

## CHAPTER 13

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# HEART VALVE DISEASE

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## INTRODUCTION

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The human heart is an efficient muscular pump that has four chambers—two atria and two ventricles—each closed off by a one-way valve. In the course of a day, the heart contracts and expands on average 100,000 times, pumping approximately 2,000 gallons of blood. By opening and closing in a synchronized manner, the four valves keep the blood flowing in a forward direction.

Blood from the veins enters the heart via the right atrium. It has a high content of carbon dioxide (a result of body metabolism), but is relatively depleted of oxygen, which has been absorbed by the body's tissues. After filling, the right atrium contracts, sending the blood through the tricuspid valve, which opens into the right ventricle. Blood is pumped through the pulmonary valve into the lungs. From the lungs, where it has been enriched in oxygen and depleted of carbon dioxide, the blood returns to the left atrium. It is then pumped through the mitral valve into the left ventricle. Finally, it is pumped out through the aortic valve into the aorta and the rest of the circulatory system.

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## HOW VALVES WORK

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To control the flow of blood, all valves have thin flaps of muscle tissue, called leaflets or cusps, that open to let the blood through and close to prevent it from flowing backward. The mitral and tricuspid valves are shaped somewhat like parachutes. When open, their leaflets—three in the tricuspid and two in the mitral valve—form a ring resembling the wide end of a funnel. The leaflets are connected by chords—strings of strong fibrous tissue referred to as chordae tendineae—to muscle bundles in the chamber walls. Contraction of these muscles pulls the chords, and the leaflets snap shut, closing off the heart chamber. Valves act like gates that open when pressure behind them builds up, and close after blood has passed through and pressure is reduced.

The aortic and pulmonary valves have no chords but consist of petal-like flaps of tissue—two in the pulmonary and three in the aortic valve—at the exit from the chamber, which are flung open by the flow of blood and fall back together to close off the ventricle once the blood has been ejected.

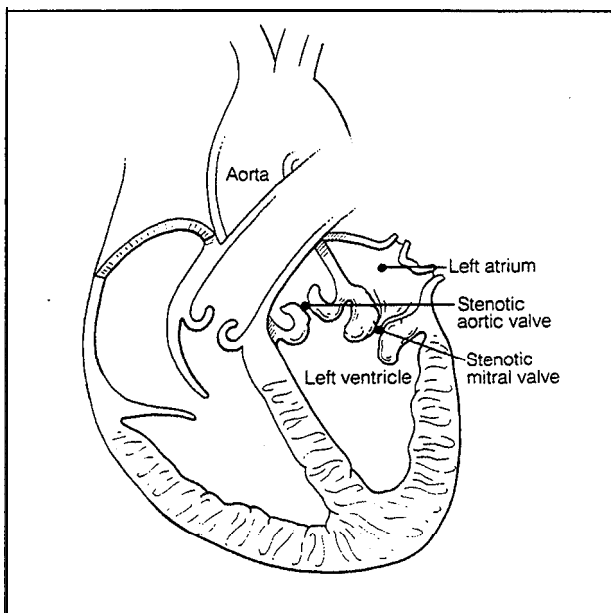
The mitral and aortic valves are the most common

sites of heart valve disease, because of their location on the left side of the heart. The left chambers have a greater workload, because they pump blood to the entire body, whereas the right chambers push blood only to the lungs. Any abnormality in the valves of the left atrium and ventricle is more likely to produce symptoms and be quickly noticed by both patients and physicians.

Two major problems may arise in the functioning of the valves: They may fail either to open fully or to close properly. The narrowing of a valve, called stenosis, occurs when the leaflets become rigid, thickened, or fused together, reducing the opening through which the blood passes from one chamber to another. As its flow is obstructed, the blood accumulates in the chamber, causing the heart to work harder in order to push it through. (See Figure 13.1.)

When the valve fails to close properly—a condition referred to as insufficiency and also called incompetence or regurgitation—a portion of the ejected blood flows backward. For example, if the aortic valve is unable to close properly, some of the blood that is pumped forward from the left ventricle to the aorta leaks back into the ventricle. In severe cases, as much as 90 percent of the entire pumped volume may flow back. To compensate for the leak, the heart must enlarge in order to pump out an extra volume of blood with each beat, which significantly increases its workload.

**Figure 13.1**  
Diagram of the heart showing aortic and mitral valve stenosis, in which the valves are narrowed and unable to open fully. This results in an inadequate amount of blood flowing into the aorta (aortic stenosis) or left ventricle (mitral stenosis).



In some cases, stenosis and insufficiency may occur together. This happens when the leaflets become shrunken and stiff and the valve is fixed in a half-open position.

Valvular stenosis and insufficiency can gradually wear out the heart. At first, heart muscle dilates and thickens. This enables it to compensate for the extra work and allows the heart to supply an adequate amount of blood to the body. Eventually, however, the enlarged heart may grow weaker and become unable to pump blood as efficiently as before.

(Specific valve disorders are discussed at the end of the chapter.)

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## COMPLICATIONS AND SEQUELAE

### HEART VALVE DISEASE

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The major complication of heart valve disease is congestive heart failure, a condition that occurs when the heart is unable to pump out an adequate volume of blood. Blood backs up, engorges the veins in the lungs and other parts of the body, and causes a congestion of fluid in body tissues. Fluid may collect in the lungs, obstructing the passage of air and oxygen exchange and interfering with breathing. During the day, when the person spends a great deal of time in the upright position, it may also buildup fluid in the legs. Therefore, breathlessness, which is characteristic of congestive heart failure, is a major symptom of heart valve disease, along with swelling of the ankles. Other symptoms may include fatigue, fainting, palpitations, and chest pain. (See Chapter 14.)

Heart valve disease can also lead to heart muscle disease and disruption of the heartbeat—complications often associated with congestive heart failure. Another serious complication is formation of blood clots, which may become detached and travel through the bloodstream (at which point they are known as emboli). If one of these gets stuck in a small blood vessel, the organ affected may not get enough blood. A clot in the brain may cause a stroke. An embolus to the leg may result in pain, discoloration, or, in extreme instances, gangrene. Clots may form because the surface of a damaged valve is roughened; this interferes with the smooth and steady flow of blood, creating areas where it stagnates or swirls in place. Sticky substances in the blood congregate and a clot forms.

Many diseases of the valves take 20 to 30 years to develop, and by the time a patient becomes aware of

Table 13.1  
Typical Prophylactic Antibiotic Schedule

Dental Procedures and Surgery of the Upper Respiratory Tract			
Category of patient	Medication	Category of patient	Medication
Patients at risk (includes those with prosthetic heart valves and other high risk patients)	3 grams oral amoxicillin 1 hour prior to procedure and then 1.5 grams 6 hours after initial dose	Patients considered to be at a high risk who are allergic to amoxicillin, ampicillin, and penicillin	1 gram of vancomycin given by IV over 60 minutes, begun 60 minutes before procedure; no repeat dose necessary
Patient allergic to amoxicillin/penicillin	800 milligrams erythromycin 2 hours prior to procedure and then 400 milligrams, then ½ the dose 6 hours after initial dose		
	or	<b>Gastrointestinal and Genitourinary Tract Procedures</b>	
	300 milligrams clindamycin 1 hour before procedure and 150 milligrams six hours after initial dose	<b>Category of patient</b>	<b>Medication</b>
Patients unable to take oral medication (pills)	2 grams ampicillin by injection or IV 30 minutes before procedure and then 1 gram 6 hours after initial dose	Most patients	2 grams of ampicillin given by injection plus 1.5 milligrams per kilogram (not to exceed 80 milligrams) gentamicin 30 minutes before procedure, followed by 1.5 grams of oral amoxicillin 6 or 8 hours after initial dose
	or	Patients allergic to amoxicillin, ampicillin, or penicillin	1 gram of vancomycin given by IV over 60 minutes plus 1.5 milligrams per kilogram (not to exceed 80 milligrams) gentamicin, given by injection or IV, 60 minutes before procedure; may be repeated once 8 hours after initial dose
	Initial ampicillin followed by 1.5 grams of amoxicillin orally (suspension) 6 hours later		
	or	Alternate regimen for low-risk patients	3 grams of amoxicillin orally 1 hour before procedure and 1.5 grams 6 hours after initial dose
Patients considered to be at a high risk who are not candidates for the standard regimen	2 grams of ampicillin plus 1.5 milligrams per kilogram (not to exceed 80 milligrams) gentamicin given by IV or injection 30 minutes before procedure followed by 1.5 grams of amoxicillin orally 6 or 8 hours after the initial dose		

Note: In patients with compromised renal function, it may be necessary to modify or omit the second dose of antibiotics. Intramuscular injections may be contraindicated in patients receiving anticoagulants.

Source: Adapted from *Prevention of Bacterial Endocarditis*, by the Committee on Rheumatic Fever, Endocarditis and Kawasaki Disease. JAMA 1990; 264:2919-2922. Also excerpted in *J. Amm Dent. Assoc.* 1991.

## MAJOR CARDIOVASCULAR DISORDERS

the symptoms, the condition has often progressed to an advanced stage. Many damaged valves, however, may not cause any trouble at all, and people with one or more abnormal valves can go through a normal life. Often a routine physical examination will detect a murmur, suggesting that one of the heart valves is roughened or diseased. The murmur results from blood moving through a narrowed valve or blood swirling back and forth through a valve that remains partially open. People with slightly damaged valves may require no treatment, but may receive advice on prophylactic measures, such as taking antibiotics before dental and surgical procedures to reduce the risk of a valve infection called endocarditis. (See Table 13.1.)

Although the decrease in rheumatic fever, an important cause of valve problems, has led to a drastic reduction in the incidence of some forms of valve disorders in the United States, heart valve disease remains a relatively common form of cardiac disease. However, advances in diagnostic and surgical procedures, as well as a greater general awareness of cardiovascular disorders, have greatly improved survival rates in the past 20 to 25 years. A murmur that indicates a possible heart valve problem may not be of any significance or cause for concern. A patient who has been told he or she has such a murmur may simply have to be followed more carefully than someone without the problem.

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## CAUSES OF HEART VALVE DISEASE

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### RHEUMATIC FEVER

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In the past, heart valve disease in the United States was usually caused by rheumatic fever, an inflammatory condition that often starts with a strep throat (a streptococcal bacterial infection). Fortunately, it is an uncommon disease today.

It can affect any tissues in the body, including the joints, the brain, and the skin, but, most important, it can scar the heart muscle, and particularly the heart valves. Damage is caused not by the bacteria themselves, but by an autoimmune response—a process in which the body, while fighting the bacterial infection, mistakenly begins to damage its own tissues. Rheumatic fever usually affects children 5 to 15 years old, but its consequences, referred to as rheumatic heart disease, can smolder throughout a lifetime.

No laboratory test offers a definitive diagnosis of rheumatic fever, but the condition can be recognized by a series of characteristic signs, including mild fatigue, fever, and pain and swelling of the joints, which may emerge several weeks after all symptoms of a streptococcal infection have disappeared. Except for acute cases, symptoms of heart trouble generally appear much later in life, some 20 years after the initial infection. If a streptococcal sore throat is treated promptly, rheumatic fever and heart disease usually can be prevented. It is therefore important to diagnose the condition early and use the appropriate antibiotic. A course of penicillin or another antibiotic for seven days will usually control most cases of streptococcal infection. There exist, however, rare cases when antibiotics suppress the infection but rheumatic fever and rheumatic heart disease develop. Some patients who develop heart valve disease many years later are not even aware of having had rheumatic fever.

Antibiotic treatment has dramatically reduced the incidence of rheumatic heart disease and associated deaths in industrialized countries. Although rheumatic heart disease still affects some 2 million Americans and continues to be an important cause of valve problems, many of these cases represent instances of residual disease from an era when antibiotics were not commonly used. Nonrheumatic causes of heart valve disease today are by far more common in the United States.

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### INFECTIVE ENDOCARDITIS (BACTERIAL ENDOCARDITIS)

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Another inflammatory condition that can lead to heart valve disease is infective endocarditis—an infection of the endocardium, the lining that covers the inner walls of the heart's chambers and the valves. It occurs when bacteria, fungi, or other microorganisms multiply on the valves' inner lining and form small, warty nodules or cauliflower-like polyps. Since the condition is most often caused by two types of bacteria, streptococci and staphylococci, it is frequently referred to as bacterial endocarditis. Fatigue, a low-grade fever, weakness, and joint aches may indicate that this disease is present. In persons with heart valve disease, of course, these symptoms do not always indicate endocarditis and may just be the flu, for example. However, a heart infection should be considered.

Endocarditis is twice as common in men as in women, and it seldom occurs in people whose valves

are completely normal and healthy. In fact, it is relatively uncommon even in people with heart valve disease. It often results from an untreated infection elsewhere in the body, and usually affects the valves that have a congenital abnormality or that have already been damaged by rheumatic fever or another form of disease. It is also seen in people who have artificial valves. Another group at risk are drug abusers who use contaminated hypodermic needles.

Colonies of microorganisms that grow on the endocardium can cause holes in the valve, distort its shape, and completely disrupt its function. Clusters of infectious organisms may stimulate the formation of emboli, which travel through the circulation and end up blocking small blood vessels. The infection may take an acute form and lead to heart failure and death if left untreated, or it may linger undetected for much longer before producing disturbing symptoms. To prevent the occurrence of endocarditis in patients who have damaged or artificial valves, the American Heart Association recommends that antibiotics be taken before dental treatment, surgery involving the respiratory tract, gastrointestinal or genitourinary surgery, invasive diagnostic procedures, or any other procedure that may stimulate the release of bacteria into the bloodstream.

### MYXOMATOUS DEGENERATION

In the elderly, one of the most common causes of heart valve disease is a process called myxomatous degeneration, which usually affects the mitral valve that connects the left atrium and ventricle. This dysfunction stems from a series of metabolic changes in the course of which the valve's tissue loses its elasticity, becomes weak and flabby, and becomes covered by a buildup of starch deposits. The chords that control the opening and closing of the valve may break off. It is not known what triggers myxomatous degeneration. Many elderly people with this condition are unaware of it and have no symptoms or other adverse effects.

### CALCIFIC DEGENERATION

Another common cause of heart valve disease in the elderly is calcific degeneration, a process in which calcium deposits build up on the valve. This type of tissue degeneration usually causes aortic stenosis, a narrowing of the aortic valve. It may also affect part of the mitral valve, causing it to become leaky or regurgitate. In many elderly persons, aortic stenosis may not manifest any symptoms.

### CONGENITAL ANOMALIES

Heart valve disease may also result from congenital abnormalities, problems that are present from birth. The most common congenital defect is a misshapen aortic valve, which has two leaflets instead of three and is therefore referred to as bicuspid. The defect does not usually produce any symptoms, although such a valve is more prone to develop an infection. The defect may be corrected by surgery, which is usually not performed unless there are symptoms or repeated valve infections. Most of the time this is not a serious problem. Congenital malformation may also be present in the mitral valve, which results in mitral stenosis.

### OTHER CAUSES

Finally, heart valve disease may be a result of other heart disease, particularly coronary artery disease or a heart attack. These conditions can cause injury to one of the papillary muscles that support the valves, so that it doesn't close properly. Heart attacks, for example, often disrupt the closing of the mitral valve, leading to mitral regurgitation.

## DIAGNOSIS

Valve disorders can usually be diagnosed by listening to the heart with a stethoscope. While no sound is heard when blood flows through a normal valve, its passage through a diseased valve creates a whooshing noise, referred to as a murmur. The heart sounds normally consist of regular double throbs—one heard upon the simultaneous closing of the mitral and tricuspid valves, and the second heard immediately afterward, when the aortic and pulmonary valves close almost at the same time. Heartbeats sound like lub-dub, lub-dub. When a valve is damaged and fails to close or open completely, blood will create a swirling current as it is squeezed through a narrow opening or regurgitated in the wrong direction, and a murmur is produced. In the case of stenosis, the sound may be a rough, short, low-pitched murmur; with a valve insufficiency, the sound may be higher-pitched, softer, and longer.

Murmurs are present in a great number of healthy people and do not necessarily indicate disease. Physicians can usually tell when murmurs or any deviations from the normal heart sounds signal a cause for concern. An electrocardiogram (ECG) and chest

## MAJOR CARDIOVASCULAR DISORDERS

X-ray are two diagnostic techniques that can provide important information about heart size and activity. They may, for example, reveal that the heart is enlarged, which is often a sign of heart valve or other cardiac disease. However, while both these methods are useful for detecting valve disorders, they are not especially helpful in making a specific diagnosis. Listening with a stethoscope is actually more helpful.

A major diagnostic tool in assessing valve disorders is echocardiography, a noninvasive and painless procedure that has revolutionized the evaluation of heart diseases. In echocardiography, high-frequency sound waves (like sonar waves) are bounced off the heart's tissues, allowing physicians to visualize the shape and motion of the valves, the size of the valve's opening, and the thickness of chamber walls. One variety of this procedure, called Doppler echocardiography, makes it possible to measure the speed and flow of blood and is particularly helpful in assessing to what extent a valve is stenotic or leaky. While these procedures are more definitive, they are expensive and often not necessary for making a diagnosis,

Once a valve disorder has been detected, if less invasive procedures have failed to provide sufficient information about it, or if surgery is being considered, diagnosis is usually established on the basis of cardiac catheterization. Fortunately, this procedure is rarely necessary for making a diagnosis, but it is often indicated prior to surgery. A thin plastic tube called a catheter is inserted into the patient's artery and guided to the heart. When the catheter is in place, a chemical dye is injected through the tube. The dye shows up on the X-ray, allowing physicians to visualize the inside of the heart, to see whether all the blood is flowing in the proper direction or if there is any backflow, and to assess the function of the chamber muscle and the performance of natural or prosthetic valves. In addition, it displays any blockage of coronary arteries, which can accompany a valve disorder and can be corrected at the same time as valve surgery is performed. (For more information, see Chapter 10.)

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## TYPES OF HEART VALVE DISEASE

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### MITRAL VALVE PROLAPSE

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This disease is also known as click-murmur syndrome, floppy-valve syndrome, balloon mitral valve,

and Barlow's syndrome. It is a deformity of the mitral valve that may prevent its leaflets from closing properly. One or both leaflets maybe bulging, or the entire valve may be out of its normal position. Depending on the degree of the deformity, the prolapse can lead to mitral regurgitation.

Mitral valve prolapse is the most common type of valvular disorder, and perhaps the best known to the general public. Although a larger number of cases than in the past are now being diagnosed by physicians, most of these are mild, and the increase probably reflects a heightened awareness of the disorder rather than an actual increase in the incidence rate of new cases. The prevalence (total number of cases) is unknown, but the syndrome is believed to affect, to some extent, 5 to 10 percent of the population in the United States. Women are affected by mitral valve prolapse much more often than men. One possible explanation is that in women the mitral valve tends to be larger in relation to the left ventricle than in men, and may therefore tend to fit less well.

The disorder is believed to be primarily hereditary, as approximately half of family members of people with mitral valve prolapse also have been found to be affected. It is often associated with myxomatous degeneration, and it maybe a part of genetic diseases involving other organs of the body. The disorder tends to be more easily detected in adolescents and young adults. It is usually recognized by characteristic clicks and murmurs that can be heard with a stethoscope.

In the vast majority of patients, mitral valve prolapse is very mild and produces no symptoms at all. Unfortunately, many individuals with a mitral-click syndrome or mitral prolapse have become anxious or overly concerned as a result of excessive emphasis by their doctors on this murmur or their disease. Symptoms that do appear are often vague and cannot always be attributed to the valve defect. They may include palpitations, breathlessness, chest pain, and fatigue. While for many years the disorder was thought to be associated with nervousness, weakness, anxiety, and various other forms of malaise, most experts today discount this connection for lack of firmly established evidence. There may be some association between mitral valve prolapse and an overactive sympathetic or automatic nervous system.

Generally, when there are no symptoms or when symptoms are mild, no treatment is required. In a very small number of patients, however, mitral valve prolapse can result in mitral insufficiency. Extra beats or episodes of tachycardia may also become frequent enough to cause symptoms. In some cases of mitral

insufficiency, patients may be advised to refrain from strenuous activities such as competitive sports. Unusual or rapid rhythms maybe relieved by the use of beta blockers, which help to slowdown the heart rate.

People with mitral valve prolapse are also at an increased risk of developing infective endocarditis. This is particularly true of patients in whom the prolapse causes mitral insufficiency these people should consult their physicians regarding possible preventive antibiotic treatment.

### MITRAL STENOSIS

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While in infants mitral stenosis can, in rare cases, be caused by congenital abnormalities, in adults it usually develops as a result of rheumatic fever suffered in childhood. With the decrease in the incidence of rheumatic fever, the incidence of this type of valvular disorder has dropped sharply in recent years.

Symptoms of mitral stenosis are slow to develop and usually do not appear until 10 to 20 years after an episode of rheumatic fever. The disorder is usually diagnosed when patients are in their 30s or 40s. Once symptoms appear, they tend to progress.

Since the mitral valve is located between the left atrium or upper heart chamber and the left ventricle, the major pumping chamber, its stenosis or narrowing results in an increase in the pressure in the left atrium. This pressure is transmitted back through veins to the lungs, causing congestion of the air passageways. The buildup of pressure, fluid, or both in the lungs is one manifestation of congestive heart failure and results in dyspnea (shortness of breath), the major symptom of mitral valve stenosis. It should be understood that heart failure may be serious but does not imply that the heart is unable to function. Many patients whose failure has been controlled are able to live long, productive lives. Mitral stenosis can be aggravated by atrial fibrillation, a condition in which the atrium weakens and moves in fine, quivery movements instead of a pumping action. The result is that blood is not pumped efficiently into the lower heart chambers.

Patients with mitral stenosis who develop heart failure are treated with diuretics. If they develop atrial fibrillation they may be given digitalis, quinidine, or a similar drug, as well as blood-thinning medications (anticoagulants) to prevent clots. In severe cases, the valve may have to be widened in an operation called mitral valvotomy. It can also be widened by a balloon catheter during cardiac catheterization, a procedure called valvuloplasty. This valve can also be replaced if repair is not feasible.

### MITRAL REGURGITATION

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Mitral regurgitation is most often caused by rheumatic heart disease, a type of degeneration of the valve, dysfunction of the muscles that control the closing of the valve, or rupture of the valve's chords. A heart attack may result in mitral insufficiency if a portion of the heart that supports the position of the valve is disrupted. Prolapse of the mitral valve may also be associated with insufficiency. In rare cases, insufficiency is a result of a congenital defect or disorder.

As in the case of stenosis, mitral regurgitation may be present without symptoms for many years. If a great deal of leakage occurs between the atrium and ventricle and this persists over long periods, in time pressure will build up in the lungs and breathlessness will result. In acute cases, such as those following a heart attack or damage caused by infective endocarditis, symptoms maybe sudden and severe. Patients may go into heart failure, and urgent therapy becomes necessary.

There are no medications that will help to heal the valves; therapy is directed toward relief of shortness of breath and various other changes that may occur. These include diuretics, digitalis, and quinidine. Severe cases are more likely to be treated by surgical valve replacement rather than repair. Some patients with mitral regurgitation are at a high risk of endocarditis and should receive prophylactic (preventive) antibiotic treatment before any procedure, from dental work to major surgery, that may involve possible blood infections. There are many older people who function without difficulty despite having had rheumatic fever and mitral insufficiency in childhood.

### AORTIC STENOSIS

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There are three major causes of aortic stenosis: calcific degeneration or deposits of calcium on the valve (primarily affects the elderly), congenital abnormality (uncommon), and rheumatic fever. Even in the case of a congenital defect, symptoms are most likely to appear only in adulthood. Whether the cause is rheumatic, degenerative, or congenital, the leaflets of the valve are usually covered with calcium deposits, which can completely distort their shape. While the condition may produce no symptoms for many years, it may cause chest pain, fainting, and shortness of breath during exercise if narrowing of the valve becomes severe. The disorder is recognized by a characteristic murmur; it can become quite loud and is usually easily recognized when listening with a stethoscope.

Stenosis of the aortic valve obstructs the flow of blood from the left ventricle, causing it to enlarge or thicken and eventually weaken over time. Under normal conditions, even in the presence of aortic stenosis, the ventricle can maintain the output of blood to the body at a regular level by pumping harder, but at times of physical exertion it may not be able to maintain an output of blood sufficient to supply blood to the brain. Fainting may result. Patients with aortic stenosis should refrain from strenuous activity. Moderate exercise is usually well tolerated. Surgical repair of severe aortic stenosis has been successfully performed in thousands of people. The presence of a narrowed aortic valve may result in less blood getting into the coronary arteries which supply blood to heart muscle. Angina may result even after moderate exercise. This may be a sign that the valve should be repaired.

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#### AORTIC REGURGITATION

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In its acute form, aortic regurgitation usually occurs as a result of an infection that leaves holes in the valve's leaflets, but this condition is uncommon. The chronic form, which is more common, is usually a consequence of the widening of the aorta in the region where it connects to the valve, or from valve disease, rheumatic fever, etc. In most cases, it is not known what causes the widening of the aortic ring, which prevents the valve from properly closing off the left ventricle. Sometimes the aorta may be widened due to a genetic disorder, such as Marfan syndrome, a congenital disease of connective tissue. In the past, aortic insufficiency was frequently caused by syphilis, but since the advent of penicillin for treating syphilis, this is no longer the case.

Aortic regurgitation, like other valve abnormalities, often produces no symptoms for many years. Breathlessness, sometimes accompanied by chest pain and ankle swelling, may be noticed after many years if the condition is severe. The constant swirling or regurgitation of blood results in a dilation or enlargement of the left ventricle. Eventually, the burden becomes too great and the blood backs up. If symptoms are severe, valve replacement may become necessary. The acute form of the disorder may lead to heart failure and requires emergency surgery and valve replacement.

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#### TRICUSPID STENOSIS AND REGURGITATION

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These disorders account for less than 5 percent of valvular disease. They seldom occur as a single symp-

tom; they usually accompany other types of valve problems or cardiac abnormalities. Abnormalities of the tricuspid valve are generally caused by rheumatic fever or metabolic abnormalities affecting the heart. Among the major symptoms they produce are swelling of the legs and fatigue.

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#### PULMONARY STENOSIS AND REGURGITATION

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These disorders—particularly pulmonary stenosis—are also rare and are primarily due to congenital defects. Children born with a severely narrowed pulmonary valve may require immediate surgical intervention for survival.

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## TREATMENT

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#### DRUGS

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None of the drugs prescribed for valve disorders are curative; rather, their major functions are to reduce the severity of symptoms, possibly reduce the workload of the heart, and prevent complications. Digitalis medications are most often used in patients with heart valve disease. They increase the heart's efficiency in pumping blood and may help relieve the symptoms of heart failure. Digitalis-like medications also help in managing some arrhythmias (abnormalities of the heartbeat) that may occur as a result of valve disorders. Other classes of drug that may be prescribed for the symptoms resulting from heart-valve disorders include:

- *Vasodilators.* These drugs dilate blood vessels and are used to treat congestive heart failure associated with heart valve disease (usually valvular insufficiency). They help to reduce the pressure against which the heart must pump. These drugs include the ACE inhibitors, nitroglycerin, and prazosin (Minipress), among others.
- *Diuretics.* These remove salts and water from the body. They reduce the workload on the heart (which may be overburdened by the presence of a valve disorder) by decreasing the volume of blood that needs to be pumped. Diuretics include furosemide (Lasix) and hydrochlorothiazide combinations (Hydrodiuril), among others.

- *Anticoagulants.* These include medications such as warfarin (Coumadin), which help to prevent formation of blood clots that may block blood vessels.
- *Antiarrhythmics.* Drugs such as quinidine and procainamide help control arrhythmias, or irregular heartbeats, which are fairly common in heart valve disease.

(For more information about these medications, see Chapter 23.)

### BALLOON VALVULOPLASTY

This relatively new technique is increasingly used as an alternative to surgical repair of valvular stenosis. A deflated balloon attached to the end of a catheter is introduced through an artery into the heart to the center of the valve opening and then inflated. The method, which is used primarily to correct the narrowing of the mitral and occasionally the aortic valves, can alleviate symptoms and partially clear the obstruction. While somewhat less effective than surgery, it is a much simpler, safer, and less expensive procedure, although it is not yet clear whether it can provide a permanent solution to valve stenosis. Balloon valvuloplasty is more successful in repairing the mitral valve than in repairing aortic stenosis. In elderly patients who might not tolerate surgery or where a long convalescence should be avoided, the procedure may be helpful in relieving symptoms.

### SURGICAL REPAIR

Surgical treatment is reserved for severe cases of heart valve disease when symptoms suggest progression of the disease. Thus, in the case of stenosis, it is usually performed if the opening of the mitral valve is less than a quarter of its normal size or the opening in an aortic valve is a third of normal. During the operation, the surgeon can stretch and open the valve's leaflets; this may not completely correct the obstruction but can reduce the symptoms.

In case of a tear, the surgeon may repair the leaky valve by suturing and tightening the leaflets or chords. When leaflets of the mitral valve fail to close, it may be possible to pull the base of the valve to-

gether or make the whole valve smaller, to facilitate the closure. In the majority of cases, however, a severely stenotic valve, particularly if it is also leaky or insufficient, has to be replaced.

### VALVE REPLACEMENT SURGERY

This type of surgery is usually recommended when the damage to the valve is severe enough to be potentially life-threatening. There may, for example, be a risk that the valve disorder could cause sudden death, as in the case of severe aortic stenosis. The mitral and aortic valves, which are the gates controlling blood flow into and out of the heart's two main pumping chambers, are the ones that most often need to be replaced.

There are two types of prosthetic valves that can be used to replace the original valves: mechanical and biologic. Mechanical valves are made of synthetic materials: metal alloys, carbon, and various plastics. They come in two major designs. One, called a caged-ball valve, consists of a small cage containing a ball that pops up when blood is ejected and then drops down to seal the chamber. The other, referred to as tilting-disk valve, consists of a round disk pivoting inside a ring, which can tilt to a horizontal or vertical position to let the blood through or prevent its flow.

Mechanical valves are more durable than biologic ones and can last for 20 years or more without having to be replaced. They do, however, tend to promote abnormal clot formation, so patients must take anticoagulant drugs as a preventive measure. Thus, mechanical valves cannot be implanted in patients who have bleeding problems, ulcers, or other conditions precluding a long-term use of anti-blood-clotting medications. Biologic valves may also be preferred in elderly patients, when the issue of durability is less crucial.

Biologic valves can be composed of animal or human valve tissue. Because of the scarcity of human valves available for transplantation, pig valves, specially processed and sutured into a synthetic cloth, are most often used. They are well tolerated by the human body and are much less likely to require blood-thinning therapy, but they tend to be less durable; after 10 years, some 60 percent need to be replaced.

(For more information on surgical repair and replacement, see Chapter 25.)