General

Guideline Title

2014 AHA/ACC guideline for the management of patients with valvular heart disease: a report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines.

Bibliographic Source(s)


Guideline Status

This is the current release of the guideline.


Recommendations

Major Recommendations

Note from the National Guideline Clearinghouse (NGC) and the American College of Cardiology (ACC) and the American Heart Association (AHA): Two guidelines from the ACC, the AHA, and collaborating societies address the risk of aortic dissection in patients with bicuspid aortic valves and severe aortic enlargement: the "2010 ACCF/AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM Guidelines for the Diagnosis and Management of Patients With Thoracic Aortic Disease" and the "2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease." However, the 2 guidelines differ with regard to the recommended threshold of aortic root or ascending aortic dilatation that would justify surgical intervention in patients with bicuspid aortic valves. The ACC and AHA therefore convened a subcommittee representing members of the 2 guideline writing committees to review the evidence, reach consensus, and draft a statement of clarification for both guidelines. This statement of clarification uses the
ACC/AHA revised structure for delineating the Class of Recommendation and Level of Evidence to provide recommendations that replace the intervention recommendations in the Bicuspid Aortic Valve section, below. See the ACC/AHA Statement of Clarification in the "Availability of Companion Documents" field.

Definitions for the levels of the evidence (A–C) and classes of recommendations (I–III) are provided at the end of the "Major Recommendations" field.

General Principles

Diagnosis and Follow-up

Diagnostic Testing–Initial Diagnosis

Class I

Transthoracic echocardiography (TTE) is recommended in the initial evaluation of patients with known or suspected valvular heart disease (VHD) to confirm the diagnosis, establish etiology, determine severity, assess hemodynamic consequences, determine prognosis, and evaluate for timing of intervention (Carabello et al., 1986; Currie et al., “Continuous-wave Doppler determination,” 1985; Currie et al., “Continuous-wave Doppler echocardiographic,” 1985; Dujardin et al., 1997; Enriquez-Sarano et al., 2005; Enriquez-Sarano et al., “Echocardiographic prediction of left ventricular function,” 1994; Nishimura et al., 1994; Oh et al., 1988; Otto et al., 1997; Otto et al., 1991; Otto et al., 1986; Otto, Pearlman, & Gardner, 1989; Pellikka et al., 2005; Zile et al., 1984; Dujardin et al., 1999; Bonow et al., 1991). (Level of Evidence: B)

Diagnostic Testing–Changing Signs or Symptoms

Class I

TTE is recommended in patients with known VHD with any change in symptoms or physical examination findings. (Level of Evidence: C)

Diagnostic Testing–Routine Follow-up

Class I

Periodic monitoring with TTE is recommended in asymptomatic patients with known VHD at intervals depending on valve lesion, severity, ventricular size, and ventricular function. (Level of Evidence: C)

Diagnostic Testing–Cardiac Catheterization

Class I

Cardiac catheterization for hemodynamic assessment is recommended in symptomatic patients when noninvasive tests are inconclusive or when there is a discrepancy between the findings on noninvasive testing and physical examination regarding severity of the valve lesion. (Level of Evidence: C)

Diagnostic Testing–Exercise Testing

Class IIa

Exercise testing is reasonable in selected patients with asymptomatic severe VHD to 1) confirm the absence of symptoms, or 2) assess the hemodynamic response to exercise, or 3) determine prognosis (Aviles et al., 2001; Otto et al., 1992; Lancellotti et al., 2005; Marechaux et al., 2010; Messika-Zeitoun et al., 2006). (Level of Evidence: B)

Basic Principles of Medical Therapy

Secondary Prevention of Rheumatic Fever

Class I
Secondary prevention of rheumatic fever is indicated in patients with rheumatic heart disease, specifically mitral stenosis (MS) (see Tables 5 and 6 in the original guideline document) (Gerber et al., 2009). (Level of Evidence: C)

**Infective Endocarditis (IE) Prophylaxis**

**Class IIa**

Prophylaxis against IE is reasonable for the following patients at highest risk for adverse outcomes from IE before dental procedures that involve manipulation of gingival tissue, manipulation of the periapical region of teeth, or perforation of the oral mucosa (Horstkotte, 1987; Strom et al., 1998; Duval et al., 2006) (Level of Evidence: B):
- Patients with prosthetic cardiac valves
- Patients with previous IE
- Cardiac transplant recipients with valve regurgitation due to a structurally abnormal valve
- Patients with congenital heart disease with:
  - Unrepaired cyanotic congenital heart disease, including palliative shunts and conduits
  - Completely repaired congenital heart defect repaired with prosthetic material or device, whether placed by surgery or catheter intervention, during the first 6 months after the procedure
  - Repaired congenital heart disease with residual defects at the site or adjacent to the site of a prosthetic patch or prosthetic device

**Class III: No Benefit**

Prophylaxis against IE is not recommended in patients with VHD who are at risk of IE for nondental procedures (e.g., transesophageal echocardiography [TEE], esophagogastroduodenoscopy, colonoscopy, or cystoscopy) in the absence of active infection (Guarner-Argente et al., 2011). (Level of Evidence: B)

The Heart Valve Team and Heart Valve Centers of Excellence

**Class I**

Patients with severe VHD should be evaluated by a multidisciplinary Heart Valve Team when intervention is considered. (Level of Evidence: C)

**Class IIa**

Consultation with or referral to a Heart Valve Center of Excellence is reasonable when discussing treatment options for 1) asymptomatic patients with severe VHD, 2) patients who may benefit from valve repair versus valve replacement, or 3) patients with multiple comorbidities for whom valve intervention is considered. (Level of Evidence: C)

**Aortic Stenosis (AS)**

See Table 8 in the original guideline document for the stages of valvular AS.

**Diagnosis and Follow-up**

**Diagnostic Testing—Initial Diagnosis**

**Class I**

TTE is indicated in patients with signs or symptoms of AS or a bicuspid aortic valve for accurate diagnosis of the cause of AS, hemodynamic severity, left ventricular (LV) size, and systolic function, and for determining prognosis and timing of valve intervention (Oh et al., 1988; Otto et al., 1997; Galan, Zoghbi, & Quinones, 1991). (Level of Evidence: B)

**Class IIa**
Low-dose dobutamine stress testing using echocardiographic or invasive hemodynamic measurements is reasonable in patients with stage D2 AS with all of the following (Lin et al., 1998; Monin et al., 2001; Clavel et al., 2008) (Level of Evidence: B):

- Calcified aortic valve with reduced systolic opening
- Left ventricular ejection fraction (LVEF) <50%
- Calculated valve area ≤1.0 cm²
- Aortic velocity <4.0 m per second or mean pressure gradient <40 mm Hg

**Diagnostic Testing—Exercise Testing**

**Class IIa**

Exercise testing is reasonable to assess physiological changes with exercise and to confirm the absence of symptoms in asymptomatic patients with a calcified aortic valve and an aortic velocity 4.0 m per second or greater or mean pressure gradient 40 mm Hg or higher (stage C) (Otto et al., 1997; Lancellotti et al., 2005; Marechaux et al., 2010; Das, Rimington, & Chambers, 2005). (Level of Evidence: B)

**Class III: Harm**

Exercise testing should not be performed in symptomatic patients with AS when the aortic velocity is 4.0 m per second or greater or mean pressure gradient is 40 mm Hg or higher (stage D) (Atterhog, Jonsson, & Samuelsson, 1979). (Level of Evidence: B)

**Medical Therapy**

**Class I**

Hypertension in patients at risk for developing AS (stage A) and in patients with asymptomatic AS (stages B and C) should be treated according to standard guideline-directed medical therapy (GDMT), started at a low dose, and gradually titrated upward as needed with frequent clinical monitoring (O’Brien et al., 2004; Chockalingam et al., 2004; Nadir et al., 2011). (Level of Evidence: B)

**Class IIb**

Vasodilator therapy may be reasonable if used with invasive hemodynamic monitoring in the acute management of patients with severe decompensated AS (stage D) with New York Heart Association (NYHA) class IV heart failure (HF) symptoms. (Level of Evidence: C)

**Class III: No Benefit**

Statin therapy is not indicated for prevention of hemodynamic progression of AS in patients with mild-to-moderate calcific valve disease (stages B to D) (Rossebo et al., 2008; Cowell et al., 2005; Chan et al., 2010). (Level of Evidence: A)

**Timing of Intervention**

**Class I**

Aortic valve replacement (AVR) is recommended in symptomatic patients with severe AS (stage D1) with (Zoghbi et al., 2009; Otto & Pearlman, 1988; Turina et al., 1987; Kelly et al., 1988) (Level of Evidence: B):

- Decreased systolic opening of a calcified or congenitally stenotic aortic valve
- An aortic velocity 4.0 m per second or greater or mean pressure gradient 40 mm Hg or higher
- Symptoms of HF, syncope, exertional dyspnea, angina, or presyncope by history or on exercise testing

AVR is recommended for asymptomatic patients with severe AS (stage C2) and an LVEF less than 50% with decreased systolic opening of a calcified aortic valve with an aortic velocity 4.0 m per second or greater or mean pressure gradient 40 mm Hg or higher (Connolly et al., 1997; Tribouilloy...
et al., "Outcome," 2009). *(Level of Evidence: B)*

AVR is indicated for patients with severe AS (stage C or D) when undergoing cardiac surgery for other indications when there is decreased systolic opening of a calcified aortic valve and an aortic velocity 4.0 m per second or greater or mean pressure gradient 40 mm Hg or higher (Rosenhek et al., 2000; Smith et al., 2004). *(Level of Evidence: B)*

**Class IIa**

AVR is indicated for patients with severe AS (stage C or D) when undergoing cardiac surgery for other indications when there is decreased systolic opening of a calcified aortic valve and an aortic velocity 4.0 m per second or greater or mean pressure gradient 40 mm Hg or higher (Rosenhek et al., 2000; Smith et al., 2004). *(Level of Evidence: B)*

AVR is reasonable for asymptomatic patients with very severe AS (stage C1) with (Lancellotti et al., 2010; Rosenhek et al., 2010) *(Level of Evidence: B):*

- Decreased systolic opening of a calcified valve
- An aortic velocity 5.0 m per second or greater or mean pressure gradient 60 mm Hg or higher
- A low surgical risk

AVR is reasonable in apparently asymptomatic patients with severe AS (stage C1) with (Otto et al., 1997; Marechaux et al., 2010) *(Level of Evidence: B):*

- A calcified aortic valve
- An aortic velocity of 4.0 m per second to 4.9 m per second or mean pressure gradient of 40 mm Hg to 59 mm Hg
- An exercise test demonstrating decreased exercise tolerance or a fall in systolic blood pressure (BP)

AVR is reasonable in symptomatic patients with low-flow/low-gradient severe AS with reduced LVEF (stage D2) with a (Nishimura et al., 2002; Monin et al., 2003; Fougeres et al., 2012) *(Level of Evidence: B):*

- A calcified aortic valve with reduced systolic opening
- Resting valve area 1.0 cm$^2$ or less
- Aortic velocity less than 4 m per second or mean pressure gradient less than 40 mm Hg
- LVEF less than 50%
- A low-dose dobutamine stress study that shows an aortic velocity 4 m per second or greater or mean pressure gradient 40 mm Hg or higher with a valve area 1.0 cm$^2$ or less at any dobutamine dose

AVR is reasonable in symptomatic patients with low-flow/low-gradient severe AS (stage D3) with an LVEF 50% or greater, a calcified aortic valve with significantly reduced leaflet motion, and a valve area 1.0 cm$^2$ or less only if clinical, hemodynamic, and anatomic data support valve obstruction as the most likely cause of symptoms and data recorded when the patient is normotensive (systolic BP <140 mm Hg) indicate *(Level of Evidence: C):*

- An aortic velocity less than 4 m per second or mean pressure gradient less than 40 mm Hg
- A stroke volume index less than 35 mL/m$^2$
- An indexed valve area 0.6 cm$^2$/m$^2$ or less

AVR is reasonable for patients with moderate AS (stage B) with an aortic velocity between 3.0 m per second and 3.9 m per second or mean pressure gradient between 20 mm Hg and 39 mm Hg who are undergoing cardiac surgery for other indications. *(Level of Evidence: C)*

**Class IIb**

AVR may be considered for asymptomatic patients with severe AS (stage C1) with an aortic velocity 4.0 m per second or greater or mean pressure gradient 40 mm Hg or higher if the patient is at low surgical risk and serial testing shows an increase in aortic velocity 0.3 m per second or greater per year. *(Level of Evidence: C)*

**Choice of Intervention**

**Class I**

Surgical AVR is recommended in patients who meet an indication for AVR with low or intermediate surgical risk (O'Brien et al., 2009; Horstkotte & Loogen, 1988). *(Level of Evidence: A)*

For patients in whom transcatheter aortic valve replacement (TAVR) or high-risk surgical AVR is being
considered, a Heart Valve Team consisting of an integrated, multidisciplinary group of healthcare professionals with expertise in VHD, cardiac imaging, interventional cardiology, cardiac anesthesia, and cardiac surgery should collaborate to provide optimal patient care. (Level of Evidence: C) TAVR is recommended in patients who meet an indication for AVR who have a prohibitive risk for surgical AVR and a predicted post-TAVR survival greater than 12 months (Kodali et al., 2012; Leon et al., 2010). (Level of Evidence: B)

Class IIa

TAVR is a reasonable alternative to surgical AVR in patients who meet an indication for AVR and who have high surgical risk for surgical AVR (Makkar et al., 2012; Smith et al., 2011). (Level of Evidence: B)

Class IIb

Percutaneous aortic balloon dilation may be considered as a bridge to surgical AVR or TAVR in patients with severe symptomatic AS. (Level of Evidence: C)

Class III: No Benefit

TAVR is not recommended in patients in whom existing comorbidities would preclude the expected benefit from correction of AS (Kodali et al., 2012). (Level of Evidence: B)

Aortic Regurgitation (AR)

Chronic AR

Diagnosis and Follow-up

Diagnostic Testing–Initial Diagnosis

Class I

TTE is indicated in patients with signs or symptoms of AR (stages A to D) for accurate diagnosis of the cause of regurgitation, regurgitant severity, and LV size and systolic function, and for determining clinical outcome and timing of valve intervention (Bonow et al., 1991; Detaint et al., 2008; Pizarro et al., 2011; Teague et al., 1986; Bonow et al., 1983; Scognamiglio, Fasoli, & Dalla, 1986; Siemienczuk et al., 1989; Tornos et al., 1995; Ishii et al., 1996; Scognamiglio et al., 1994; Borer et al., 1998). (Level of Evidence: B)

TTE is indicated in patients with dilated aortic sinuses or ascending aorta or with a bicuspid aortic valve (stages A and B) to evaluate the presence and severity of AR (Attenhofer et al., 2000). (Level of Evidence: B)

Cardiac magnetic resonance (CMR) is indicated in patients with moderate or severe AR (stages B, C, and D) and suboptimal echocardiographic images for the assessment of LV systolic function, systolic and diastolic volumes, and measurement of AR severity (Gelfand et al., 2006; Cawley et al., 2013). (Level of Evidence: B)

Medical Therapy

Class I

Treatment of hypertension (systolic BP >140 mm Hg) is recommended in patients with chronic AR (stages B and C), preferably with dihydropyridine calcium channel blockers or angiotensin-converting enzyme (ACE) inhibitors/angiotensin-receptor blockers (ARBs) (Scognamiglio et al., 1994; Evangelista et al., 2005). (Level of Evidence: B)

Class IIa

Medical therapy with ACE inhibitors/ARBs and beta blockers is reasonable in patients with severe AR who have symptoms and/or LV dysfunction (stages C2 and D) when surgery is not performed because
of comorbidities (Sondergaard et al., 2000; Elder et al., 2011). (Level of Evidence: B)

Timing of Intervention

Class I

AVR is indicated for symptomatic patients with severe AR regardless of LV systolic function (stage D) (Dujardin et al., 1999; Greves et al., 1981; Klodas et al., 1997). (Level of Evidence: B)

AVR is indicated for asymptomatic patients with chronic severe AR and LV systolic dysfunction (LVEF <50%) at rest (stage C2) if no other cause for systolic dysfunction is identified (Forman, Firth, & Barnard, 1980; Greves et al., 1981; Chaliki et al., 2002; Bhudia et al., 2007). (Level of Evidence: B)

AVR is indicated for patients with severe AR (stage C or D) while undergoing cardiac surgery for other indications. (Level of Evidence: C)

Class IIa

AVR is reasonable for asymptomatic patients with severe AR with normal LV systolic function (LVEF ≥50%) but with severe LV dilation (left ventricular end-systolic dimension [LVESD] >50 mm or indexed LVESD >25 mm/m²) (stage C2) (Van Rossum et al., 1988; Bonow et al., 1988; Gaasch et al., 1983). (Level of Evidence: B)

AVR is reasonable in patients with moderate AR (stage B) while undergoing surgery on the ascending aorta, coronary artery bypass graft (CABG), or mitral valve surgery. (Level of Evidence: C)

Class IIb

AVR may be considered for asymptomatic patients with severe AR and normal LV systolic function at rest (LVEF ≥50%, stage C1) but with progressive severe LV dilatation (LV end-diastolic dimension >65 mm) if surgical risk is low. (Level of Evidence: C)

Bicuspid Aortic Valve and Aortopathy

Bicuspid Aortic Valve

Diagnosis and Follow-up

Diagnostic Testing–Initial Diagnosis

Class I

An initial TTE is indicated in patients with a known bicuspid aortic valve to evaluate valve morphology, to measure the severity of AS and AR, and to assess the shape and diameter of the aortic sinuses and ascending aorta for prediction of clinical outcome and to determine timing of intervention (Pachulski, Weinberg, & Chan, 1991; Hahn et al., 1992; Nistri et al., 1999; Keane et al., 2000; Novaro et al., 2003; Schaefer et al., 2008). (Level of Evidence: B)

Aortic magnetic resonance angiography or computed tomography (CT) angiography is indicated in patients with a bicuspid aortic valve when morphology of the aortic sinuses, sinotubular junction, or ascending aorta cannot be assessed accurately or fully by echocardiography. (Level of Evidence: C)

Diagnostic Testing–Routine Follow-up

Serial evaluation of the size and morphology of the aortic sinuses and ascending aorta by echocardiography, CMR, or CT angiography is recommended in patients with a bicuspid aortic valve and an aortic diameter greater than 4.0 cm, with the examination interval determined by the degree and rate of progression of aortic dilation and by family history. In patients with an aortic diameter greater than 4.5 cm, this evaluation should be performed annually. (Level of Evidence: C)

Intervention

Note: The following 3 recommendations (Class I and Class IIa below) on surgery for aortic dilatation in patients with bicuspid aortic valves have been updated and replaced. See the ACC/AHA Statement of
Clarification in the "Availability of Companion Documents" field for further information, including the updated recommendations.

Class I

Operative intervention to repair the aortic sinuses or replace the ascending aorta is indicated in patients with a bicuspid aortic valve if the diameter of the aortic sinuses or ascending aorta is greater than 5.5 cm (Tzemos et al., 2008; Michelena et al., 2011; Davies et al., 2002). (Level of Evidence: B)

Class IIa

Operative intervention to repair the aortic sinuses or replace the ascending aorta is reasonable in patients with bicuspid aortic valves if the diameter of the aortic sinuses or ascending aorta is greater than 5.0 cm and a risk factor for dissection is present (family history of aortic dissection or if the rate of increase in diameter is ≥0.5 cm per year). (Level of Evidence: C)

Replacement of the ascending aorta is reasonable in patients with a bicuspid aortic valve who are undergoing aortic valve surgery because of severe AS or AR if the diameter of the ascending aorta is greater than 4.5 cm. (Level of Evidence: C)

Mitral Stenosis (MS)

Rheumatic MS

**Diagnosis and Follow-up**

**Diagnostic Testing–Initial Diagnosis**

Class I

TTE is indicated in patients with signs or symptoms of MS to establish the diagnosis, quantify hemodynamic severity (mean pressure gradient, mitral valve area, and pulmonary artery pressure), assess concomitant valvular lesions, and demonstrate valve morphology (to determine suitability for mitral commissurotomy) (Baumgartner et al., 2009; Sugeng et al., 2003; Schlosshan et al., 2011; Leavitt, Coat, & Falk, 1991; Chung, Karamanoglu, & Kovacs, 2004; Zoghbi et al., 2009; Wilkins et al., 1988; Abascal et al., 1990; Cannan et al., 1997; Thomas et al., 1988). (Level of Evidence: B)

TEE should be performed in patients considered for percutaneous mitral balloon commissurotomy to assess the presence or absence of left atrial thrombus and to further evaluate the severity of mitral regurgitation (MR) (Schlosshan et al., 2011; Ellis et al., 2006; Kronzon et al., 1990; Tessier et al., 1994). (Level of Evidence: B)

**Diagnostic Testing–Exercise Testing**

Exercise testing with Doppler or invasive hemodynamic assessment is recommended to evaluate the response of the mean mitral gradient and pulmonary artery pressure in patients with MS when there is a discrepancy between resting Doppler echocardiographic findings and clinical symptoms or signs. (Level of Evidence: C)

**Medical Therapy**

Class I

Anticoagulation (vitamin K antagonist [VKA] or heparin) is indicated in patients with 1) MS and atrial fibrillation (AF) (paroxysmal, persistent, or permanent), 2) MS and a prior embolic event, or 3) MS and a left atrial thrombus (Wilson & Greenwood, 1954; Rowe et al., 1960; Olesen, 1962; Szekely, 1964; Perez-Gomez et al., 2004; Omran et al., 2000; Singer et al., 2008). (Level of Evidence: B)

Class IIa

Heart rate control can be beneficial in patients with MS and AF and fast ventricular response. (Level
Heart rate control may be considered for patients with MS in normal sinus rhythm and symptoms associated with exercise (Stoll et al., 1995; Monmeneu Menadas et al., 2002). (Level of Evidence: B)

**Intervention**

**Class I**

Percutaneous mitral balloon commissurotomy is recommended for symptomatic patients with severe MS (mitral valve area ≤1.5 cm², stage D) and favorable valve morphology in the absence of left atrial thrombus or moderate-to-severe MR (Arora et al., 1993; Turi et al., 1991; Patel et al., 1991; Ben Farhat et al., 1998; Cotrufo et al., 1999; Reyes et al., 1994; Bouleti et al., 2012). (Level of Evidence: A)

Mitral valve surgery (repair, commissurotomy, or valve replacement) is indicated in severely symptomatic patients (NYHA class III to IV) with severe MS (mitral valve area ≤1.5 cm², stage D) who are not high risk for surgery and who are not candidates for or who have failed previous percutaneous mitral balloon commissurotomy (Ellis et al., 1973; John et al., 1983; Finnegan et al., 1974; Mullin et al., 1974; Halseth et al., 1980; Gross et al., 1981). (Level of Evidence: B)

Concomitant mitral valve surgery is indicated for patients with severe MS (mitral valve area ≤1.5 cm², stage C or D) undergoing cardiac surgery for other indications. (Level of Evidence: C)

**Class IIa**

Percutaneous mitral balloon commissurotomy is reasonable for asymptomatic patients with very severe MS (mitral valve area ≤1.0 cm², stage C) and favorable valve morphology in the absence of left atrial thrombus or moderate-to-severe MR (Abascal et al., 1990; Iung et al., 1996; Arat et al., 2008; Vincens et al., 1995). (Level of Evidence: C)

Mitral valve surgery is reasonable for severely symptomatic patients (NYHA class III to IV) with severe MS (mitral valve area ≤1.5 cm², stage D), provided there are other operative indications (e.g., aortic valve disease, coronary artery disease [CAD], tricuspid regurgitation [TR], aortic aneurysm). (Level of Evidence: C)

**Class IIb**

Percutaneous mitral balloon commissurotomy may be considered for asymptomatic patients with severe MS (mitral valve area ≤1.5 cm², stage C) and valve morphology favorable for percutaneous mitral balloon commissurotomy in the absence of left atrial thrombus or moderate-to-severe MR who have new onset of AF. (Level of Evidence: C)

Percutaneous mitral balloon commissurotomy may be considered for symptomatic patients with mitral valve area greater than 1.5 cm² if there is evidence of hemodynamically significant MS based on pulmonary artery wedge pressure greater than 25 mm Hg or mean mitral valve gradient greater than 15 mm Hg during exercise. (Level of Evidence: C)

Percutaneous mitral balloon commissurotomy may be considered for severely symptomatic patients (NYHA class III to IV) with severe MS (mitral valve area ≤1.5 cm², stage D) who have a suboptimal valve anatomy and who are not candidates for surgery or at high risk for surgery. (Level of Evidence: C)

Concomitant mitral valve surgery may be considered for patients with moderate MS (mitral valve area 1.6 cm² to 2.0 cm²) undergoing cardiac surgery for other indications. (Level of Evidence: C)

Mitral valve surgery and excision of the left atrial appendage may be considered for patients with severe MS (mitral valve area ≤1.5 cm², stages C and D) who have had recurrent embolic events while receiving adequate anticoagulation. (Level of Evidence: C)

**Mitral Regurgitation**
Chronic Primary MR

**Diagnosis and Follow-up**

**Diagnostic Testing–Initial Diagnosis**

**Class I**

TTE is indicated for baseline evaluation of LV size and function, right ventricular (RV) function and left atrial size, pulmonary artery pressure, and mechanism and severity of primary MR (stages A to D) in any patient suspected of having chronic primary MR (Zoghbi et al., 2003; Enriquez-Sarano et al., 2005; Rosenhek et al., 2006; Recusani et al., 1991; Bargiggia et al., 1991; Rivera et al., 1992; Crawford et al., 1990; Enriquez-Sarano et al., “Echocardiographic prediction of survival,” 1994; Tribouilloy et al., “Survival,” 2009; Grigioni et al., 2008; Ghoreishi et al., 2011; Rozich et al., 1992; Tribouilloy et al., 1999; Pflugfelder et al., 1989; Pu et al., 2001; Pu et al., 1996; Lang et al., 2012; Witkowski et al., 2013; Magne et al., 2012). *(Level of Evidence: B)*

CMR is indicated in patients with chronic primary MR to assess LV and RV volumes, function, or MR severity and when these issues are not satisfactorily addressed by TTE (Pflugfelder et al., 1989; Ozdogan et al., 2009; Myerson, Francis, & Neubauer, 2010). *(Level of Evidence: B)*

Intraoperative TEE is indicated to establish the anatomic basis for chronic primary MR (stages C and D) and to guide repair (Dahm et al., 1987; Saiki et al., 1998). *(Level of Evidence: B)*

TEE is indicated for evaluation of patients with chronic primary MR (stages B to D) in whom noninvasive imaging provides nondiagnostic information about severity of MR, mechanism of MR, and/or status of LV function. *(Level of Evidence: C)*

**Diagnostic Testing–Exercise Testing**

**Class IIa**

Exercise hemodynamics with either Doppler echocardiography or cardiac catheterization is reasonable in symptomatic patients with chronic primary MR where there is a discrepancy between symptoms and the severity of MR at rest (stages B and C) (Tischler et al., 1994; Magne et al., 2010). *(Level of Evidence: B)*

Exercise treadmill testing can be useful in patients with chronic primary MR to establish symptom status and exercise tolerance (stages B and C). *(Level of Evidence: C)*

**Medical Therapy**

**Class IIa**

Medical therapy for systolic dysfunction is reasonable in symptomatic patients with chronic primary MR (stage D) and LVEF less than 60% in whom surgery is not contemplated (Tsutsui et al., 1994; Varadarajan et al., 2008; Ahmed et al., 2012; Nemoto et al., 2002; Schon, 1994). *(Level of Evidence: B)*

**Class III: No Benefit**

Vasodilator therapy is not indicated for normotensive asymptomatic patients with chronic primary MR (stages B and C1) and normal systolic LV function (Schon, 1994; Tischler, Rowan, & LeWinter, 1998; Wisenbaugh et al., 1994; Dujardin et al., 2001; Harris, Aeppli, & Carey, 2005; Kizilbash et al., 1998). *(Level of Evidence: B)*

**Intervention**

**Class I**

Mitral valve surgery is recommended for symptomatic patients with chronic severe primary MR (stage D) and LVEF greater than 30% (Tribouilloy et al., 1999; Gillinov et al., 2010). *(Level of Evidence: B)*

Mitral valve surgery is recommended for asymptomatic patients with chronic severe primary MR and
LV dysfunction (LVEF 30% to 60% and/or LVESD ≥40 mm, stage C2) (Crawford et al., 1990; Enriquez-Sarano et al., Echocardiographic assessment of survival," 1994; Tribouilloy et al., "Survival," 2009; Grigioni et al., 2008; Grigioni et al., 1999; Schuler et al., 1979; Starling, 1995). (Level of Evidence: B)

Mitral valve repair is recommended in preference to MVR when surgical treatment is indicated for patients with chronic severe primary MR limited to the posterior leaflet (Gammie et al., 2009; Rozich et al., 1992; Rushmer, 1956; Hansen et al., 1989; Sarris et al., 1988; Goldman et al., 1987; David et al., 1984; Hennein et al., 1990; Cohn, 1988; Cosgrove et al., 1986; "STS online risk calculator," 2013; David et al., 1983; Horskotte et al., 1993; Vassileva et al., 2013; Braunberger et al., 2001; David et al., 2005; McClure et al., 2013). (Level of Evidence: B)

Mitral valve repair is recommended in preference to mitral valve replacement (MVR) when surgical treatment is indicated for patients with chronic severe primary MR involving the anterior leaflet or both leaflets when a successful and durable repair can be accomplished (Bolling et al., 2010; Braunberger et al., 2001; David et al., 2005; McClure et al., 2013; Chikwe et al., 2011; Badhwar et al., 2012; Grossi et al., 1998; Chauvaud et al., 2001). (Level of Evidence: B)

Concomitant mitral valve repair or MVR is indicated in patients with chronic severe primary MR undergoing cardiac surgery for other indications (Gillinov et al., 2003). (Level of Evidence: B)

Class IIa

Mitral valve repair is reasonable in asymptomatic patients with chronic severe primary MR (stage C1) with preserved LV function (LVEF >60% and LVESD <40 mm) in whom the likelihood of a successful and durable repair without residual MR is greater than 95% with an expected mortality rate of less than 1% when performed at a Heart Valve Center of Excellence (Rosenhek et al., 2006; Bolling et al., 2010; Kang et al., 2009; Gillinov et al., 2008; Duran et al., 1994; Suri et al., 2013; Suri et al., 2009). (Level of Evidence: B)

Mitral valve repair is reasonable for asymptomatic patients with chronic severe nonrheumatic primary MR (stage C1) and preserved LV function (LVEF >60% and LVESD <40 mm) in whom there is a high likelihood of a successful and durable repair with 1) new onset of AF or 2) resting pulmonary hypertension (pulmonary artery systolic arterial pressure >50 mm Hg) (Ghoreishi et al., 2011; Kang et al., 2009; Ngaage et al., 2007; Raine, Dark, & Bourke, 2004; Cox, 1991; Kobayashi et al., 1996; Kawaguchi et al., 1996; Olasinska-Wisniewska et al., 2012). (Level of Evidence: B)

Concomitant mitral valve repair is reasonable in patients with chronic moderate primary MR (stage B) when undergoing cardiac surgery for other indications. (Level of Evidence: C)

Class IIb

Mitral valve surgery may be considered in symptomatic patients with chronic severe primary MR and LVEF less than or equal to 30% (stage D). (Level of Evidence: C)

Mitral valve repair may be considered in patients with rheumatic mitral valve disease when surgical treatment is indicated if a durable and successful repair is likely or when the reliability of long-term anticoagulation management is questionable (Bolling et al., 2010; Vassileva et al., 2013; Chauvaud et al., 2001). (Level of Evidence: B)

Transcatheter mitral valve repair may be considered for severely symptomatic patients (NYHA class III to IV) with chronic severe primary MR (stage D) who have favorable anatomy for the repair procedure and a reasonable life expectancy but who have a prohibitive surgical risk because of severe comorbidities and remain severely symptomatic despite optimal GDMT for HF (Feldman et al., 2011). (Level of Evidence: B)

Class III: Harm

MVR should not be performed for the treatment of isolated severe primary MR limited to less than one half of the posterior leaflet unless mitral valve repair has been attempted and was unsuccessful (Gammie et al., 2009; Braunberger et al., 2001; David et al., 2005; McClure et al., 2013). (Level of Evidence: B)

Chronic Secondary MR
Diagnosis and Follow-up

Class I

TTE is useful to establish the etiology of chronic secondary MR (stages B to D) and the extent and location of wall motion abnormalities and to assess global LV function, severity of MR, and magnitude of pulmonary hypertension. (Level of Evidence: C)

Noninvasive imaging (stress nuclear/positron emission tomography, CMR, or stress echocardiography), cardiac CT angiography, or cardiac catheterization, including coronary arteriography, is useful to establish etiology of chronic secondary MR (stages B to D) and/or to assess myocardial viability, which in turn may influence management of functional MR. (Level of Evidence: C)

Medical Therapy

Class I

Patients with chronic secondary MR (stages B–D) and HF with reduced LVEF should receive standard GDMT therapy for HF, including ACE inhibitors, ARBs, beta blockers, and/or aldosterone antagonists as indicated (Rowe et al., 1960; "Effect of enalapril," 1992; Granger et al., 2003; Eriksson et al., 1994; Pitt et al., 1999; Krum et al., 2003). (Level of Evidence: A)

Cardiac resynchronization therapy with biventricular pacing is recommended for symptomatic patients with chronic severe secondary MR (stages B–D) who meet the indications for device therapy (St John Sutton et al., 2003; van Bommel et al., 2011). (Level of Evidence: A)

Intervention

Class IIa

Mitral valve surgery is reasonable for patients with chronic severe secondary MR (stages C and D) who are undergoing CABG or AVR. (Level of Evidence: C)

Class IIb

Mitral valve repair or replacement may be considered for severely symptomatic patients (NYHA class III–IV) with chronic severe secondary MR (stage D) who have persistent symptoms despite optimal GDMT for HF (Grigioni et al., 2001; Lancellotti, Gerard, & Pierard, 2005; Trichon et al., 2003; Rossi et al., 2011; Fattouch et al., 2009; Mihaljevic et al., 2007; Wu et al., 2005; Harris et al., 2002; Benedetto et al., 2009; Deja et al., 2012; Cohn et al., 1995; Chan et al., 2012). (Level of Evidence: B)

Mitral valve repair may be considered for patients with chronic moderate secondary MR (stage B) who are undergoing other cardiac surgery. (Level of Evidence: C)

Tricuspid Valve Disease

Tricuspid Regurgitation

Diagnosis and Follow-up

Class I

TTE is indicated to evaluate severity of TR, determine etiology, measure sizes of right-sided chambers and inferior vena cava, assess RV systolic function, estimate pulmonary artery systolic pressure, and characterize any associated left-sided heart disease. (Level of Evidence: C)

Class IIa

Invasive measurement of pulmonary artery pressures and pulmonary vascular resistance can be useful in patients with TR when clinical and noninvasive data regarding their values are discordant.
CMR or real-time 3-dimensional (3D) echocardiography may be considered for assessment of RV systolic function and systolic and diastolic volumes in patients with severe TR (stages C and D) and suboptimal 2-dimensional (2D) echocardiograms. (Level of Evidence: C)

Exercise testing may be considered for the assessment of exercise capacity in patients with severe TR with no or minimal symptoms (stage C). (Level of Evidence: C)

Medical Therapy

Diuretics can be useful for patients with severe TR and signs of right-sided HF (stage D). (Level of Evidence: C)

Medical therapies to reduce elevated pulmonary artery pressures and/or pulmonary vascular resistance might be considered in patients with severe functional TR (stages C and D). (Level of Evidence: C)

Intervention

Tricuspid valve surgery is recommended for patients with severe TR (stages C and D) undergoing left-sided valve surgery. (Level of Evidence: C)

Tricuspid valve repair can be beneficial for patients with mild, moderate, or greater functional TR (stage B) at the time of left-sided valve surgery with either 1) tricuspid annular dilation or 2) prior evidence of right HF (Dreyfus et al., 2005; Van de Veire et al., 2011; Benedetto et al., 2012; Chan et al., 2009; Calafiore et al., 2009; Di Mauro et al., 2009; Yilmaz et al., 2011; Calafiore et al., 2011; Navia et al., 2012; Kim et al., 2012). (Level of Evidence: B)

Tricuspid valve surgery can be beneficial for patients with symptoms due to severe primary TR that are unresponsive to medical therapy (stage D). (Level of Evidence: C)

Tricuspid valve repair may be considered for patients with moderate functional TR (stage B) and pulmonary artery hypertension at the time of left-sided valve surgery. (Level of Evidence: C)

Tricuspid valve surgery may be considered for asymptomatic or minimally symptomatic patients with severe primary TR (stage C) and progressive degrees of moderate or greater RV dilation and/or systolic dysfunction. (Level of Evidence: C)

Reoperation for isolated tricuspid valve repair or replacement may be considered for persistent symptoms due to severe TR (stage D) in patients who have undergone previous left-sided valve surgery and who do not have severe pulmonary hypertension or significant RV systolic dysfunction. (Level of Evidence: C)

Reoperation for isolated tricuspid valve repair or replacement may be considered for persistent symptoms due to severe TR (stage D) in patients who have undergone previous left-sided valve surgery and who do not have severe pulmonary hypertension or significant RV systolic dysfunction. (Level of Evidence: C)

Tricuspid Stenosis (TS)

Diagnosis and Follow-up

TTE is indicated in patients with TS to assess the anatomy of the valve complex, evaluate severity of stenosis, and characterize any associated regurgitation and/or left-sided valve disease. (Level of
Evidence: C)

Class IIb

Invasive hemodynamic assessment of severity of TS may be considered in symptomatic patients when clinical and noninvasive data are discordant. (Level of Evidence: C)

Intervention

Class I

Tricuspid valve surgery is recommended for patients with severe TS at the time of operation for left-sided valve disease. (Level of Evidence: C)
Tricuspid valve surgery is recommended for patients with isolated, symptomatic severe TS. (Level of Evidence: C)

Class IIb

Percutaneous balloon tricuspid commissurotomy might be considered in patients with isolated, symptomatic severe TS without accompanying TR. (Level of Evidence: C)

Prosthetic Valves

Evaluation and Selection of Prosthetic Valves

Diagnosis and Follow-up

Class I

An initial TTE study is recommended in patients after prosthetic valve implantation for evaluation of valve hemodynamics (Burstow et al., 1989; Baumgartner et al., 1992; Vandervoort et al., 1995; Dumesnil et al., 1990). (Level of Evidence: B)
Repeat TTE is recommended in patients with prosthetic heart valves if there is a change in clinical symptoms or signs suggesting valve dysfunction. (Level of Evidence: C)
TEE is recommended when clinical symptoms or signs suggest prosthetic valve dysfunction. (Level of Evidence: C)

Class IIa

Annual TTE is reasonable in patients with a bioprosthetic valve after the first 10 years, even in the absence of a change in clinical status. (Level of Evidence: C)

Intervention

Class I

The choice of valve intervention, that is, repair or replacement, as well as type of prosthetic heart valve, should be a shared decision-making process that accounts for the patient's values and preferences, with full disclosure of the indications for and risks of anticoagulant therapy and the potential need for and risk of reoperation. (Level of Evidence: C)
A bioprosthesis is recommended in patients of any age for whom anticoagulant therapy is contraindicated, cannot be managed appropriately, or is not desired. (Level of Evidence: C)

Class IIa

A mechanical prosthesis is reasonable for AVR or MVR in patients less than 60 years of age who do not have a contraindication to anticoagulation (Hammermeister et al., 2000; Badhwar et al., 2012; Weber et al., 2012). (Level of Evidence: B)
A bioprosthesis is reasonable in patients more than 70 years of age (Banbury et al., 2002; Dellgren et al., 2002; Borger et al., 2006; Myken & Bech-Hansen, 2009). (Level of Evidence: B)
Either a bioprosthetic or mechanical valve is reasonable in patients between 60 and 70 years of age
(Oxenham et al., 2003; Stassano et al., 2009). (Level of Evidence: B)

Class IIb

Replacement of the aortic valve by a pulmonary autograft (the Ross procedure), when performed by an experienced surgeon, may be considered in young patients when VKA anticoagulation is contraindicated or undesirable. (Level of Evidence: C)

Antithrombotic Therapy for Prosthetic Valves

Medical Therapy

Class I

Anticoagulation with a VKA and international normalized ratio (INR) monitoring is recommended in patients with a mechanical prosthetic valve (Cannegieter, Rosendaal, & Briet, 1994; Stein et al., 2001; Schlitt et al., 2003). (Level of Evidence: A)

Anticoagulation with a VKA to achieve an INR of 2.5 is recommended in patients with a mechanical AVR (bileaflet or current-generation single tilting disc) and no risk factors for thromboembolism (Torella et al., 2010; Hering et al., 2005; Acar et al., 1996). (Level of Evidence: B)

Anticoagulation with a VKA is indicated to achieve an INR of 3.0 in patients with a mechanical AVR and additional risk factors for thromboembolic events (AF, previous thromboembolism, LV dysfunction, or hypercoagulable conditions) or an older-generation mechanical AVR (such as ball-in-cage) (Horstkotte, Scharf, & Schultheiss, 1995). (Level of Evidence: B)

Anticoagulation with a VKA is indicated to achieve an INR of 3.0 in patients with a mechanical MVR (Horstkotte, Scharf, & Schultheiss, 1995; Pruefer, Dahm, & Dohmen, 2001). (Level of Evidence: B)

Aspirin 75 mg to 100 mg daily is recommended in addition to anticoagulation with a VKA in patients with a mechanical valve prosthesis (Meschengieser et al., 1997; Turpie et al., 1993). (Level of Evidence: A)

Class IIa

Aspirin 75 mg to 100 mg per day is reasonable in all patients with a bioprosthetic aortic or mitral valve (Heras et al., 1995; Colli et al., 2007; Aramendi et al., 2005; Nunez et al., 1984). (Level of Evidence: B)

Anticoagulation with a VKA is reasonable for the first 3 months after bioprosthetic MVR or repair to achieve an INR of 2.5 (Russo et al., 2008). (Level of Evidence: C)

Class IIb

Anticoagulation, with a VKA, to achieve an INR of 2.5 may be reasonable for the first 3 months after bioprosthetic AVR (Merie et al., 2012). (Level of Evidence: B)

Clopidogrel 75 mg daily may be reasonable for the first 6 months after TAVR in addition to life-long aspirin 75 mg to 100 mg daily. (Level of Evidence: C)

Class III: Harm

Anticoagulant therapy with oral direct thrombin inhibitors or anti-Xa agents should not be used in patients with mechanical valve prostheses ("FDA Drug Safety Communication," 2012; Van de Werf et al., 2012; Eikelboom et al., 2013). (Level of Evidence: B)

Bridging Therapy for Prosthetic Valves

Medical Therapy

Class I

Continuation of VKA anticoagulation with a therapeutic INR is recommended in patients with mechanical heart valves undergoing minor procedures (such as dental extractions or cataract removal) where bleeding is easily controlled. (Level of Evidence: C)
Temporary interruption of VKA anticoagulation, without bridging agents while the INR is subtherapeutic, is recommended in patients with a bileaflet mechanical AVR and no other risk factors for thrombosis who are undergoing invasive or surgical procedures. (Level of Evidence: C)

Bridging anticoagulation with either intravenous unfractionated heparin (UFH) or subcutaneous low-molecular-weight heparin (LMWH) is recommended during the time interval when the INR is subtherapeutic preoperatively in patients who are undergoing invasive or surgical procedures with a 1) mechanical AVR and any thromboembolic risk factor, 2) older-generation mechanical AVR, or 3) mechanical MVR. (Level of Evidence: C)

Class IIa

Administration of fresh frozen plasma or prothrombin complex concentrate is reasonable in patients with mechanical valves receiving VKA therapy who require emergency noncardiac surgery or invasive procedures. (Level of Evidence: C)

Excessive Anticoagulation and Serious Bleeding with Prosthetic Valves

Class IIa

Administration of fresh frozen plasma or prothrombin complex concentrate is reasonable in patients with mechanical valves and uncontrollable bleeding who require reversal of anticoagulation (Weibert et al., 1997; Yiu et al., 2006). (Level of Evidence: B)

Prosthetic Valve Thrombosis

Diagnosis and Follow-up

Class I

TTE is indicated in patients with suspected prosthetic valve thrombosis to assess hemodynamic severity and follow resolution of valve dysfunction (Barbetseas et al., 1998; Tong et al., 2004). (Level of Evidence: B)

TEE is indicated in patients with suspected prosthetic valve thrombosis to assess thrombus size and valve motion (Tong et al., 2004; Roudaut, Serri, & Lafitte, 2007; Deviri et al., 1991). (Level of Evidence: B)

Class IIa

Fluoroscopy or CT is reasonable in patients with suspected valve thrombosis to assess valve motion. (Level of Evidence: C)

Medical Therapy

Class IIa

Fibrinolytic therapy is reasonable for patients with a thrombosed left-sided prosthetic heart valve, recent onset (<14 days) of NYHA class I to II symptoms, and a small thrombus (<0.8 cm²) (Tong et al., 2004; Roudaut et al., 2003). (Level of Evidence: B)

Fibrinolytic therapy is reasonable for thrombosed right-sided prosthetic heart valves (Keuleers et al., 2011; Caceres-Loriga et al., 2006). (Level of Evidence: B)

Intervention

Class I

Emergency surgery is recommended for patients with a thrombosed left-sided prosthetic heart valve with NYHA class III to IV symptoms (Roudaut et al., 2009; Keuleers et al., 2011; Karthikeyan et al., 2013). (Level of Evidence: B)

Class IIa
Emergency surgery is reasonable for patients with a thrombosed left-sided prosthetic heart valve with a mobile or large thrombus (>0.8 cm$^2$) (Tong et al., 2004; Deviri et al., 1991; Roudaut et al., 2009). (*Level of Evidence: C*)

Prosthetic Valve Stenosis

*Intervention*

**Class I**

Repeat valve replacement is indicated for severe symptomatic prosthetic valve stenosis. (*Level of Evidence: C*)

Prosthetic Valve Regurgitation

*Intervention*

**Class I**

Surgery is recommended for operable patients with mechanical heart valves with intractable hemolysis or HF due to severe prosthetic or paraprosthetic regurgitation (Miller et al., 1995; Akins et al., 2005). (*Level of Evidence: B*)

**Class IIa**

Surgery is reasonable for operable patients with severe symptomatic or asymptomatic bioprosthetic regurgitation. (*Level of Evidence: C*)

Percutaneous repair of paravalvular regurgitation is reasonable in patients with prosthetic heart valves and intractable hemolysis or NYHA class III/IV HF who are at high risk for surgery and have anatomic features suitable for catheter-based therapy when performed in centers with expertise in the procedure (Sorajja et al., "Percutaneous," 2011; Ruiz et al., 2011; Sorajja et al., "Long-term," 2011). (*Level of Evidence: B*)

Infective Endocarditis

*Diagnosis and Follow-up*

**Class I**

At least 2 sets of blood cultures should be obtained in patients at risk for IE (e.g., those with congenital or acquired VHD, previous IE, prosthetic heart valves, certain congenital or heritable heart malformations, immunodeficiency states, or injection drug users) who have unexplained fever for more than 48 hours (Lopez et al., 2013) (*Level of Evidence: B*) or patients with newly diagnosed left-sided valve regurgitation. (*Level of Evidence: C*)

The Modified Duke Criteria should be used in evaluating a patient with suspected IE (see Tables 24 and 25 in the original guideline document) (Durack, Lukes, & Bright, 1994; Kupferwasser et al., 2001; Li et al., 2000; Perez-Vazquez et al., 2000). (*Level of Evidence: B*)

Patients with IE should be evaluated and managed with consultation of a multispecialty Heart Valve Team including an infectious disease specialist, cardiologist, and cardiac surgeon. In surgically managed patients, this team should also include a cardiac anesthesiologist (Botelho-Nevers et al., 2009). (*Level of Evidence: B*)

TTE is recommended in patients with suspected IE to identify vegetations, characterize the hemodynamic severity of valvular lesions, assess ventricular function and pulmonary pressures, and detect complications (Mugge et al., 1989; Burger et al., 1991; Irani, Grayburn, & Afridi, 1996; Liu et al., 2009; Kemp, Citrin, & Byrd, 1999). (*Level of Evidence: B*)

TEE is recommended in all patients with known or suspected IE when TTE is nondiagnostic, when complications have developed or are clinically suspected, or when intracardiac device leads are present (Erbel et al., 1988; Daniel et al., 1991; Sochowski & Chan, 1993; Shively et al., 1991; Pedersen et al., 1991; Ronderos et al., 2004; Roe et al., 2000; Karalis et al., 1992; El-Ahdab et al., 2004).
TTE and/or TEE are recommended for re-evaluation of patients with IE who have a change in clinical signs or symptoms (e.g., new murmur, embolism, persistent fever, HF, abscess, or atrioventricular heart block) and in patients at high risk of complications (e.g., extensive infected tissue/large vegetation on initial echocardiogram or staphylococcal, enterococcal, fungal infections) (Rohmann et al., 1991; Mylonakis & Calderwood, 2001). (Level of Evidence: B)

Intraoperative TEE is recommended for patients undergoing valve surgery for IE (Shapira et al., 2007; Yao et al., 2009). (Level of Evidence: B)

**Class IIa**

TEE is reasonable to diagnose possible IE in patients with *Staphylococcal aureus* (*S. aureus*) bacteremia without a known source (Watanakunakorn, 1994; Abraham et al., 2004; Kaasch et al., 2011). (Level of Evidence: B)

TEE is reasonable to diagnose IE of a prosthetic valve in the presence of persistent fever without bacteremia or a new murmur (San Martin et al., 2010; Knudsen et al., 2011). (Level of Evidence: B)

Cardiac CT is reasonable to evaluate morphology/anatomy in the setting of suspected paravalvular infections when the anatomy cannot be clearly delineated by echocardiography (Fagman et al., 2012; Feuchtner et al., 2009; Gahide et al., 2010; Lentini et al., 2009). (Level of Evidence: B)

**Class IIb**

TEE might be considered to detect concomitant staphylococcal IE in nosocomial *S. aureus* bacteremia with a known portal of entry from an extracardiac source (Rasmussen et al., 2011; Fowler et al., 1997; Sullenberger, Avedissian, & Kent, 2005). (Level of Evidence: B)

**Medical Therapy**

**Class I**

Appropriate antibiotic therapy should be initiated and continued after blood cultures are obtained with guidance from antibiotic sensitivity data and infectious disease consultants (Lopez et al., 2013). (Level of Evidence: B)

**Class IIa**

It is reasonable to temporarily discontinue anticoagulation in patients with IE who develop central nervous system symptoms compatible with embolism or stroke regardless of the other indications for anticoagulation (Masuda et al., 1992; Tornos et al., 1999; Carpenter & McAllister, 1983; Lieberman et al., 1978; Wilson et al., 1978; Ananthasubramaniam et al., 2001). (Level of Evidence: B)

**Class IIb**

Temporary discontinuation of VKA anticoagulation might be considered in patients receiving VKA anticoagulation at the time of IE diagnosis (Tornos et al., 1999; Pruitt et al., 1978; Chan et al., 2008; Fang et al., 2007; Rasmussen et al., 2009). (Level of Evidence: B)

**Class III: Harm**

Patients with known VHD should not receive antibiotics before blood cultures are obtained for unexplained fever. (Level of Evidence: C)

**Intervention**

**Class I**

Decisions about timing of surgical intervention should be made by a multispecialty Heart Valve Team of cardiology, cardiothoracic surgery, and infectious disease specialists (Botelho-Nevers et al., 2009). (Level of Evidence: B)

Early surgery (during initial hospitalization before completion of a full therapeutic course of
antibiotics) is indicated in patients with IE who present with valve dysfunction resulting in symptoms of HF (Jault et al., 1997; Hasbun et al., 2003; Kiefer et al., 2011; Tomos et al., 1992; Gordon et al., 2000; Wang et al., 2007). *(Level of Evidence: B)*

Early surgery (during initial hospitalization before completion of a full therapeutic course of antibiotics) is indicated in patients with left-sided IE caused by *S. aureus*, fungal, or other highly resistant organisms (Wang et al., 2007; Remadi et al., 2007; Hill et al., "Infective," 2007; Aksoy et al., 2007; Ellis et al., 2001; Wolff et al., 1995; Chirouze et al., 2004; Melgar et al., 1997). *(Level of Evidence: B)*

Early surgery (during initial hospitalization before completion of a full therapeutic course of antibiotics) for IE is indicated in patients with evidence of persistent infection as manifested by persistent bacteremia or fevers lasting longer than 5 to 7 days after onset of appropriate antimicrobial therapy (Wang et al., 2007; Wolff et al., 1995; Chirouze et al., 2004; Klieverik et al., 2009; Hill et al., "Abscess," 2007; Manne et al., 2012). *(Level of Evidence: B)*

Surgery is recommended for patients with prosthetic valve endocarditis (PVE) and relapsing infection (defined as recurrence of bacteremia after a complete course of appropriate antibiotics and subsequently negative blood cultures) without other identifiable source for portal of infection. *(Level of Evidence: C)*

Complete removal of pacemaker or defibrillator systems, including all leads and the generator, is indicated as part of the early management plan in patients with IE with documented infection of the device or leads (Sohail et al., 2008; Athan et al., 2012; Rundstrom et al., 2004; Ho et al., 2010). *(Level of Evidence: B)*

*Class IIa*

Complete removal of pacemaker or defibrillator systems, including all leads and the generator, is reasonable in patients with valvular IE caused by *S. aureus* or fungi, even without evidence of device or lead infection (Sohail et al., 2008; Athan et al., 2012; Rundstrom et al., 2004; Ho et al., 2010). *(Level of Evidence: B)*

Complete removal of pacemaker or defibrillator systems, including all leads and the generator, is reasonable in patients undergoing valve surgery for valvular IE. *(Level of Evidence: C)*

Early surgery (during initial hospitalization before completion of a full therapeutic course of antibiotics) is reasonable in patients with IE who present with recurrent emboli and persistent vegetations despite appropriate antibiotic therapy (Mugge et al., 1989; Thuny et al., 2005; Kang et al., 2012). *(Level of Evidence: B)*

*Class IIb*

Early surgery (during initial hospitalization before completion of a full therapeutic course of antibiotics) may be considered in patients with native valve endocarditis (NVE) who exhibit mobile vegetations greater than 10 mm in length (with or without clinical evidence of embolic phenomenon) (Mugge et al., 1989; Thuny et al., 2005; Kang et al., 2012). *(Level of Evidence: B)*

*Pregnancy and VHD*

*Native Valve Stenosis*

*Class I*

All patients with suspected valve stenosis should undergo a clinical evaluation and TTE before pregnancy. *(Level of Evidence: C)*

All patients with severe valve stenosis (stages C and D) should undergo prepregnancy counseling by a cardiologist with expertise in managing patients with VHD during pregnancy. *(Level of Evidence: C)*

All patients referred for a valve operation before pregnancy should receive prepregnancy counseling.
by a cardiologist with expertise in managing patients with VHD during pregnancy about the risks and benefits of all options for operative interventions, including mechanical prosthesis, bioprosthesis, and valve repair. (Level of Evidence: C)

Pregnant patients with severe valve stenosis (stages C and D) should be monitored in a tertiary care center with a dedicated Heart Valve Team of cardiologists, surgeons, anesthesiologists, and obstetricians with expertise in the management of high-risk cardiac patients during pregnancy. (Level of Evidence: C)

**Diagnosis and Follow-up**

**Class IIa**

Exercise testing is reasonable in asymptomatic patients with severe AS (aortic velocity ≥4.0 m per second or mean pressure gradient ≥40 mm Hg, stage C) before pregnancy. (Level of Evidence: C)

**Medical Therapy**

**Class I**

Anticoagulation should be given to pregnant patients with MS and AF unless contraindicated. (Level of Evidence: C)

**Class IIa**

Use of beta blockers as required for rate control is reasonable for pregnant patients with MS in the absence of contraindication if tolerated. (Level of Evidence: C)

**Class IIb**

Use of diuretics may be reasonable for pregnant patients with MS and HF symptoms (stage D). (Level of Evidence: C)

**Class III: Harm**

ACE inhibitors and ARBs should not be given to pregnant patients with valve stenosis (Schaefer, 2003; Cooper et al., 2006; Shotan et al., 1994). (Level of Evidence: B)

**Intervention**

**Class I**

Valve intervention is recommended before pregnancy for symptomatic patients with severe AS (aortic velocity ≥4.0 m per second or mean pressure gradient ≥40 mm Hg, stage D). (Level of Evidence: C)

Valve intervention is recommended before pregnancy for symptomatic patients with severe MS (mitral valve area ≤1.5 cm², stage D). (Level of Evidence: C)

Percutaneous mitral balloon commissurotomy is recommended before pregnancy for asymptomatic patients with severe MS (mitral valve area ≤1.5 cm², stage C) who have valve morphology favorable for percutaneous mitral balloon commissurotomy. (Level of Evidence: C)

**Class IIa**

Valve intervention is reasonable before pregnancy for asymptomatic patients with severe AS (aortic velocity ≥4.0 m per second or mean pressure gradient ≥40 mm Hg, stage C). (Level of Evidence: C)

Percutaneous mitral balloon commissurotomy is reasonable for pregnant patients with severe MS (mitral valve area ≤1.5 cm², stage D) with valve morphology favorable for percutaneous mitral balloon commissurotomy who remain symptomatic with NYHA class III to IV HF symptoms despite medical therapy (Abouzied et al., 2001; Ben Farhat et al., 1997; de Souza et al., 2001; Glantz et al., 1993; Jung et al., 1994). (Level of Evidence: B)

Valve intervention is reasonable for pregnant patients with severe MS (mitral valve area ≤1.5 cm²,
stage D) and valve morphology not favorable for percutaneous mitral balloon commissurotomy only if there are refractory NYHA class IV HF symptoms. (Level of Evidence: C)

Valve intervention is reasonable for pregnant patients with severe AS (mean pressure gradient ≥40 mm Hg, stage D) only if there is hemodynamic deterioration or NYHA class III to IV HF symptoms (Tzemos et al., 2009; Banning, Pearson, & Hall, 1993; Easterling et al., 1988; Lao et al., 1993; McIvor, 1991; Myerson et al., 2005; Tumelero et al., 2004). (Level of Evidence: B)

**Class III: Harm**

Valve operation should not be performed in pregnant patients with valve stenosis in the absence of severe HF symptoms. (Level of Evidence: C)

Native Valve Regurgitation

**Diagnosis and Follow-up**

**Class I**

All patients with suspected valve regurgitation should undergo a clinical evaluation and TTE before pregnancy. (Level of Evidence: C)

All patients with severe valve regurgitation (stages C and D) should undergo prepregnancy counseling by a cardiologist with expertise in managing patients with VHD during pregnancy. (Level of Evidence: C)

All patients referred for a valve operation before pregnancy should receive prepregnancy counseling by a cardiologist with expertise in managing patients with VHD during pregnancy regarding the risks and benefits of all options for operative interventions, including mechanical prosthesis, bioprosthesis, and valve repair. (Level of Evidence: C)

Pregnant patients with severe regurgitation (stages C and D) should be monitored in a tertiary care center with a dedicated Heart Valve Team of cardiologists, surgeons, anesthesiologists, and obstetricians with expertise in managing high-risk cardiac patients. (Level of Evidence: C)

**Class IIa**

Exercise testing is reasonable in asymptomatic patients with severe valve regurgitation (stage C) before pregnancy. (Level of Evidence: C)

**Medical Therapy**

**Class III: Harm**

ACE inhibitors and ARBs should not be given to pregnant patients with valve regurgitation (Schaefer, 2003; Cooper et al., 2006; Shotan et al., 1994). (Level of Evidence: B)

**Intervention**

**Class I**

Valve repair or replacement is recommended before pregnancy for symptomatic women with severe valve regurgitation (stage D). (Level of Evidence: C)

**Class IIa**

Valve operation for pregnant patients with severe valve regurgitation is reasonable only if there are refractory NYHA class IV HF symptoms (stage D). (Level of Evidence: C)

**Class IIb**

Valve repair before pregnancy may be considered in the asymptomatic patient with severe MR (stage C) and a valve suitable for valve repair, but only after detailed discussion with the patient about the risks and benefits of the operation and its outcome on future pregnancies. (Level of Evidence: C)
Class III: Harm

Valve operations should not be performed in pregnant patients with valve regurgitation in the absence of severe intractable HF symptoms. *(Level of Evidence: C)*

Prosthetic Valves in Pregnancy

Diagnosis and Follow-up

Class I

All patients with a prosthetic valve should undergo a clinical evaluation and baseline TTE before pregnancy. *(Level of Evidence: C)*

All patients with a prosthetic valve should undergo prepregnancy counseling by a cardiologist with expertise in managing patients with VHD during pregnancy. *(Level of Evidence: C)*

TTE should be performed in all pregnant patients with a prosthetic valve if not done before pregnancy. *(Level of Evidence: C)*

Repeat TTE should be performed in all pregnant patients with a prosthetic valve who develop symptoms. *(Level of Evidence: C)*

TEE should be performed in all pregnant patients with a mechanical prosthetic valve who have prosthetic valve obstruction or experience an embolic event. *(Level of Evidence: C)*

Pregnant patients with a mechanical prosthesis should be monitored in a tertiary care center with a dedicated Heart Valve Team of cardiologists, surgeons, anesthesiologists, and obstetricians with expertise in the management of high-risk cardiac patients. *(Level of Evidence: C)*

Medical Therapy

Class I

Therapeutic anticoagulation with frequent monitoring is recommended for all pregnant patients with a mechanical prosthesis (Chan, Anand, & Ginsberg, 2000; Meschengieser et al., 1999). *(Level of Evidence: B)*

Warfarin is recommended in pregnant patients with a mechanical prosthesis to achieve a therapeutic INR in the second and third trimesters (Abildgaard et al., 2009; McLintock, McCowan, & North, 2009; Oran, Lee-Parritz, & Ansell, 2004; Quinn et al., 2009; Sillesen et al., 2011; DeSanto et al., 2012). *(Level of Evidence: B)*

Discontinuation of warfarin with initiation of intravenous UFH (with an activated partial thromboplastin time [aPTT] >2 times control) is recommended before planned vaginal delivery in pregnant patients with a mechanical prosthesis. *(Level of Evidence: C)*

Low-dose aspirin (75 mg to 100 mg) once per day is recommended for pregnant patients in the second and third trimesters with either a mechanical prosthesis or bioprosthesis. *(Level of Evidence: C)*

Class IIa

Continuation of warfarin during the first trimester is reasonable for pregnant patients with a mechanical prosthesis if the dose of warfarin to achieve a therapeutic INR is 5 mg per day or less after full discussion with the patient about risks and benefits (Chan, Anand, & Ginsberg, 2000; Meschengieser et al., 1999; Sillesen et al., 2011; DeSanto et al., 2012; Salazar et al., 1996; Vitale, De Feo, & Cotrufo, 2002). *(Level of Evidence: B)*

Dose-adjusted LMWH at least 2 times per day (with a target anti-Xa level of 0.8 U/mL to 1.2 U/mL, 4 to 6 hours postdose) during the first trimester is reasonable for pregnant patients with a mechanical prosthesis if the dose of warfarin is greater than 5 mg per day to achieve a therapeutic INR (Abildgaard et al., 2009; McLintock, McCowan, & North, 2009; Oran, Lee-Parritz, & Ansell, 2004; Quinn et al., 2009; Rowan et al., 2001; James et al., 2006). *(Level of Evidence: B)*

Dose-adjusted continuous intravenous UFH (with an aPTT at least 2 times control) during the first trimester is reasonable for pregnant patients with a mechanical prosthesis if the dose of warfarin is greater than 5 mg per day to achieve a therapeutic INR (Chan, Anand, & Ginsberg, 2000;
Class IIb

Dose-adjusted LMWH at least 2 times per day (with a target anti-Xa level of 0.8 U/mL to 1.2 U/mL, 4 to 6 hours postdose) during the first trimester may be reasonable for pregnant patients with a mechanical prosthesis if the dose of warfarin is 5 mg per day or less to achieve a therapeutic INR (Abildgaard et al., 2009; McLintock, McCowan, & North, 2009; Oran, Lee-Parritz, & Ansell, 2004; Quinn et al., 2009; Rowan et al., 2001; James et al., 2006; Yinon et al., 2009). (Level of Evidence: B)

Dose-adjusted continuous infusion of UFH (with aPTT at least 2 times control) during the first trimester may be reasonable for pregnant patients with a mechanical prosthesis if the dose of warfarin is 5 mg per day or less to achieve a therapeutic INR (Chan, Anand, & Ginsberg, 2000; Meschengieser et al., 1999; Salazar et al., 1996). (Level of Evidence: B)

Class III: Harm

LMWH should not be administered to pregnant patients with mechanical prostheses unless anti-Xa levels are monitored 4 to 6 hours after administration (McLintock, McCowan, & North, 2009; Oran, Lee-Parritz, & Ansell, 2004; Ginsberg et al., 2003; Rowan et al., 2001; James et al., 2006). (Level of Evidence: B)

Surgical Considerations

Evaluation of Coronary Anatomy

Class I

Coronary angiography is indicated before valve intervention in patients with symptoms of angina, objective evidence of ischemia, decreased LV systolic function, history of CAD, or coronary risk factors (including men age >40 years and postmenopausal women). (Level of Evidence: C)

Coronary angiography should be performed as part of the evaluation of patients with chronic severe secondary MR. (Level of Evidence: C)

Class IIa

Surgery without coronary angiography is reasonable for patients having emergency valve surgery for acute valve regurgitation, disease of the aortic sinuses or ascending aorta, or IE. (Level of Evidence: C)

CT coronary angiography is reasonable to exclude the presence of significant obstructive CAD in selected patients with a low/intermediate pretest probability of CAD. A positive coronary CT angiogram (the presence of any epicardial CAD) is confirmed with invasive coronary angiography (American College of Cardiology Foundation Task Force on Expert Consensus Documents et al., 2010; Gilard et al., 2006; Manghat et al., 2006; Meijboom et al., 2006; Reant et al., 2006; Scheffel et al., 2007; Galas et al., 2012). (Level of Evidence: B)

Concomitant Procedures

Intervention for CAD

Class IIa

CABG or percutaneous coronary intervention (PCI) is reasonable in patients undergoing valve repair or replacement with significant CAD (≥70% reduction in luminal diameter in major coronary arteries or ≥50% reduction in luminal diameter in the left main coronary artery). (Level of Evidence: C)

Intervention for AF

Class IIa
A concomitant maze procedure is reasonable at the time of mitral valve repair or replacement for treatment of chronic, persistent AF. (Level of Evidence: C)

A full biatrial maze procedure, when technically feasible, is reasonable at the time of mitral valve surgery, compared with a lesser ablation procedure, in patients with chronic, persistent AF (Doukas et al., 2005; Blomstrom-Lundqvist et al., 2007). (Level of Evidence: B)

**Class IIb**

A concomitant maze procedure or pulmonary vein isolation may be considered at the time of mitral valve repair or replacement in patients with paroxysmal AF that is symptomatic or associated with a history of embolism on anticoagulation. (Level of Evidence: C)

Concomitant maze procedure or pulmonary vein isolation may be considered at the time of cardiac surgical procedures other than mitral valve surgery in patients with paroxysmal or persistent AF that is symptomatic or associated with a history of emboli on anticoagulation. (Level of Evidence: C)

**Class III: No Benefit**

Catheter ablation for AF should not be performed in patients with severe MR when mitral repair or replacement is anticipated, with preference for the combined maze procedure plus mitral valve repair (Liu et al., 2010). (Level of Evidence: B)

**Noncardiac Surgery in Patients with VHD**

**Intervention**

**Class IIa**

Moderate-risk elective noncardiac surgery with appropriate intraoperative and postoperative hemodynamic monitoring is reasonable to perform in patients with asymptomatic severe AS (Agarwal et al., 2013; Zahid et al., 2005; Torsher et al., 1998; Calleja et al., 2010). (Level of Evidence: B)

Moderate-risk elective noncardiac surgery with appropriate intraoperative and postoperative hemodynamic monitoring is reasonable to perform in patients with asymptomatic severe MR. (Level of Evidence: C)

Moderate-risk elective noncardiac surgery with appropriate intraoperative and postoperative hemodynamic monitoring is reasonable to perform in patients with asymptomatic severe AR and a normal LVEF. (Level of Evidence: C)

**Class IIb**

Moderate-risk elective noncardiac surgery in patients with appropriate intraoperative and postoperative hemodynamic monitoring may be reasonable to perform in asymptomatic patients with severe MS if valve morphology is not favorable for percutaneous balloon mitral commissurotomy. (Level of Evidence: C)

**Definitions:**

Applying Classification of Recommendations and Level of Evidence

<table>
<thead>
<tr>
<th>Size of Treatment Effect</th>
<th>CLASS I Benefit &gt;&gt;&gt; Risk Procedure/Treatment SHOULD be performed/administered</th>
<th>CLASS IIa Benefit &gt;&gt; Risk Additional studies with focused objectives needed IT IS REASONABLE to perform procedure/administer treatment</th>
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<td>CDR III: No Benefit</td>
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<td>Harmful to patients</td>
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<p>| Estimate of Certainty (Precision) of LEVEL A Multiple populations Recommendation that procedure or treatment is useful/effective Recommendation in favor of treatment or procedure being Recommendation's usefulness/efficacy less well established Recommendation that procedure or treatment is not useful/effective and may be harmful |</p>
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<th>Treatment Effect</th>
<th>Size of Treatment Effect</th>
<th>Sufficient evidence from meta-analyses or randomized trials</th>
<th>USEFUL/EFFECTIVE</th>
<th>SOME conflicting evidence</th>
<th>GREATER conflicting evidence</th>
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<td>LEVEL B</td>
<td>Data derived from multiple randomized trials or meta-analyses</td>
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<tr>
<td>Evaluated*</td>
<td>LEVEL C</td>
<td>Recommendation that procedure or treatment is useful/effective Evidence from single randomized trial or nonrandomized studies</td>
<td>Recommendation that procedure or treatment is useful/effective Only expert opinion, case studies, or standard of care</td>
<td>Recommendation in favor of treatment or procedure being useful/effective Only diverging expert opinion, case studies, or standard of care</td>
<td>Recommendation that procedure or treatment is not useful/effective and may be harmful</td>
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</table>

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. Although randomized trials are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as sex, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use.

**Clinical Algorithm(s)**

The following algorithms are provided in the original guideline document:

- Indications for AVR in Patients with AS
- Indications for AVR for Chronic AR
- Indications for Intervention for Rheumatic MS
- Indications for Surgery for MR
- Indications for Surgery
- Anticoagulation for Prosthetic Valves
- Evaluation and Management of Suspected Prosthetic Valve Thrombosis
- Diagnosis and Treatment of IE
- Anticoagulation of Pregnant Patients with Mechanical Valves
- Evaluation and Management of CAD in Patients Undergoing Valve Surgery

**Scope**

**Disease/Condition(s)**

Valvular heart disease (VHD) and associated disorders:

- Aortic stenosis (AS)
- Aortic regurgitation (AR)
- Bicuspid aortic valve and aortopathy
- Mitral stenosis (MS)
- Mitral regurgitation (MR)
- Tricuspid valve disease
- Prosthetic valve thrombosis, stenosis, and regurgitation
- Infective endocarditis (IE)
- VHD during pregnancy
Guideline Category
Diagnosis
Evaluation
Management
Prevention
Risk Assessment
Treatment

Clinical Specialty
Anesthesiology
Cardiology
Critical Care
Emergency Medicine
Family Practice
Internal Medicine
Obstetrics and Gynecology
Radiology
Thoracic Surgery

Intended Users
Advanced Practice Nurses
Physician Assistants
Physicians

Guideline Objective(s)
- To assist clinicians in clinical decision making by describing a range of generally acceptable approaches to the diagnosis, management, and prevention of valvular heart disease (VHD) and related disorders
- To define practices that meet the needs of most patients in most circumstances
- To provide the clinician with concise, evidence-based, contemporary recommendations and the supporting documentation to encourage their use

Target Population
Adult patients with suspected or confirmed valvular heart disease (VHD)

Note: Management of patients with congenital heart disease and infants and children with valve disease are not addressed in this guideline.
Interventions and Practices Considered

Diagnosis/Evaluation

- Transthoracic echocardiography (TTE)
- Cardiac catheterization for hemodynamic assessment
- Transesophageal echocardiography (TEE)
- Aortic magnetic resonance angiography (MRA) or computed tomography angiography (CTA)
- Noninvasive imaging (stress nuclear/positron emission tomography, cardiac magnetic resonance [CMR] imaging, or stress echocardiography)
- Exercise testing/stress testing
- Invasive measurement of pulmonary artery pressures and pulmonary vascular resistance for tricuspid regurgitation (TR)
- Blood cultures and modified Duke criteria for infective endocarditis (IE)
- Evaluation by Heart Valve Team

Management/Treatment

General
- Secondary prevention of rheumatic fever
- IE prophylaxis
- Referral to Heart Valve Center of Excellence

Aortic stenosis (AS)
- Medical therapy for hypertension
- Vasodilator therapy
- Statin therapy (not recommended)
- Aortic valve replacement (AVR; surgical or transcatheter approach)

Aortic regurgitation (AR)
- Medical therapy for hypertension: dihydropyridine calcium channel blockers or angiotensin-converting enzyme (ACE) inhibitors/angiotensin-receptor blockers (ARBs)
- AVR: timing of intervention
- Aortic valve repair in selected patients

Bicuspid aortic valve and aortopathy: operative intervention to repair the aortic sinuses or replace the ascending aorta

Mitral stenosis (MS)
- Anticoagulation (vitamin K antagonist [VKA] or heparin)
- Medical therapy for heart rate control
- Mitral valve surgery: repair, percutaneous mitral balloon commissurotomy, or valve replacement
- Excision of left atrial appendage

Mitral regurgitation (MR)
- Medical therapy for systolic dysfunction/heart failure
- Cardiac resynchronization therapy
- Vasodilator therapy (not recommended)
- Mitral valve surgery: repair or replacement

Tricuspid regurgitation
- Diuretics
- Tricuspid valve repair or replacement

Tricuspid stenosis
- Tricuspid valve surgery
- Percutaneous balloon tricuspid commissurotomy

Prosthetic valves
- Choice of valve intervention: repair or replacement
- Choice of prosthetic heart valve: bioprosthesis or mechanical valve
- Pulmonary autograft
- Antithrombotic therapy for prosthetic valve (VKA with international normalized ratio [INR])
monitoring, aspirin, clopidogrel)
Bridging therapy for prosthetic valves
Management of excessive anticoagulation and serious bleeding (fresh frozen plasma, prothrombin complex concentrate)
Management of prosthetic valve thrombosis (emergency surgery, fibrinolysis)
Management of prosthetic valve stenosis (repeat valve replacement)
Management of prosthetic valve regurgitation (surgery)

Infective endocarditis
  Appropriate antibiotic therapy
  Temporary discontinuation of anticoagulation therapy
  Surgical intervention
  Removal of pacemaker or defibrillator systems

Pregnancy and valvular heart disease (VHD)
  Clinical evaluation and TTE before pregnancy
  Prepregnancy counseling concerning risks and benefits of operative interventions
  Management and monitoring by dedicated Heart Valve Team
  Exercise testing
  Medical therapy: anticoagulation, beta-blockers, diuretics, avoidance of ACE inhibitors and ARBs
  Valve interventions before and during pregnancy
  Discontinuation of warfarin and initiation of unfractionated heparin (UFH) before delivery
  Use of low-molecular-weight heparin (LMWH) with mechanical prosthesis with monitoring of anti-Xa levels

Surgical considerations
  Coronary evaluation prior to valve surgery (coronary angiography, coronary CT angiography)
  Valve surgery with or without coronary artery bypass graft (CABG) or percutaneous coronary intervention (PCI)
  Interventions for atrial fibrillation: concomitant maze procedure or pulmonary vein isolation at the time of mitral valve surgery
  Noncardiac surgery with appropriate intraoperative and postoperative hemodynamic monitoring

Major Outcomes Considered

- Sensitivity and specificity of tests for evaluating heart valve disorders
- Functional status (New York Heart Association)
- Progression rate
- Exercise tolerance
- Mortality/death
- Survival rate
- Restenosis rate
- Freedom from reoperation
- Freedom from recurrent valve disease
- Valve-related complications

Methodology

Methods Used to Collect/Select the Evidence

Searches of Electronic Databases

Description of Methods Used to Collect/Select the Evidence
An extensive review was conducted on literature published through November 2012, and other selected references through October 2013 were reviewed by the guideline writing committee. Searches were extended to studies, reviews, and other evidence conducted on human subjects and that were published in English from PubMed, EMBASE, Cochrane, Agency for Healthcare Research and Quality Reports, and other selected databases relevant to this guideline. Key search words included but were not limited to the following: valvular heart disease, aortic stenosis, aortic regurgitation, bicuspid aortic valve, mitral stenosis, mitral regurgitation, tricuspid stenosis, tricuspid regurgitation, pulmonic stenosis, pulmonic regurgitation, prosthetic valves, anticoagulation therapy, infective endocarditis, cardiac surgery, and transcatheter aortic valve replacement. Additionally, the committee reviewed documents related to the subject matter previously published by the American College of Cardiology (ACC) and American Heart Association (AHA). The references selected and published in this document are representative and not all-inclusive.

Number of Source Documents
Not stated

Methods Used to Assess the Quality and Strength of the Evidence
Weighting According to a Rating Scheme (Scheme Given)

Rating Scheme for the Strength of the Evidence
Applying Classification of Recommendations and Level of Evidence

<table>
<thead>
<tr>
<th>Size of Treatment Effect</th>
<th>CLASS I Benefit &gt;&gt; Risk Procedure/Treatment SHOULD be performed/administered</th>
<th>CLASS IIa Benefit &gt;&gt; Risk Additional studies with focused objectives needed IT IS REASONABLE to perform procedure/administer treatment</th>
<th>CLASS IIb Benefit ≥ Risk Additional studies with broad objectives needed; additional registry data would be helpful Procedure/Treatment MAY BE CONSIDERED</th>
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<tr>
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Estimate of Certainty (Precision) of Treatment Effect

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<tr>
<th>LEVEL A</th>
<th>Multiple populations evaluated* Data derived from multiple randomized clinical trials or meta-analyses</th>
<th>Recommendation that procedure or treatment is useful/effective Sufficient evidence from multiple randomized trials or meta-analyses</th>
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<td>LEVEL B</td>
<td>Limited populations evaluated* Data derived from a single randomized trial or nonrandomized studies</td>
<td>Recommendation that procedure or treatment is useful/effective Evidence from single randomized trial or nonrandomized studies</td>
<td>Recommendation in favor of treatment or procedure being useful/effective Some conflicting evidence from single randomized trial or nonrandomized studies</td>
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<tr>
<td>LEVEL C</td>
<td>Very limited populations evaluated* Only consensus opinion of experts, case studies, or standard of care</td>
<td>Recommendation that procedure or treatment is useful/effective Only expert opinion, case studies, or standard of care</td>
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*Data available from clinical trials or registries about the usefulness/efficacy in different subpopulations, such as sex, age, history of diabetes, history of prior myocardial infarction, history of heart failure, and prior aspirin use.

Methods Used to Analyze the Evidence

Review of Published Meta-Analyses

Systematic Review with Evidence Tables

Description of the Methods Used to Analyze the Evidence

In analyzing the data and developing recommendations and supporting text, the writing committee uses evidence-based methodologies developed by the Task Force. The Level of Evidence (LOE) is an estimate of the certainty or precision of the treatment effect. The writing committee reviews and ranks evidence supporting each recommendation, with the weight of evidence ranked as LOE A, B, or C, according to specific definitions that are included in the "Rating Scheme for the Strength of the Evidence" field. Studies are identified as observational, retrospective, prospective, or randomized where appropriate.

Methods Used to Formulate the Recommendations

Expert Consensus

Description of Methods Used to Formulate the Recommendations

Experts in the subject under consideration are selected from both the American College of Cardiology (ACC) and the American Heart Association (AHA) to examine subject-specific data and write guidelines. Writing committees are specifically charged with performing a literature review; weighing the strength of evidence for or against particular tests, treatments, or procedures; and including estimates of expected health outcomes where such data exist. Patient-specific modifiers, comorbidities, and issues of patient preference that may influence the choice of tests or therapies are considered, as well as frequency of follow-up and cost effectiveness. When available, information from studies on cost is considered; however, a review of data on efficacy and outcomes constitutes the primary basis for preparing recommendations in this guideline.

In analyzing the data and developing recommendations and supporting text, the writing committee uses evidence-based methodologies developed by the Task Force. The Class of Recommendation (COR) is an estimate of the size of the treatment effect, with consideration given to risks versus benefits, as well as evidence and/or agreement that a given treatment or procedure is or is not useful/effective or in some situations may cause harm. The writing committee reviews and ranks evidence supporting each recommendation, with the weight of evidence ranked as Level of Evidence (LOE) A, B, or C, according to specific definitions that are included in the "Rating Scheme for the Strength of the Evidence" field. Studies are identified as observational, retrospective, prospective, or randomized, as appropriate. For certain conditions for which inadequate data are available, recommendations are based on expert consensus and clinical experience and are ranked as LOE C. When recommendations at LOE C are supported by historical clinical data, appropriate references (including clinical reviews) are cited if available. For issues with sparse available data, a survey of current practice among the clinician members of the writing committee is the basis for LOE C recommendations and no references are cited.

A new addition to this methodology is separation of the Class III recommendations to delineate whether the recommendation is determined to be of "no benefit" or is associated with "harm" to the patient. In addition, in view of the increasing number of comparative effectiveness studies, comparator verbs and
suggested phrases for writing recommendations for the comparative effectiveness of one treatment or strategy versus another are included for COR I and IIa, LOE A or B only.

In view of the advances in medical therapy across the spectrum of cardiovascular diseases, the Task Force has designated the term guideline-directed medical therapy (GDMT) to represent optimal medical therapy as defined by ACC/AHA guideline (primarily Class I)-recommended therapies. This new term, GDMT, is used herein and throughout subsequent guidelines.

Because the ACC/AHA practice guidelines address patient populations (and clinicians) residing in North America, drugs that are not currently available in North America are discussed in the text without a specific COR. For studies performed in large numbers of subjects outside North America, each writing committee reviews the potential impact of different practice patterns and patient populations on the treatment effect and relevance to the ACC/AHA target population to determine whether the findings should inform a specific recommendation.

Organization of the Writing Committee

The committee was composed of clinicians, who included cardiologists, interventionalists, surgeons, and anesthesiologists. The committee also included representatives from the American Association for Thoracic Surgery, American Society of Echocardiography (ASE), Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons (STS).

Rating Scheme for the Strength of the Recommendations

See the "Rating Scheme for the Strength of the Evidence" field.

Cost Analysis

The guideline developers reviewed published cost analyses.

Method of Guideline Validation

External Peer Review

Internal Peer Review

Description of Method of Guideline Validation

The document was reviewed by 2 official reviewers each nominated by both the American College of Cardiology (ACC) and the American Heart Association (AHA), as well as 1 reviewer each from the American Association for Thoracic Surgery, American Society of Echocardiography (ASE), Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, Society of Thoracic Surgeons (STS), and 39 individual content reviewers (which included representatives from the following ACC committees and councils: Adult Congenital and Pediatric Cardiology Section, Association of International Governors, Council on Clinical Practice, Cardiovascular Section Leadership Council, Geriatric Cardiology Section Leadership Council, Heart Failure and Transplant Council, Interventional Council, Lifelong Learning Oversight Committee, Prevention of Cardiovascular Disease Committee, and Surgeon Council).

This document was approved for publication by the governing bodies of the ACC and AHA and endorsed by the American Association for Thoracic Surgery, ASE, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and STS.
Evidence Supporting the Recommendations

References Supporting the Recommendations


Ananthasubramaniam K, Beattie JN, Rosman HS, Jayam V, Borzak S. How safely and for how long can warfarin therapy be withheld in prosthetic heart valve patients hospitalized with a major hemorrhage?. Chest. 2001 Feb;119(2):478-84. PubMed

Anguera I, Miro JM, Vilacosta I, Almirante B, Anguita M, Muñoz P, Roman JA, de Alarcon A, Ripoll T,


Di Mauro M, Bivona A, IacÃ² AL, Contini M, Gagliardi M, Varone E, Gallina S, Calafiore AM. Mitral valve


FDA Drug Safety Communication: Pradaxa (dabigatran etexilate mesylate) should not be used in patients with mechanical prosthetic heart valves. [internet]. U.S. Food and Drug Administration (FDA); 2012 [accessed 2014 Feb 20].


Leavitt JI, Coats MH, Falk RH. Effects of exercise on transmitral gradient and pulmonary artery pressure


Ngaage DL, Schaff HV, Mullany CJ, Barnes S, Dearani JA, Daly RC, Orszulak TA, Sundt TM. Influence of preoperative atrial fibrillation on late results of mitral repair: is concomitant ablation justified?. Ann


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<td>Sohail MR, Uslan DZ, Khan AH, Friedman PA, Hayes DL, Wilson WR, Steckelberg JM, Jenkins SM,</td>
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Trichon BH, Felker GM, Shaw LK, Cabell CH, O'Connor CM. Relation of frequency and severity of mitral regurgitation to survival among patients with left ventricular systolic dysfunction and heart failure. Am J Cardiol. 2003 Mar 1;91(5):538-43. PubMed


Wilson WR, Geraci JE, Danielson GK, Thompson RL, Spittell JA, Washington JR, Giuliani ER. Anticoagulant therapy and central nervous system complications in patients with prosthetic valve...


Type of Evidence Supporting the Recommendations

The type of supporting evidence is identified and graded for each recommendation (see the "Major Recommendations" field).

Benefits/Harms of Implementing the Guideline Recommendations

Potential Benefits
Appropriate management of patients with valvular heart disease (VHD)

Potential Harms

- Peri-operative and post-operative morbidity and mortality, including side effects of anesthetic medications
- Short- and long-term complications of valve repair and replacement including thromboembolic risks
- Bleeding complications associated with anticoagulant therapy
- Side effects of cardiovascular drugs
- False-negative results of transesophageal echocardiography (TEE)
- Major complications can occur during pregnancy in patients with prosthetic valves. The increased hemodynamic burden of pregnancy can lead to heart failure if there is prosthetic valve thrombosis, stenosis, regurgitation, or patient-prosthesis mismatch. There is an increased risk for thrombosis of mechanical valves due to the hypercoagulable state of pregnancy.

Contraindications

Contraindications

- Intra-aortic balloon counterpulsation is contraindicated in patients with acute severe aortic regurgitation (AR).
- Cardiac magnetic resonance imaging is contraindicated in patients with implanted devices.
- The presence of either severe and uncorrectable pulmonary hypertension or significant right ventricular (RV) dysfunction constitutes a relative contraindication to reoperation for isolated tricuspid valve repair or replacement.
- Aspirin intolerance or history of bleeding is a contraindication to use of aspirin in combination with a vitamin K antagonist (VKA).
- The U.S. Food and Drug Administration (FDA) has issued a specific contraindication for use of dabigatran in patients with mechanical heart valves.
- Angiotensin-converting enzyme (ACE) inhibitors and angiotensin-receptor blockers (ARBs) are contraindicated during pregnancy due to fetal toxicity, including renal or tubular dysplasia, oligohydramnios, growth retardation, ossification disorders of the skull, lung hypoplasia, and intrauterine fetal death.
- Macrolide antibiotics should not be used in persons taking other medications that inhibit cytochrome
P450 3A, such as azole antifungal agents, human immunodeficiency virus (HIV) protease inhibitors, and some selective serotonin reuptake inhibitors.

Qualifying Statements

Because the American College of Cardiology (ACC)/American Heart Association (AHA) practice guidelines address patient populations (and clinicians) residing in North America, drugs that are not currently available in North America are discussed in the text without a specific class of recommendation (COR). For studies performed in large numbers of subjects outside North America, each writing committee reviews the potential impact of different practice patterns and patient populations on the treatment effect and relevance to the ACC/AHA target population to determine whether the findings should inform a specific recommendation.

The ACC/AHA practice guidelines are intended to assist clinicians in clinical decision making by describing a range of generally acceptable approaches to the diagnosis, management, and prevention of specific diseases or conditions. The guidelines attempt to define practices that meet the needs of most patients in most circumstances. The ultimate judgment about care of a particular patient must be made by the clinician and patient in light of all the circumstances presented by that patient. As a result, situations may arise in which deviations from these guidelines may be appropriate. Clinical decision making should involve consideration of the quality and availability of expertise in the area where care is provided. When these guidelines are used as the basis for regulatory or payer decisions, the goal should be improvement in quality of care. The Task Force recognizes that situations arise in which additional data are needed to inform patient care more effectively; these areas are identified within each respective guideline when appropriate.

Prescribed courses of treatment in accordance with these recommendations are effective only if followed. Because lack of patient understanding and adherence may adversely affect outcomes, clinicians should make every effort to engage the patient’s active participation in prescribed medical regimens and lifestyles. In addition, patients should be informed of the risks, benefits, and alternatives to a particular treatment and should be involved in shared decision making whenever feasible, particularly for COR IIa and IIb, for which the benefit-to-risk ratio may be lower.

Implementation of the Guideline

Description of Implementation Strategy

An implementation strategy was not provided.

Implementation Tools

Clinical Algorithm

Quick Reference Guides/Physician Guides

Resources

Slide Presentation

For information about availability, see the Availability of Companion Documents and Patient Resources fields below.
Institute of Medicine (IOM) National Healthcare Quality Report Categories

IOM Care Need
Getting Better
Living with Illness
Staying Healthy

IOM Domain
Effectiveness
Patient-centeredness

Identifying Information and Availability

Bibliographic Source(s)


Adaptation
Not applicable: The guideline was not adapted from another source.

Date Released
1998 Nov 1 (revised 2014 June 10)

Guideline Developer(s)
American College of Cardiology Foundation - Medical Specialty Society
American Heart Association - Professional Association

Source(s) of Funding
The American College of Cardiology and the American Heart Association

Guideline Committee
American College of Cardiology/American Heart Association Task Force on Practice Guidelines
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Guideline Endorser(s)

American Association for Thoracic Surgery - Medical Specialty Society
American Society of Echocardiography - Professional Association
Society for Cardiovascular Angiography and Interventions - Medical Specialty Society
Society of Cardiovascular Anesthesiologists - Medical Specialty Society
Society of Thoracic Surgeons - Medical Specialty Society

Guideline Status

This is the current release of the guideline.


Guideline Availability

Available from the Journal of the American College of Cardiology (JACC) Web site and from the Circulation Web site.

Print copies: Available from the American College of Cardiology, 2400 N Street NW, Washington DC, 20037; (800) 253-4636 (US only).

Availability of Companion Documents

The following are available:


Methodology manual and policies from the ACCF/AHA Task Force on Practice Guidelines. 2010 Jun. 88
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