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ACC/AHA Pocket Guideline

Based on the ACC/AHA 2006 Guideline Revision

Management of Patients With Valvular Heart Disease

June 2006

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Management of Patients With Valvular Heart Disease

June 2006

Writing Committee

Robert O. Bonow, MD, FACC, FAHA, Chair
Blase A. Carabello, MD, FACC, FAHA
Kanu Chatterjee, MD, FACC
Antonio C. de Leon, Jr., MD, FACC, FAHA
David P. Faxon, MD, FACC, FAHA
Michael D. Freed, MD, FACC, FAHA
William H. Gaasch, MD, FACC, FAHA
Bruce Whitney Lytle, MD, FACC
Rick A. Nishimura, MD, FACC, FAHA
Patrick T. O'Gara, MD, FACC, FAHA
Robert A. O'Rourke, MD, MACC, FAHA
Catherine M. Otto, MD, FACC, FAHA
Pravin M. Shah, MD, MACC, FAHA
Jack S. Shanewise, MD

The following material was adapted from the *ACC/AHA 2006 Guidelines for the Management of Patients With Valvular Heart Disease* (published in the August 1, 2006, issues of *Journal of the American College of Cardiology* and *Circulation).* For a copy of the full report or published executive summary, visit our Web sites at *http://www.acc.org* or *http://www.americanheart.org* or call the ACC Resource Center at 1-800-253-4636, ext. 694.

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I. Introduction

Valvular heart disease is one of several cardiac disorders that affect a large number of people who require diagnostic procedures and long-term management. The *Pocket Guideline for Management of Patients With Valvular Heart Disease* provides rapid prompts for 3 specific aspects of the management of patients with valvular heart disease. The pocket guide is derived from the full text of the *ACC/AHA 2006 Guidelines for the Management of Patients With Valvular Heart Disease*. These guidelines were first published in 1998 and then revised in 2006. The full-text guidelines provide a more detailed explanation of the management of valvular heart disease, along with appropriate caveats and levels of evidence. The executive summary of the guidelines was published in the *Journal of American College of Cardiology* and *Circulation*. Both the full guidelines and the executive summary are available online, at *http://www.acc.org* or *http://www.americanheart.org*. Users of this pocket guide should consult those documents for additional information.

Scope of the Pocket Guide

The *Guidelines for the Management of Patients With Valvular Heart Disease* cannot be reproduced in their entirety in a pocket guide format. For this reason, the pocket guide focuses on the 3 aspects of management in the conditions that are most frequently encountered in the practice of adult cardiology:

- Indications for echocardiography
- Indications for valvular surgery or percutaneous intervention
- Antithrombotic management of prosthetic heart valves

Classification of Recommendations

A classification of recommendation and a level of evidence have been assigned to each recommendation. Classifications of recommendations and levels of evidence are expressed in the American College of Cardiology/American Heart Association (ACC/AHA) format as follows and described in more detail in *Figure 1*:

Class I	Conditions for which there is evidence for and/or general agreement that the procedure or treatment is beneficial, useful, and effective.
Class II	Conditions for which there is conflicting evidence and/or a divergence of opinion about the usefulness/efficacy of a procedure or treatment.

Class IIa Weight of evidence/opinion is in favor of usefulness/efficacy.

Class IIb Usefulness/efficacy is less well established by evidence/opinion.

Class III Conditions for which there is evidence and/or general agreement that the procedure/treatment is not useful/effective and in some cases may be harmful.

Level of Evidence In addition, the weight of evidence in support of the recommendation is listed as follows:

Level of Evidence A Data derived from multiple randomized clinical trials.

Level of Evidence B Data derived from a single randomized trial or nonrandomized studies.

Level of Evidence C Only consensus opinion of experts, case studies, or standard-of-care.

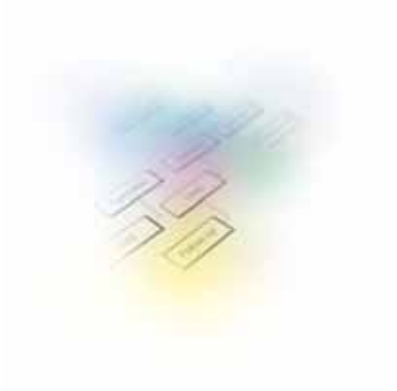


Figure 1. Applying Classification of Recommendations and Level of Evidence in ACC/AHA Format

ESTIMATE OF CERTAINTY (PRECISION) OF TREATMENT EFFECT	SIZE OF TREATMENT EFFECT	
	CLASS I ***Benefit >>> Risk*** **Procedure/Treatment SHOULD be performed/ administered**	**CLASS IIA** ***Benefit >> Risk*** ***Additional studies with focused objectives needed*** **IT IS REASONABLE to perform procedure/administer treatment**
LEVEL A **Multiple (3-5) population risk strata evaluated*** **General consistency of direction and magnitude of effect**	■ Recommendation that procedure or treatment is useful/effective ■ Sufficient evidence from multiple randomized trials or meta-analyses	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from multiple randomized trials or meta-analyses
LEVEL B **Limited (2-3) population risk strata evaluated***	■ Recommendation that procedure or treatment is useful/effective ■ Limited evidence from single randomized trial or nonrandomized studies	■ Recommendation in favor of treatment or procedure being useful/effective ■ Some conflicting evidence from single randomized trial or nonrandomized studies
LEVEL C **Very limited (1-2) population risk strata evaluated***	■ Recommendation that procedure or treatment is useful/effective ■ Only expert opinion, case studies, or standard-of-care	■ Recommendation in favor of treatment or procedure being useful/effective ■ Only diverging expert opinion, case studies, or standard-of-care
Suggested phrases for writing recommendations†	should is recommended is indicated is useful/effective/beneficial	is reasonable can be useful/effective/beneficial is probably recommended or indicated

Class IIb	Class III
Benefit ≥ Risk *Additional studies with broad objectives needed; additional registry data would be helpful* **Procedure/Treatment MAY BE CONSIDERED**	*Risk ≥ Benefit* *No additional studies needed* **Procedure/Treatment should NOT be performed/administered SINCE IT IS NOT HELPFUL AND MAY BE HARMFUL**
■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from multiple randomized trials or meta-analyses	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Sufficient evidence from multiple randomized trials or meta-analyses
■ Recommendation's usefulness/efficacy less well established ■ Greater conflicting evidence from single randomized trial or nonrandomized studies	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Limited evidence from single randomized trial or nonrandomized studies
■ Recommendation's usefulness/efficacy less well established ■ Only diverging expert opinion, case studies, or standard-of-care	■ Recommendation that procedure or treatment is not useful/effective and may be harmful ■ Only expert opinion, case studies, or standard-of-care
may/might be considered may/might be reasonable usefulness/effectiveness is unknown/unclear/uncertain or not well established	is not recommended is not indicated should not is not useful/effective/beneficial may be harmful

* Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as gender, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use. A recommendation with Level of Evidence B or C does not imply that the recommendation is weak. Many important clinical questions addressed in the guidelines do not lend themselves to clinical trials. Even though randomized trials are not available, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

† In 2003 the ACC/AHA Task Force on Practice Guidelines recently provided a list of suggested phrases to use when writing recommendations. All recommendations in this guideline have been written in full sentences that express a complete thought, such that a recommendation, even if separated and presented apart from the rest of the document (including headings above sets of recommendations), would still convey the full intent of the recommendation. It is hoped that this will increase readers' comprehension of the guidelines and will allow queries at the individual recommendation level.

The following abbreviations are used throughout this pocket guide:

AR	aortic regurgitation
AS	aortic stenosis
AVR	aortic valve replacement
BAV	bicuspid aortic valve
CABG	coronary artery bypass grafting
ECG	electrocardiogram
EF	ejection fraction
IE	infective endocarditis
INR	international normalized ratio
LMWH	low-molecular-weight heparin
LV	left ventricular
MR	mitral regurgitation
MRI	magnetic resonance imaging
MS	mitral stenosis
MV	mitral valve
MVP	mitral valve prolapse
NYHA	New York Heart Association
PMBV	percutaneous mitral balloon valvotomy
RV	right ventricular
TEE	transesophageal echocardiography
TTE	transthoracic echocardiography
TR	tricuspid regurgitation
UFH	unfractionated heparin
2-D	2-dimensional

II. Indications for 2-D and Doppler Echocardiography

A. Severity of Valve Disease

The severity of valve disease can be determined on the basis of a detailed, comprehensive 2-dimensional (2-D) and Doppler echocardiogram. The committee recommends that quantitative Doppler criteria be used to grade the severity of the valve lesion *(Table 1)*. In certain situations, cardiac catheterization is required for further clarification of severity of the valve lesion.

B. Aortic Stenosis

The 2-D echocardiogram is valuable for confirming the presence of aortic stenosis (AS) and determining left ventricular (LV) size and function, the degree of hypertrophy, and the presence of other associated valve disease. In most patients, the severity of the stenotic lesion can be defined with Doppler echocardiographic measurements of a Doppler peak velocity, a mean transvalvular pressure gradient, and derived valve area.

Recommendations for Echocardiography in Aortic Stenosis

Class I	1. Echocardiography is recommended for the following: A. Diagnosis and assessment of AS severity. *(Level of Evidence: B)* B. Assessment of LV wall thickness, size, and function. *(Level of Evidence: B)*

continued on page 12

Table 1. Classification of the Severity of Valve Disease in Adults

A. Left-sided valve disease

Aortic Stenosis

Indicator	Mild	Moderate	Severe
Jet velocity (m/s)	Less than 3.0	3.0-4.0	Greater than 4.0
Mean gradient (mm Hg)*	Less than 25	25-40	Greater than 40
Valve area (cm^2)	Greater than 1.5	1.0-1.5	Less than 1.0
Valve area index (cm^2/m^2)			Less than 0.6

Mitral Stenosis

	Mild	Moderate	Severe
Mean gradient (mm Hg)*	Less than 5	5-10	Greater than 10
Pulmonary artery systolic pressure (mm Hg)	Less than 30	30-50	Greater than 50
Valve area (cm^2)	Greater than 1.5	1.0-1.5	Less than 1.0

Aortic Regurgitation

	Mild	Moderate	Severe
Qualitative			
Angiographic grade	1+	2+	3-4+
Color Doppler jet width	Central jet, width less than 25% of LVOT	Greater than mild but no signs of severe AR	Central jet, width greater than 65% LVOT
Doppler vena contracta width (cm)	Less than 0.3	0.3-0.6	Greater than 0.6
Quantitative (cath or echo)			
Regurgitant volume (ml/beat)	Less than 30	30-59	Greater than or equal to 60
Regurgitant fraction (%)	Less than 30	30-49	Greater than or equal to 50
Regurgitant orifice area (cm^2)	Less than 0.10	0.10-0.29	Greater than or equal to 0.30
Additional Essential Criteria			
Left ventricular size			Increased

Mitral Regurgitation

	Mild	Moderate	Severe
Qualitative			
Angiographic grade	1+	2+	3-4+
Color Doppler jet area	Small, central jet (less than 4 cm^2 or less than 20% LA area)	Signs of MR greater than mild present, but no criteria for severe MR	Vena contracta width greater than 0.7 cm with large central MR jet (area greater than 40% of LA area) or with a wall-impinging jet of any size, swirling in LA
Doppler vena contracta width (cm)	Less than 0.3	0.3 – 0.69	Greater than or equal to 0.70
Quantitative (cath or echo)			
Regurgitant volume (ml/beat)	Less than 30	30-59	Greater than or equal to 60
Regurgitant fraction (%)	Less than 30	30-49	Greater than or equal to 50
Regurgitant orifice area (cm^2)	Less than 0.20	0.2-0.39	Greater than or equal to 0.40
Additional Essential Criteria			
Left atrial size			Enlarged
Left ventricular size			Enlarged

B. Right-sided valve disease

	Characteristic
Severe tricuspid stenosis:	Valve area less than 1.0 cm^2
Severe tricuspid regurgitation:	Vena contracta width greater than 0.7 cm and Systolic flow reversal in hepatic veins
Severe pulmonic stenosis:	Jet velocity greater than 4 m/s or maximum gradient greater than 60 mm Hg
Severe pulmonic regurgitation:	Color jet fills outflow tract Dense continuous wave Doppler signal with a steep deceleration slope

*Valve gradients are flow dependent and when used as estimates of severity of valve stenosis should be assessed with knowledge of cardiac output or forward flow across the valve. Modified from the Journal of the American Society of Echocardiography, 16, Zoghbi WA, Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler echocardiography, 777–802, Copyright 2003, with permission from American Society of Echocardiography.

AR = aortic regurgitation; **cath** = catheterization; **echo** = echocardiography; **LA** = left atrial/atrium; **LVOT** = left ventricular outflow tract; **MR** = mitral regurgitation.

C. Re-evaluation of patients with known AS and changing symptoms or signs. *(Level of Evidence: B)*

D. Assessment of changes in hemodynamic severity and LV function in patients with known AS during pregnancy. *(Level of Evidence: B)*

2. Transthoracic echocardiography (TTE) is recommended for re-evaluation of asymptomatic patients every year for severe AS; every 1 to 2 years for moderate AS; every 3 to 5 years for mild AS. *(Level of Evidence: B)*

Class IIa

1. Dobutamine stress echocardiography is reasonable to evaluate patients with low-flow/low-gradient AS and LV dysfunction. *(Level of Evidence: B)*

In selected patients with low-flow/low-gradient AS and LV dysfunction, it may be useful to determine the transvalvular pressure gradient and to calculate valve area during a baseline state and again during exercise or low-dose pharmacological (i.e., dobutamine infusion) stress, with the goal of determining whether stenosis is severe or only moderate in severity. Such studies can be performed in experienced echocardiographic or cardiac catheterization laboratories.

C. Aortic Regurgitation

Echocardiography is indicated to confirm the diagnosis of aortic regurgitation (AR) when it is equivocal on the basis of physical examination; to assess the cause of AR and valve morphology;

to provide a semiquantitative estimate of the severity of regurgitation; to assess the ventricular response to volume overload, which includes LV dimension, mass, and systolic function; and to assess aortic root size.

Recommendations for Echocardiography in Aortic Regurgitation

Class I

1. Echocardiography is indicated for the following:

A. Diagnosis and assessment of severity of acute or chronic AR. *(Level of Evidence: B)*

B. Assessment of the cause of chronic AR (including valve morphology and aortic root size and morphology) and assessment of LV hypertrophy, dimension (or volume), and systolic function. *(Level of Evidence: B)*

C. Assessment of AR and severity of aortic dilatation in patients with enlarged aortic roots. *(Level of Evidence: B)*

D. Re-evaluation of LV size and function in asymptomatic patients with severe AR. *(Level of Evidence: B)*

E. Re-evaluation of mild, moderate, or severe AR in patients with new or changing symptoms. *(Level of Evidence: B)*

Radionuclide angiography and magnetic resonance imaging (MRI) can also be used to assess the ventricular response to the volume overload, and they are useful in patients with unsatisfactory echocardiograms. MRI and cardiac computed tomography may be useful to further evaluate the size of the aorta. Exercise testing is reasonable for assessment of functional capacity and symptomatic response in patients with a history of equivocal symptoms.

Once the chronicity and stability of the process have been established, the frequency of clinical re-evaluation and repeat noninvasive testing depends on the severity of AR, degree of LV dilatation, level of systolic function, and whether previous serial studies have revealed progressive changes in LV size or function. Repeat echocardiograms are also recommended at the onset of symptoms, when there is an equivocal history of changing symptoms or exercise tolerance, or when there are clinical findings that suggest worsening AR or progressive LV dilatation.

D. Bicuspid Aortic Valve With Dilated Ascending Aorta

There is growing awareness that many patients with bicuspid aortic valves (BAV) have disorders of vascular connective tissue, which may result in dilatation of the aortic root or ascending aorta even in the absence of hemodynamically significant AS or AR. Aortic root or ascending aortic dilatation can progress with time, and there is a risk of aortic dissection that is related to the severity and rate of dilatation. Echocardiography remains the primary imaging technique for identifying and following

these patients. More accurate quantification of the diameter of the aortic root and ascending aorta, as well as full assessment of the degree of enlargement, can be obtained with cardiac MRI or computed tomography.

Recommendations for Echocardiography (or Other Imaging Modalities) in Patients With Bicuspid Aortic Valve and Dilated Ascending Aorta

Class I

1. Patients with known BAV should undergo an initial transthoracic echocardiogram to assess diameter of the aortic root and ascending aorta. *(Level of Evidence: B)*

2. Cardiac MRI or cardiac computed tomography is indicated in patients with BAV when morphology of the aortic root or ascending aorta cannot be assessed accurately by echocardiography. *(Level of Evidence: C)*

3. Patients with BAV and dilatation of the aortic root or ascending aorta (diameter greater than 4.0 cm*) should undergo serial evaluation of aortic root/ascending aorta size and morphology by echocardiography, cardiac magnetic resonance, or computed tomography on a yearly basis. *(Level of Evidence: C)*

**Consider lower threshold values for patients of small stature of either gender.*

E. Mitral Stenosis

Two-dimensional echocardiography should be used in patients with mitral stenosis (MS) to assess the morphology of the mitral valve (MV), including leaflet mobility, leaflet thickness, leaflet calcification, and subvalvular and commissural fusion. These features are important in considering the timing and type of intervention. Doppler echocardiography assesses the hemodynamic severity of MS, estimates pulmonary artery systolic pressure from the tricuspid regurgitation (TR) velocity signal, and assesses severity of concomitant mitral regurgitation (MR) or AR. Formal hemodynamic exercise testing can be done using either a supine bicycle or an upright treadmill with Doppler recordings of transmitral and tricuspid velocities.

Recommendations for Echocardiography in Mitral Stenosis

Class I

1. Echocardiography is indicated for the following:

A. Diagnosis of MS, assessment of severity, assessment of concomitant valvular lesions, and assessment of valve morphology (to determine suitability for percutaneous mitral balloon valvotomy [PMBV]). *(Level of Evidence: B)*

B. Re-evaluation in patients with known MS and changing symptoms or signs. *(Level of Evidence: B)*

C. Assessment of the hemodynamic response by exercise Doppler echocardiography when there is a discrepancy between resting Doppler echocardiographic findings, clinical findings, symptoms, and signs. *(Level of Evidence: C)*

2. Transesophageal echocardiography (TEE) is indicated for the following:

A. Assessment of presence or absence of left atrial thrombus and assessment of severity of MR in patients considered for PMBV. *(Level of Evidence: C)*

B. Assessment of MV morphology and hemodynamics in patients when TTE provides suboptimal data. *(Level of Evidence: C)*

Class IIa

1. Echocardiography is reasonable in the re-evaluation of asymptomatic patients with MS and stable clinical findings to assess pulmonary artery pressure (for those with severe MS, every year; moderate MS, every 1 to 2 years; and mild MS, every 3 to 5 years). *(Level of Evidence: C)*

Class III

1. TEE is not indicated in patients with MS for routine evaluation of MV morphology and hemodynamics when complete TTE data are satisfactory. *(Level of Evidence: C)*

F. Mitral Valve Prolapse

Two-dimensional and Doppler echocardiography constitutes the most useful noninvasive test for defining MV prolapse (MVP). On 2-D echocardiography, systolic displacement of 1 or both mitral leaflets in the parasternal long-axis view,

particularly when they coapt on the atrial side of the annular plane, indicates a high likelihood of MVP. The diagnosis of MVP is even more certain when leaflet thickness is greater than 5 mm. The echocardiographic criteria for MVP should include structural changes such as leaflet thickening, redundancy, annular dilatation, and chordal elongation.

Recommendations for Echocardiography in Asymptomatic Mitral Valve Prolapse

Class I	1. Echocardiography is indicated for the diagnosis of MVP and assessment of MR, leaflet morphology, and ventricular compensation in asymptomatic patients with physical signs of MVP. *(Level of Evidence: B)*
Class IIa	1. Echocardiography can be effective for A. Excluding MVP in asymptomatic patients who have been diagnosed without clinical evidence to support the diagnosis. *(Level of Evidence: C)* B. Risk stratification in asymptomatic patients with physical signs of MVP or known MVP. *(Level of Evidence: C)*
Class III	1. Echocardiography is not indicated to exclude MVP in asymptomatic patients with ill-defined symptoms in the absence of a constellation of clinical symptoms or physical findings suggestive of MVP or a positive family history. *(Level of Evidence: B)*

2. Routine repetition of echocardiography is not indicated for the asymptomatic patient who has MVP and no MR or MVP and mild MR with no changes in clinical signs or symptoms. *(Level of Evidence: C)*

G. Mitral Regurgitation

Two-dimensional and Doppler echocardiography is indispensable in the management of patients with MR and should be used to assess the severity of MR, the LV response to volume overload (including LV size and systolic function ejection fraction [EF] and end-systolic dimension), left atrial size and pulmonary artery systolic pressure. Echocardiography may also identify the anatomic cause of MR, which is important for determining the feasibility of successful MV repair.

Recommendations for Echocardiography in Mitral Regurgitation

Class I

1. TTE is indicated for the following:

A. Baseline evaluation of LV size and function, right ventricular (RV) and left atrial size, pulmonary artery pressure, and severity of MR *(Table 1)* in any patient suspected of having MR. *(Level of Evidence: C)*

B. Delineation of the mechanism of MR. *(Level of Evidence: B)*

C. Annual or semiannual surveillance of LV function (estimated by EF and end-systolic dimension) in asymptomatic patients with moderate to severe MR. *(Level of Evidence: C)*

D. Assessment of the MV apparatus and LV function after a change in signs or symptoms. *(Level of Evidence: C)*

E. Assessment of LV size and function and MV hemodynamics in the initial evaluation after MV replacement or MV repair. *(Level of Evidence: C)*

Class IIa

1. Exercise Doppler echocardiography is reasonable in asymptomatic patients with severe MR to assess exercise tolerance and the effects of exercise on pulmonary artery pressure and MR severity. *(Level of Evidence: C)*

Class III

1. TTE is not indicated for routine follow-up evaluation of asymptomatic patients with mild MR and normal LV size and systolic function. *(Level of Evidence: C)*

Recommendations for Transesophageal Echocardiography in Mitral Regurgitation

Class I

1. Preoperative or intraoperative TEE is indicated to establish the anatomic basis for severe MR to assess feasibility of repair and to guide repair

	in patients in whom surgery is recommended. *(Level of Evidence: B)* 2. TEE is indicated for evaluation of MR when TTE provides nondiagnostic information regarding severity of MR, mechanism of MR, and/or status of LV function. *(Level of Evidence: B)*
Class IIa	1. Preoperative TEE is reasonable in asymptomatic patients with severe MR who are considered for surgery to assess feasibility of repair. *(Level of Evidence: C)*
Class III	1. TEE is not indicated for routine follow-up or surveillance of asymptomatic patients with native valve MR. *(Level of Evidence: C)*

Asymptomatic patients with mild MR and no evidence of LV enlargement or dysfunction or pulmonary hypertension can be monitored clinically on a yearly basis, but yearly echocardiograms are not necessary unless there is clinical evidence that regurgitation has worsened. In patients with moderate MR, clinical evaluations and echocardiograms should be performed yearly. Patients with severe MR should be monitored with clinical evaluation and echocardiography every 6 to 12 months to assess symptoms or transition to asymptomatic LV dysfunction.

III. Indications for Valve Surgery or Percutaneous Intervention

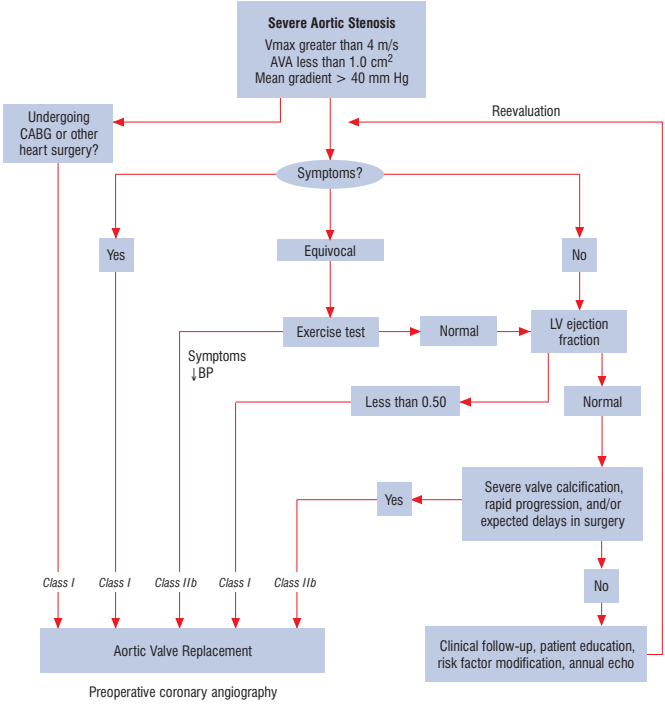
A. Aortic Stenosis

Aortic valve replacement (AVR) is clearly indicated in symptomatic patients with severe AS *(Figure 2)*. Patients with moderate or severe AS, even without symptoms, who undergo another cardiac operation should undergo AVR at the time of surgery. Management decisions are more controversial in asymptomatic patients with severe AS.

Recommendations for Aortic Valve Replacement in Aortic Stenosis

Class I	1. AVR is indicated for the following patients: A. Symptomatic patients with severe AS.† *(Level of Evidence: B)* B. Patients with severe AS† undergoing coronary artery bypass graft surgery (CABG), surgery on the aorta, or replacement or repair of other heart valves. *(Level of Evidence: C)* C. Patients with severe AS† and LV systolic dysfunction (EF less than 0.50). *(Level of Evidence: C)*
Class IIa	1. AVR is reasonable for patients with moderate AS† undergoing CABG or surgery on the aorta or other heart valves. *(Level of Evidence: B)*

Figure 2. Management Strategy for Patients With Severe Aortic Stenosis



Preoperative coronary angiography should be performed routinely, as determined by age, symptoms, and coronary risk factors. Cardiac catheterization and angiography may also be helpful when there is discordance between clinical findings and echocardiography (echo). Modified from Otto CM. Valvular aortic stenosis: disease severity and timing of intervention. J Am Coll Cardiol 2006;47:2141–51.

AVA = aortic valve area; **BP** = blood pressure; **CABG** = coronary artery bypass graft surgery; **LV** = left ventricular; **Vmax** = maximal velocity across aortic valve by Doppler echocardiography.

Class IIb

1. AVR may be considered for the following patients:

A. Asymptomatic patients with severe AS† and abnormal response to exercise (e.g., development of symptoms or asymptomatic hypotension). *(Level of Evidence: C)*

B. Adults with severe asymptomatic AS† if there is a high likelihood of rapid progression (age, calcification, and coronary artery disease) or if surgery might be delayed at the time of symptom onset. *(Level of Evidence: C)*

C. Patients undergoing CABG who have mild AS† when there is evidence, such as moderate to severe valve calcification, that progression may be rapid. *(Level of Evidence: C)*

D. Asymptomatic patients with extremely severe AS (aortic valve area less than 0.6 cm^2, mean gradient greater than 60 mm Hg, and jet velocity greater than 5.0 m per second) when the expected operative mortality is 1.0% or less. *(Level of Evidence: C)*

Class III

1. AVR is not useful for the prevention of sudden death in asymptomatic patients with AS who have none of the findings listed under the Class IIa/IIb recommendations. *(Level of Evidence: B)*

†*Objective definition of valve severity is provided in Table 1.*

B. Aortic Regurgitation

AVR is indicated for patients with chronic severe AR who have cardiac symptoms and for asymptomatic patients with LV systolic dysfunction at rest, marked LV dilatation, or severely dilated aortic roots *(Figure 3)*. Patients with BAV may have dilated aortas; surgery to repair the aortic root or replace the ascending aorta may be indicated depending on the size of the aorta.

Recommendations for Aortic Valve Replacement in Chronic Severe Aortic Regurgitation

Class I

1. AVR is indicated for the following patients:

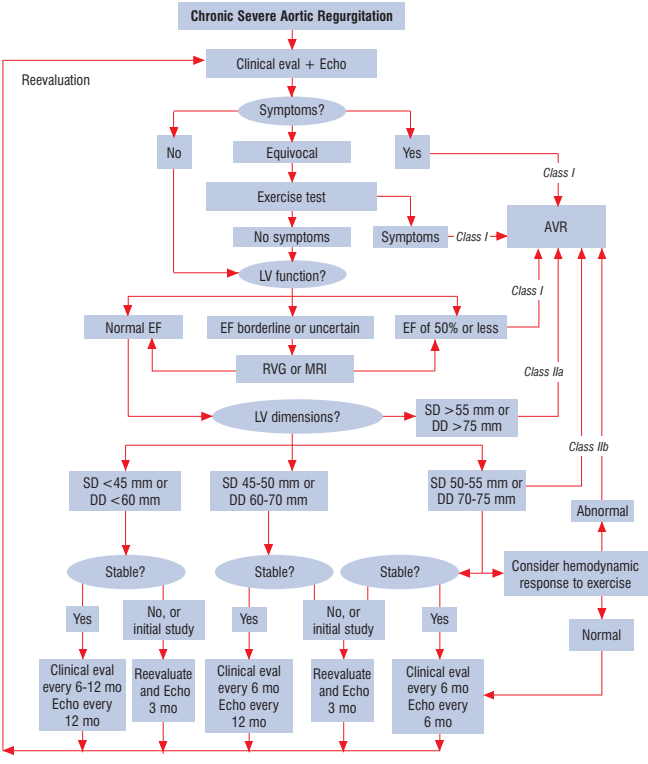
A. Symptomatic patients with severe AR irrespective of LV systolic function. *(Level of Evidence: B)*

B. Asymptomatic patients with chronic severe AR and LV systolic dysfunction (EF 0.50 or less) at rest. *(Level of Evidence: B)*

C. Patients with chronic severe AR while undergoing CABG or surgery on the aorta or other heart valves. *(Level of Evidence: C)*

2. Surgery to repair the aortic root or replace the ascending aorta is indicated in patients with BAV if the diameter of the aortic root or ascending aorta is greater than 5.0 cm* or if the rate of increase in diameter is 0.5 cm per year or more. *(Level of Evidence: C)*

Figure 3. Management Strategy for Patients With Chronic Severe Aortic Regurgitation



Cardiac catheterization and angiography may also be helpful when there is discordance between clinical findings and echocardiography. "Stable" refers to stable echocardiographic measurements. In some centers, serial follow-up may be performed with RVG or MRI rather than echocardiography to assess LV volume and systolic function.

AVR = aortic valve replacement; **DD** = end-diastolic dimension; **Echo** = echocardiography; **EF** = ejection fraction; **eval** = evalutation; **LV** = left ventricular; **MRI** = magnetic resonance imaging; **RVG** = radionuclide ventriculography; **SD** = end-systolic dimension.

3. In patients with BAV undergoing AVR because of severe AS or AR (see Sections 3.1.7. and 3.2.3.8. in the full-text guidelines), repair of the aortic root or replacement of the ascending aorta is indicated if the diameter of the aortic root or ascending aorta is greater than 4.5 cm.* *(Level of Evidence: C)*

Class IIa

1. AVR is reasonable for asymptomatic patients with severe AR with normal LV systolic function (EF greater than 0.50) but with severe LV dilatation (end-diastolic dimension greater than 75 mm or end-systolic dimension greater than 55 mm).* *(Level of Evidence: B)*

Class IIb

1. AVR may be considered in the following patients:

A. Patients with moderate AR while undergoing CABG or surgery on the ascending aorta. *(Level of Evidence: C)*

B. Asymptomatic patients with severe AR and normal LV systolic function at rest (EF greater than 0.50) when the degree of LV dilatation exceeds an end-diastolic dimension of 70 mm or end-systolic dimension of 50 mm, when there is evidence of progressive LV dilatation, declining exercise tolerance, or abnormal hemodynamic responses to exercise.* *(Level of Evidence: C)*

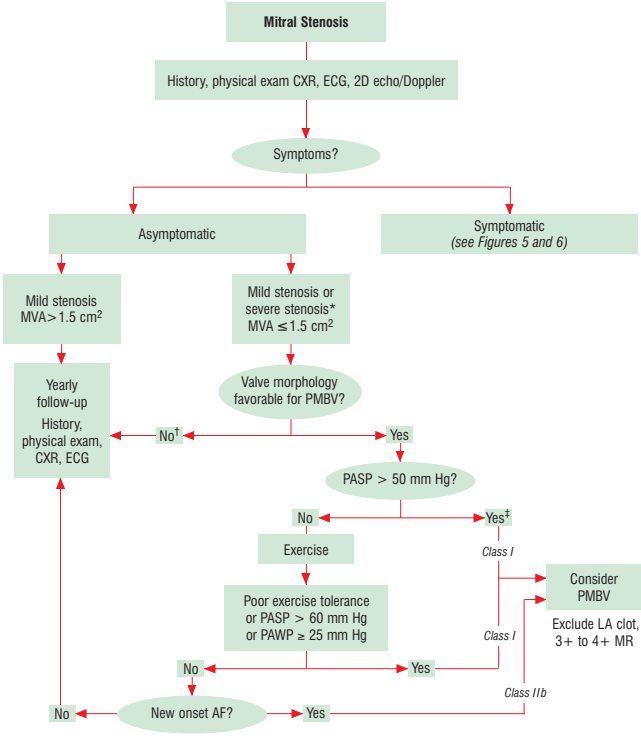
Class III 1. AVR is not indicated for asymptomatic patients with mild, moderate, or severe AR and normal LV systolic function at rest (EF greater than 0.50) when the degree of dilatation is not moderate or severe (end-diastolic dimension less than 70 mm, end-systolic dimension less than 50 mm).*
(Level of Evidence: B)

**Consider lower threshold values for patients of small stature of either gender.*

C. Mitral Stenosis

Indications for intervention in patients with MS depend on symptoms, pulmonary artery pressure, RV function, and the feasibility of performing PMBV *(Figures 4-6)*. If there is a discrepancy between symptoms and hemodynamic data, formal exercise testing with hemodynamics (invasive or noninvasive) may be useful to differentiate symptoms due to MS from those due to other causes. Patients who are symptomatic with a significant elevation of pulmonary artery pressure (greater than 60 mm Hg), mean transmitral gradient (greater than 15 mm Hg), or pulmonary artery wedge pressure (25 mm Hg) with exertion have hemodynamically significant MS independent of the calculated valve area, and further intervention should be considered.

Figure 4. Management Strategy for Patients With Mitral Stenosis



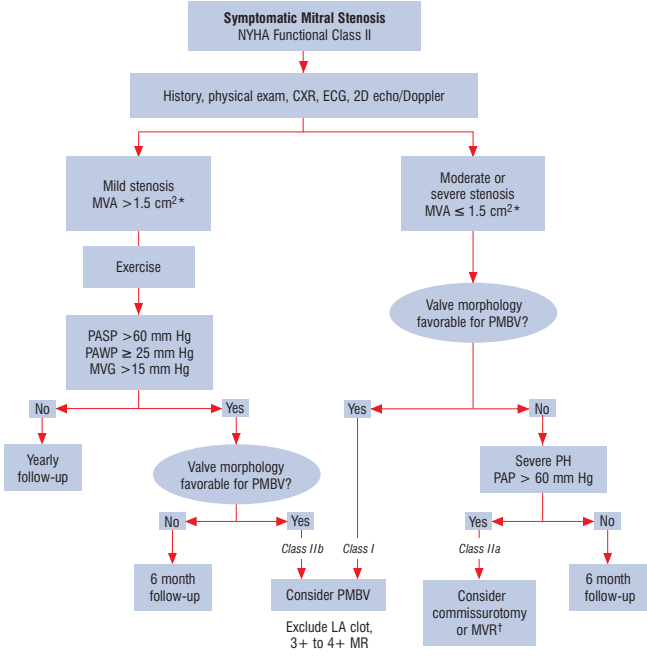
*The writing committee recognizes that there may be variability in the measurement of mitral valve area (MVA) and that the mean transmitral gradients, pulmonary artery wedge pressure (PAWP), and pulmonary artery systolic pressure (PASP) should also be taken into consideration.

† There is controversy as to whether patients with severe mitral stenosis (MVA < 1.0 cm^2) and severe pulmonary hypertension (pulmonary artery pressure > 60 mm Hg) should undergo percutaneous mitral balloon valvotomy (PMBV) or mitral valve replacement to prevent right ventricular failure.

‡ Assuming no other cause for pulmonary hypertension is present.

AF = atrial fibrillation; **CXR** = chest X-ray; **ECG** = electrocardiogram; **echo** = echocardiography; **LA** = left atrial; **MR** = mitral regurgitation; **2D** = 2-dimensional.

Figure 5. Management Strategy for Patients With Mitral Stenosis and Mild Symptoms

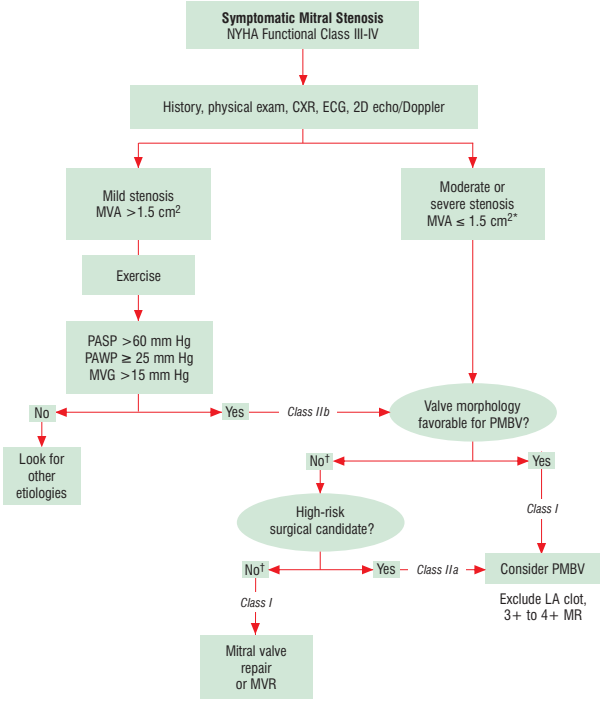


*The writing committee recognizes that there may be variability in the measurement of mitral valve area (MVA) and that the mean transmitral gradients, pulmonary artery wedge pressure (PAWP), and pulmonary artery systolic pressure (PASP) should also be taken into consideration.

† There is controversy as to whether patients with severe mitral stenosis (MVA < 1.0 cm^2) and severe pulmonary hypertension (PH; PASP > 60 mm Hg) should undergo percutaneous mitral balloon valvotomy (PMBV) or mitral valve replacement (MVR) to prevent right ventricular failure.

CXR = chest X-ray; **ECG** = electrocardiogram; **echo** = echocardiography; **LA** = left atrial; **MR** = mitral regurgitation; **MVG** = mean mitral valve pressure gradient; **PAP** = pulmonary artery pressure; **2D** = 2-dimensional.

Figure 6. Management Strategy for Patients with Mitral Stenosis and Moderate to Severe Symptoms



*The writing committee recognizes that there may be variability in the measurement of mitral valve area (MVA) and that the mean transmitral gradients, pulmonary artery wedge pressure (PAWP), and pulmonary artery systolic pressure (PASP) should also be taken into consideration.

† It is controversial as to which patients with less favorable valve morphology should undergo percutaneous mitral balloon valvotomy (PMBV) rather than mitral valve surgery *(see text)*.

CXR = chest X-ray; **ECG** = electrocardiogram; **echo** = echocardiography; **LA** = left atrial; **MR** = mitral regurgitation; **MVG** = mean mitral valve pressure gradient; **MVR** = mitral valve replacement; **NYHA** = New York Heart Association; **2D** = 2-dimensional.

Recommendations for Percutaneous Mitral Balloon Valvotomy for Mitral Stenosis

Class I

1. PMBV is indicated for the following patients with moderate or severe MS† and valve morphology favorable for PMBV in the absence of left atrial thrombus or moderate to severe MR:

A. Symptomatic patients (NYHA functional class II, III, or IV). *(Level of Evidence: A)*

B. Asymptomatic patients who have pulmonary hypertension (pulmonary artery systolic pressure greater than 50 mm Hg at rest or greater than 60 mm Hg with exercise). *(Level of Evidence: C)*

Class IIa

1. PMBV is reasonable for patients with moderate or severe MS† who have a nonpliable calcified valve, are in NYHA functional class III-IV, and are either not candidates for surgery or are at high risk for surgery. *(Level of Evidence: C)*

Class IIb

1. PMBV may be considered for the following patients in the absence of left atrial thrombus or moderate to severe MR:

A. Asymptomatic patients with moderate or severe MS† and valve morphology favorable for PMBV who have new onset of atrial fibrillation. *(Level of Evidence: C)*

B. Symptomatic patients (NYHA functional class II, III, or IV) with MV area greater than 1.5 cm^2 if there is evidence of hemodynamically significant MS based on pulmonary artery systolic pressure greater than 60 mm Hg, pulmonary artery wedge pressure of 25 mm Hg or more, or mean MV gradient greater than 15 mm Hg during exercise. *(Level of Evidence: C)*

C. Patients with moderate or severe MS who have a nonpliable calcified valve and are in NYHA functional class III-IV, as an alternative to surgery. *(Level of Evidence: C)*

Class III

1. PMBV is not indicated for patients with mild MS. *(Level of Evidence: C)*

2. PMBV should not be performed in patients with moderate to severe MR or left atrial thrombus. *(Level of Evidence: C)*

Indications for Surgery for Mitral Stenosis (Valve Repair or Replacement)

Class I

1. MV surgery (repair if possible) is indicated in patients with symptomatic (NYHA functional class III-IV) moderate or severe MS† and with acceptable operative risk when (1) PMBV is unavailable, (2) PMBV is contraindicated because of left atrial thrombus despite anticoagulation or because

concomitant moderate to severe MR is present, or (3) the valve morphology is not favorable for PMBV. *(Level of Evidence: B)*

2. Symptomatic patients with moderate to severe MS† who also have moderate to severe MR should receive MV replacement, unless MV repair is possible at the time of surgery. *(Level of Evidence: C)*

Class IIa

1. MV replacement is reasonable for patients with severe MS† and severe pulmonary hypertension (pulmonary artery systolic pressure greater than 60 mm Hg) with NYHA functional class I-II symptoms who are not considered candidates for PMBV or surgical MV repair. *(Level of Evidence: C)*

Class IIb

1. MV repair may be considered for asymptomatic patients with moderate or severe MS† who have had recurrent embolic events while receiving adequate anticoagulation and who have valve morphology favorable for repair. *(Level of Evidence: C)*

Class III

1. MV repair for MS is not indicated for patients with mild MS. *(Level of Evidence: C)*

2. Closed commissurotomy should not be performed in patients undergoing MV repair; open commissurotomy is the preferred approach. *(Level of Evidence: C)*

†*Objective definition of valve severity is provided in Table 1.*

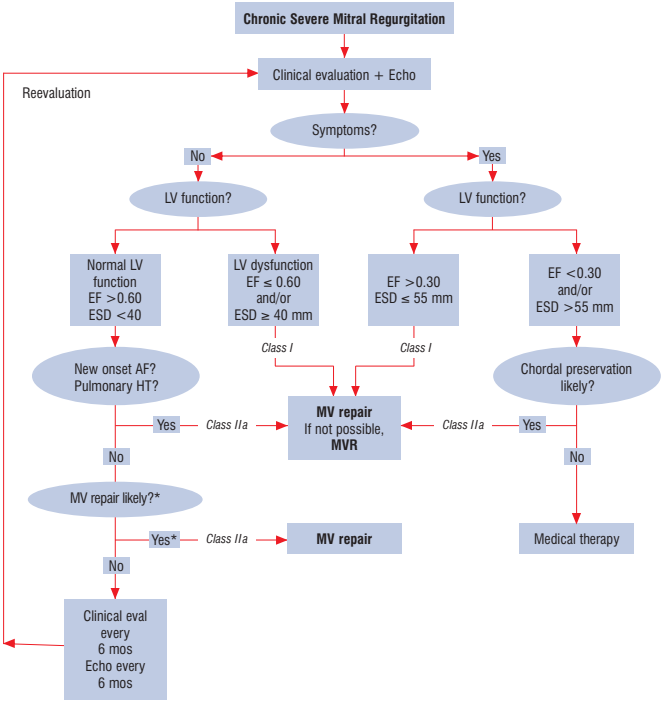
D. Mitral Regurgitation

Factors influencing the timing of surgery for MR include symptoms, LV EF, LV end-systolic dimension, atrial fibrillation, and pulmonary hypertension *(Figure 7)*. In most situations, MV repair is the operation of choice for those patients with suitable MV anatomy.

Operation is indicated for most patients with severe MR and any symptoms. Operation is also indicated in asymptomatic patients who demonstrate mild to moderate LV dysfunction (EF 0.30 to 0.60 and end-systolic dimension 40 to 55 mm). The patient with severe LV dysfunction (EF less than 0.30 and/or end-systolic dimension greater than 55 mm) poses a higher risk but may undergo surgery if chordal preservation is likely.

There is controversy regarding the timing of surgery in the asymptomatic patient with severe MR and normal LV function. If MV repair can be performed with a high degree of success and the operative risk is low, it is reasonable to proceed with surgery to prevent irreversible LV dysfunction from occurring. However, this "early" operation should only be performed at centers in which there is a high likelihood of successful MV repair because of their demonstrated expertise in this area.

Figure 7. Management Strategy for Patients With Chronic Severe Mitral Regurgitation



*Mitral valve (MV) repair may be performed in asymptomatic patients with normal left ventricular (LV) function if performed by an experienced surgical team and the likelihood of successful MV repair is greater than 90%.

AF = atrial fibrillation; **Echo** = echocardiography; **EF** = ejection fraction; **ESD** = end-systolic dimension; **HT** = hypertension; **MV** = mitral valve; **MVR** = mitral valve replacement.

Recommendations for Mitral Valve Surgery in Nonischemic Severe Mitral Regurgitation

Class I

1. MV surgery is recommended for the following patients:

A. Symptomatic patients with acute severe MR.† *(Level of Evidence: B)*

B. Patients with chronic severe MR† and NYHA functional class II, III, or IV symptoms in the absence of severe LV dysfunction (severe LV dysfunction is defined as EF less than 0.30 and/or end-systolic dimension greater than 55 mm). *(Level of Evidence: B)*

C. Asymptomatic patients with chronic severe MR† and mild to moderate LV dysfunction, EF 0.30 to 0.60, and/or end-systolic dimension greater than or equal to 40 mm. *(Level of Evidence: B)*

2. MV repair is recommended over MV replacement (MVR) in the majority of patients with severe chronic MR† who require surgery, and patients should be referred to surgical centers experienced in MV repair. *(Level of Evidence: C)*

Class IIa

1. MV repair is reasonable in experienced surgical centers for asymptomatic patients with chronic severe MR† with preserved LV function (EF greater than 0.60 and end-systolic dimension less than 40 mm) in whom the likelihood of successful repair without residual MR is greater than 90%. *(Level of Evidence: B)*

2. MV surgery is reasonable for the following patients:

A. Asymptomatic patients with chronic severe MR†, preserved LV function, and (1) new onset of atrial fibrillation or (2) pulmonary hypertension (pulmonary artery systolic pressure greater than 50 mm Hg at rest or greater than 60 mm Hg with exercise). *(Level of Evidence: C)*

B. Patients with chronic severe MR† due to a primary abnormality of the mitral apparatus, NYHA functional class III-IV symptoms, and severe LV dysfunction (EF less than 0.30 and/or end-systolic dimension greater than 55 mm) in whom MV repair is highly likely. *(Level of Evidence: C)*

Class IIb

1. MV repair may be considered for patients with chronic severe secondary MR† due to severe LV dysfunction (EF less than 0.30) who have persistent NYHA functional class III-IV symptoms despite optimal therapy for heart failure, including biventricular pacing. *(Level of Evidence: C)*

Class III

1. MV surgery is not indicated for asymptomatic patients with MR and preserved LV function (EF greater than 0.60 and end-systolic dimension less than 40 mm) in whom significant doubt about the feasibility of repair exists. *(Level of Evidence: C)*

2. Isolated MV surgery is not indicated for patients with mild or moderate MR. *(Level of Evidence: C)*

†*Objective definition of valve severity is provided in Table 1.*

E. Infective Endocarditis

Surgery is indicated in patients with life-threatening heart failure or cardiogenic shock due to surgically treatable valvular heart disease with or without proven infective endocarditis (IE) if the patient has a reasonable prospect of recovery with satisfactory quality of life after the operation. In the setting of acute IE, surgery should not be delayed when heart failure exists.

Indications for surgery for IE in patients with stable hemodynamics are less clear. Surgery is recommended for patients with annular or aortic abscesses, those with infections resistant to antibiotic therapy, and those with fungal endocarditis. Prosthetic valve endocarditis and native valve endocarditis caused by *Staphylococcus aureus* are almost always surgical diseases. Early surgery in MV endocarditis caused by virulent organisms (such as *S. aureus* or fungi) may make repair possible.

When at all possible, MV repair should be performed instead of MVR in the setting of active infection because of the risk of infection of prosthetic materials. Aortic valves may often be repaired as well if there are leaflet perforations, and this is preferable to AVR for the same reasons.

Indications for Surgery for Native Valve Endocarditis

Class I

1. Surgery of the native valve is indicated in the following patients with IE:

A. Patients who present with valve stenosis or regurgitation resulting in heart failure. *(Level of Evidence: B)*

B. Patients who present with AR or MR with hemodynamic evidence of elevated LV end-diastolic or left atrial pressures (e.g., premature closure of MV with AR, rapid decelerating MR signal by continuous-wave Doppler [*v*-wave cutoff sign], or moderate or severe pulmonary hypertension). *(Level of Evidence: B)*

C. Patients with IE caused by fungal or other highly resistant organisms. *(Level of Evidence: B)*

D. Patients with complications of heart block, annular or aortic abscess, or destructive penetrating lesions (e.g., sinus of Valsalva to right atrium, right ventricle, or left atrium fistula; mitral leaflet perforation with aortic valve endocarditis; or infection in annulus fibrosa). *(Level of Evidence: B)*

Class IIa

1. Surgery of the native valve is reasonable in patients with IE who present with recurrent emboli and persistent vegetations despite appropriate antibiotic therapy. *(Level of Evidence: C)*

Class IIb

1. Surgery of the native valve may be considered in patients with IE who present with mobile vegetations in excess of 10 mm with or without emboli. *(Level of Evidence: C)*

Indications for Surgery for Prosthetic Valve Endocarditis

Class I

1. Consultation with a cardiac surgeon is indicated for patients with IE of a prosthetic valve. *(Level of Evidence: C)*

2. Surgery is indicated for the following patients with IE of a prosthetic valve:

A. Patients who present with heart failure. *(Level of Evidence: B)*

B. Patients who present with dehiscence evidenced by cine fluoroscopy or echocardiography. *(Level of Evidence: B)*

C. Patients who present with evidence of increasing obstruction or worsening regurgitation. *(Level of Evidence: C)*

D. Patients who present with complications, for example, abscess formation. *(Level of Evidence: C)*

Class IIa	1. Surgery is reasonable for patients with IE of a prosthetic valve who present with A. Evidence of persistent bacteremia or recurrent emboli despite appropriate antibiotic treatment. *(Level of Evidence: C)* B. Relapsing infection. *(Level of Evidence: C)*
Class III	1. Routine surgery is not indicated for patients with uncomplicated IE of a prosthetic valve caused by first infection with a sensitive organism. *(Level of Evidence: C)*

F. Major Criteria for Valve Selection

The major advantages of a mechanical valve over a bioprosthesis are a low rate of structural deterioration and a better survival rate in younger patients. Major disadvantages are increased incidence of bleeding due to need for antithrombotic therapy and the increased risk of thrombosis.

The major advantage of a bioprosthesis over a mechanical prosthesis is the lack of need for antithrombotic therapy. The major disadvantage is the increased rate of structural valve deterioration. The rate of structural valve deterioration in the aortic position in patients 65 years of age or greater is lower than for those less than 65 years of age. The final decision regarding a mechanical valve versus a bioprosthesis is based

on multiple factors, including patient age, overall longevity of the valve, relative contraindications to anticoagulation, and lifestyle.

In general, MV repair is preferable to MVR, provided it is feasible and that the appropriate skill level and experience are available to perform this procedure successfully.

Pregnancy poses a difficult problem. The disadvantages of a mechanical valve are the complications of warfarin or UFH therapy that may affect the patient or the fetus. The disadvantage of a bioprosthesis is the relatively higher rate of early structural valve deterioration.

If a patient needs antithrombotic therapy for any reason (i.e., atrial fibrillation or the presence of a mechanical valve in another position), the major advantage of a biological valve is reduced.

Recommendations for Aortic Valve Selection

Class I

1. A mechanical prosthesis is recommended for AVR in patients with a mechanical valve in the mitral or tricuspid position. *(Level of Evidence: C)*

2. A bioprosthesis is recommended for AVR in patients of any age who will not take warfarin or who have major medical contraindications to warfarin therapy. *(Level of Evidence: C)*

Class IIa

1. Patient preference is a reasonable consideration in the selection of aortic valve operation and valve prosthesis. A mechanical prosthesis is reasonable for AVR in patients under 65 years of age who do not have a contraindication to anticoagulation. A bioprosthesis is reasonable for AVR in patients under 65 years of age who elect to receive this valve for lifestyle considerations after detailed discussions of the risks of anticoagulation versus the likelihood that a second AVR may be necessary in the future. *(Level of Evidence: C)*

2. A bioprosthesis is reasonable for AVR in patients aged 65 years or older without risk factors for thromboembolism. *(Level of Evidence: C)*

3. Aortic valve re-replacement with a homograft is reasonable for patients with active prosthetic valve endocarditis. *(Level of Evidence: C)*

Class IIb

1. A bioprosthesis might be considered for AVR in a woman of childbearing age. *(Level of Evidence: C)*

Recommendations for Mitral Valve Selection

Class I	1. A bioprosthesis is indicated for MVR in a patient who will not take warfarin, is incapable of taking warfarin, or has a clear contraindication to warfarin therapy. *(Level of Evidence: C)*
Class IIa	1. A mechanical prosthesis is reasonable for MVR in patients under 65 years of age with long-standing atrial fibrillation. *(Level of Evidence: C)* 2. A bioprosthesis is reasonable for MVR in patients 65 years of age or older. *(Level of Evidence: C)* 3. A bioprosthesis is reasonable for MVR in patients under 65 years of age in sinus rhythm who elect to receive this valve for lifestyle considerations after detailed discussions of the risks of anticoagulation versus the likelihood that a second MVR may be necessary in the future. *(Level of Evidence: C)*

IV. Antithrombotic Management of Prosthetic Heart Valves

A. Indications for Anticoagulation in Patients With Prosthetic Heart Valves

All patients with mechanical valves require warfarin therapy, as indicated in *Table 2*. The risk of embolization is greater with the valve in the mitral position than in the aortic position. Other risk factors for increased risk of embolization include atrial fibrillation, LV dysfunction, clotting disorder, and prior embolic events. With either type of prosthesis or valve location, the risk of emboli is higher in the first few months after valve insertion, before the valve is fully endothelialized. In most patients with a mechanical prosthesis, the target international normalized ratio (INR) is 2.5 to 3.5. The target INR can be reduced to 2.0 to 3.0 in those patients with a new-generation AVR and no other risk factors for thromboembolic events.

Aspirin is recommended for all patients with prosthetic heart valves: aspirin alone (75 to 100 mg per day) in patients with bioprostheses and no risk factors or aspirin (75 to 100 mg per day) combined with warfarin in patients with mechanical heart valves and high-risk patients with bioprostheses. In high-risk patients who cannot take aspirin, the addition of clopidogrel to warfarin therapy should be considered.

Table 2. Recommendations for Antithrombotic Therapy in Patients With Prosthetic Heart Valves

Valve Type	Aspirin (75-100 mg)	Warfarin (INR 2.0-3.0)	Warfarin (INR 2.5-3.5)	No Warfarin
Mechanical Prosthetic				
A. AVR – Low Risk				
■ Less than 3 months	Class I	Class I	Class IIa	
■ Greater than 3 months	Class I	Class I		
B. AVR – High Risk	Class I		Class I	
C. MVR	Class I		Class I	
Biological Prosthetic				
A. AVR – Low Risk				
■ Less than 3 months	Class I	Class IIa		Class IIb
■ Greater than 3 months	Class I			Class IIa
B. AVR – High Risk	Class I	Class I		
C. MVR – Low Risk				
■ Less than 3 months	Class I	Class IIa		
■ Greater than 3 months	Class I			Class IIa
D. MVR – High Risk	Class I	Class I		

Depending on patients' clinical status, antithrombotic therapy must be individualized *(see special situations in text)*. In patients receiving warfarin, aspirin is recommended in virtually all situations. Risk factors: atrial fibrillation, LV dysfunction, previous thromboembolism, and hypercoagulable condition. INR should be maintained between 2.5 and 3.5 for aortic disk valves and Starr-Edwards valves. Modified from McAnulty JH, Rahimtoola SH. Antithrombotic therapy in valvular heart disease. In: Schlant R, Alexander RW, editors. Hurst's The Heart. New York, NY: McGraw-Hill, 1998:1867–74. Reprinted with permission from the McGraw-Hill Companies.

AVR = aortic valve replacement; **MVR** = mitral valve replacement.

Recommendations for Antithrombotic Therapy in Patients With Prosthetic Heart Valves

Class I

1. After AVR with bileaflet mechanical or Medtronic Hall prostheses, warfarin is indicated to achieve an INR of 2.0 to 3.0 in patients with no risk factors,‡ and to achieve an INR of 2.5 to 3.5 in patients with risk factors.‡ *(Level of Evidence: B)*

2. After AVR with Starr-Edwards valves or mechanical disc valves (other than Medtronic Hall prostheses), warfarin is indicated to achieve an INR of 2.5 to 3.5 in patients with no risk factors.‡ *(Level of Evidence: B)*

3. After MVR with any mechanical valve, warfarin is indicated to achieve an INR of 2.5 to 3.5. *(Level of Evidence: C)*

4. After AVR or MVR with a bioprosthesis and no risk factors,‡ aspirin is indicated at 75 to 100 mg per day. *(Level of Evidence: C)*

5. After AVR with a bioprosthesis in patients with risk factors,‡ warfarin is indicated to achieve an INR of 2.0 to 3.0. *(Level of Evidence: C)*

6. After MVR with a bioprosthesis in patients with risk factors,‡ warfarin is indicated to achieve an INR of 2.5 to 3.5. *(Level of Evidence: C)*

7. For those patients who are unable to take warfarin after AVR or MVR, aspirin is indicated in a dose of 75 to 325 mg per day.
(Level of Evidence: B)

8. The addition of aspirin 75 to 100 mg once daily to therapeutic warfarin is recommended for all patients with mechanical heart valves and those patients with biological valves who have risk factors.‡ *(Level of Evidence: B)*

Class IIa

1. During the first 3 months after AVR with a mechanical prosthesis, it is reasonable to give warfarin to achieve an INR of 2.5 to 3.5.
(Level of Evidence: C)

2. During the first 3 months after AVR or MVR with a bioprosthesis in patients with no risk factors,‡ it is reasonable to give warfarin to achieve an INR of 2.0 to 3.0.
(Level of Evidence: C)

Class IIb

1. In high-risk patients with prosthetic heart valves in whom aspirin cannot be used, it may be reasonable to give clopidogrel (75 mg per day) or warfarin to achieve an INR of 3.5 to 4.5.
(Level of Evidence: C)

‡ *Risk factors include atrial fibrillation, previous thromboembolism, LV dysfunction, and hypercoagulable condition.*

B. Embolic Events During Adequate Antithrombotic Therapy

In the patient who has a definite embolic episode while undergoing adequate antithrombotic therapy, the dosage of antithrombotic therapy should be increased, when clinically safe, as follows:

- Warfarin, INR 2.0 to 3.0: warfarin dose increased to achieve INR of 2.5 to 3.5
- Warfarin, INR 2.5 to 3.5: warfarin dose may need to be increased to achieve INR of 3.5 to 4.5
- Not taking aspirin: aspirin 75 to 100 mg per day should be initiated
- Warfarin plus aspirin 75 to 100 mg per day: aspirin dose may also need to be increased to 325 mg per day if the higher dose of warfarin is not achieving the desired clinical result
- Aspirin alone: aspirin dose may need to be increased to 325 mg per day, clopidogrel 75 mg per day added, and/or warfarin added.

C. Excessive Anticoagulation

In most patients with an INR above the therapeutic range, excessive anticoagulation can be managed by withholding warfarin and monitoring the level of anticoagulation. Rapid decreases in INR to less than the therapeutic range will increase the risk of thromboembolism. Patients with an INR of 5 to 10 who are not bleeding can be treated as follows:

- Hold warfarin and administer 1 to 2.5 mg of oral vitamin K1
- Determine INR after 24 h and subsequently as needed
- Restart warfarin and adjust dose appropriately to ensure the INR is in the therapeutic range
- Emergency use of fresh frozen plasma is preferable to high-dose vitamin K1, especially parenteral vitamin K1.

D. Antithrombotic Therapy in Patients Requiring Noncardiac Surgery/Dental Care

Antithrombotic therapy should not be stopped for procedures in which bleeding is either unlikely or would be inconsequential if it occurred. When bleeding is likely or its potential consequences are severe, antithrombotic therapy should be altered. The use of "bridging" unfractionated heparin (UFH) or low-molecular-weight heparin (LMWH) therapy when stopping the warfarin is dependent on the absence or presence of other risk factors, which include atrial fibrillation, previous thromboembolism, hypercoagulable condition, LV dysfunction, and the presence of a mitral prosthesis.

Recommendations for Antithrombotic Therapy in Patients

Class I

1. In patients at low risk of thrombosis, defined as those with a bileaflet mechanical AVR with no risk factors,[§] it is recommended that warfarin be stopped 48 to 72 h before the procedure (so the INR falls to less than 1.5) and restarted within 24 h after the procedure. Heparin is usually unnecessary. *(Level of Evidence: B)*

2. In patients at high risk of thrombosis, defined as those with any mechanical MVR or a mechanical AVR with any risk factor,§ therapeutic doses of intravenous UFH should be started when the INR falls below 2.0 (typically 48 h before surgery), stopped 4 to 6 h before the procedure, restarted as early after surgery as bleeding stability allows, and continued until the INR is again therapeutic with warfarin therapy. *(Level of Evidence: B)*

Class IIa

1. It is reasonable to give fresh frozen plasma to patients with mechanical valves who require interruption of warfarin therapy for emergency noncardiac surgery, invasive procedures, or dental care. Fresh frozen plasma is preferable to high-dose vitamin K1. *(Level of Evidence: B)*

Class IIb

1. In patients at high risk of thrombosis (see above), therapeutic doses of subcutaneous UFH (15,000 U every 12 h) or LMWH (100 U per kg every 12 h) may be considered during the period of a subtherapeutic INR. *(Level of Evidence: B)*

Class III 1. In patients with mechanical valves who require interruption of warfarin therapy for noncardiac surgery, invasive procedures, or dental care, high-dose vitamin K1 should not be given routinely, because this may create a hypercoagulable condition. *(Level of Evidence: B)*

§ *Risk factors: atrial fibrillation, previous thromboembolism, LV dysfunction, hypercoagulable conditions, older generation thrombogenic valves, mechanical tricuspid valves, or more than 1 mechanical valve.*

E. Pregnancy

Anticoagulation for prosthetic valves during pregnancy presents a difficult problem. Warfarin is probably safe during the first 6 weeks of gestation, but there is a risk of embryopathy if warfarin is taken between 6 and 12 weeks of gestation. Warfarin is also relatively safe during the 2nd and 3rd trimester of pregnancy, but needs to be discontinued and switched to a heparin compound several weeks before delivery. Several studies strongly suggest that UFH or LMWH therapy is safe for the fetus but poses a high incidence of thromboembolic complications, including fatal valve thrombosis. Thus, warfarin is more efficacious than UFH for thromboembolic prophylaxis of women with mechanical heart valves in pregnancy, but with an increased risk of embryopathy. There are still insufficient

grounds to make definitive recommendations about optimal antithrombotic therapy in pregnant patients with mechanical heart valves because properly designed studies have not been performed. The final decision on the anticoagulation regimen requires discussion with the patient regarding the risks and benefits of each approach. For any anticoagulation, intensive monitoring is required.

Selection of Anticoagulation Regimen in Pregnant Patients With Mechanical Prosthetic Valves

Class I

1. All pregnant patients with mechanical prosthetic valves must receive continuous therapeutic anticoagulation with frequent monitoring. *(Level of Evidence: B)*

2. For women requiring long-term warfarin therapy who are attempting pregnancy, pregnancy tests should be monitored with discussions about subsequent anticoagulation therapy, so that anticoagulation can be continued uninterrupted when pregnancy is achieved. *(Level of Evidence: C)*

3. Pregnant patients with mechanical prosthetic valves who elect to stop warfarin between weeks 6 and 12 of gestation should receive continuous IV UFH, dose-adjusted UFH, or dose-adjusted subcutaneous LMWH. *(Level of Evidence: C)*

4. For pregnant patients with mechanical prosthetic valves up to 36 weeks of gestation, the therapeutic

choice of continuous intravenous or adjusted-dose subcutaneous UFH, dose-adjusted LMWH, or warfarin should be discussed fully. If continuous IV UFH is used, the fetal risk is lower but the maternal risks of prosthetic valve thrombosis, systemic embolization, infection, osteoporosis and heparin-induced thrombocytopenia are relatively higher. *(Level of Evidence: C)*

5. In pregnant patients with mechanical prosthetic valves who receive dose-adjusted LMWH, the LMWH should be administered twice daily subcutaneously to maintain the anti-Xa level between 0.7 to 1.2 units 4 h after administration. *(Level of Evidence: C)*

6. In pregnant patients with mechanical prosthetic valves who receive dose-adjusted UFH, the aPTT should be at least twice control. *(Level of Evidence: C)*

7. In pregnant patients with mechanical prosthetic valves who receive warfarin, the INR goal should be 3.0 (range 2.5 to 3.5). *(Level of Evidence: C)*

8. In pregnant patients with mechanical prosthetic valves, warfarin should be discontinued and continuous IV UFH given starting at 2 to 3 weeks before planned delivery. *(Level of Evidence: C)*

Class IIa

1. In patients with mechanical prosthetic valves, it is reasonable to avoid warfarin between weeks 6 and 12 of gestation owing to the high risk of fetal defects. *(Level of Evidence: C)*

2. In patients with mechanical prosthetic valves, it is reasonable to resume heparin 4 to 6 h after delivery and begin oral warfarin in the absence of significant bleeding. *(Level of Evidence: C)*

3. In patients with mechanical prosthetic valves, it is reasonable to give low-dose aspirin (75 to 100 mg per day) in the second and third trimesters of pregnancy in addition to anticoagulation with warfarin or heparin. *(Level of Evidence: C)*

Class III

1. LMWH should not be administered to pregnant patients with mechanical prosthetic valves unless anti-Xa levels are monitored 4 to 6 hours after administration. *(Level of Evidence: C)*

2. Dipyridamole should not be used instead of aspirin as an alternative antiplatelet agent in pregnant patients with mechanical prosthetic valves because of its harmful effects on the fetus. *(Level of Evidence: B)*

F. Thrombosis of Prosthetic Heart Valves

Obstruction of prosthetic heart valves may be caused by thrombus formation, pannus ingrowth, or a combination of both. The cause may be difficult to determine and requires

knowledge of the clinical presentation and findings on echocardiography, including TEE. Emergency surgery is indicated for the patient with NYHA functional class III-IV heart failure or the patient with a large thrombus burden. Fibrinolytic therapy for a left-sided prosthetic valve obstructed by thrombus is associated with significant risks (cerebral emboli in 12% to 15%) but may be used in patients at high risk for surgery or those with stable hemodynamics and a small clot burden.

Recommendations for Thrombosis of Prosthetic Heart Valves

Class I	1. Transthoracic and Doppler echocardiography is indicated in patients with suspected prosthetic valve thrombosis to assess hemodynamic severity. *(Level of Evidence: B)* 2. TEE and/or fluoroscopy is indicated in patients with suspected valve thrombosis to assess valve motion and clot burden. *(Level of Evidence: B)*
Class IIa	1. Emergency operation is reasonable for the following patients with a thrombosed left sided prosthetic valve: A. Patients with NYHA functional class III-IV symptoms. *(Level of Evidence: C)* B. Patients with a large clot burden. *(Level of Evidence: C)*

2. Fibrinolytic therapy is reasonable for thrombosed right-sided prosthetic heart valves with NYHA functional class III-IV symptoms or a large clot burden. *(Level of Evidence C)*

Class IIb

1. Fibrinolytic therapy may be considered as a first-line therapy for the following patients with a thrombosed left sided prosthetic valve:

A. Patients with NYHA functional class I-II symptoms, and a small clot burden. *(Level of Evidence: B)*

B. Patients with a NYHA functional class III-IV symptoms, and a small clot burden if surgery is high risk or not available. *(Level of Evidence: B)*

C. Patients with an obstructed prosthetic valve who have NYHA functional class II-IV symptoms and a large clot burden if emergency surgery is high risk or not available. *(Level of Evidence: C)*

2. Intravenous heparin as an alternative to fibrinolytic therapy may be considered for patients with a thrombosed valve who are in NYHA functional class I-II and have a small clot burden. *(Level of Evidence: C)*

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