lymphocytes are carried by the blood to sites of infection and inflammation.

Respiratory System
- The exchange of gases between carbon dioxide and oxygen takes place in the capillary network of the lungs.

Digestive System
- Blood picks up the end products of digestion for distribution to other organs of the body.

Urinary System
- Blood pressure affects the filtration rate in the kidneys.
- As the blood is filtered through the kidneys, waste products, excess electrolytes, and excess fluid are removed; this action preserves blood volume.

Reproductive System
- Estrogen maintains vascular health in women.
- Engorgement of the blood vessels in the male maintains erection of the penis.

Medical Terminology

a-	without
phas	speech
-ia	abnormal condition of
a/phas/ia	abnormal condition of being without speech
arterio	arteries
-sclerosis	hardening
arterio/sclerosis	hardening of the arteries
athero	fatty
athero/sclerosis	hardening of the arteries by fat
cerebr	main brain
-al	pertaining to
vascular	blood vessels
cerebr/al vascular accident	accident pertaining to the blood vessels in the main brain
cyan	blue
-osis	process of becoming
cyan/osis	process of becoming blue
diastol	relaxation
-ic	pertaining to
diastol/ic pressure	pertaining to the relaxation phase of the heart cycle
dys-	difficult
dys/phas/ia	pertaining to difficulty in speech
embol	plug or clot
-ism	condition of
embol/ism	condition of having a blood clot
hemi-	half
-plegia	paralysis
hemi/plegia	condition of paralysis on one side or half
hyper-	over or excessive
tens	condition of tension or pressure
-ion	process of
hyper/tens/ion	condition of excessive blood pressure
hypo-	under
hypo/tens/ion	condition of low blood pressure
phleb	vein
-itis	inflammation of
phleb/itis	inflammation of a vein
systol	contraction
systol/ic pressure	pertaining to the contraction phase of the heart cycle

Study Tools

Workbook	Activities for Chapter 14
Online Resources	• PowerPoint presentations • Animations

Review Questions

Select the letter of the choice that best completes the statement.

1. The name of the blood vessel that supplies the myocardium is the
   a. coronary artery.
   b. brachial artery.
   c. aorta.
   d. subclavian artery.

2. Special circulation that collects blood from the organs of digestion and takes it to the liver is the
   a. coronary.
   b. fetal.
   c. cardiopulmonary.
   d. portal.

3. The most common site for taking a pulse is the
   a. popliteal artery.
   b. dorsalis pedis artery.
   c. radial artery.
   d. temporal artery.

4. The blood vessel that carries blood away from the heart to the lungs is called the
   a. pulmonary artery.
   b. pulmonary vein.
   c. coronary sinus.
   d. coronary artery.

5. The inner layer of the artery is called the
   a. tunica adventitia.
   b. tunica intima.
   c. tunica media.
   d. externa.

6. The blood supply to the brain is carried by the
   a. external carotid artery.
   b. popliteal artery.
   c. internal carotid artery.
   d. coronary artery.

7. The blood supply returns from the legs through the
   a. saphenous vein.
   b. external jugular vein.
   c. superior vena cava.
   d. hepatic vein.

8. A buildup of fat in the arterial walls can cause the disease of
   a. gangrene.
   b. atherosclerosis.
   c. arteriosclerosis.
   d. aneurysm.

9. An inflammation of the lining of the vein is called
   a. hemorrhoid.
   b. thrombus.
   c. embolism.
   d. phlebitis.

10. The thinning and ballooning of an artery is called
    a. aneurysm.
    b. arteriosclerosis.
    c. phlebitis.
    d. atherosclerosis.

Matching

Match each term in Column I with its correct description in Column II.

COLUMN I	COLUMN II
_____ 1. capillaries	a. small arteries that lead to capillaries
_____ 2. valves	b. deposit of fatty substances in the arteries
_____ 3. arterioles	c. blood pressure over 140/90
_____ 4. aorta	d. permit blood flow in only one direction
_____ 5. coronary	e. goes to the liver from the small intestine
_____ 6. hypertension	f. blood vessels that carry blood back to the heart
_____ 7. atherosclerosis	g. largest artery in the body
_____ 8. portal vein	h. loss of elasticity in the arteries
_____ 9. superior and inferior vena cavae	i. connect arterioles with venules
_____ 10. arteriosclerosis	j. arteries that nourish the heart

Applying Theory to Practice

1. You are a red blood cell and you are leaving the arch of the aorta. Trace your journey to the right great toe. Name all the blood vessels through which you will travel.
2. You are a red blood cell in the left finger. You need oxygen and you must get to the lungs. Trace your journey from the finger to the lungs. Name the blood vessels and structures through which you will travel.
3. Your grandmother has symptoms of peripheral vascular disease that the physicians say is a result of arteriosclerosis. Explain to your grandmother PVD and arteriosclerosis. If the following arteries are affected—carotid artery, coronary artery, renal artery, and femoral artery—what complication may occur? Describe how arteriosclerosis can be prevented.
4. The fetal heart is unique. Why is it different? Describe the structures of the fetal heart that change at birth.
5. Take the pulse and blood pressure of a 20-year-old, a 40-year-old, and a 70-year-old. Compare the results; if they are different, why are they different?
6. Why is hypertension called the "silent killer?" What is considered normal blood pressure? What are the complications of hypertension?

Case Study

Mrs. Frances arrives in the emergency department with her son George. She cannot speak and there is weakness and numbness on her right side. She is seen by Victoria, the nurse practitioner, who also notices a drooping on the right side of Mrs. Frances's face. George states that his mother was fine, eating her breakfast when this occurred. Victoria checks the woman's BP and it is 200/100. The emergency department physician and Victoria examine the patient, and the physician makes the diagnosis of a cerebral vascular accident (CVA).

1. Describe what a CVA is. What is the other name given to a CVA?
2. What is the correlation between Mrs. Frances's BP and her CVA?
3. What other body systems will be affected because of the CVA?
4. What is the major cause of strokes?
5. Explain the simple tests Victoria will do to determine Mrs. Frances's state of paralysis.
6. Mrs. Frances cannot speak. Which side of her brain was affected?
7. List some of the therapies Mrs. Frances will need.
8. Explain some of the actions people can take to avoid a CVA.

Lab Activity 14-1

Structure of Blood Vessels

- *Objective:* To observe the structure of the various blood vessels in the human body
- *Materials needed:* microscopic slides of cross sections of a normal artery, vein, and an atherosclerotic artery; microscope; textbook; disposable gloves; biodegradable container for slides; household bleach; paper; pencil

Step 1: Put on gloves.

Step 2: Observe the slide of the structure of the normal artery. Record a brief description of the features you see.

Step 3: Observe the slide of the structure of a vein. Record a brief description of the features you see.

Step 4: What is the difference between the artery and the vein? Record your observations.

Step 5: Observe the slide of the atherosclerotic artery. Compare with the diagram in the textbook. Record your observations. Contrast the appearance of the normal artery with the appearance of the atherosclerotic artery.

Step 6: Place slides in the biodegradable container for disposal.

Step 7: Clean all equipment with household bleach.

Step 8: Remove gloves and wash your hands. ■

Lab Activity 14-2

Principal Arteries and Veins

- *Objective:* To locate and identify the major arteries and veins within the body
- *Materials needed:* unlabeled anatomical charts of the major arteries and veins, magnetic labels with the names of the arteries and veins, textbook, paper, pencil

Step 1: Locate and name the arteries on the anatomical chart that supply the following organs or body regions with blood: brain, face, pectoral girdle, upper arm, radius, ulna, heart, lungs, liver, stomach, spleen, kidney, intestines, femur, tibia, fibula, and pelvic girdle. Place the names of the arteries in their appropriate places on the chart.

Step 2: Compare your answers to the diagrams in this chapter of the textbook.

Step 3: Locate and name the veins that return the blood to the heart from the following organs or body regions: brain, face, pectoral girdle, upper arm, radius, ulna, heart, lungs, liver, stomach, spleen, kidney, intestines, femur, tibia, fibula, and pelvic girdle. Place the names of the veins in their appropriate places on the chart.

Step 4: Compare your answers to the diagrams in this chapter of the textbook.

Step 5: Do the arteries and veins that supply these locations have the same or similar names? Record your answer.

Lab Activity 14-3

Vital Signs

- *Objective:* To determine the pulse points in the body and to take a pulse
- *Materials needed:* wristwatch with second hand, textbook, paper, pencil

Note: This activity must be done with a lab partner.

Step 1: Have your lab partner sit with the wrist resting on a table.

Step 2: Locate your partner's radial pulse with the pads of your first three fingers. (Remember: Do not use the thumb because it has its own pulse.)

Step 3: Gently compress the radial artery to feel the pulse.

Step 4: Count the pulse for 1 full minute. Take notice of the rhythm and volume. Record the pulse and describe any irregularities you notice.

Step 5: On your lab partner, locate and take the pulse at the following pulse points: temporal, carotid, brachial, popliteal, and dorsalis pedis. Compare locations with the diagram in this chapter of the textbook. Record the count at each pulse point. Does any reading differ from another? Record your answer.

Step 6: Switch places with your lab partner and repeat steps 1 through 5.