In order to survive, all cells need a consistent supply of blood to deliver oxygen and nutrients and to remove wastes. When the blood supply or perfusion is impaired, ischemia develops and can progress to necrosis, if prolonged. For this reason, perfusion is a critical concept for nurses to understand and incorporate into practice. The purpose of this concept analysis is to help the nurse acquire foundational knowledge about perfusion across the lifespan. In practice, nurses should be able to design behaviors that optimize perfusion, identify individuals at risk of impaired perfusion, recognize when individuals are experiencing an impairment of perfusion, and respond with appropriate interventions.

**DEFINITION(S)**

For the purpose of this concept analysis, tissue perfusion refers to the flow of blood through arteries and capillaries delivering nutrients and oxygen to cells and removing cellular waste products. Perfusion is a normal physiologic process that requires the heart to generate sufficient cardiac output to transport blood through patent blood vessels for distribution in the tissues throughout the body. Thus maintaining cardiovascular health is essential to optimal perfusion. The extent of tissue damage from impaired perfusion depends on the size and location of the blood vessel and whether the blood supply is reduced or completely interrupted. When blood supply is available but decreased, the term ischemia is used. For example, when blood supply from coronary arteries to the myocardium is decreased but not absent, the term myocardial ischemia is used. The chest pain produced is called angina pectoris and the function of myocardial cells is reduced, but cells do not die. However, prolonged ischemia of tissue leads to necrosis, and eventually infarction if blood supply is not restored. Myocardial infarction indicates death of myocardial tissue with an inability to regenerate.

**SCOPE AND CATEGORIES**

The concept of perfusion and problems associated with impaired perfusion represent a wide range of physiologic processes and conditions. The scope of perfusion ranges from optimal perfusion to no perfusion (Figure 15-1).
Various degrees of reduced perfusion lie between the two ends of the spectrum. Two broad categories that describe the process and problems associated with perfusion are central perfusion (mechanisms for blood delivery) and local or tissue perfusion (actual amount of blood available to target tissues). Both of these categories are presented in Figure 15-2 and described further in the following sections.

**Central Perfusion**

Central perfusion involves mechanisms that direct the total amount of blood pumped from the heart to the periphery. Central perfusion output is an outcome of coordinated effects of electrical and mechanical factors that ultimately push blood to all organ systems through capillaries and return the blood to the heart. Although the mechanics of flow are the same to each target tissue, various factors can reduce cardiac output from the heart or cause systemic vasodilation or vasoconstriction to impair central perfusion. When central perfusion is impaired, clinical manifestations are systemic; in other words, the entire body is affected. Significant reduction of central perfusion results in shock, which occurs when blood supply to tissues is impaired because of inadequate cardiac output, significant blood loss, or vasodilation throughout the body.

**Local/Tissue Perfusion**

Tissue perfusion refers to the volume of blood that flows through target tissues. This perfusion is supplied by blood flowing from arteries to capillaries, which are surrounded by smooth muscles. The force of ventricular contractions creates a pressure, called capillary hydrostatic pressure, which pushes blood through capillaries into the interstitial spaces allowing delivery of oxygen, fluid, and nutrients to cells. Different organs and tissues require different volumes of blood to maintain adequate function. Some organs such as the brain and intestines require much larger volumes of perfused blood compared to the heart. Inadequate tissue perfusion is linked to impaired local perfusion or from a multitude of causes, such as a blocked blood vessel (atherosclerosis) or excessive edema within the capillaries and tissues.

**RISK FACTORS**

Adequate perfusion is required for life; therefore all individuals, regardless of age, gender, race, or socioeconomic status, are potentially at risk for impaired perfusion. Nurses need to recognize that some individuals are at greater risk for impairment. Some of these risk factors are controllable lifestyle behaviors, whereas others are not.

Populations at greatest risk of impaired perfusion are middle age and older adults, especially among males and African Americans. Also at risk are infants with congenital heart defects. Children and young adults commonly experience impaired perfusion as a result of trauma; this leads to central perfusion failure attributable to blood loss.

Adults in middle and old age are commonly affected by atherosclerosis involving the heart and peripheral vessels, myocardial disease, and other chronic conditions that negatively impact the cardiovascular system. Atherosclerosis is characterized by plaques of cholesterol and other lipids lining the inner layers of arteries, which results in obstructed blood flow. Older adults are at risk for impaired perfusion because of anatomic changes expected with advanced age such as fibrosis and sclerosis of the sinoatrial node and mitral and aortic valves.

A number of modifiable and nonmodifiable risk factors linked to impaired perfusion are presented in Table 15-1.

**PHYSIOLOGIC PROCESSES AND CONSEQUENCES**

Perfusion of blood begins when the heart is stimulated by an electrical impulse that originates in the sinoatrial (SA) node and travels to the atrioventricular (AV) node. From the AV node the impulse moves through a series of branches (bundle of His) and Purkinje fibers in the myocardium, which causes the ventricles to contract. The phase of the cardiac cycle when the ventricles contract is called systole. As the ventricles contract, they create a pressure that closes the mitral and tricuspid valves, preventing the backflow of blood into the atria. This ventricular pressure forces the aortic and pulmonic valves to open, resulting in ejection of blood into the aorta (from the left ventricle) and the pulmonary arteries (from the right ventricle). As blood is ejected, the ventricular pressure decreases, causing the aortic and pulmonic valves to close. The ventricles relax to fill with blood. The movement of blood from the atria to the ventricles is accomplished when the pressure of the blood in the atria becomes higher than the pressure in the ventricles. The higher atrial pressures passively open the mitral and tricuspid valves, allowing blood to fill the ventricles. The phase of the cardiac cycle when ventricles fill with blood is called diastole. Figure 15-3 shows the flow of blood through the right and left sides of the heart.

Pressure generated from the myocardial contraction supplies blood to the peripheral vascular system. Arteries, capillaries, and veins provide blood flow to and from tissues. The tough and tensile arteries and their smaller branches, the arterioles, are subjected to remarkable pressure from the cardiac output. They maintain blood pressure by constricting or dilating in response to stimuli. The more passive veins and their smaller branches, the venules, are less sturdy but more expansible, enabling them to act as a reservoir for extra blood, if needed, to decrease the workload on the heart. Pressure within the veins is low when compared with arterial circulation. The valves in each vein keep blood flowing in a forward direction toward the heart.
FIGURE 15-2 Arteries Supplying Central and Local Perfusion. (From Seidel et al: Mosby’s guide to physical examination, St Louis, 2011, Mosby.)

Detailed figures clarify key health and illness concepts – in this example, a diagram depicts connected pulmonary and systemic circulatory systems and how to trace the flow of blood.
TABLE 15-1 INDIVIDUAL RISK FACTORS FOR IMPAIRED PERFUSION

<table>
<thead>
<tr>
<th>MODIFIABLE RISK FACTORS</th>
<th>UNMODIFIABLE RISK FACTORS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking: nicotine vasoconstricts</td>
<td>Age: increases with age</td>
</tr>
<tr>
<td>Elevated serum lipids: contribute to atherosclerosis</td>
<td>Gender: men &gt; women</td>
</tr>
<tr>
<td>Sedentary lifestyle: contributes to obesity</td>
<td>Genetics: family history</td>
</tr>
<tr>
<td>Obesity: increases risk for type 2 diabetes and atherosclerosis</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus: increases risk of atherosclerosis</td>
<td></td>
</tr>
<tr>
<td>Hypertension: increases work of myocardium</td>
<td></td>
</tr>
</tbody>
</table>

Consequences of Impaired Central Perfusion

Impairment of central perfusion occurs in conditions that decrease cardiac output or cause shock. Cardiac output is decreased when there is inadequate perfusion to the myocardium, inadequate impulse conduction through the heart, or malfunction of heart valves. First, any occlusion or constriction of coronary arteries that reduces blood flow to the myocardium can result in a myocardial infarction that decreases cardiac output. This impairment prevents the myocardium from performing the mechanical function of pumping blood to the body. Second, altered impulse conduction through the heart (from the SA node through the AV node to the right and left bundle branches and Purkinje fibers) interrupts the electrical function necessary for the myocardium to contract. Third, malfunction of heart valves, either stenosis or insufficiency, impairs flow of blood through the heart. Shock, the inability of central perfusion to supply blood to peripheral tissues, occurs when the heart is unable to act as a pump.

FIGURE 15-3 Diagram Showing Serially Connected Pulmonary and Systemic Circulatory Systems and How to Trace the Flow of Blood. Right heart chambers propel un oxygenated blood through the pulmonary circulation, and the left heart propels oxygenated blood through the systemic circulation. (From Huether S, McCance K: Understanding pathophysiology, ed 4, St Louis, 2008, Mosby/Elsevier.)
Consequences of Impaired Tissue Perfusion

Impairment of tissue perfusion is associated with occlusion, constriction, or dilation of arteries or veins. Atherosclerosis or thrombi can occlude arteries and thrombi can occlude veins. Vasocostriction can occur from frostbite. Examples of dilation are aneurysms in arteries and varicose veins. Impaired tissue perfusion interferes with blood flow, resulting in ischemia to localized tissue and, if uncorrected, cellular death.

Ischemia is reversible cellular injury that occurs when the demand for oxygen exceeds the supply because of a reduction or cessation of blood flow. This is an example of the interrelationship between the cardiovascular and respiratory systems, because cells are deprived of oxygen either from the lack of blood flow or from the lack of oxygen, or both.

Decreased oxygen to the mitochondria reduces adenosine triphosphate (ATP) production, which causes two problems. First, when oxygen is not available for the cells’ usual oxidative metabolism, they are forced to use anaerobic metabolism, creating ATP from glycogen, to maintain cell function. This process creates lactic acid, which accumulates in the cell and causes cellular acidosis. The cellular acidosis causes lysosomes, the cell’s digestive organelles, to swell and eventually release acidic enzymes that autodigest cellular structures. Destruction of tissues releases enzymes such as creatine kinase (CK); measurement of these enzymes after a myocardial infarction indicates the degree of damage to the heart muscle. Figure 15-4 presents a concept map of the physiologic effects of ischemia.

The second problem with lack of ATP is the inability to maintain the adenosinetriphosphatase (ATPase) pumps. The sodium-potassium pump normally uses energy provided by ATP to pump sodium out of the cell and allow potassium into the cell. When ATP is unavailable, a potassium deficit develops in the cell, which can cause dysrhythmias in myocardial tissue. Also, the sodium remains in the cell and draws in water, resulting in swelling within the cell, dilation of the endoplasmic reticulum, decreased mitochondrial function, and increased membrane permeability. The increased membrane permeability allows calcium ions to enter the mitochondria, where they activate lipases and proteases and increase the production of free radicals. The membrane damage initiates the inflammatory process, producing prostaglandins, thromboxanes, and cytokines. When ischemia

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**FIGURE 15-4 Hypoxic Injury Induced by Ischemia.** Purple boxes involve reversible cell injury, light blue boxes involve irreversible cell death, and green boxes are clinical manifestations. (From Huether S, McCance K: Understanding pathophysiology, ed 4, St Louis, 2008, Mosby/Elsevier).
ASSESSMENT

Sources of data come from the patient as well as from physical assessment and laboratory findings. Assessment of perfusion involves recognizing indications of adequate and inadequate perfusion. The presence of central perfusion is noted by heart rate and blood pressure measurements within normal limits. Cerebral tissue perfusion is indicated by the patient’s orientation to time, place, person, and situation; expected bilateral movement and sensation; clear speech; presence of carotid pulses; and absence of carotid bruit. Peripheral tissue perfusion is present when the patient’s extremities are warm with color appropriate for race and the radial and dorsalis pedis pulse rates are between 60 and 100 beats per minute with regular rhythm, easily palpable upstroke, and smooth, rounded contour. Adequate peripheral tissue perfusion is also indicated when the capillary refill time is less than 2 seconds and the ankle-brachial index is greater than 0.9. Patients’ reports of adequate perfusion include the presence of warm hands and feet and the absence of continuous pain in fingers and toes or leg pain when walking.1

History

Baseline History

When collecting subjective data from patients, nurses ask about lifestyle behaviors including diet, exercise, smoking, and alcohol consumption. A diet high in fat and carbohydrates together with minimal or infrequent exercise contributes to atherosclerosis and obesity. The nicotine present in cigarettes constricts blood vessels, contributing to hypertension and increasing the workload of the heart. Excessive alcohol intake is associated with dysrhythmias. Also, patients are asked if any chronic diseases, such as diabetes mellitus, renal failure, and hypertension, are present in either the patient or the patient’s family. Nurses ask patients for a list of medications they take, both prescription and over-the-counter, including the reason for each medication and its efficacy. Patients are also asked about use of recreational or street drugs, such as cocaine because it is associated with myocardial infarction and stroke.3

Problem-Based History

When providing their history, patients may describe pain, shortness of breath (dyspnea), edema (swelling), and fainting (dizziness). When these symptoms are reported, the nurse follows up with a symptom analysis to obtain additional data, including the onset of the symptom; the location, duration, and severity of the symptom; a description of the symptom; factors that alleviate or aggravate the symptom; other associated symptoms; actions taken by the patient to relieve the symptom.5

Pain. A common symptom reported by patients with impaired tissue perfusion is pain. When there is inadequate perfusion to carry needed oxygen to meet tissue needs, patients experience ischemic pain. Ischemic pain occurs by the same process whether it is occurring in the coronary arteries of the heart or the femoral arteries of the legs.

Chest pain may be due to impaired blood flow to the myocardium or pulmonary emboli. Patients experience myocardial ischemia, also called stable angina, when there is an increased demand for oxygen on the heart. They often report a precipitating event such as physical exertion, exposure to cold temperatures, or emotional stress. Patients with angina pectoris describe their chest pain as a constricting or squeezing sensation that is relieved with rest and/or by taking one or more nitroglycerin tablets. By contrast, patients having acute coronary syndrome (unstable angina advancing to myocardial infarction) report severe chest pain that is not relieved by rest or nitroglycerin; shortness of breath; radiating pain to the jaw or arms; and nausea, vomiting, and diaphoresis. Although men and women may experience the same symptoms, some women report atypical chest pain, shortness of breath, and fatigue as their only indications of myocardial infarction. Patients experiencing pulmonary emboli report varied and nonspecific symptoms. Classic symptoms of chest pain and shortness of breath are reported only by about 20% of patients. The pain onset varies from gradual to sudden. Pleuritic chest pain also is reported at the onset of a pulmonary embolus.4

Pain in the legs attributable to impaired perfusion may be caused by peripheral arterial disease (PAD) or a deep vein thrombus. Patients with PAD may report pain when walking that is relieved with rest, called intermittent claudication. This pain indicates an inadequate supply of blood to transport needed oxygen to meet the demands of the leg muscles. As the arterial occlusion increases, patients may report “rest pain,” which is leg pain while walking that is not relieved with rest. By contrast a venous thromboembolism causes pain because of pressure within the vein. Edema also develops from the obstruction of venous blood flow.

Dyspnea. Inadequate circulation of blood interferes with oxygen transport to tissues, making patients dyspneic or short of breath during activity. Thus this symptom may be reported by patients with primary perfusion problems, such as heart failure, or by those with primary gas exchange problems, such as chronic obstructive pulmonary disease. Patients may report having to sleep sitting up or using several pillows to prop up during the night. Lightheadedness may be reported attributable to inadequate oxygen transport to the brain. Nurses inquire about the duration of patients’ shortness of breath as well as if the dyspnea occurs on inhalation or exhalation, or both. They ask what makes the dyspnea better and what makes it worse. Nurses ask if patients have any other symptoms occurring at the same time such as chest pain or swelling of the feet and ankles.5 When an infant is being evaluated for heart disease, the mother or caretaker may report the infant needing to stop sucking “to catch his or her breath” or the infant exhibited a blush color around the lips when sucking.5

SOURCES OF DATA
Edema (swelling). Patients may report their socks leaving an indentation around their legs or edema in their feet that is worse at the end of the day. This edema reflects excessive fluid in the interstitial spaces, which indicates a fluid overload or an accumulation of fluids. The excessive fluid may occur from renal disease when blood cannot be filtered by the kidneys. Right-sided heart failure is another cause of peripheral edema that develops if the right ventricle is unable to eject its usual volume of blood. Reflux of blood occurs from the right ventricle into the right atrium, and then into the inferior and superior venae cavae. Because of the buildup of blood, the veins are unable to transport blood back to the right side of the heart, resulting in an accumulation of blood in the venous system that pushes fluid into the interstitial spaces, causing edema. Incompetent veins that develop from varicose veins may cause peripheral edema. Use Figure 15-2 to review the flow of blood from the venules of each organ to the right side of the heart.

Dizziness or fainting. Patients may report feeling dizzy. Using a symptom analysis, nurses collect more data to learn when this lightheadedness occurs as well as aggravating and relieving factors. If the dizziness occurs when the patient sits up suddenly, it is called orthostatic hypotension, which is defined as a 20 to 30 mm Hg drop in systolic blood pressure when a patient moves from a lying to a sitting or standing position. Nurses inquire about the duration of the dizziness. For many patients the dizziness subsides if they sit for a few seconds before standing. In contrast, dizziness unrelated to position changes may be caused by inadequate blood flow to the brain. The carotid arteries may be obstructed from atherosclerosis, preventing adequate blood flow to the brain.

Examination Findings
Central Perfusion
When assessing patients experiencing inadequate central perfusion, nurses may notice changes in vital signs such as hypotension or tachycardia. When assessing for orthostatic hypotension, blood pressure is measured in three positions: lying, sitting, and standing. Nurses compare these three blood pressure readings to confirm position changes as a contributing factor to the dizziness or fainting. Auscultation of the patient’s heart may reveal S1 and S2 heart sounds as expected as well as S3 or S4 heart sounds or murmurs, indicating turbulent blood flow through the heart. There may be a change in mentation reflecting impaired blood flow to the brain, or shortness of breath can result from insufficient oxygenation of the blood or the accumulation of blood in the pulmonary capillaries. Additional findings may include changes in heart rhythm indicating altered cardiac electrical function; peripheral edema can develop from fluid retention or inadequate cardiac output. Patients may have a sympathetic nervous system response causing diaphoresis or anxiety.

Infants may have low weight and failure-to-thrive attributable to a weak suck and dyspnea while feeding. Children may not be as active and may squat on the playground to compensate for impaired perfusion. Characteristic heart murmurs are heard in infants with congenital heart disorders such as atrial septal defect, ventricular septal defect, and patent ductus arteriosus. Infants with coarctation of the aorta have high blood pressure and bounding pulses in the arms, but lower blood pressure, weak to absent pulses, and cool lower extremities.

Tissue Perfusion
Manifestations of poor tissue perfusion are dependent upon the tissues involved. When assessing patients with impaired blood flow to the lower extremities, the nurse may notice less hair on the legs and pale skin on inspection. Palpation reveals cool skin, diminished to absent dorsalis pedis or posterior tibial pulses, and slowed capillary refill time. An ankle-brachial index (ABI) measurement of <0.9 indicates that the brachial blood pressure is stronger than the ankle blood pressure, confirming reduced perfusion to the lower extremities.

When ischemia involves the kidneys, for example in response to hemorrhagic shock, kidneys produce less urine because of lack of blood flow. The lack of perfusion stimulates the renin–angiotensin–aldosterone (RAA) system, resulting in a relative increase in blood pressure because of the effects both of angiotensin II (vasoconstricts blood vessels) and of increases in aldosterone secretion (retains sodium and then water, causing peripheral edema).

When ischemia involves the brain, manifestations produced depend on the extent of ischemia and the areas of the brain affected. For example, when mild atherosclerosis occludes the right carotid artery, patients experience a transient ischemic attack (TIA) that may involve left-sided weakness and difficulty speaking, conditions that usually resolve within 24 hours. In contrast, if blood supply to the right anterior cerebral artery is reduced or absent, patients will have a reduce level of consciousness and paralysis of the left leg.

Diagnostic Tests
Blood Tests
Enzymes and markers. Enzymes released from damaged cells and circulate in the blood can be measured to help confirm impaired perfusion.
• Creatine kinase (CK) is an enzyme present in myocardium (CK-MB), in muscle (CK-MM), and in brain (CK-BB) tissues. When enzymes are isolated, the level of CK-MB is elevated after a myocardial infarction.
• Lactate dehydrogenase (LDH) is an enzyme found in large amounts in the heart, liver, muscles, and erythrocytes. When enzymes are isolated, the level of LDH1 iso-enzyme is elevated after damage to the myocardium and erythrocytes.
• Natriuretic peptides include two hormones. Atrial natriuretic peptide (ANP) is a hormone secreted from right atrial cells when right atrial pressure increases; it is used to detect heart failure. Brain-type natriuretic peptide (BNP) is a hormone secreted from cardiac cells in increased amounts when pressures are high; it is used to detect heart failure.
• Troponin is a myocardial muscle protein released after myocardial injury. Increased blood levels of this protein are found in patients who have had a myocardial
infarction. Troponin also can be used to predict the likelihood of future cardiac events.\(^7\)

- Homocysteine (Hcy) is an amino acid produced during protein metabolism. Elevated levels of Hcy can be hereditary or acquired from dietary deficiencies such as vitamin B\(_6\), vitamin B\(_12\), or folate. The link to perfusion is that elevated levels of Hcy have been identified as a predictor of coronary artery disease (CAD), cerebrovascular accident, peripheral arterial disease, and venous thrombosis.\(^8\) Hcy promotes atherosclerosis by causing endothelial damage, promoting deposits of low-density lipoproteins, and promoting vascular smooth muscle growth.\(^7\) Testing for Hcy has been recommended in those patients with a familial predisposition for early cardiovascular disease or history of cardiovascular disease in the absence of other common risk factors.\(^8\)

- C-reactive protein (CRP) is a protein produced by the liver during acute inflammation and is emerging as an independent risk factor for CAD. Measurement of CRP using a high-sensitivity test (hsCRP) has been shown to predict the risk of future cardiac events in patients with unstable angina and myocardial infarction.\(^8\)

**Serum lipids.** Serum lipids provide information about the risk of atherosclerotic disease and include total cholesterol, low-density lipoproteins (LDLs), high-density lipoproteins (HDLs), very-low-density lipoproteins (VLDLs), and triglycerides. These lipoproteins serve numerous functions in the body, such as transport of lipids and fat-soluble vitamins. When lipoprotein levels are high, it can lead to atherosclerosis, which is the underlying cause of many cardiovascular events such as heart attack, stroke, and peripheral arterial disease, and venous thrombosis.\(^8\)

**Electrocardiogram**

An electrocardiogram (EKG) is performed by placing 12 leads on the patient’s chest to record the electrical impulses through the heart. Six leads record electrical impulses in the frontal plane, whereas the remaining six leads record electrical impulses in the horizontal plane. The waveforms generated detect cardiac dysrhythmias by documenting on a screen or paper the electrical impulses generated by the heart during contraction and relaxation of atria and ventricles.\(^7\) A 12-lead EKG is obtained to detect myocardial ischemia or infarction when patients complain of chest pain. An EKG also is used to continuously monitor the heart rhythm using one or more leads. Four leads are commonly used to monitor heart rhythm at the bedside.\(^9\)

**Cardiac Stress Tests**

**Exercise cardiac stress test.** The exercise cardiac stress test (ECST) is one of the most common cardiac stress tests because it is relatively simple and noninvasive. Using a standardized protocol, the patient exercises on a treadmill with a progressive increase in speed and elevation. During the test, an EKG is recorded along with regular monitoring of heart rate and rhythm, blood pressure, and respiratory rate. If coronary artery disease is present, changes in electrical conduction or other symptoms such as chest pain may occur.

**Pharmacologic stress test.** Another common cardiac stress test involves the administration of certain pharmacologic agents which stimulate the physiologic effects of exercise. This is often done when patients are unable to perform the exercise stress test due to underlying conditions. Agents often administered include dobutamine and adenosine. EKG monitoring (or radionuclide imaging) is performed while the pharmacologic agents are given to detect problems with conduction, heart rate, or strength of contractions.

**Radiographic Studies**

**Chest x-ray.** Chest x-rays provide visualization of the lungs, ribs, clavicles, vertebrae, heart, and major thoracic vessels. For patients with impaired perfusion, x-rays are taken to visualize the size of the heart and lung fields.\(^8\)

**Ultrasound.** Venous compression ultrasound is performed to determine if deep femoral, popliteal, and posterior tibial veins collapse with application of external pressure, which is normal. Veins with a deep vein thrombosis are unable to collapse. Duplex ultrasound is a combination of compression ultrasound and Doppler flow studies. Veins are examined for filling defects to help determine the location and extent of thrombus.\(^10\)

**Arteriogram.** An arteriogram allows visualization of arteries by injecting radiopaque contrast into them so that the location and extent of occlusion can be identified. A cardiac catheterization is one type of arteriogram that allows visualization of coronary arteries and heart chambers. A catheter is passed into the heart through a peripheral vein or artery, depending on whether catheterization of the left or right side of the heart is being performed. Pressures are recorded through the catheter and radiographic contrast is injected to visualize the patency of coronary arteries.\(^7\)

**CLINICAL MANAGEMENT**

Clinical management associated with the perfusion concept involves the prevention of illness and the early detection and appropriate management of cardiovascular problems. There are 24 objectives for heart disease and stroke in the Healthy People 2020 document that reflect primary prevention, secondary prevention, and collaborative management strategies. (See Healthy People 2020 at healthypeople.gov).

**Primary Prevention**

Primary prevention includes measures to promote health and prevent development of disease. There are several measures that prevent or diminish conditions that impair perfusion. Prevention measures are based on a heart-healthy lifestyle, which includes eating a healthy diet, exercising most days of the week, taking a daily low-dose aspirin, and not smoking. Recommendations by the American Heart Association\(^11\) are presented in Box 15-2.  

**Secondary Prevention (Screening)**

Secondary prevention includes screening and early diagnosis and prompt treatment of existing health problems. Its purpose is to shorten the duration and severity of consequences. Routine screening involves monitoring blood pressure and serum lipids.
**Services Task Force (USPSTF)** recommends screening for high blood pressure in adults ages 18 and older. For patients who have hypertension, the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure recommends screening every 2 years when blood pressures are less than 120/80 mm Hg. This same committee recommends screening every year when systolic blood pressures are 120 to 139 mm Hg or diastolic pressures are 80 to 90 mm Hg.

**Blood Pressure Screening**

Blood pressure screening is a simple and cost-effective screening recommended across the lifespan. Beginning in infancy, blood pressure screening is recommended at every well-child visit, and at least annually. Among adults, the U.S. Preventive Services Task Force (USPSTF) recommends screening for high blood pressure in adults ages 18 and older. For patients

**AMERICAN HEART ASSOCIATION HEALTH PROMOTION RECOMMENDATIONS**

1. Eat a variety of fruits, vegetables, grains, legumes, fat-free or low-fat dairy products, fish, poultry, and lean meats:
   - Reduce sodium (salt) intake to less than 1500 a day.
   - Reduce saturated and trans fats to less than 10% of calories.
2. Participate in physical activity
   - Adults >20 yrs: at least 150 minutes/week of moderate intensity activity
   - Children 12-19 yrs: at least 60 minutes of moderate intensity activity every day
3. Refrain from smoking and have no exposure to environmental tobacco smoke.
4. Maintain blood pressure:
   - Adults over 20 years of age: <120/80 mm Hg
   - Children 8 to 19 years of age: <90th percentile
5. Maintain total cholesterol
   - Adults >20 years of age <200 mg/dL
   - Children 6-19 years of age <70 mg/dL
6. Maintain fasting blood glucose
   - Adults >20 years of age: less than 100 mg/dL
   - Children 12 to 19 years of age: less than 200 mg/dL
7. Achieve and maintain desirable weight
   - Adults >20 years of age: 25 kg/m²
   - Children 12-19 years of age: <85th percentile

Lipid Screening
Recommendations for screening of lipids vary between men and women. The USPSTF strongly recommends screening men ages 35 and older for lipid disorders and screening men ages 20 to 35 if they are at increased risk for coronary artery disease. For women the USPSTF strongly recommends screening those ages 45 and older for lipid disorders if they are at increased risk for coronary heart disease. Among younger women, ages 20 to 45, The USPSTF recommends lipid screening if they are at increased risk for coronary heart disease.12

Collaborative Interventions
The management of individuals with impaired perfusion is highly dependent on the specific condition. The following sections describe common interventions implemented in the treatment of conditions resulting in impaired perfusion.

Nutrition Therapy
Nutrition therapy should meet the recommendations described under Primary Prevention, but the goal of the heart-healthy diet is tertiary prevention—to lower serum lipid levels and lose weight. For the reason, nutrition therapy is considered an intervention in both primary prevention and disease management.

Activity, Exercise, and Positioning
Activity and exercise are a regular part of any treatment regimen. Specifically it is included in the following applications:
- For the purpose of weight loss
- Cardiac rehabilitation after acute coronary syndrome13
- Progressive activity for patients with peripheral arterial disease
- Position lower extremities when seated or in bed
  - Dependent for arterial occlusion
  - Elevated for venous occlusion

Smoking Cessation
Smoking cessation is also considered both primary prevention and collaborative intervention for disease management. Refer to the Gas Exchange concept for interventions directed at smoking cessation.

Pharmacotherapy
- Vasodilators increase the diameter of blood vessels in a variety of ways that block normal mechanisms. For example, vasodilators can block the following: alpha-adrenergic receptors; calcium influx into vascular smooth muscle; formation of angiotensin II, which normally increases aldosterone concentration to retain sodium as well as vasoconstriction; or receptors that receive angiotensin II. Myocardial contractility is reduced for the purpose of lowering cardiac output by blocking calcium influx into the myocardium and blocking the beta-adrenergic receptors in the heart.13 Vasodilators are used to treat hypertension as well as angina.
- Vaspressors decrease the diameter of blood vessels by stimulating the alpha-adrenergic or dopamine receptors to effect the normal mechanism of vasoconstriction.13
- Diuretics reduce blood volume by preventing the reabsorption of sodium in the kidneys, which increases urine output.
- Antidysrhythmics correct erratic electrical impulses to create regular cardiac rhythms. These agents act by blocking electrolytes that affect electrical conduction in the heart, such as sodium, potassium, and calcium, or by blocking beta-adrenergic receptors.13
- Anticoagulants prevent blood clotting at several locations in the clotting cascade to suppress the production of fibrin. They are most effective in preventing venous thrombosis.
- Antiplatelet agents prevent platelets from aggregating to form clots. They are most effective in preventing arterial thrombosis.
- Thrombolytics disrupt blood clots that are impairing perfusion by lysing fibrin.
- Lipid-lowering agents decrease the levels of lipids that contribute to atherosclerosis and result in blood vessel occlusion by reducing the synthesis of cholesterol.

Procedures and Surgical Interventions
There are many procedures and surgical interventions that improve electrical conduction in the heart as well as perfusion. Pacemaker insertion. A pacemaker is an electronic device used to increase the heart rate in severe bradycardia by electronically stimulating the myocardium. The basic pacing circuit consists of a battery-operated pulse generator and one or more conducting leads that pace the atrium and one or both ventricles. Pacemakers can be external (temporary) or surgically implanted (permanent).14

Electrical cardioversion. The use of electric energy is an intervention to treat select abnormal cardiac rhythms. Cardiac defibrillation is used for emergency treatment during cardiac arrest when ventricular fibrillation or ventricular tachycardia is present. Synchronized cardioversion is a therapeutic procedure used to convert an abnormal rhythm, such as ventricular tachycardia with a pulse or atrial fibrillation, to a normal sinus rhythm. The procedure for cardioversion is the same as that for defibrillation with a few exceptions. If synchronized cardioversion is performed on a nonemergent basis, the patient is sedated before the procedure. The initial energy needed for synchronized cardioversion is less than the energy needed for defibrillation. Synchronized cardioversion starts at levels of 50 to 100 joules and is increased as needed.14

Intraaortic balloon pump. An intraaortic balloon pump (IABP) provides temporary circulatory assistance to the patient in the critical care unit who has a compromised heart. This pump reduces afterload to decrease the workload of the ventricles and augments the aortic diastolic pressure, resulting in improved coronary blood flow. Afterload is the force the ventricles must exert to open the pulmonic and aortic valves. The IABP consists of a sausage-shaped balloon
that is inserted percutaneously or surgically into the femoral artery. The balloon is advanced toward the heart and positioned in the descending thoracic aorta just inferior to the left subclavian artery and superior to the renal arteries. A pneumatic device fills the balloon with helium at the start of diastole and deflates it just before the next systole. The EKG is the primary trigger used to initiate deflation on the upstroke of the R wave (of the QRS complex) and inflation on the T wave. IABP therapy is referred to as counterpulsation because the timing of the balloon is opposite that of ventricular contraction.  

Heart valve surgery. Heart valve surgery is a procedure to replace or repair one or more heart valves with a prosthetic valve. This surgery is indicated for patients with valves that have stenosis (do not open completely) or insufficiency (do not close completely). Valves may be mechanical or biological. Mechanical valves are constructed of metal alloys, pyrolytic carbon, and Dacron, while biological valves are constructed from (cadaver) cardiac tissue and usually contain some manufactured materials.  

Cardiac transplantation is the transfer of a heart from one person to another to treat a variety of terminal or end-stage heart conditions.  

Coronary artery bypass graft. Coronary revascularization is accomplished with a coronary artery bypass graft (CABG). This procedure surgically implants patent blood vessels to transport blood between the aorta and the myocardium distal to the obstructed coronary artery or arteries. The internal mammary artery, radial artery, and saphenous vein from the patient are used frequently as bypass grafts. CABG requires a sternotomy to gain access to the heart and cardiopulmonary bypass (CPB) to divert the patient’s blood from the heart to the CPB machine. The CPB machine oxygenates the patient’s blood and returns it to the patient, allowing the surgeon to operate on a nonbeating, bloodless heart while perfusion to organs is maintained.  

Peripheral artery revascularization. This procedure is accomplished using an autogenous vein or synthetic graft to bypass the lesion in the artery that is impairing perfusion. Femoropopliteal bypass is an example of this procedure in which a graft is attached to the femoral artery to divert blood around the occlusion and attached to the popliteal artery. The femoral artery is clamped proximal to the insertion of the graft, allowing the surgeon to attach the graft to a bloodless artery.  

Stent placement and angioplasty. Stents are inserted into arteries to hold them open. A stent is an expandable mesh-like structure designed to expand in the artery to maintain patency. Cardiac catheterization and coronary angiography provide images of coronary circulation to identify lesions blocking coronary arteries. If appropriate, revascularization can be performed using balloon angioplasty. During this procedure, a catheter equipped with an inflatable balloon tip is inserted into the affected coronary artery. When the blockage is located, the catheter is passed through it, the balloon is inflated, and the blockage (atherosclerotic plaque) is compressed, which dilates the artery. Intracoronary stents are often inserted into the artery during an angioplasty to hold the artery open.  

Endarterectomy is a surgical procedure in which the atheromatous plaque that is a common site of perfusion to the heart.

**Clinical Nursing Skills** sections list examples of skills that can be taught in the nursing lab.  

**CLINICAL NURSING SKILLS FOR PERFUSION**

- Assessment
- Cardiac monitoring
- Hemodynamic monitoring
- Continuous arterial blood pressure monitoring
- Pulmonary artery pressure monitoring
- Circulatory assist devices
- Intraaortic balloon pump
- Ventricular assist device
- Medication administration

**INTERRELATED CONCEPTS**

Because all the cells in the body depend on perfusion to carry oxygen and nutrients to cells and remove wastes, this concept is interrelated to nearly all of the health and illness concepts within this textbook. Concepts that most closely interrelate with perfusion are Pain, Clotting, Inflammation, Gas exchange, Elimination, Cognition, Mobility, Nutrition, and Patient education (Figure 15-5).

Patients complain of pain when perfusion is impaired by clotting, whether it be in the coronary arteries, causing chest pain, or in the iliac or femoral arteries, causing leg pain when walking. Impaired tissue perfusion leading to ischemia creates lactic acid that contributes to pain.

Because impaired tissue perfusion to the legs causes pain during walking, peripheral arterial disease reduces the mobility of patients because of the pain they experience. Walking is a healthy lifestyle behavior to exercise the heart and improve central perfusion.

Inflammation occurs when there is tissue damage, which is linked to ischemia. Also it is the inflammation that develops after damage to the endothelium of arteries that initiates atherosclerosis.

Impaired perfusion results in impaired gas exchange because the blood carries oxygen from alveoli to cells and carbon dioxide away from cells to alveoli for exhalation.

Elimination from the kidneys is an indirect indicator of cardiac output because blood flows from the heart through the aorta to the renal arteries and through nephrons that produce urine.

Cognition is altered when perfusion to the brain is impaired. The neurons require a consistent supply of oxygen and glucose to maintain function.
George Jones is a 63-year-old male who went to the emergency department with chest pain. He had experienced this chest pain for 30 minutes and it was not relieved after taking four nitroglycerin tablets 5 minutes apart. He reports the pain feels “like an elephant is sitting on my chest.” He is diaphoretic and appears anxious. His vital signs are temperature 99°F, blood pressure 100/68 mm Hg, heart rate 110 beats/min, and respiratory rate 24 breaths/min. Mr. Jones is obese and has type 2 diabetes mellitus, hyperlipidemia, and hypertension. He quit smoking last year after a 40-year history of one pack of cigarettes a day. His troponin level is elevated and the EKG shows ST segment elevation. The nurse administers oxygen and draws blood for arterial blood gas analysis. Mr. Jones is told he will have a cardiac catheterization to locate the blockage, determine its severity, and evaluate left ventricular function.

The cardiac catheterization revealed a 90% blockage in one coronary artery. The cardiologist performed a balloon angioplasty to reestablish perfusion of the blocked coronary artery. Mr. Jones was discharged within 24 hours after stent placement. The nurse’s goals for Mr. Jones’ plan of care are to maintain effective cardiac output, control pain, relieve anxiety, and balance physical activity with energy-conserving activities. The nurse also played a significant role in Mr. Jones’ therapy by teaching him and his family about lifestyle changes, including diet and exercise, and the purpose of his prescribed medications, including adverse effects and the importance of following the medication regimen. Mr. Jones is referred for cardiac rehabilitation after discharge.

**Case Analysis**
This case exemplifies an impairment of local perfusion of the heart that could have developed into central impairment if Mr. Jones had not been treated. He had several risk factors, including obesity, that contributed to type 2 diabetes. The hyperlipidemia and diabetes mellitus contributed to the blockage of his coronary artery and his hypertension, which increased the workload of his heart. Mr. Jones’ manifestations were consistent with impaired tissue perfusion to the myocardium. The stent reestablished perfusion to the myocardium. Mr. Jones’ recovery and prevention of further cardiovascular disease will be improved by his lifestyle changes.
EXEMPLARS OF PERFUSION

Central Perfusion
Cardiac Dysrhythmias
- Atrial fibrillation
- Asystole
- Third-degree heart block
- Ventricular fibrillation

Valvular Heart Disease
- Aortic stenosis or insufficiency
- Mitral valve prolapse

Congenital Defects
- Atrial septal defect (ASD)
- Coarctation of the aorta
- Tetralogy of Fallot
- Ventricular septal defect (VSD)

Shock
- Anaphylactic shock
- Cardiogenic shock
- Hemorrhagic shock
- Neurogenic shock
- Septic shock

Other Conditions Associated with Central Perfusion
- Cardiomyopathy
- Cor pulmonale
- Endocarditis
- Ruptured arterial aneurysm (leading to shock)
- Heart failure
- Pulmonary hypertension

Local/Tissue Perfusion
- Atherosclerosis
- Hyperlipidemia
- Hypertension
- Myocardial infarction
- Peripheral artery disease
- Pulmonary embolism
- Stroke
- Raynaud’s disease
- Venous thrombosis

ACCESS EXEMPLAR LINKS ON pageburst

REFERENCES