Surgery for Chronic Aortic Regurgitation: When Should It Be Considered?

MELVIN D. CHEITLIN, M.D., University of California, San Francisco, School of Medicine, San Francisco, California

Deciding when to operate on a patient with chronic aortic regurgitation may be extremely difficult. The timing of surgery requires consideration of the etiology and pathophysiology of the aortic regurgitation, because aortic valve replacement carries morbidity and mortality that must be weighed against the potential problems of continued medical management. Guidelines for the use of surgery in patients with valvular disease have been developed by a joint task force of the American College of Cardiology and the American Heart Association. Practical recommendations based on these guidelines are presented. (Am Fam Physician 2001;64:1709-14.)

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Determining the point at which surgery is needed is more difficult in patients with chronic aortic regurgitation than in patients with other valvular lesions. If the aortic regurgitation develops gradually, the left ventricle can become enormous, but the patient may have few or no symptoms. Even in the absence of symptoms, the etiology of aortic regurgitation needs to be considered in deciding if and when to operate. This article discusses the pathophysiologic basis of the signs and symptoms of aortic regurgitation, with the purpose of providing practical recommendations to help physicians determine when surgical intervention is necessary.

Etiology

Aortic regurgitation can have many causes, including diseases that affect connective tissue, which is the substance of the aortic valve and the ascending aorta *(Table 1)*. In most of these diseases, aortic regurgitation progresses gradually, allowing time for the left ventricle to accommodate the large diastolic volume by increasing its end-diastolic size and developing eccentric hypertrophy. A few diseases can cause sudden severe aortic regurgitation. In these diseases, the clinical picture of acute aortic regurgitation results from a sudden and marked increase in diastolic filling volume, with no chance for the left ventricle or the stiff pericardium to accommodate this increase.

TABLE 1
Causes of Aortic Regurgitation

Rheumatic heart disease	Ascending aortic aneurysm
Congenital heart disease (e.g., bicuspid aortic valve, prolapsed aortic cusp with supracristal ventricular septal defect)	Aortitis (e.g., syphilis, Takayasu's arteritis, granulomatous aortitis)
Collagen vascular diseases (e.g., systemic lupus erythematosus)	Myxomatous aortic valve*
Connective tissue disease (e.g., Marfan syndrome, Turner's syndrome, pseudoxanthoma elasticum, ankylosing spondylitis, Ehlers-Danlos syndrome, polymyalgia rheumatica)	Calcific changes in aortic valve (together with aortic stenosis)
	Anorectic drugs
	Infective endocarditis*
	Aortic dissection*
	Trauma*

**—Associated with clinically acute aortic regurgitation.*

In chronic aortic regurgitation, valvular surgery is needed when the regurgitant volume becomes moderate to severe. However, certain etiologies may dictate surgery even if the degree of regurgitation is mild. For instance, the patient with aortic regurgitation resulting from dissection of the ascending aorta requires immediate surgery to repair the dissection. The patient with a prosthetic aortic valve who presents with infective endocarditis and an extensive annular abscess should undergo surgery before massive dehiscence occurs. Finally, the patient with a large ascending aortic aneurysm and minimal aortic regurgitation must have surgery because of the aneurysm.

Pathophysiology of Chronic Aortic Regurgitation

The diagnosis of aortic regurgitation can be made using a stethoscope. Its severity is reflected by the peripheral signs of aortic regurgitation.

In chronic aortic regurgitation, the regurgitant leak increases gradually so that the end-diastolic left ventricular volume becomes greater. The left ventricle responds with dilatation and hypertrophy (eccentric hypertrophy). With a large left ventricle, stroke volume increases enough to keep the forward effective stroke volume normal and accommodate the regurgitant volume. As the aortic regurgitation becomes severe, the increased left ventricular stroke volume delivered into the aorta results in a high systolic pressure, and the rapid runoff from the aorta back into the left ventricle results in a lower aortic diastolic pressure. Ultimately, the difference between systolic and diastolic pressure (pulse pressure) increases. The aorta becomes dilated and elongated, which explains the uncoiled aorta usually seen on the chest radiograph.

The increased pulse pressure and rapid aortic runoff result in many of the peripheral signs of severe aortic regurgitation, including the visible carotid pulse and suprasternal pulsations as well as the collapsing quality of the pulse ("water-hammer" pulse, Quincke's pulse [pulsating flushing of the nail beds]). In severe aortic regurgitation, the retrograde flow back into the left ventricle results in the to-and-fro bruit created by pressure with the bell of the stethoscope placed over the femoral artery (Duroziez's murmur). The rapid ejection of the large stroke volume leads to a sharp rise in the pulse wave, resulting in the "pistol-shot" femoral artery sound.

Pathophysiologically, the left ventricle must continue to eject a large stroke volume to keep forward stroke volume normal. The higher systolic pressure, together with the larger end-diastolic volume, results in both an afterload and a preload burden on the left ventricle. When the left ventricle can no longer deliver this stroke volume against the increased afterload, the amount of blood remaining in the ventricle increases (end-systolic volume), and the end-diastolic volume also increases to maintain the left ventricular stroke volume. This results in a decrease in the percentage of end-diastolic volume ejected, or a decreased ejection fraction. As the left ventricle enlarges and myocardial dysfunction occurs, the filling pressure rises, and the patient develops signs and symptoms of left ventricular failure.

Another problem is the effect of chronic severe aortic regurgitation on the myocardial oxygen supply/demand ratio. The demand for myocardial oxygen, and therefore coronary blood flow, is increased because the left ventricle is large and left ventricular systolic pressure has increased. At the same time, myocardial blood flow is decreased, especially to the subendocardial regions, because of the low diastolic aortic pressure. The imbalance of myocardial oxygen supply and demand may result in myocardial ischemia and its complications: angina, myocardial infarction and fibrosis, ventricular arrhythmias, syncope and sudden death.

Diagnosis

The diagnosis of aortic regurgitation is made with the stethoscope and is based on the finding of a "decrescendo" blowing diastolic murmur, which is best heard along the left sternal border.

Doppler echocardiography would show a regurgitant aortic jet in a small percentage of the general population. The leak is so small in volume that a murmur is not heard. It is presumed that this degree of aortic regurgitation is normal and does not represent disease. If no murmur or

The Author

MELVIN D. CHEITLIN, M.D., is emeritus professor of medicine at the University of California, San Francisco, School of Medicine. Dr. Cheitlin received his medical degree from Temple University School of Medicine, Philadelphia, and completed an internal medicine residency and a cardiovascular fellowship at Walter Reed Army Medical Center, Washington, D.C. Previously, Dr. Cheitlin was chief of the cardiology section at San Francisco General Hospital.

Address correspondence to Melvin D. Cheitlin, M.D., San Francisco General Hospital, Room 5G1, Cardiology Services, 1001 Potrero Ave., San Francisco, CA 94110 (e-mail: mellac@earthlink.com). Reprints are not available from the author.

peripheral signs of aortic regurgitation are present, a diagnosis of aortic regurgitation should not be made, and no follow-up echocardiography is needed.

If the aortic regurgitation is mild, the murmur may be quite high-pitched and may fade out during diastole. If the aortic regurgitation is moderate to severe and chronic, the murmur, although still blowing, is of lower frequency and louder, and usually lasts throughout diastole. Because of the large left ventricular stroke volume, a systolic ejection murmur may also be heard. This murmur can be loud and long enough to sound like aortic stenosis.

When both diastolic and systolic murmurs are heard, the decision as to which lesion (aortic stenosis or regurgitation) is significant is based on the presence of peripheral signs. If the patient has peripheral signs of aortic regurgitation, no matter how loud the systolic murmur or how soft the diastolic murmur, significant aortic regurgitation should be presumed.

The presence and severity of aortic regurgitation can usually be determined based on the physical examination alone. However, Doppler echocardiography should be performed to confirm the presence of the regurgitation, quantify its severity and look for other cardiac problems (e.g., valvular vegetations, ventricular septal defect or aortic root aneurysm) that may be important in guiding therapy.

Consideration of Aortic Valve Replacement

The presence of aortic regurgitation, even when it is moderately severe, is not necessarily an indication for surgery. When surgery is needed, aortic valve replacement, rather than repair, is usually required. Prosthetic valves, whether mechanical or biologic, have problems with durability, paraprosthetic leaks, thromboembolism and increased susceptibility to infective endocarditis. The decision to replace the valve requires that these potential problems be considered to represent less danger to the patient's well-being than continuing medical management.

NATURAL HISTORY OF AORTIC REGURGITATION

The natural history of chronic aortic regurgitation is well recognized. The asymptomatic patient who has moderate to severe aortic regurgitation may not have symptoms for many years. In seven studies,[1-7] 490 asymptomatic patients with moderate to severe aortic regurgitation were followed for a mean of 6.4 years. Based on these studies, the following can be concluded about asymptomatic chronic aortic regurgitation with normal left ventricular systolic function (i.e., an ejection fraction of 50 percent or greater)[8]:

The diagnosis of aortic regurgitation can be made using a stethoscope. Its severity determines the presence or absence of peripheral signs.

1. The rate of progression to symptoms and/or left ventricular dysfunction is less than 6 percent per year.
2. The rate of progression to asymptomatic left ventricular dysfunction is less than 3.5 percent per year.
3. The rate of sudden death is less than 0.2 percent per year.

In patients with asymptomatic chronic aortic regurgitation and left ventricular dysfunction, the rate of progression to symptoms is higher than 25 percent per year. In symptomatic patients, the mortality rate is greater than 10 percent per year.[8]

Although there is only a small chance of sudden death or left ventricular dysfunction in patients with asymptomatic chronic aortic regurgitation, these adverse events are possible. Therefore, it is important to follow asymptomatic patients for the development of symptoms and to examine them regularly to detect progression of severity. In addition, periodic quantitative evaluation of left ventricular function is necessary in patients with moderate to severe aortic regurgitation. When the history of exercise tolerance or symptoms is equivocal, exercise stress testing can be helpful.

MEDICAL TREATMENT OF AORTIC REGURGITATION

The use of afterload-reducing agents such as nifedipine (Procardia), an angiotensin-converting enzyme inhibitor or hydralazine (Apresoline) in asymptomatic patients with moderate to severe aortic regurgitation has been shown to decrease the progression of cardiac enlargement and even postpone the timing of valve replacement.[6,9,10] Afterload-reducing agents, however, are not indicated when aortic valve replacement is really needed.

PREOPERATIVE RISK ASSESSMENT

Many investigators have studied factors that predict survival and recovery of left ventricular function after aortic valve replacement. In several studies,[11,12] the development of New York Heart Association (NYHA) class III and IV symptoms, especially with an ejection fraction of less than 50 percent, was most predictive of increased mortality and

TABLE 2

ACC/AHA Class I Indications for Aortic Valve Replacement in Patients with Severe Chronic Aortic Regurgitation*

NYHA class III or IV symptoms (see Table 4), regardless of left ventricular function
NYHA class II symptoms with normal left ventricular function (ejection fraction of 50 percent or greater) and evidence of progressive left ventricular dilatation or decreasing ejection fraction at rest on serial studies, or evidence of decreasing exercise tolerance on exercise stress testing
Canadian Heart Association class II or higher angina with or without coronary disease[17]
Mild to moderate left ventricular dysfunction (ejection fraction of 25 to 49 percent)
Moderate to severe aortic regurgitation and undergoing coronary artery bypass grafting or other valvular surgery

ACC/AHA = American College of Cardiology and American Heart Association; NYHA = New York Heart Association.

**—In the ACC/AHA guidelines, class I conditions are those for which there is evidence and/or general agreement that a given procedure is useful and effective.*

Information from Bonow RO, Carabello B, de Leon AC Jr, Edmunds LH Jr, Fedderly BJ, Freed MD, et al. Guidelines for the management of patients with valvular heart disease: executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Patients with Valvular Heart Disease). Circulation 1998;98:1949-84.

decreased left ventricular myocardial function after aortic valve replacement. The duration of symptoms can also be important: the longer the patient has symptoms and the longer left ventricular dysfunction has been present before surgery, the worse the outcome.[11,13]

Doppler two-dimensional echocardiography is most often used to evaluate left ventricular function, but radioisotope angiography has also been employed to measure left ventricular volume and the ejection fraction. The measurements usually made by M-mode echocardiography are end-diastolic diameter, end-systolic diameter and fractional shortening. With two-dimensional echocardiography and radioisotope angiography, ejection fraction is most helpful in following the status of left ventricular function. Cutoff points have been 55 mm for end-systolic diameter, 25 percent for fractional shortening and 50 percent for ejection fraction.[1,3,11,14,15]

In asymptomatic patients with moderate to severe aortic regurgitation and normal systolic function, periodic quantitative evaluation of left ventricular function in the absence of a change in clinical status is recommended to look for the development of left ventricular dysfunction. No evidence supports a specific time between evaluations, but the current recommendation is every six months.[8]

Because of its effects on left ventricular end-systolic vol-

TABLE 3

ACC/AHA Class II Indications for Aortic Valve Replacement in Patients with Chronic Aortic Regurgitation*

Most authorities agree that aortic valve replacement is indicated for these conditions (ACC/AHA class IIA):
NYHA class II symptoms (see Table 4) and preserved left ventricular function with stable left ventricular size and systolic function on serial studies with stable exercise tolerance
No symptoms and normal left ventricular systolic function but severe dilatation of the left ventricle (end-diastolic diameter of greater than 75 mm or end-systolic diameter of greater than 55 mm)
Aortic valve replacement is indicated, but with less agreement, for these conditions (ACC/AHA class IIB):
Severe left ventricular dysfunction (ejection fraction of less than 25 percent)
No symptoms with normal systolic function at rest and progressive moderate degrees of left ventricular dilatation (end-diastolic diameter of 70 to 75 mm, end-systolic diameter of 50 to 55 mm)

ACC/AHA = American College of Cardiology and American Heart Association; NYHA = New York Heart Association.

**—In the ACC/AHA guidelines, class II conditions are those for which there is conflicting evidence or a divergence of opinion about the usefulness or efficacy of a procedure or treatment. For class IIA conditions, the weight of evidence or opinion is in favor of usefulness and efficacy; for class IIB conditions, the usefulness or efficacy is less well established by evidence or opinion.*

Information from Bonow RO, Carabello B, de Leon AC Jr, Edmunds LH Jr, Fedderly BJ, Freed MD, et al. Guidelines for the management of patients with valvular heart disease: executive summary. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee on Management of Patients with Valvular Heart Disease). Circulation 1998;98:1949-84.

TABLE 4
New York Heart Association Functional Classification

Class I	No symptoms or minimal symptoms with ordinary physical activity
Class II	Symptoms with ordinary activity; slight limitation of activity
Class III	Symptoms with less than ordinary activity; marked limitation of activity
Class IV	Symptoms with any physical activity, or even at rest

Adapted with permission from Criteria Committee of the New York Heart Association. Diseases of the heart and blood vessels, nomenclature and criteria for diagnosis. 6th ed. Boston: Little, Brown, 1964.

ume, end-diastolic volume and ejection fraction, exercise stress testing has been advocated for use in finding incipient decreases in myocardial function.[7,16] Normally, the ejection fraction increases with exercise. In patients who are at the end of cardiac reserve, the end-systolic ventricular volume increases and the ejection fraction decreases with exercise. It is not clear that an exercise ejection fraction is a better method than following the resting ejection fraction, exercise tolerance and symptoms in making a decision about proceeding to surgery.

Cardiac catheterization should be performed when noninvasive tests are inconclusive regarding the severity of aortic regurgitation or the status of left ventricular function, or when the findings of these tests are at odds with the clinical findings. Cardiac catheterization and coronary arteriography are also performed when it is necessary to evaluate patients at risk for coronary artery disease prior to surgery.

Valve replacement is not indicated in an asymptomatic patient with normal left ventricular function at rest and mild left ventricular dilatation.

The American College of Cardiology and American Heart Association (ACC/AHA) Task Force on Practice Guidelines of the Committee on Management of Patients with Valvular Heart Disease reviewed the literature extensively.[8] The report of this task force is a valuable resource for physicians to use in evaluating and managing patients with valvular disease. Current recommendations for aortic valve replacement are listed in *Tables 2*[8,17] *and 3*.[8] The New York Heart Association (NYHA) classification of functional capacity is given in *Table 4*.[18]

Surgery is not indicated in an asymptomatic patient with normal left ventricular systolic function at rest and mild left ventricular dilatation (end-diastolic diameter of less than 70 mm; end-systolic diameter of less than 50 mm). The medical management of patients with chronic aortic regurgitation is summarized in *Table 5*.

TABLE 5
Medical Management of the Patient with Chronic Aortic Regurgitation

- Follow the patient with a careful history for exercise capacity and symptoms, and perform physical examinations at regular intervals.
- If the patient has physical signs of moderate to severe aortic regurgitation, perform Doppler echocardiography.
- If the patient has moderate to severe aortic regurgitation and echocardiographic evidence of increased size of the left ventricle, start vasodilator therapy using nifedipine (Procardia), an angiotensin-converting enzyme inhibitor or hydralazine (Apresoline).
- If the patient's exercise capacity cannot be evaluated accurately based on the history, perform exercise stress (treadmill) testing.
- If the patient develops symptoms of decreasing exercise tolerance, angina, syncope or heart failure, repeat Doppler echocardiography and consider aortic valve replacement (see Tables 2 and 3).
- If the patient remains asymptomatic with physical signs of moderate to severe aortic regurgitation, consider yearly Doppler echocardiography to follow the left ventricular end-diastolic and end-systolic size and the ejection fraction.
- If the patient is asymptomatic and has a progressive decline in left ventricular end-diastolic and end-systolic size and a fall in the ejection fraction, consider aortic valve replacement (see Tables 2 and 3).

When aortic valve surgery with low or no operative mortality and no late complications becomes possible, valve replacement may be recommended as soon as the heart starts dilating and developing hypertrophy. However, surgery still has perioperative mortality and late morbidity. The use of surgery in an asymptomatic patient with chronic aortic regurgitation must be justified by good evidence of long-term benefit.

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