Chapter 29

Mitral Valve Disease

Thomas R. Griggs

Mitral valve leaflets consist of thin, pliable, fibrous material. The two leaflets—anterior and posterior—open by unfolding against the ventricular wall and close by apposition when the pressure in the left ventricle becomes greater than that in the left atrium. *Mitral stenosis* occurs when the mitral valve leaflets become stiffened, calcified, and unable to fully open during diastole. This process often involves the chordae tendineae, in addition to the mitral valve leaflets. *Mitral valve regurgitation* (MR) occurs when the leaflets are unable to fully close in systole. In the United States, more than 20,000 patients annually require surgery for manifestations of mitral stenosis and MR, and thousands more require monitoring and treatment.

ETIOLOGY AND PATHOGENESIS

Rheumatic fever is responsible for a majority of cases of mitral stenosis. The initial infection and its sequelae result in thickened valve leaflets and fusion of the commissure between the leaflets. Chordae tendineae are also affected and become thickened and shortened. Most valves that are affected by rheumatic fever show abnormalities of all these structures. Few patients with rheumatic mitral valve disease have pure mitral stenosis; most patients have a combination of stenosis and regurgitation. Approximately two thirds of the cases of mitral stenosis in the United States occur in women.

The normal mitral valve cross-sectional area in diastole is 4 to 6 cm^2. Blood flow is impaired when the valve orifice is narrowed to less than 2 cm^2, creating a pressure gradient with exertion. A valve area smaller than 1 cm^2 is considered critical mitral stenosis and causes a gradient across the valve at rest with chronically increased left atrial pressures (Fig. 29-1).

Chronically increased pressures in the left atrium associated with mitral stenosis result in left atrial enlargement and a predisposition for atrial fibrillation. Valves affected by mitral stenosis are also vulnerable to recurrent thrombosis and implantation of bacteria that lead to infective endocarditis.

The hemodynamic effects of chronic mitral stenosis include pulmonary venous and arterial hypertension, right ventricular (RV) hypertrophy and failure, peripheral edema, ascites, and hepatic injury with cirrhosis (Fig. 29-2).

Numerous etiologies contribute to MR. These include mitral valve prolapse, rheumatic heart disease, cardiomyopathy with ventricular dilation, ischemic heart disease involving the papillary muscles, ischemic cardiomyopathy, bacterial or fungal endocarditis, and certain collagen–vascular diseases. Disease of any component of the mitral apparatus can cause a functional failure of the valve.

With moderate or severe MR, with left ventricular contraction in systole, blood is discharged into the left atrium, in addition to traveling its usual route through the aortic valve and into the aorta. If the regurgitant volume is large, the left ventricle dilates to accommodate increased volumes (Fig. 29-3). As MR continues to progress, ventricular output capacity is challenged, increased systemic afterload generates even more regurgitation, and symptoms and other findings of MR occur (Fig. 29-4).

Infectious endocarditis, spontaneous rupture of chordae tendineae, or ischemic injury of a papillary muscle may cause acute loss of integrity of the mitral valve and acute MR. In these cases, there is no adaptation of the left atrium or pulmonary vasculature to the increased regurgitant volumes; sudden onset of acute pulmonary edema may result. Aggressive use of afterload-reducing agents is the emergent treatment, but survival usually depends on emergency repair or replacement of the valve.
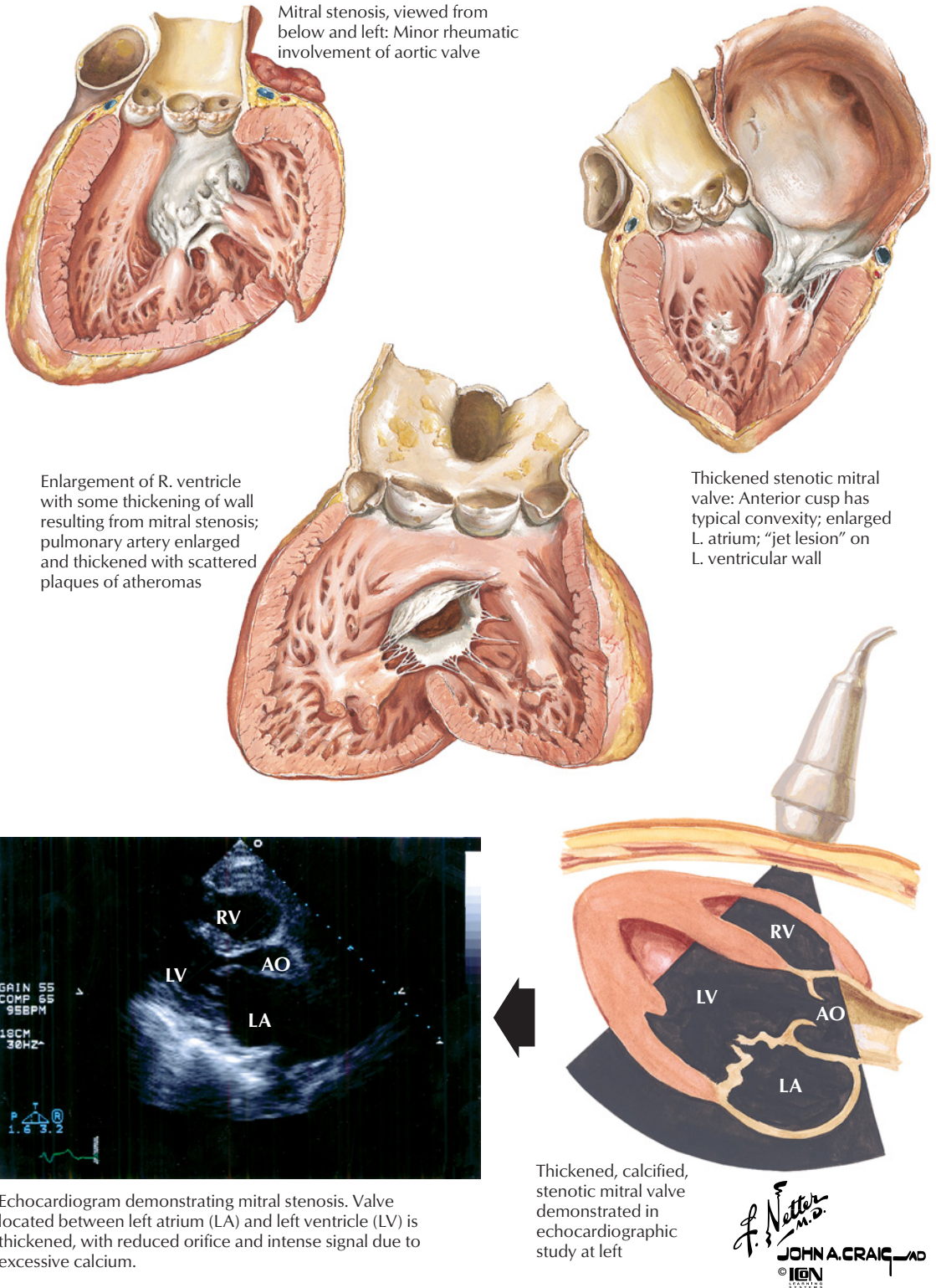
CLINICAL PRESENTATION
Mitral Stenosis

Patients notice the effects of moderate (1–2 cm^2) mitral stenosis with activity. With severe

Figure 29-1

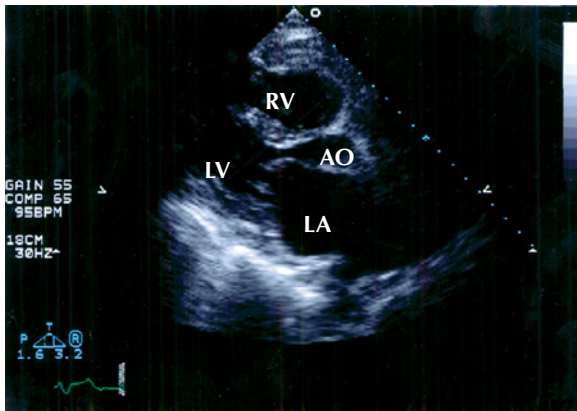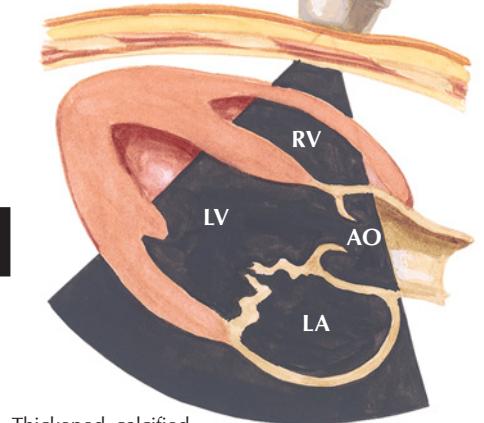# Mitral Stenosis

Mitral stenosis, viewed from below and left: Minor rheumatic involvement of aortic valve

Enlargement of R. ventricle with some thickening of wall resulting from mitral stenosis; pulmonary artery enlarged and thickened with scattered plaques of atheromas

Thickened stenotic mitral valve: Anterior cusp has typical convexity; enlarged L. atrium; "jet lesion" on L. ventricular wall

GAIN 55
COMP 65
95BPM

18CM
30HZ

P T R
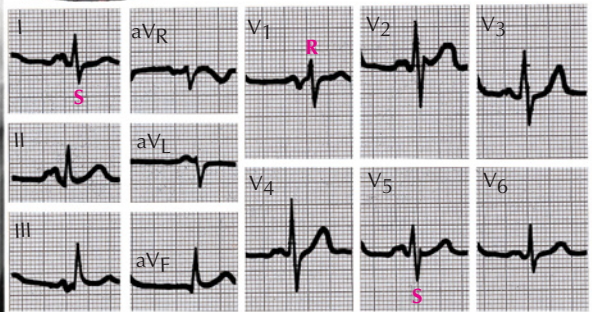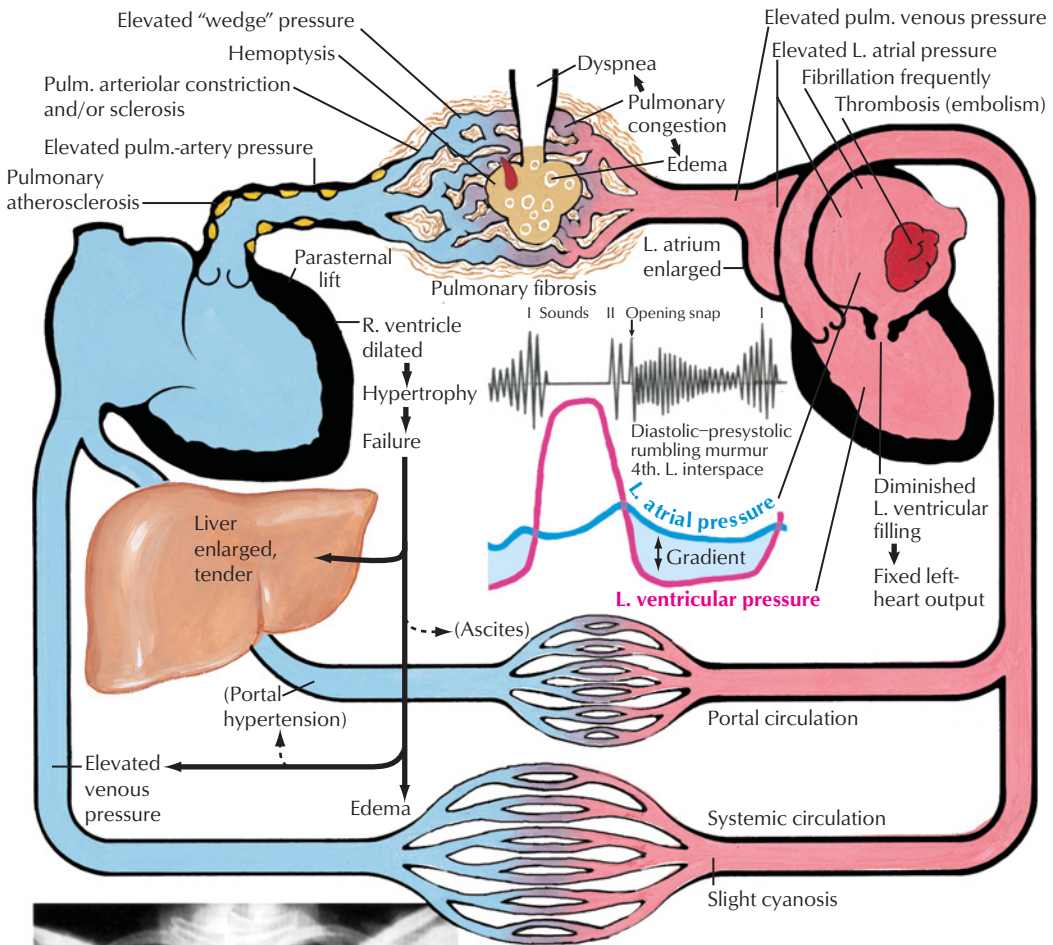1.6 3.2

RV

LV   AO

LA

RV

LV   AO

LA

Echocardiogram demonstrating mitral stenosis. Valve located between left atrium (LA) and left ventricle (LV) is thickened, with reduced orifice and intense signal due to excessive calcium.

Thickened, calcified, stenotic mitral valve demonstrated in echocardiographic study at left

VALVULAR HEART DISEASE

Figure 29-2   **Pathophysiology and Clinical Aspects of Mitral Stenosis**

Elevated "wedge" pressure

Hemoptysis

Pulm. arteriolar constriction and/or sclerosis

Elevated pulm.-artery pressure

Pulmonary atherosclerosis

Dyspnea

Pulmonary congestion

Edema

Elevated pulm. venous pressure

Elevated L. atrial pressure

Fibrillation frequently

Thrombosis (embolism)

Parasternal lift

Pulmonary fibrosis

L. atrium enlarged

R. ventricle dilated

Hypertrophy

Failure

I Sounds   II Opening snap   I

Diastolic–presystolic rumbling murmur 4th. L. interspace

L. atrial pressure

Gradient

L. ventricular pressure

Diminished L. ventricular filling

Fixed left-heart output

Liver enlarged, tender

(Ascites)

(Portal hypertension)

Portal circulation

Elevated venous pressure

Edema

Systemic circulation

Slight cyanosis

L. atrial abnormality (P "mitral") and evidence of R. ventricular hypertrophy (S in leads I and V_5, R in V_1)

Atrial fibrillation
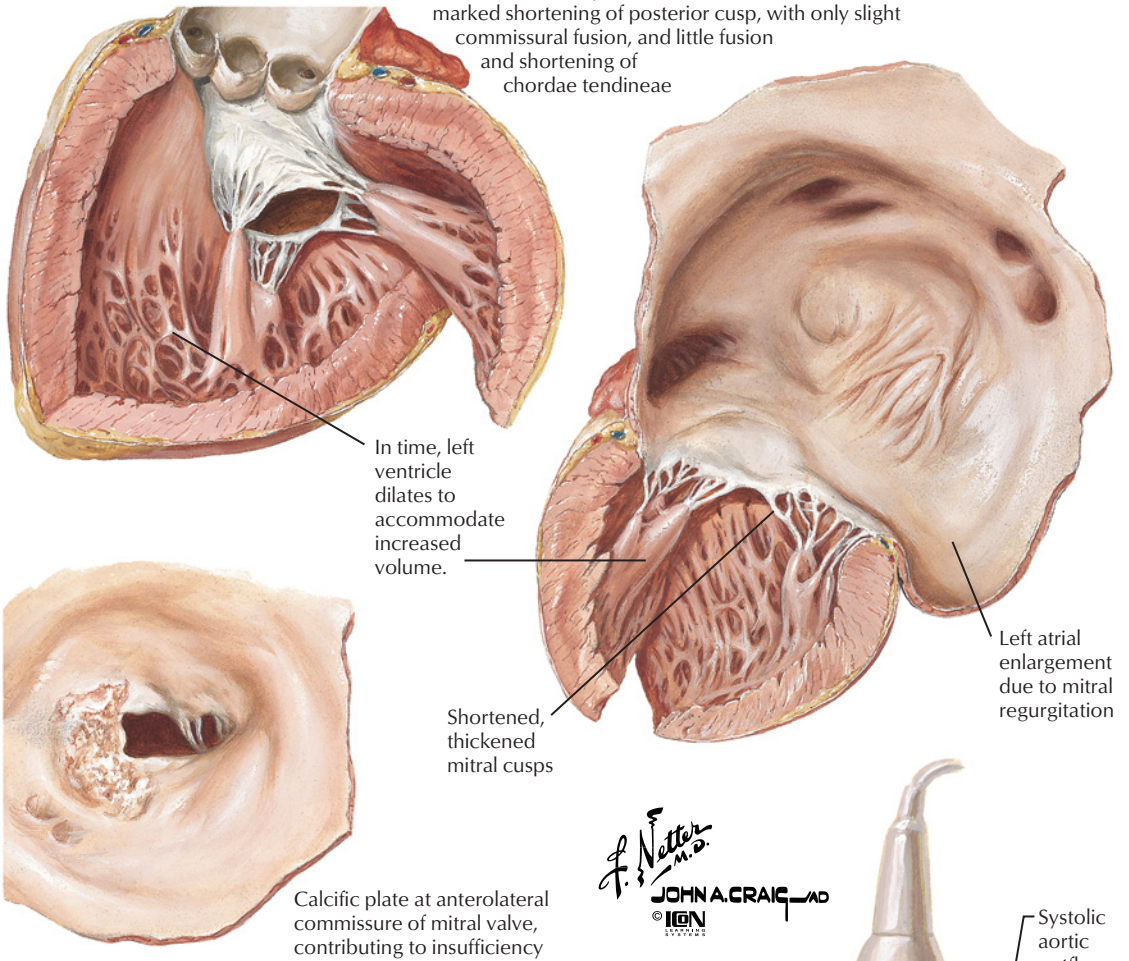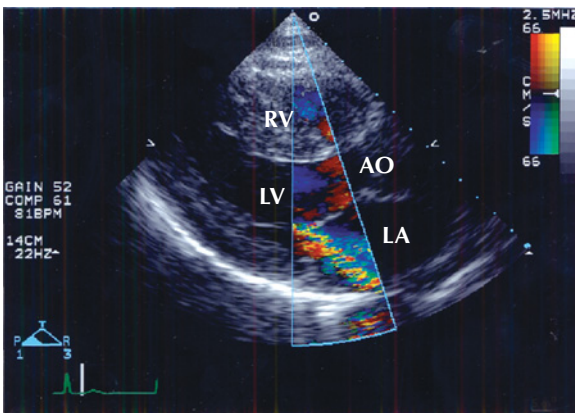
Figure 29-3

Mitral Regurgitation

Mitral insufficiency: Mitral valve viewed from below; marked shortening of posterior cusp, with only slight commissural fusion, and little fusion and shortening of chordae tendineae
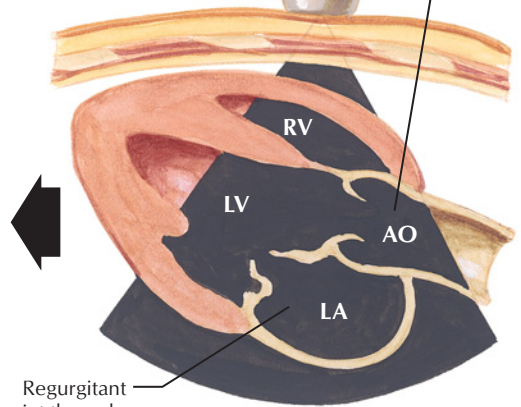
In time, left ventricle dilates to accommodate increased volume.

Left atrial enlargement due to mitral regurgitation

Shortened, thickened mitral cusps

Calcific plate at anterolateral commissure of mitral valve, contributing to insufficiency

Systolic aortic outflow

RV

AO

RV

LV

LA

LV

AO

GAIN 52
COMP 61
81BPM

14CM
22HZ

LA

Regurgitant jet through incompetent mitral valve

Color Doppler study demonstrating systolic aortic outflow (blue/red) and multicolored jet of regurgitant flow through incompetent mitral valve into left atrium (LA)
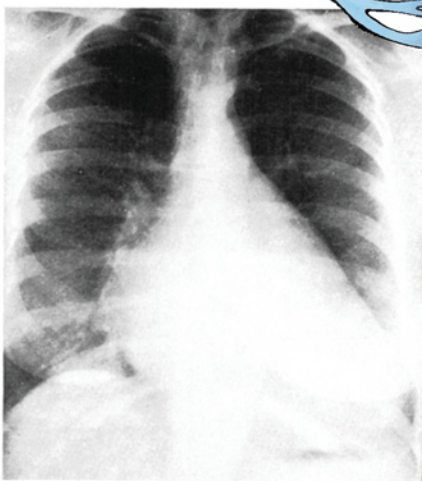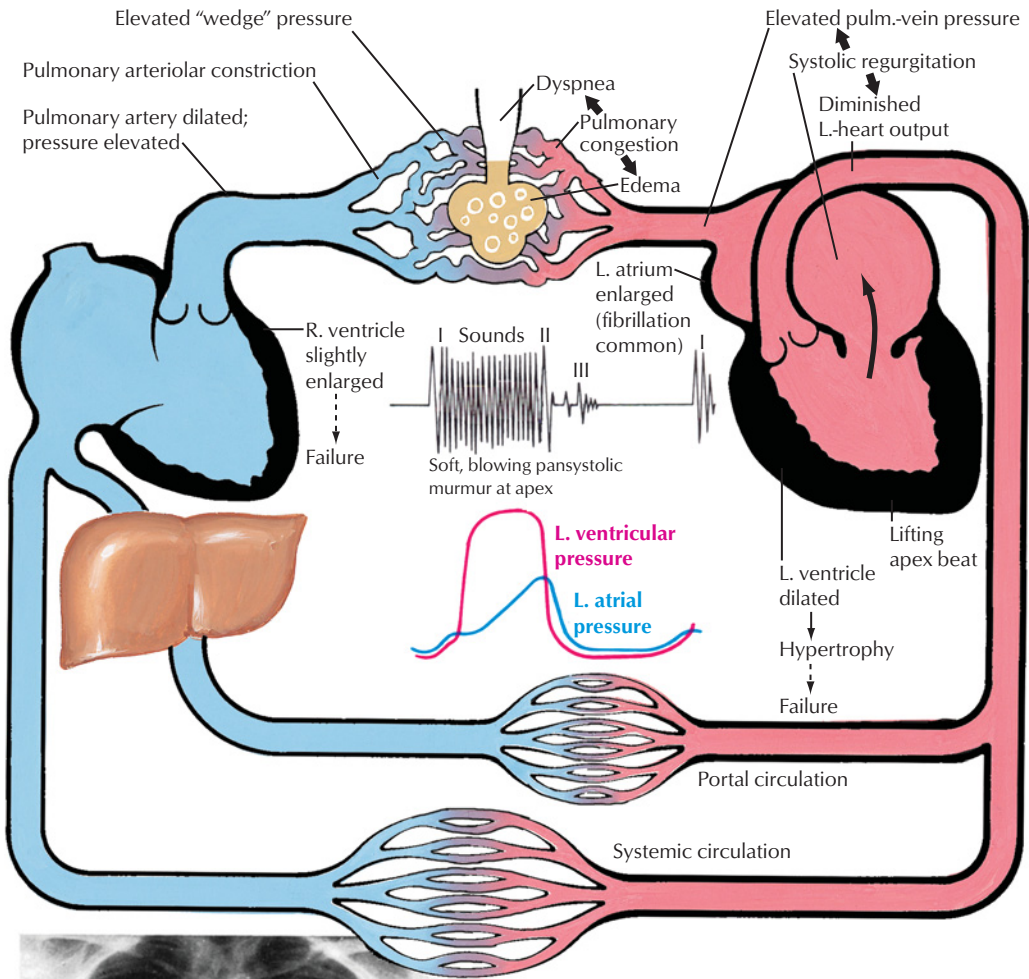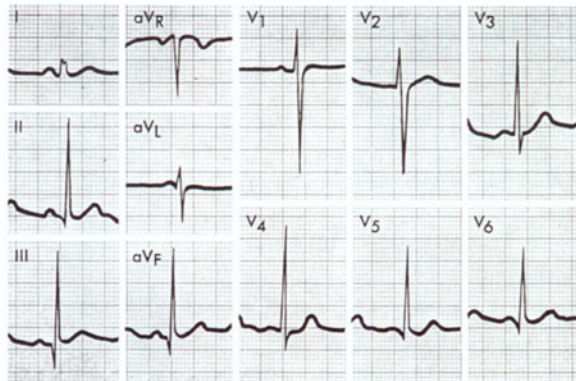
Diagram of mitral regurgitation shown in Doppler color study at left

Figure 29-4

Pathophysiology and Clinical Aspects
of Mitral Regurgitation

Elevated "wedge" pressure

Pulmonary arteriolar constriction

Pulmonary artery dilated; pressure elevated

Elevated pulm.-vein pressure

Systolic regurgitation

Diminished L.-heart output

Dyspnea

Pulmonary congestion

Edema

L. atrium enlarged (fibrillation common)

R. ventricle slightly enlarged

Failure

I Sounds II

III

I

Soft, blowing pansystolic murmur at apex

L. ventricular pressure

L. atrial pressure

Lifting apex beat

L. ventricle dilated

Hypertrophy

Failure

Portal circulation

Systemic circulation

L. and R. ventricular enlargement

Electrocardiographic evidence of l. ventricular hypertrophy (large S in V_1, large R in V_4) and minor atrial abnormality (broad P)

stenosis, dyspnea with minimal exertion and paroxysmal nocturnal dyspnea may occur. In some cases, a sudden, dramatic onset of atrial fibrillation produces the first symptoms, occasionally resulting in fatal pulmonary edema. When the development of atrial fibrillation is clinically silent, the initial event may be a stroke or other thromboembolic event. The classic presentation of severe cor pulmonale with ascites and edema is rarely seen today except in medically underserved populations. Mitral valve disease increases the risk for bacterial endocarditis, which should always be considered when symptoms worsen in a previously stable patient with mitral valve disease.

Auscultation of symptomatic mitral stenosis is characterized by a loud first heart sound, an opening snap after the second heart sound, and a low-pitched diastolic murmur with presystolic accentuation if the patient is in sinus rhythm. The *opening snap* is the sound generated by sudden full opening of the mitral valve. It can reflect the severity of the pressure gradient across the mitral valve because greater left atrial pressures generate earlier opening than do lesser ones. Therefore, the shorter the interval from A2 to opening snap, the greater the pressure gradient, and the more severe the stenosis.

The characteristic diastolic, low-frequency "rumble" or murmur associated with mitral stenosis is best heard at the apex, with the patient in the left lateral decubitus position and the bell over the point of maximal ventricular intensity. The rumble occurs throughout diastole, with accentuation in late diastole (presystole) in patients who have preserved normal sinus rhythm. This murmur can be difficult to hear and is soft and brief when the mitral stenosis is minor. Therefore, heightened awareness of possible mitral stenosis is necessary. If the murmur is inaudible during this maneuver, it can be accentuated by having the patient exercise before auscultation. This murmur sequence—loud first sound, opening snap, and diastolic rumble—is quite specific for mitral stenosis. Murmurs that mimic mitral stenosis include the Austin Flint murmur with aortic regurgitation, mitral diastolic murmurs in patients with large intracardiac shunts, and occasionally murmurs that are caused by a left atrial myxoma. However, none have all three components of classic mitral stenosis.

Electrocardiographic changes in mitral stenosis may range from minor ST-segment and T-wave abnormalities to electrocardiographic evidence of severe pulmonary hypertension and RV enlargement. The ECG pattern of left atrial and RV enlargement is a classic indicator. Atrial fibrillation is common.

Mitral Regurgitation

Even severe MR may be clinically silent. Many cases are discovered during routine examinations when the characteristic murmur is noticed. Symptoms usually begin as dyspnea on exertion. Patients may also present with acute pulmonary edema or evidence of RV failure. Sudden decompensation can occur with the onset of atrial fibrillation or the development of bacterial endocarditis.

With MR, palpation may be normal or may show a displaced, sustained left ventricular (LV) impulse with a rapid filling wave. On auscultation, the most prominent feature is a high-pitched holosystolic murmur that usually radiates to the axilla. The intensity may not correlate with the severity of the MR; even highly severe MR can be associated with virtually no murmur. ECG changes in MR are nonspecific and are primarily changes of LV hypertrophy and strain; atrial fibrillation is common.

DIFFERENTIAL DIAGNOSIS

Primary pulmonary diseases (pneumonia, tuberculosis, chronic obstructive lung disease, and pulmonary thromboembolism) have presentations similar to that of mitral valve disease: dyspnea on exertion or pulmonary edema. Dyspnea may also be present in chronic interstitial pulmonary diseases, pulmonary hypertension, and malignancies that involve the chest. Heart diseases to consider are ischemic heart disease, congenital heart disease, dilated cardiomyopathy, and hypertrophic cardiomyopathy. Chronic pericardial disease with restriction can cause RV failure that mimics the pulmonary hypertension associated with mitral valve disease.

DIAGNOSTIC APPROACH

Many pulmonary diseases can be differentiated from mitral valve disease by means of chest imaging, including both radiography and

computerized tomographic scanning. When an initial evaluation has focused the differential diagnosis on mitral valve disease, the most helpful clinical tool is echocardiography (see also chapter 4). In rheumatic mitral valve disease, echocardiography can demonstrate thickening, calcification, poor mobility of the valve, and thickening of subvalvular structures. The degree of valvular stenosis or regurgitation can be estimated using Doppler ultrasonography. When necessary, the anatomy of the valve and subvalvular apparatus can be further defined by transesophageal echocardiography. The goals of echocardiography are to evaluate the severity of the stenosis or regurgitation, the mobility of the valve, the involvement of subvalvular structures, and the degree of calcification and to detect intracardiac thrombi. Echocardiography provides information about LV contractile function and an accurate estimation of pulmonary artery pressure and RV function. It can also identify bacterial and fungal vegetations, intracardiac masses (especially left atrial myxoma), and intraventricular septal defects, all conditions that can complicate the diagnosis of mitral valve disease.

Cardiac catheterization is indicated in the few patients with a questionable diagnosis and in those patients for whom surgical treatment is contemplated. Catheterization is performed to quantify the mitral valve area; document key elements of hemodynamics, such as cardiac output and systemic resistance; define the degree of pulmonary hypertension; and to determine whether coexistent coronary artery disease is present.

MANAGEMENT AND THERAPY

Asymptomatic patients with mild, uncomplicated mitral valve disease may require only prophylaxis for endocarditis. In symptomatic patients, diuretics can help to reduce pulmonary congestion. With mitral stenosis, the time for ventricular filling is critically important; HR should be maintained as low as is practical with a β-blocker or a calcium channel blocker, such as verapamil or diltiazem. Patients with atrial fibrillation must be treated with warfarin anticoagulation unless it is contraindicated.

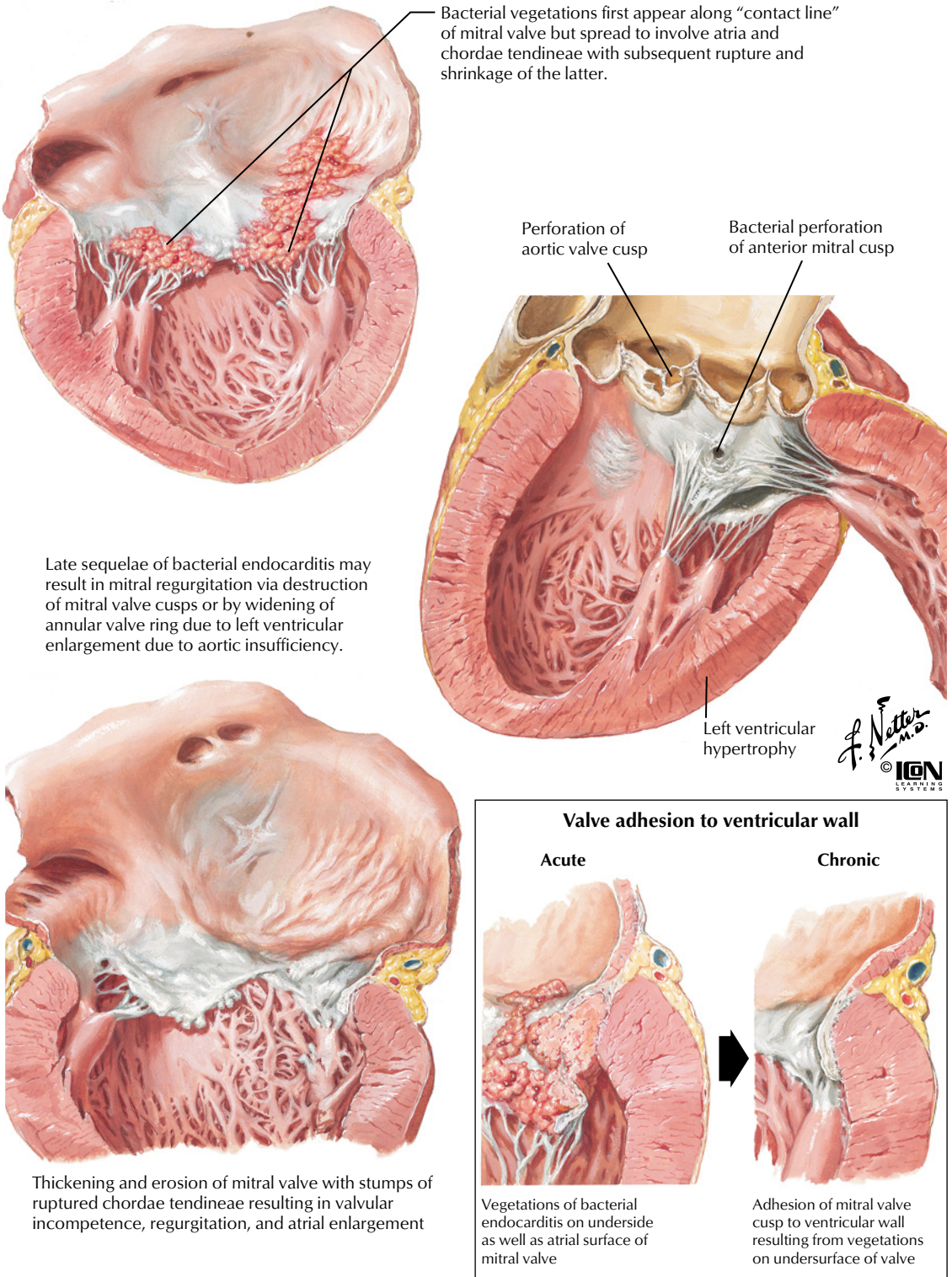Symptomatic mitral stenosis can be improved by means of percutaneous balloon mitral valvotomy, surgical valvotomy, or surgical replacement of the mitral valve. Various criteria are used to determine the timing of surgery, ranging from the development of symptoms in a patient with known severe mitral stenosis to the new diagnosis of severe mitral stenosis in a young person. In selected patients, in whom there is little valvular calcification, little involvement of the subvalvular apparatus, and minimal or no mitral valve regurgitation, percutaneous balloon valvotomy is the treatment of choice. Longitudinal studies have documented event-free survival to be greater than 70% at 7 years.

Open valvotomy is a repair procedure that involves direct visualization by the surgeon, allowing for débridement of the valve structure and reconstruction of subvalvular apparatus. Because the approach used also allows for valve replacement, in patients who are questionable candidates for valvotomy, the decision can be made during surgery whether repair or replacement is the most appropriate choice. Mitral valve replacement continues to be an alternative for patients with severe mitral stenosis and is especially appropriate for patients with significant MR (see chapter 34).

The timing of surgical intervention for patients with MR is critical. In most cases, MR is well tolerated, and the patient is asymptomatic for many years. Delaying surgery as long as possible avoids the trauma, expense, and risk of surgery. However, every effort must be made to proceed with surgery before ventricular function has degenerated. Assessments of LV systolic function involve measurement of the ejection fraction. The reduced wall tension and afterload of MR allow the ejection fraction to be preserved late into the course of the disease; therefore, any decrement in ejection fraction may represent a considerable decrease in myocardial functional reserve. In general, mitral valve surgery should be considered in a patient with known moderate to severe MR when the patient is symptomatic or there is objective evidence of decreased LV function.

Valve repair for severe MR improves mortality and decreases the frequency of complications. Valves must be relatively free of calcification and have pliable leaflets with chordae tendineae that can be separated, reinforced, or reattached as needed. Placement of a reinforcing mitral ring

Figure 29-5   ## Bacterial Endocarditis in Mitral Valvular Disease

Bacterial vegetations first appear along "contact line" of mitral valve but spread to involve atria and chordae tendineae with subsequent rupture and shrinkage of the latter.

Perforation of aortic valve cusp

Bacterial perforation of anterior mitral cusp

Late sequelae of bacterial endocarditis may result in mitral regurgitation via destruction of mitral valve cusps or by widening of annular valve ring due to left ventricular enlargement due to aortic insufficiency.

Left ventricular hypertrophy

Thickening and erosion of mitral valve with stumps of ruptured chordae tendineae resulting in valvular incompetence, regurgitation, and atrial enlargement

Valve adhesion to ventricular wall

Acute

Chronic

Vegetations of bacterial endocarditis on underside as well as atrial surface of mitral valve

Adhesion of mitral valve cusp to ventricular wall resulting from vegetations on undersurface of valve

is frequently included in the repair. Advantages of valve repair over replacement are that it provides patients with functional subvalvular components, including the papillary muscles, and that the natural tissues in the valve are much more resistant to thrombogenicity than any artificial surface, obviating the use of warfarin anticoagulant.

Mitral regurgitation resulting from dilated cardiomyopathy is an especially troublesome problem that is caused by dilation of the mitral ring and ventricles and results in anatomic deformity of the relation of the papillary muscles and chordae tendineae to the mitral valve leaflets. The resulting MR increases the need for ejection volume and decreases forward blood flow. In this situation, repair or replacement of the mitral valve may fail to improve symptoms and is associated with an extremely high risk of operative death. New percutaneous approaches for mitral valve repair in this circumstance are currently in clinical trials to determine safety and efficacy.

Coronary heart disease can cause MR by means of several mechanisms. The mitral valve is tethered to papillary muscles that are dependent on myocardial blood flow. Acute ischemia to the area providing blood flow to the papillary muscles can cause temporary MR. Infarction of the papillary muscle will cause permanent failure of the subvalvular apparatus. Acute myocardial infarction that involves a papillary muscle causes severe, acute, life-threatening MR, with mortality rates of nearly 30% if not surgically and emergently corrected. In some circumstances, an infarction results in rupture of the tip of the papillary muscle with acute MR. This is almost always fatal unless surgically corrected. Finally, patients with extensive myocardial scarring caused by previous infarction and associated dilation of the ventricle, ischemic cardiomyopathy, can have severe MR because of dilation of the mitral ring and abnormal alignment of the papillary muscles, chordae tendineae, and valve leaflets.

Any structural abnormality of the valve can result in flow aberrations that promote deposition of microthrombi. These can be the nidus for a bacterial or fungal infection with simultaneous septicemia, resulting in further damage associated with endocarditis (Fig. 29-5). Endocarditis can affect valve competency because of interference in valve function by vegetations or by destruction or fenestration of the valve leaflets. Although endocarditis is usually managed with antibiotics, the damage effected by the bacteria is permanent, as is the resultant MR. Indications for surgery after cured bacterial endocarditis are identical to those for other causes for MR. In addition, acute surgical care is indicated for extremely large vegetations, when heart failure is otherwise unmanageable, when a myocardial abscess is documented, and for patients with persistent bacteremia.

FUTURE DIRECTIONS

Improving worldwide morbidity and mortality associated with rheumatic heart disease necessitates better systems of hygiene and improved prophylactic treatment of streptococcal infection, especially the current drug-resistant strains. The prevalence of MR will increase as the population ages, spurring improvements in several areas: imaging with more accurate estimates of ventricular reserve, surgical technology with early repair of severely regurgitant valves, balloon valvotomy with improved patient selection and equipment, and minimally invasive surgical techniques with reduced recovery time and morbidity. Better treatment for atrial fibrillation and improved therapies for prevention of thrombosis will greatly improve the quality of life for patients with mitral valve disease and valve prostheses.

REFERENCES

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Enriquez-Sarano M. Timing of mitral valve surgery. Heart 2002;87:79–85.

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