CHAPTER 13 Heart

The circulatory system is the longest system of the body. If one were to lay all of the blood vessels in a single human body end to end, they would stretch one fourth the way from earth to the moon, a distance of some 60,000 miles.  

FUNCTIONS OF THE CIRCULATORY SYSTEM

1. The heart is the pump that circulates blood to all parts of the body.
2. Arteries, veins, and capillaries are the structures that take blood from the heart to the cells and return blood from the cells back to the heart.
3. Blood carries oxygen and nutrients to the cells and carries the waste products away.
4. The lymph system (see Chapter 15) returns excess fluid from the tissues to the general circulation and manufactures lymphocytes.

ORGANS OF THE CIRCULATORY SYSTEM

The organs of the circulatory system include the heart, arteries, veins, and capillaries. The blood and lymphatic system are part of the circulatory system. The heart is the muscular pump which is responsible for circulating the blood throughout the body.

MAJOR BLOOD CIRCUITS

Blood leaves the heart through arteries and returns by veins. The blood uses two circulation routes:

1. The general (or systemic) circulation carries blood throughout the body. Figure 13-1.
2. The cardiopulmonary circulation carries blood from the heart to the lungs and back. Figure 13-2.

CHANGES IN THE COMPOSITION OF CIRCULATING BLOOD

The major substances added to and removed from the blood as it circulates through organs along the various sites of the circulatory system are outlined in Table 13-1. This table includes only the major changes in the blood as it passes through certain specialized organs or structures.
Table 13-1: Changes in the Compositions of the Blood

<table>
<thead>
<tr>
<th>ORGANS</th>
<th>BLOOD LOSES</th>
<th>BLOOD GAINS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Olfactory glands</td>
<td>glucose, sodium and others</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>Gastrointestinal tract</td>
<td>water, urea and acids</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>Liver</td>
<td>excess glucose, amino acids</td>
<td>formed glutamine, urea, and plasma proteins</td>
</tr>
<tr>
<td>Lungs</td>
<td>carbon dioxide and water</td>
<td>Oxygen</td>
</tr>
<tr>
<td>Muscles</td>
<td>sucrose and oxygen</td>
<td>Carbon dioxide</td>
</tr>
<tr>
<td>Skin, hair, and visceral veins</td>
<td>sucrose and oxygen</td>
<td>End products of digestion, glutamine, and others</td>
</tr>
</tbody>
</table>

THE HEART

The blood's circulatory system is extremely efficient. The main organ responsible for this efficiency is the heart, a tough, simply constructed muscle about the size of a closed fist.

The adult human heart is about 5 inches long and 3.5 inches wide, weighing less than 1 pound (12 to 13 oz). Figure 13-3. The importance of a healthy, well-functioning heart is obvious: to circulate life-sustaining blood throughout the body. When the heart stops beating, life stops as well. To explain further, if the blood flow to the brain ceases for 3 seconds or more, the subject loses consciousness. After 15 to 20 seconds, the muscles twitch convulsively; after 6 to 9 minutes without blood flow, the brain cells are irreversibly damaged.

The heart is located in the thoracic cavity. This places the heart between the lungs, behind the sternum, in front of the thoracic vertebrae, and above the diaphragm. Although the heart is centrally located, its axis of symmetry is not along the midline. The heart's apex (conical tip) lies on the diaphragm and points to the left of the body. It is at the apex where the heartbeat is most easily felt and heard through the stethoscope.

Try this simple demonstration: Place the disk or bowl of a stethoscope over the heart's apex. This is the area between the fifth and sixth ribs,
along an imaginary line extending from the middle of the leftclevis. Since the heart is left and found so easily at the apex, this gives rise to the popular but incorrect notion that the heart is located on the left side of the body.

Knowledge of the correct position of the heart can make all the difference in the treatment of cardiac arrest. During such a medical emergency, the combination of manual heart compression and artificial respiration can save a life. This lifesaving technique is known as cardiopulmonary resuscitation (CPR) and should be performed only by those specifically trained in CPR. All health care workers should have current CPR certification.

**Structure of the Heart**

The heart is a hollow, muscular, double pump that circulates the blood through the blood vessel to all parts of the body. Surrounding the heart is a double layer of fibrous tissue called the pericardium, Figure 13.2. Between these two pericardial layers is a space filled with a lubricating fluid called pericardial fluid. This fluid prevents the two layers from rubbing against each other and creating friction. The thin inner layer covering the heart is the visceral or serous pericardium. The tough outer membrane is the parietal or fibrous pericardium. Cardiac muscle tissue, or myocardium, makes up the major portion of the heart. On the inner lining lies a smooth tissue called the endocardium. The endocardium covers the heart valves and lines the blood vessels providing smooth transit for the flowing blood.

A frontal view of the human heart reveals a thick, muscular wall separating it into a right and a left half. This partition, known as the septum, completely separates the blood in the right half from that in the left half. See Figure 13.4a. Structures leading to and from the heart are:

- **Superior vena cava** and **inferior vena cava**—the large venous blood vessels which bring deoxygenated blood (which has lesser amounts of oxygen) to the right atrium from all parts of the body
- **Coronary sinus**—from the heart muscle to the right atrium

- **Pulmonary artery**—takes blood away from the right ventricle to the lungs for oxygenation
- **Pulmonary veins**—bring oxygenated blood from the lungs to the left atrium
- **Aorta**—takes blood away from the left ventricle to the rest of the body

**Chambers and Valves**

The human heart is separated into right and left halves by the septum. In turn, each half is divided into two parts, thus creating four chambers. The two upper chambers are called the right atrium and the left atrium (pl. atria). The **atrium** may be referred to as the atricle. The lower chambers are the **right ventricle** and the **left ventricle**, Figure 13.4.

The heart has four valves which permit the blood to flow in one direction only. These valves open and close during the contraction of the heart, preventing the blood from flowing backwards. Figure 13.4c.

Atrioventricular valves are located between the atria and the ventricles.

- **The tricuspid valve** is positioned between the right atrium and the right ventricle. Its name comes from the fact that there are three points, or cusps, of attachment. The **chordae tendineae** are small fibrous strands connecting the edges of the tricuspid valve to the papillary muscle of the myocardium. When the right ventricle contracts the papillary muscle contracts pulling on the chordae tendineae to prevent inversion of the tricuspid valve. See Figure 13.4b. It allows blood to flow from the right atrium into the right ventricle, but not in the opposite direction.

- **The bicuspid or mitral valve** (resembles a bishop's hat, called a mitre) is located between the left atrium and the left ventricle. Blood flows from left atrium into the left ventricle, preventing backflow from the left ventricle to the left atrium.

Semicircular valves are located where blood will leave the heart:

- **The pulmonary semilunar valve** is at the orifice of the pulmonary artery. It allows blood to travel from the right ventricle into the pulmonary artery, and then into the lungs.
- **The aortic semilunar valve** is at the orifice of the aorta. This valve permits the blood to pass from the left ventricle into the aorta, but not backwards into the left ventricle. See Figure 13.4.
The average adult body contains about 5,000 ml of blood. This means all the blood is pumped through the heart about once every minute. Exercise increases cardiac output, because the heart rate is increased. Factors that exercise, muscles receive about 50% of the cardiac output. At rest, the muscles receive only 27% of the cardiac output.

**Blood Supply to the Heart**

The heart receives its blood supply from the coronary arteries, which branch into right and left coronary arteries. (Further discussion on this subject can be found in Chapter 14.)

**Heart Sounds**

The physician listens at specific locations on the chest wall to hear how the heart is functioning. During the cardiac cycle, the valves make a sound when they close. These are referred to as the **lub-dup sounds**.

The lub sound is heard first and is made by the valves (tricuspid and bicuspid) closing between the atria and ventricles. The physician refers to it as the S1 sound. It is heard loudest at the apex of the heart.

The dup sound is heard second and is shorter and higher pitched. It is caused by the semilunar valves in the aorta and the pulmonary artery closing. The physician refers to it as the S2 sound. Certain conditions can cause changes in the action of the heart valves.

**CONTROL OF HEART CONTRACTIONS**

A heart removed from the body will continue to beat rhythmically, which shows that heartbeat generates in the heart muscle itself. The heart rate is also affected by the endocrine and nervous systems. The myoendocards contracts rhythmically to perform its duty as a forceful pump.

Control of heart muscle contractions is found within a group of conducting cells located at the opening of the superior vena cava into the right atrium. These cells are known as the **sinatrial (SA) node**. The SA node sends out an electrical impulse that begins and regulates the heart. The impulse spreads out over the atria, making them contract or depolarize. This causes blood to flow downward from the upper atrial chamber to the atriocentric openings.

The electrical impulse eventually reaches the **atrioventricular (AV) node**, which is another conducting cell group located between the atria and ventricles.

From the AV node, the electrical impulse is carried to conducting fibers in the septum. These conducting fibers are known as the **atrioventricular bundle** or the **bundle of His**. It divides into a right and left branch. Each branch then subdivides into a fine network of branches spreading throughout the ventricles called the Purkinje network. The electrical impulse travels along the Purkinje fibers to the ventricles causing them to contract. The heart then rests briefly (repolarizes). See Figures 13-6.

The combined action of the SA and AV nodes is instrumental in the cardiac cycle. The cardiac cycle comprises one complete heartbeat, with both atrial and ventricular contractions.

1. The SA node stimulates the contraction of both atria. Blood flows from the atria into the ventricles through the open tricuspid and mitral valves. At this time, the ventricles are relaxed, allowing them to fill with the blood. At this point, since the semilunar valves are closed, the blood cannot enter the pulmonary artery or aorta.

2. The AV node stimulates the contraction of both ventricles so that the blood in the ventricles is pumped into the pulmonary artery and the aorta through the semilunar valves which are now open. At this point the atria are relaxed and the tricuspid and mitral valves closed.

3. The ventricles relax; the semilunar valves are closed to prevent the blood flowing back into the ventricles. The heart rests briefly (repolarization). The cycle begins again with the signal from the SA node.

This action of the heart is known as the cardiac cycle and represents one heartbeat. Each cardiac cycle takes 0.8 second. The average person's heart rate is between 72 and 80 beats per minute.

**Electrocardiogram (ECG or EKG)**

The electrocardiogram (ECG or EKG) is a device used to record the electrical activity of the heart that causes the contraction (systole) and the

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**Figure 13-5** Physiology of the heart

1. Blood reaches heart through inferior vena cava (IVC) and inferior vena cava (IVC), and aorta valve (AV) to the left atrium.
2. To tricuspid valve.
3. To right ventricle.
4. To pulmonary valve (semilunar).
5. To main pulmonary artery.
6. To right pulmonary artery.
7. To left pulmonary artery and right pulmonary artery.
8. To lungs—blood receives O2.
9. From lungs to pulmonary veins.
10. To left atrium.
11. To tricuspid valve.
12. To left atrium.
13. To semilunar valve (semilunar valve).
14. To aorta (lateral artery in the body).
15. Blood with oxygen then goes to all cells of the body.
Q wave is a negative deflection or wave.
R wave is a positive deflection or wave.
S wave is a negative wave.
T wave is a positive wave and represents ventricular repolarization.

**Figure 13-6 Cardiac cycle and ECG reading**

Relaxation (diastole) of the atria and ventricles during the cardiac cycle, Figure 13-6.

The baseline, or isoelectric line, of the ECG is the flat line that separates the various waves. It is present when there is no current flowing in the heart. The waves are either deflecting upward, known as a positive deflection, or deflecting downward, known as a negative deflection. The P, QRS, and T waves recorded during the ECG represent the depolarization (contraction) and repolarization (restitution) of the myocardial cells. The P wave represents atrial depolarization; QRS represents ventricular depolarization; and the T wave represents ventricular repolarization.

By observing the size, shape, and location of each wave, the physician can analyze and interpret the conduction of electricity through the cardiac cells, the heart’s rate, the heart’s rhythm, and the general health of the heart.

**Figure 13-7 Cardiac catheterization**

The impact of aging on the heart influences the total cardiovascular system. The heart, as a muscular organ, changes as muscle fibers are replaced by fibrous tissue. This change leads to a diminished contractility and filling capacity. Heart valves increase in thickness that may modify the normal closing of the valves, causing murmurs. Cardiac output decreases as one ages. The diminished output becomes significant when an elderly person is physically or mentally stressed by illness, strenuous physical activity, or other disabilities.

**DIAGNOSTIC TESTS FOR HEART AND CIRCULATORY FUNCTION**

**Cardiac catheterization** is the insertion of a catheter usually into the femoral artery or vein. The catheter tip is fed up into the chambers of the heart, Figure 13-7. Dye is injected and pictures are taken as the fluid moves through the chambers of the heart. The patient may experience a warm or flushing sensation as the dye moves through the circulatory system, but this lasts only a few seconds. This test is useful to determine patency of the coronary blood vessels as well as the efficiency of the structures of the heart. Patients must be told if they are allergic to shellfish.

**Stress tests** determine how the physiological stress of vigorous exercise affects the heart. The test is done while a patient is exercising on a bicycle or treadmill under careful supervision. Any abnormalities may be seen on the ECG.

**DISEASES OF THE HEART**

One of the leading causes of death is cardiovascular disease. Common symptoms of heart disease are as follows:

- **Arrhythmia** or dysrhythmia—the term used to discuss any change or deviation from the normal rate or rhythm of the heart
**Diseases of the Coronary Artery**

**Coronary artery disease (CAD)** is a narrowing of the arteries that supply oxygen and nutrient-filled blood to the heart muscle. The narrowing usually results from the buildup of plaque on the artery walls (atherosclerosis). If the artery becomes completely blocked, a myocardial infarction may occur. To prevent coronary artery disease, one needs to change lifestyle habits such as no smoking, increased exercise, and reduction of cholesterol levels. Angina is one of the most important symptoms of this disease.

**Angina pectoris** is the severe chest pain that arises when the heart does not receive enough oxygen. It is not a disease in itself, but a symptom of an underlying problem with the coronary circulation. The chest pain radiates from the precordial area to the left shoulder, down the arm along the ulnar nerve. Victims often experience a feeling of impending death. Angina pectoris occurs quite suddenly; it may be brought on by stress or physical exhaustion. It may be treated with the drug nitroglycerine, which helps to dilate the coronary arteries to permit blood flow to the heart.

**Myocardial infarction**, commonly known as an “MI” or “heart attack,” is caused by a lack of blood supply to the heart muscle, the myocardium. This may be due to blockage of the coronary artery by a blood clot, narrowing of the coronary artery as a result of atherosclerosis, a loss of elasticity and thickening of the wall, or thromboembolism (caused by plaque buildup in the arteries walls). Figure 13-8. The heart muscle becomes damaged due to lack of blood supply. The amount of tissue affected depends on how much of the heart area is deprived of blood. Symptoms are crushing, severe chest pain radiating to the left shoulder, arm, neck, and jaw. Patients may also complain of nausea, increased perspiration, fatigue, and dyspnea. Mortality is highest when treatment is delayed; therefore, immediate medical care is critical. Treatment consists of bed rest, oxygen, and medication. Morphine or demerol is given to alleviate the pain. Drugs such as tPA are used to dissolve the blood clot, and cardioprotective drugs such as digitoxin are used to slow and strengthen the heart beat. Anticoagulant therapy is used to prevent further clots from forming. Angioplasty and bypass surgery may also be necessary.

**Infectious Diseases of the Heart**

A bacteria or virus is usually the cause of infectious diseases of the heart. These conditions may be treated with antibiotic therapy.

**Pericarditis** is an inflammation of the outer membrane covering the heart. The symptoms are pain in the chest area radiating to the heart, cough, dyspnea (difficulty in breathing), rapid pulse, and fever.

**Myocarditis** is an inflammation of the heart muscle. The symptoms may be the same as pericarditis.

**Endocarditis** is an inflammation of the endocardium that lines the heart and covers the valves. This causes the formation of rough spots in the endocardium, which may lead to the development of a fatal blood clot.

**Rheumatic heart disease** may be a result of a person having frequent strep throat infections during childhood; these infections may lead to rheumatic fever. The antibodies which form to protect the child from the strep throat or rheumatic fever may also attack the lining of the heart, especially the mitral or aortic valve. The valve becomes inflamed and may be scarred, which leads to narrowing of the valve. The mitral valve is then unable to close properly, which interferes with the blood flow from the left atrium to the left ventricle. It is most important that children who have streptococcal infections are treated with antibiotic therapy.

**Prevention of Heart Disease**

The National Institute of Health has stated that following lifestyle changes would reduce the risk of heart attacks. These include not smoking.
Triglycerides and Cholesterol Levels

The blood contains cholesterol and other fat substances known as triglycerides. High levels of cholesterol are a major contributor to coronary artery disease. The two main types of cholesterol are low density lipoprotein (LDL), or the "bad cholesterol", which causes a buildup of fat in the arteries, and high density lipoprotein (HDL), known as "good cholesterol" because it helps to counter the buildup on artery walls by picking up previously deposited cholesterol and transporting it to the liver for disposal. Triglycerides are another form of fat. Increasing evidence shows that high triglyceride levels increase the risk for coronary artery disease. Excess dietary fat intake is converted into triglycerides.

<table>
<thead>
<tr>
<th>CHOLESTEROL AND TRIGLYCERIDE VALUES</th>
<th>DESIRABLE</th>
<th>BORDERLINE</th>
<th>UNDESIRABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cholesterol</td>
<td>Below 200</td>
<td>200-239</td>
<td>240 and above</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>Below 130</td>
<td>130-145</td>
<td>150 and above</td>
</tr>
<tr>
<td>HDL cholesterol</td>
<td>Above 45</td>
<td>40-55</td>
<td>Below 40</td>
</tr>
<tr>
<td>Triglycerides</td>
<td>Below 150</td>
<td>150-199</td>
<td>Above 200</td>
</tr>
</tbody>
</table>

Levels are given for adults age 20 and older. If you have coronary artery disease, diabetes, or multiple coronary artery disease, the desirable values for total and LDL cholesterol are lower (LDL should be at or below 100).

Regular exercise, maintaining ideal weight, estrogen replacement therapy for postmenopausal women, reduction of blood triglycerides and cholesterol levels, and maintaining normal blood pressure. In the blood there are two types of blood cholesterol: high density lipoprotein (HDL) and low density lipoprotein (LDL). The benefits of increasing the HDL ratio to the LDL ratio are significant: medication and diet help to increase HDL.

Heart Failure

Heart failure occurs when the ventricles of the heart are unable to contract effectively and blood pools in the heart. Different symptoms can arise depending on which ventricle fails to beat properly. If the left ventricle fails, dyspnea occurs. If the right ventricle fails, engorgement of organs with venous blood occurs, as well as edema (excessive fluid in tissues) and ascites (abnormal accumulation of serous fluid in the abdominal cavity). Other symptoms may include lung congestion and coughing.

Congestive Heart Failure

Congestive heart failure is similar to heart failure, but in addition there is edema of the lower extremities. Blood backs up into the lung vessels, and fluid extends into the air passages. Treatment consists of diuretics and inotropic agents (drugs that reduce the amount of fluid in the body).

Rhythm/Conduction Defects

A conduction, or rhythm, defect is said to occur when the conduction system of the heart is affected. Heart block is the interruption of the AV node message from the SA node. The interruption occurs in varying degrees. The abnormal patterns are seen on an electrocardiogram. First-degree block is characterized by a prolonged delay at the AV node before the impulse is transmitted to the ventricles. Second-degree block can be of two forms. One occurs in cycles of delayed impulses until the SA node fails to conduct to the AV node, then returns to near normal. A second form is characterized by a pattern of every second, third, or fourth impulse being conducted to the ventricles. This causes a decrease in heart output and usually progresses to the third degree. Third-degree block is known as "complete heart block." There is no impulse carried over from the pacemaker. Because the heart is essential to life, there is a built-in safety factor. The atria continue to beat 72 beats per minute while the ventricles contract independently at about half the atrial rate, adequate to sustain life but resulting in a severe decrease in cardiac output. Conduction defects may be treated by medications and/or the use of an artificial pacemaker.

Premature contractions is arrhythmia disorder which occurs when an area of the heart known as an ectopic (abnormal place) pacemaker (not the SA node) fires and stimulates a contraction of the myocardium. There are three types identified by the area of their location: atrial, ventricular, or AV junctional. Premature atrial contractions (PACs) cause the atria to contract ahead of the anticipated time. Premature junctional contractions (PJC) have the ectopic pacemaker focused in the junction of the AV node and the bundle of His. Usually PACs and PJC are of no clinical significance and are usually caused by stress, nicotine, caffeine, or fatigue. Premature ventricular contractions (PVCs) originate in the ventricle and cause contractions ahead of the next anticipated beat. They can be benign or deadly (ventricular fibrillation). If frequent (five to six per minute) or in pairs, they may require immediate intervention to decrease the irritability of the cardiac muscle and maintain cardiac output.

In fibrillation, the rhythm breaks down and muscle fibers fibrillate at random without coordination. This results in ineffective heart action and is a life-threatening condition. An electrical device called a defibrillator is used to discharge a strong electrical current through the patient’s heart through electrode paddles held against the bare chest wall. The shock interferes with the uncoordinated action and attempts to shock the SA node to resume its control.

Career Profile: Emergency Medical Technician and Paramedic

Emergency medical technicians and paramedics respond to medical emergencies. Once they arrive at a scene, they determine the nature and extent of the patient's condition. They also try to determine if the patient has a preexisting medical problem. Following strict procedures, they give appropriate emergency care and then transport the patient to a medical facility. Guidance for handling complicated problems is given by radio or phone from a physician.
EMTs and paramedics may use special equipment such as defibrillators. The specific responsibilities between EMTs and paramedics depend on their level of qualification and training. The National Registry of Emergency Medical Technicians registers emergency medical services at four levels: first responder, EMT-basic, EMT-intermediate and EMT-paramedic.

EMTs and paramedics work both indoors and outdoors in all types of weather. They are required to do considerable kneeling, bending, and heavy lifting. Formal training and certification is needed in all states to become an EMT or paramedic. Job outlook is good, as demand is expected to grow faster than average.

**Types of Heart Surgery**

- **Angioplasty** or balloon surgery, is a procedure to help open clogged vessels. A small deflated balloon is able to be threaded into the coronary artery; when it reaches the blocked area, the balloon is inflated. The balloon is then opened and closed a few times, until the blockage is pushed against the arterial wall and the area is unblocked. The balloon is then deflated and removed. Figure 13-9.

- **Coronary bypass** involves surgically providing a detour or bypass to allow the blood supply to go around the blocked area of the coronary artery. Figure 13-10. A healthy blood vessel, usually a vein from the leg, is used for this purpose. The vein is inserted before the blocked area and provides another route for the blood supply to the myocardiun.

- **Cardiac stents** are tiny webbed, stainless steel devices, which hold arteries open after an angioplasty. Figure 13-9. About 25% of the patients who are stented develop restenosis, where scar tissue forms inside the stent and reblocks the arteries. A procedure called brachytherapy, which uses radiation to destroy the scar tissue, may be done. In this procedure, a conventional angioplasty is done and then a radiation source is applied through a tiny balloon inside the stent. While the radioactive material stays in place just a few minutes, it effectively eliminates the cells that produce the scar tissue. The radiation is used in such a controlled manner that it does not affect other sections of the body. The newest techniques use a specially coated stent that resists the formation of scar tissue.

- **Transmyocardial laser revascularization (TMR)** is the use of lasers to puncture holes in the heart muscle to improve blood flow. This procedure will benefit patients who are not candidates for bypass or angioplasty surgery. The laser instrument is placed on the heart muscle around a blocked artery and the heart muscle is mapped. The laser's energy creates a tiny hole about 1 mm in size through the heart wall to the blood-filled chamber. The outside of the hole heals in a matter of minutes, but the channel created remains. The new channel allows blood
from the heart chamber to reach the heart muscle. The trauma caused by the laser beam stimulates the growth of new blood vessels. The full effect of the TMR does not take place until about 2 weeks to 6 months after surgery.

HEART TRANSPLANTS

A heart transplant is needed in cases when the individual’s own heart can no longer function properly. This happens when someone has suffered repeated heart attacks and there is irreparable damage to the heart muscle, valves, or blood vessels leading to and from the heart. Occasionally, a baby or young child might need a heart transplant because of a congenital (present at birth) heart defect.

There are always problems that follow even the most “successful” of heart transplants, however. The problem is one of histocompatibility (matching of tissue type) and organ rejection. Heart transplants that occur between two unrelated people must be monitored carefully. When the heart from the donor is placed into the recipient’s body, the recipient’s body chemically recognizes the donated heart as a “foreign tissue.” Thus, the recipient’s immune system starts to reject the transplanted heart.

Medical science has constructed the rejection by developing chemicals called immunosuppressants. These drugs suppress the recipient’s immune system so it will not form antibodies to reject the donated heart. Supressing the recipient’s immune system indefinitely is not medically wise because he or she will be more susceptible to disease and infection. Occasionally a heart transplant patient dies not from problems arising from the donated heart but from a case of pneumonitis.

continued

Pacemakers, Defibrillators, and Artificial Hearts

PACEMAKERS

A pacemaker is a surgically implanted electronic device that regulates the patient’s heartbeat. Figure 13-11. It may be implanted to regulate irregular heartbeats. In addition, a pacemaker is frequently prescribed to speed the heart rate of patients who have a rate under 60 beats per minute (bradycardia).

Patients with cardiac pacemakers should not undergo magnetic resonance imaging (MRI) procedures. Devices that emit electromagnetic fields (including magnets) may alter pacemaker functioning. Researchers have observed interference from cellular phones only when they are held directly over the pacemaker. Patients should avoid using a cellular telephone in a shirt pocket over or close to the pacemaker while the telephone is on. Patients with pacemakers should check their

continued

pule rate to determine if the pacemaker is functioning properly.

DEFIBRILLATORS

A defibrillator is a device that shocks the heart to return it to a normal rhythm. The implantable defibrillator protects patients at risk from severe ventricular tachycardia. Medications and pacemakers are the most common treatment for arrhythmias, but for a small proportion of patients, the implantable defibrillator can save lives.

The wearable defibrillator is a vest-like device worn outside the body for patients with serious heart attack risks. It generates unnecessary shock less frequently than implantable defibrillators do.

The automated external defibrillator is a new generation of affordable, easy to use, and extremely portable defibrillators that are being kept where people live and work. Most airlines, sporting arenas, community sites, and industries have them available for use.

HEART-ASSIST DEVICES

Ventricular-assist device. A device that helps the heart pump and is used mainly while patients are waiting for a heart transplant.

Artificial hearts. Over the past 50 years, researchers have been searching for an implantable artificial heart. The device must be durable and powerful enough to pump 100,000 times per day. It has to be small enough to be placed inside a patient’s chest. A battery-powered titanium and plastic model heart was implanted in a patient in 2001. This heart has been approved only for those patients who are too sick to be eligible for a transplant. At present, this device is only expected to prolong the life span by 30 to 60 days. The most that can be expected at present is an artificial heart that would allow a patient to survive until a transplant becomes available. To date, artificial hearts have had a very small impact. Cardiovascular researchers continue to work toward developing a practical artificial heart that will sustain life over longer periods.

Career Profile

Cardiovascular Technologists and Technicians

Cardiovascular technologists and technicians assist physicians in diagnosing and treating cardiac and peripheral vascular disease. Cardiovascular technicians may also be known as EKG technicians because they take electrocardiograms. More skilled technicians may also do Holter monitor and stress testing. Cardiovascular technologists who specialize in cardiac catheterization procedures are called cardiologists.

Education to prepare a technician for EKG, Holter, and stress testing usually requires a one-year certificate program. Training for cardiology technicians involves a two-year program, which is dedicated to core courses and clinical practice. The job prospects for cardiologists are excellent. However, cardiovascular technologists’ job prospects are not as good because nurses and others may be trained to do procedures such as EKG and stress testing.
Medical Terminology

tightness with pain
presence of
chest
presence
presence of pain in the chest
vessel
surgical repair
surgical repair of vessels
slow
heart
condition of
condition of slow heart
strength
pertaining to
pertaining to heart strengthener
electric current or activity
recording of
recording of electric activity of the heart
within, inner
inflammation of
inflammation within the heart
muscle
presence of
presence of heart muscle
area of tissue death
area of tissue death in the heart muscle
around
inflammation around the heart
wall, partition
presence of
presence of partition
chest
instrument used to examine
instrument used to examine the chest
rapid, fast
rapid or fast heart rate

REVIEW QUESTIONS

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

1. The organs of the circulatory system include the:
   a. heart, blood vessels, and liver
   b. heart, blood vessels, and lungs
   c. heart, blood vessels, and lymph
   d. heart, blood vessels, and kidneys

2. The outer layer of the heart is called the:
   a. myocardium
   b. endocardium
   c. pericardium
   d. pleural lining

3. The muscle layer of the heart is called the:
   a. myocardium
   b. endocardium
   c. pericardium
   d. pleural lining

4. The valve between the right atrium and the right ventricle is called the:
   a. tricuspid valve
   b. aortic semilunar valve
   c. bicuspid valve
   d. pulmonary semilunar valve

5. The blood vessel that brings blood to the right atrium is called the:
   a. pulmonary vein
   b. aorta
   c. pulmonary artery
   d. vena cava

6. The pacemaker of the heart is the:
   a. SA node
   b. AV node
   c. Bundle branches
   d. Purkinje fibers

7. The heart contracts in this fashion:
   a. bundle branches, AV node, SA node
   b. AV node, bundle branches, SA node
   c. SA node, AV node, bundle branches
   d. bundle branches, SA node, AV node

8. The device used to measure the electrical activity of the heart is called an:
   a. EKG
   b. MRI
   c. ECG
   d. EKG
9. A heart rate below 60 is called:
   a. bradycardia
   b. tachycardia
   c. arrhythmia
   d. murmur

10. An inflammation of the inner layer of the heart is called:
   a. pericarditis
   b. myocarditis
   c. endocarditis
   d. phlebitis

11. The term "heart attack" is another name for:
   a. rheumatic heart disease
   b. myocardial infarction
   c. heart block
   d. congestive heart failure

12. The treatment for a heart attack may include all but:
   a. angioplasty
   b. antibiotics
   c. coronary bypass
   d. anticoagulants

13. Another name for stationary blood clot is a:
   a. embolus
   b. steatosis
   c. thrombus
   d. thrombosis

14. The treatment for conduction defect may include:
   a. coronary bypass
   b. cardiac c. insertion of a pacemaker
   c. insertion of a pacemaker
   d. angioplasty

15. The circulation that carries blood from the heart to lungs and back to heart is the:
   a. coronary
   b. fetal
   c. cardiopulmonary
   d. portal

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**LABELING**

Locate and label the various structures of the heart. Also include valves, vessels, and nodes. Trace blood from right atrium to aorta.