



CLINICAL FOCUS

Conditions and Diseases Affecting the Heart

INFLAMMATION OF HEART TISSUES

Endocarditis (en'do-kar-dī'tis) is inflammation of the endocardium. It affects the valves more severely than other areas of the heart and can lead to deposition of scar tissue, causing valves to become stenosed or incompetent.

Myocarditis (mī'o-kar-dī'tis) is inflammation of the myocardium and can lead to heart failure.

Pericarditis is inflammation of the pericardium. Pericarditis can result from bacterial or viral infections and can be extremely painful.

Rheumatic (roo-mat'ik) **heart disease** can result from a streptococcal infection in young people. Toxin produced by the bacteria can cause an immune reaction called rheumatic fever about 2–4 weeks after the infection. The immune reaction can cause inflammation of the endocardium, called **rheumatic endocarditis**. The inflamed valves, especially the bicuspid valve, can become stenosed or incompetent. The effective treatment of streptococcal infections with antibiotics has reduced the frequency of rheumatic heart disease.

REDUCED BLOOD FLOW TO CARDIAC MUSCLE

Coronary heart disease reduces the amount of blood that the coronary arteries are able to deliver to the myocardium. The reduction in blood flow damages the myocardium. The degree of damage depends on the size of the arteries involved, whether occlusion (blockage) is partial or complete, and whether occlusion is gradual or sudden. As the walls of the arteries thicken and harden with age, the volume of blood they can supply to the heart muscle declines, and the heart's ability to pump blood decreases. Inadequate blood flow to the heart muscle can result in angina pectoris, which is a poorly localized sensation of pain in the region of the chest, left arm, and left shoulder.

Degenerative changes in the artery wall can cause the inside surface of the artery to become roughened. The chance of platelet aggregation increases at the rough surface, which increases the chance of **coronary thrombosis** (throm-bo'sis; formation of a blood clot in a coronary vessel). Inadequate blood flow can cause an **infarct** (in'farkt), an area of damaged cardiac

tissue. A heart attack is often referred to as a coronary thrombosis, or a **myocardial infarct**. The outcome of coronary thrombosis depends on the extent of the damage to heart muscle caused by inadequate blood flow and whether other blood vessels can supply enough blood to maintain the heart's function. Death can occur swiftly if the infarct is large; if the infarct is small, the heart can continue to function. In most cases, scar tissue replaces damaged cardiac muscle in the area of the infarct.

People who survive myocardial infarctions often lead fairly normal lives if they take precautions. Most cases call for moderate exercise, adequate rest, a disciplined diet, and reduced stress.

CONGENITAL CONDITIONS AFFECTING THE HEART

Congenital heart disease is the result of abnormal development of the heart. The following conditions are common congenital defects.

Septal defect is a hole in a septum between the left and right sides of the heart. The hole may be in the interatrial or interventricular septum. These defects allow blood to flow from one side of the heart to the other and, as a consequence, greatly reduce the pumping effectiveness of the heart (see chapter 29).

Patent ductus arteriosus (dūk'tūs ar-ter'e-o-sūs) results when a blood vessel called the **ductus arteriosus**, which is present in the fetus, fails to close after birth. The ductus arteriosus extends between the pulmonary trunk and the aorta. It allows blood to pass from the pulmonary trunk to the aorta, thus bypassing the lungs. This is normal before birth because the lungs are not functioning (see chapter 29). If the ductus arteriosus fails to close after birth, blood flows in the opposite direction, from the aorta to the pulmonary trunk. As a consequence, blood flows through the lungs under higher pressure, causing damage to the lungs. In addition, the amount of work required of the left ventricle to maintain adequate systemic blood pressure increases.

Stenosis (ste-nō'sis) **of a heart valve** is a narrowed opening through one of the heart valves. In aortic or pulmonary valve stenosis, the heart's workload is increased because the ven-

tricles must contract with a much greater force to pump blood from the ventricles. Stenosis of the bicuspid valve prevents the flow of blood into the left ventricle, causing blood to back up in the left atrium and in the lungs, resulting in congestion of the lungs. Stenosis of the tricuspid valve causes blood to back up in the right atrium and systemic veins, causing swelling in the periphery.

An **incompetent heart valve** is one that leaks. Blood, therefore, flows through the valve when it is closed. The heart's workload is increased because incompetent valves reduce the heart's pumping efficiency. For example, an incompetent aortic semilunar valve allows blood to flow from the aorta into the left ventricle during diastole. Thus, the left ventricle fills with blood to a greater degree than normal. The increased filling of the left ventricle results in a greater stroke volume because of Starling's law of the heart. The pressure produced by the contracting ventricle and the pressure in the aorta are greater than normal during ventricular systole. The pressure in the aorta, however, decreases very rapidly as blood leaks into the left ventricle during diastole.

An incompetent bicuspid valve allows blood to flow back into the left atrium from the left ventricle during ventricular systole. This increases the pressure in the left atrium and pulmonary veins, which results in pulmonary edema. Also, the stroke volume of the left ventricle is reduced, which causes a decrease in systemic blood pressure. Similarly, an incompetent tricuspid valve allows blood to flow back into the right atrium and systemic veins, causing edema in the periphery.

Cyanosis (st-ā-nō'sis) is a symptom of inadequate heart function in babies suffering from congenital heart disease. The term *blue baby* is sometimes used to refer to infants with cyanosis. Low blood oxygen levels in the peripheral blood vessels cause the skin to look blue.

HEART FAILURE

Heart failure is the result of progressive weakening of the heart muscle and the failure of the heart to pump blood effectively. Hypertension (high blood pressure) increases the afterload on the heart, can produce significant enlargement of the heart, and can finally result in heart

failure. Advanced age, malnutrition, chronic infections, toxins, severe anemias, and hyperthyroidism can cause degeneration of the heart muscle, resulting in heart failure. Hereditary factors can also be responsible for increased susceptibility to heart failure.

HEART MEDICATIONS

Digitalis (dij-i-tal'is, dij-i-ta'lis) slows and strengthens contractions of the heart muscle by increasing the amount of Ca^{2+} that enters cardiac muscle cells and by prolonging the action potentials' refractory period. This drug is frequently given to people who suffer from heart failure, although it also can be used to treat atrial tachycardia.

Nitroglycerin (ni-tro-glis'er-in) causes dilation of all of the veins and arteries, including coronary arteries, without an increase in heart rate or stroke volume. When all blood vessels dilate, a greater volume of blood pools in the dilated blood vessels, causing a decrease in the venous return to the heart. The flow of blood through coronary arteries also increases. The reduced preload causes cardiac output to decrease, resulting in a decreased amount of work performed by the heart. Nitroglycerin is frequently given to people who suffer from coronary artery disease, which restricts coronary blood flow. The decreased work performed by the heart reduces the amount of oxygen required by the cardiac muscle. Consequently, the heart does not suffer from a lack of oxygen, and angina pectoris does not develop.

Beta-adrenergic-blocking agents reduce the rate and strength of cardiac muscle contractions, thus reducing the heart's demand for oxygen. These blocking agents bind to receptors for norepinephrine and epinephrine and prevent these substances from having their normal effects. They are often used to treat people who suffer from rapid heart rates, certain types of arrhythmias, and hypertension.

Calcium channel blockers reduce the rate at which Ca^{2+} diffuse into cardiac muscle cells and smooth muscle cells. Because the action potentials that produce cardiac muscle contractions depend in part on the flow of Ca^{2+} into cardiac muscle cells, calcium channel blockers can be used to control the force of heart contractions and to reduce arrhythmia, tachycardia, and hypertension. Because the entry of Ca^{2+} into smooth muscle cells causes contraction, calcium channel blockers cause dilation of coronary blood vessels and can be used to treat angina pectoris.

Antihypertensive (an'te-hi-per-ten'siv) agents comprise several drugs used specifically to treat hypertension. These drugs reduce blood pressure and, therefore, reduce the work required by the heart to pump blood. In addition, the reduction of blood pressure reduces the risk for heart attacks and strokes. Drugs used to treat hypertension include those that reduce the activity of the sympathetic nervous system, dilate arteries and veins, increase urine production (diuretics), and block the conversion of angiotensinogen to angiotensin I.

Anticoagulants (an'te-kö-ag'n-lantz) prevent clot formation in persons with damage to heart valves or blood vessels or in persons who have had a myocardial infarction. Aspirin functions as a weak anticoagulant.

INSTRUMENTS AND SELECTED PROCEDURES

An **artificial pacemaker** is an instrument placed beneath the skin, equipped with an electrode that extends to the heart. The instrument provides an electric stimulus to the heart at a set frequency. Artificial pacemakers are used in patients in whom the natural pacemaker of the heart does not produce a heart rate high enough to sustain normal physical activity. Artificial pacemakers can increase the heart rate as increases in physical activity occur. Pacemakers can also detect cardiac arrest, extreme arrhythmias, or fibrillation. In response, strong stimulation of the heart by the pacemaker may restore heart function.

A **heart lung machine** serves as a temporary substitute for a patient's heart and lungs. It oxygenates the blood, removes carbon dioxide, and pumps blood throughout the body. It has made possible many surgeries on the heart and lungs.

Heart valve replacement or repair is a surgical procedure performed on those who have diseased valves that are so deformed and scarred from conditions such as endocarditis that the valves are severely incompetent or stenosed. Substitute valves made of synthetic materials, such as plastic or Dacron, are effective; valves transplanted from pigs are also used.

A **heart transplant** is a surgical procedure made possible when the immune characteristics of a donor and the recipient are closely matched (see chapter 22). The heart of a recently deceased donor is transplanted to the recipient, and the diseased heart of the recipient is removed. People who have received heart transplants must continue to take drugs that suppress their immune responses for the rest of

their lives. If they do not, their immune system will reject the transplanted heart.

An **artificial heart** is a mechanical pump that replaces the heart. It is still experimental and cannot be viewed as a permanent substitute for the heart. It has been used to keep a patient alive until a donor heart can be found.

Cardiac assistance involves temporarily implanting a mechanical device that assists the heart in pumping blood. In some cases, the decreased workload on the heart provided by the device appears to promote recovery of failing hearts, and the device has been successfully removed. In **cardiomyoplasty**, a piece of a back muscle (latissimus dorsi) is wrapped around the heart and stimulated to contract in synchrony with the heart.

PREVENTION OF HEART DISEASE

Heart disease is a major cause of death. Several precautions can be taken to help prevent heart disease. Proper nutrition is important in reducing the risk for heart disease (see chapter 25). A recommended diet is low in fats, especially saturated fats and cholesterol, and low in refined sugar. Diets should be high in fiber, whole grains, fruits, and vegetables. Total food intake should be limited to avoid obesity, and sodium chloride intake should be reduced.

Smoking and the excessive use of alcohol should be avoided. Smoking increases the risk for heart disease at least 10-fold, and excessive alcohol use also substantially increases the risk for heart disease.

Chronic stress, frequent emotional upsets, and a lack of physical exercise can increase the risk for cardiovascular disease. Remedies include relaxation techniques and aerobic exercise programs involving gradual increases in duration and difficulty in activities, such as walking, swimming, jogging, and aerobic dancing.

Hypertension (hi'per-ten'shün) is abnormally high systemic blood pressure. It affects about one-fifth of the U.S. population. Regular blood pressure measurements are important because hypertension does not produce obvious symptoms. If hypertension cannot be controlled by diet and exercise, it is important to treat the condition with prescribed drugs. The cause of hypertension in most cases is unknown.

Some data suggest that taking an aspirin daily reduces the chance of a heart attack. Aspirin inhibits the synthesis of prostaglandins in platelets, thereby helping prevent clot formation (see chapter 19).