Table 1. ACC/AHA Applying Class of Recommendation and Level of Evidence to Clinical Strategies, Interventions, Treatments, or Diagnostic Testing in Patient Care (Updated May 2019)*

<table>
<thead>
<tr>
<th>CLASS (STRENGTH) OF RECOMMENDATION</th>
<th>Benefit &gt;&gt;&gt; Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
</tr>
<tr>
<td>• Is recommended</td>
<td></td>
</tr>
<tr>
<td>• Is indicated/useful/effective/beneficial</td>
<td></td>
</tr>
<tr>
<td>• Should be performed/administered/other</td>
<td></td>
</tr>
<tr>
<td>• Comparative-Effectiveness Phrases†:</td>
<td></td>
</tr>
<tr>
<td>- Treatment/strategy A is recommended/indicated in preference to treatment B</td>
<td></td>
</tr>
<tr>
<td>- Treatment A should be chosen over treatment B</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL (QUALITY) OF EVIDENCE‡</th>
<th>LEVEL A</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High-quality evidence‡ from more than 1 RCT</td>
<td></td>
</tr>
<tr>
<td>• Meta-analyses of high-quality RCTs</td>
<td></td>
</tr>
<tr>
<td>• One or more RCTs corroborated by high-quality registry studies</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS 2a (MODERATE)</th>
<th>Benefit &gt;&gt; Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
</tr>
<tr>
<td>• Is reasonable</td>
<td></td>
</tr>
<tr>
<td>• Can be useful/effective/beneficial</td>
<td></td>
</tr>
<tr>
<td>• Comparative-Effectiveness Phrases†:</td>
<td></td>
</tr>
<tr>
<td>- Treatment/strategy A is probably recommended/indicated in preference to treatment B</td>
<td></td>
</tr>
<tr>
<td>- It is reasonable to choose treatment A over treatment B</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL B-R</th>
<th>(Randomized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Moderate-quality evidence‡ from 1 or more RCTs</td>
<td></td>
</tr>
<tr>
<td>• Meta-analyses of moderate-quality RCTs</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS 2b (Weak)</th>
<th>Benefit ≥ Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
</tr>
<tr>
<td>• May/might be reasonable</td>
<td></td>
</tr>
<tr>
<td>• May/might be considered</td>
<td></td>
</tr>
<tr>
<td>• Usefulness/effectiveness is unknown/unclear/uncertain or not well-established</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL B-NR</th>
<th>(Nonrandomized)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Moderate-quality evidence‡ from 1 or more well-designed, well-executed nonrandomized studies, observational studies, or registry studies</td>
<td></td>
</tr>
<tr>
<td>• Meta-analyses of such studies</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS 3: No Benefit (MODERATE)</th>
<th>Benefit = Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
</tr>
<tr>
<td>• Is not recommended</td>
<td></td>
</tr>
<tr>
<td>• Is not indicated/useful/effective/beneficial</td>
<td></td>
</tr>
<tr>
<td>• Should not be performed/administered/other</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL C-LD</th>
<th>(Limited Data)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Randomized or nonrandomized observational or registry studies with limitations of design or execution</td>
<td></td>
</tr>
<tr>
<td>• Meta-analyses of such studies</td>
<td></td>
</tr>
<tr>
<td>• Physiological or mechanistic studies in human subjects</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CLASS 3: Harm (STRONG)</th>
<th>Risk &gt; Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suggested phrases for writing recommendations:</td>
<td></td>
</tr>
<tr>
<td>• Potentially harmful</td>
<td></td>
</tr>
<tr>
<td>• Causes harm</td>
<td></td>
</tr>
<tr>
<td>• Associated with excess morbidity/mortality</td>
<td></td>
</tr>
<tr>
<td>• Should not be performed/administered/other</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>LEVEL C-EO</th>
<th>(Expert Opinion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Consensus of expert opinion based on clinical experience.</td>
<td></td>
</tr>
</tbody>
</table>

COR and LOE are determined independently (any COR may be paired with any LOE).

A recommendation with LOE C does not imply that the recommendation is weak. Many important clinical questions addressed in guidelines do not lend themselves to clinical trials. Although RCTs are unavailable, there may be a very clear clinical consensus that a particular test or therapy is useful or effective.

*The outcome or result of the intervention should be specified (an improved clinical outcome or increased diagnostic accuracy or incremental prognostic information).

†For comparative-effectiveness recommendation (COR 1 and 2a; LOE A and B only), studies that support the use of comparator verbs should involve direct comparisons of the treatments or strategies being evaluated.

‡The method of assessing quality is evolving, including the application of standardized, widely used, and preferably validated evidence grading tools; and for systematic reviews, the incorporation of an Evidence Review Committee. COR indicates Class of Recommendation; EO, expert opinion; LD, limited data; LOE, Level of Evidence; NR, nonrandomized; R, randomized, and RCT, randomized controlled trial.
Evaluation of the Patient With Known or Suspected Native VHD

**Initial Diagnosis**

- **History & Physical**
  - VHD Presence & Severity
  - Co-morbidities
  - Heart Failure
- **ECG & CXR**
  - Rhythm
  - LV Function
  - Hypertrophy
- **TTE**
  - Concurrent Valvular Disorders
  - Associated Abnormalities
  - LV Function & Anatomy
- **Hemodynamics**
  - CW & PW Doppler
  - Flow Reversal
  - PA Systolic Pressure
  - RV Size
- **Regurgitant Lesions**
  - Regurgitant orifice area
  - Regurgitant volume
  - Regurgitant fraction

**Stenotic Lesions**

- Maximum velocity
- Mean gradient
- Valve area

**Abbreviations:** CW indicates continuous wave; LV, left ventricle; PASP, pulmonary artery systolic pressure; PW, pulsed wave; RV, right ventricle; TTE, transthoracic echocardiography; and VHD, valvular heart disease.
Table 3. Additional Diagnostic Evaluation in VHD

<table>
<thead>
<tr>
<th>Test</th>
<th>Description</th>
</tr>
</thead>
</table>
| Chest X-Ray       | • Important for symptomatic patient  
                     • Establishes heart size  
                     • Presence or absence of pulmonary vascular congestion, intrinsic lung disease, calcification of aorta & pericardium |
| TEE               | Provides high-quality assessment of mitral and prosthetic valve, including definition of intracardiac masses & possible associated abnormalities |
| CMR               | • Provides assessment of LV volumes and function, valve severity, and aortic dilation  
                     • Quantitation of aortic regurgitant severity in selected cases. |
| PET-CT            | Aids in determination of active infection or inflammation                     |
| Cardiac Catheterization | Provides measurement of intracardiac and pulmonary pressures, valve severity, and hemodynamic response to exercise & drugs |
| Exercise Testing  | • Gives an objective measure of exercise capacity  
                     • Identifies patients at high risk |

Pre-procedural Testing Required Before Valve Intervention

- **Dental examination**: Rules out potential infection sources
- **CT coronary or invasive coronary angiogram**: Gives an assessment of coronary anatomy
- **CT: Peripheral**: Assesses femoral access for TAVI and other transcatheter procedures
- **CT: Cardiac**: Assesses suitability for TAVI and other transcatheter procedures

Abbreviations: CW indicates continuous wave; LV, left ventricle; PASP, pulmonary artery systolic pressure; PW, pulsed wave; RV, right ventricle; TTE, transthoracic echocardiography; and VHD, valvular heart disease.
<table>
<thead>
<tr>
<th>STAGE</th>
<th>DEFINITION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>At Risk</td>
<td>Patients with risk factors for development of VHD</td>
</tr>
<tr>
<td>B</td>
<td>Progressive</td>
<td>Patients with progressive VHD (mild to moderate severity and asymptomatic)</td>
</tr>
<tr>
<td>C</td>
<td>Asymptomatic Severe</td>
<td>Asymptomatic patients who have the criteria for severe VHD:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C1: Asymptomatic patients with severe VHD in whom the LV or RV remains compensated</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• C2: Asymptomatic patients with severe VHD with decompensation of the LV or RV</td>
</tr>
<tr>
<td>D</td>
<td>Symptomatic Severe</td>
<td>Patients who have developed symptoms as a result of VHD</td>
</tr>
</tbody>
</table>

Abbreviations: C1 indicates stage C1; C2; stage C2; LV, left ventricle; RV, right ventricle; and VHD, valvular heart disease.
## Table 5. Frequency of Echocardiograms in Asymptomatic Patients With VHD and Normal LV Function

<table>
<thead>
<tr>
<th></th>
<th>Aortic Stenosis *</th>
<th>Aortic Regurgitation</th>
<th>Mitral Stenosis</th>
<th>Mitral Regurgitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Progressive (Stage B)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Every 3–5 y (mild severity; Vmax 2.0–2.9 m/s)</td>
<td>Every 3–5 y (mild severity)</td>
<td>Every 3–5 y (MV area &gt;1.5 cm²)</td>
<td>Every 3–5 y (mild severity)</td>
</tr>
<tr>
<td></td>
<td>Every 1–2 y moderate severity; Vmax 3.0–3.9 m/s)</td>
<td>Every 1–2 y (moderate severity)</td>
<td>(MV area &gt;1.5 cm²)</td>
<td>Every 1–2 y (moderate severity)</td>
</tr>
<tr>
<td>Severe asymptomatic (Stage C1)</td>
<td>Every 6–12 mo (Vmax ≥4 m/s)</td>
<td>Every 6–12 mo</td>
<td>Every 1–2 y (MV area 1.0–1.5 cm²)</td>
<td>Every 6–12 months</td>
</tr>
<tr>
<td></td>
<td>Dilating LV: More frequently</td>
<td></td>
<td>Every year (MV area &lt;1.0 cm²)</td>
<td>Dilating LV: More frequently</td>
</tr>
</tbody>
</table>

Patients with mixed valve disease may require serial evaluations at intervals earlier than recommended for single-valve lesions. These intervals apply to most patients with each valve lesion and do not take into consideration the etiology of the valve disease. *With normal stroke volume. Stages C2 and D disease are not included in this table because they would be considered candidates for intervention.

Abbreviations: CMR indicates cardiac magnetic resonance; LV, left ventricle; mo, month; m/s, milliseconds; MV, mitral valve; STS, Society of Thoracic Surgeons; TAVI, transcatheter aortic valve implantation; TTE, transthoracic echocardiography; VHD, valvular heart disease; y, year; Vmax, maximum transvalvular velocity.
Recommended Treatment Regimens & Duration of Secondary Prophylaxis

**Table 6. Secondary Prevention of Rheumatic Fever**

<table>
<thead>
<tr>
<th>Type</th>
<th>Duration After Last Attack (whichever is longer)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rheumatic fever with carditis AND persistent VHD (clinical or echo)</td>
<td>10 years Until patient is 40 years of age</td>
</tr>
<tr>
<td>Rheumatic fever with carditis BUT NO VHD</td>
<td>10 years Until patient is 21 years of age</td>
</tr>
<tr>
<td>Rheumatic fever WITHOUT carditis</td>
<td>5 years Until patient is 21 years of age</td>
</tr>
</tbody>
</table>

**Table 7. Duration of Secondary Prophylaxis for Rheumatic Fever**

<table>
<thead>
<tr>
<th>Antibiotics for Prevention</th>
<th>Dosage *</th>
</tr>
</thead>
<tbody>
<tr>
<td>Penicillin G benzathine</td>
<td>1.2 million U IM q4 weeks†</td>
</tr>
<tr>
<td>Penicillin V potassium</td>
<td>200 mg orally twice daily</td>
</tr>
<tr>
<td>Sulfadiazine</td>
<td>1 gram orally once daily</td>
</tr>
<tr>
<td>Macrolide or azalide antibiotic (for patients allergic to penicillin and sulfadiazine) ‡</td>
<td>Varies</td>
</tr>
</tbody>
</table>

*In patients with documented valvular heart disease, the duration of rheumatic fever prophylaxis should be ≥10 y or until the patient is 40 y of age (whichever is longer). Lifelong prophylaxis may be recommended if the patient is at high risk of group A streptococcus exposure. Secondary rheumatic heart disease prophylaxis is required even after valve replacement. †Administration every 3 week is recommended in certain high-risk situations. ‡Macrolide antibiotics should not be used in persons taking other medications that inhibit cytochrome P450 3A, such as azole antifungal agents, HIV protease inhibitors, and some selective serotonin reuptake inhibitors.

Abbreviations: IM indicates intramuscular; mg; milligrams; Q; every; RHD, rheumatic heart disease; U; units; and VHD, valvular heart disease.
# Classification of Recommendations for RHD & IE

<table>
<thead>
<tr>
<th></th>
<th>Secondary Prevention of Rheumatic Fever</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In patients with rheumatic heart disease, secondary prevention of rheumatic fever is indicated.</td>
</tr>
</tbody>
</table>

## Infective Endocarditis Prophylaxis

<table>
<thead>
<tr>
<th></th>
<th>Antibiotic prophylaxis is reasonable before dental procedures that involve manipulation of gingival tissue, manipulation of the periapical region of teeth, or perforation of the oral mucosa in patients with VHD when:</th>
</tr>
</thead>
</table>
| 2a | • Prosthetic cardiac valves, including transcatheter prostheses and homograft  
• Prosthetic material used for cardiac valve repair (annuloplasty rings, chords, or clips)  
• Previous infective endocarditis  
• Unrepaired cyanotic congenital heart disease or repaired congenital heart disease, with residual shunts or valvular regurgitation at the site of or adjacent to the site of a prosthetic patch or prosthetic device  
• Cardiac transplant with valve regurgitation attributable to a structurally abnormal valve |

## No Benefit

|   | Antibiotic prophylaxis is not recommended for nondental procedures in the absence of active infection. Examples ➔ Transesophageal echocardiogram, esophagogastroduodenoscopy, colonoscopy, or cystoscopy |

**Abbreviations:** IE indicates infective endocarditis; RHD, rheumatic heart disease; VHD valvular heart disease.
* In patients with mechanical heart valves with or without AF who require long-term anticoagulation with VKA to prevent valve thrombosis, NOACs are not recommended. Class 3:Harm.

Abbreviations: AF indicates atrial fibrillation; CHA2DS2-VASc score, congestive heart failure, hypertension, age ≥ 75 years, diabetes mellitus, stroke or transient ischemic attack (TIA), vascular disease, age 65 to 74 years, sex category, MS, mitral stenosis; NOAC, non-vitamin K oral anticoagulant; VHD, valvular heart disease; and VKA, vitamin K antagonist.
Management of Patients with VHD After Valve Intervention

### Periodic Assessment is Needed

#### Procedural Complications
- Post Op AF
- Stroke
- Bleeding
- Vascular Complications
- Pericarditis

#### Patient Management
- Evaluate and treat patients with CAD risk factors according to guidelines
- Encourage heart healthy lifestyle behaviors
- Endocarditis prophylaxis
- Periodic imaging

#### If Symptoms After Valve Intervention:
- Assess valve function
- Evaluate and treat concurrent cardiac and non-cardiac conditions
- For VKA anticoagulation, review INR

**Abbreviations:** 1̊ indicates primary; 2̊, secondary; AF, atrial fibrillation; CAD, coronary artery disease; INR, international normalized ratio; Op, operative; VHD, valvular heart disease; and VKA, vitamin K antagonist.

# Imaging After Valve Intervention

<table>
<thead>
<tr>
<th>Valve Intervention</th>
<th>Minimal Imaging Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bicuspid Aortic Valve Replacement</strong></td>
<td>Continue monitoring if post aortic valve replacement aortic diameter ≥4 cm</td>
</tr>
<tr>
<td><strong>SURGICAL</strong></td>
<td></td>
</tr>
<tr>
<td>Mechanical Valve</td>
<td>Baseline</td>
</tr>
<tr>
<td>Bioprosthetic Valve</td>
<td>Baseline, 5 &amp; 10 years post surgery, then annually</td>
</tr>
<tr>
<td>Mitral Valve Repair</td>
<td>Baseline, 1 year, then every 2 to 3 years</td>
</tr>
<tr>
<td><strong>TRANSCATHETER</strong></td>
<td></td>
</tr>
<tr>
<td>Bioprosthetic Valve</td>
<td>Baseline, then annually</td>
</tr>
<tr>
<td>Mitral Valve Repair</td>
<td>Baseline, then annually</td>
</tr>
</tbody>
</table>

**Abbreviations:** cm indicates centimeters; LV, left ventricle; and PA, pulmonary artery.
Table 13. The Evaluation and Management of Aortic Stenosis

<table>
<thead>
<tr>
<th>STAGE</th>
<th>VALVE ANATOMY</th>
<th>VALVE HEMODYNAMICS</th>
<th>SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>• Bicuspid aortic valve or other congenital valve anomaly</td>
<td>• Aortic $V_{\text{max}} &lt; 2$ m/s with normal leaflet motion</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>• Aortic valve sclerosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td>• Mild to moderate leaflet calcification</td>
<td>• Mild AS: $V_{\text{max}} 2 - 2.9$ m/s or mean $\Delta P &lt; 20$ mmHg</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>• Fibrosis of a bicuspid or trileaflet valve with reduction in systolic motion</td>
<td>• Moderate AS: $V_{\text{max}} 3 - 3.9$ m/s or mean $\Delta P 20 - 39$ mmHg</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rheumatic valve changes with commissural fusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>C</td>
<td>• C1: Asymptomatic severe AS</td>
<td>• C1 and C2: $V_{\text{max}} \geq 4$ m/s or mean $\Delta P \geq 40$ mmHg, AVA typically $\leq 1$ cm$^2$ (or AVAi 0.6 cm$^2$/m$^2$) but not required to define severe AS</td>
<td>C1: None; exercise testing reasonable to confirm symptom status</td>
</tr>
<tr>
<td></td>
<td>• C2: Asymptomatic severe AS with left ventricular systolic dysfunction (LVEF &lt;50%)</td>
<td>• Very severe AS: $V_{\text{max}} \geq 5$ m/s or mean $\Delta P \geq 60$ mmHg</td>
<td>C2: None</td>
</tr>
<tr>
<td></td>
<td>• Both C1 and C2 may show:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Severe leaflet calcification/fibrosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Congenital stenosis with severely reduced leaflet opening</td>
<td></td>
<td></td>
</tr>
<tr>
<td>D</td>
<td>• D1: Symptomatic severe high-gradient AS</td>
<td>• D1: $V_{\text{max}} \geq 4$ m/s or mean $\Delta P \geq 40$ mmHg, AVA typically $\leq 1$ cm$^2$ (or AVAi 0.6 cm$^2$/m$^2$) but may be larger with mixed AS/AR</td>
<td>Exertional dyspnea, angina, syncope or presyncope, heart failure, exercise intolerance</td>
</tr>
<tr>
<td></td>
<td>• D2: Symptomatic severe low-flow low-gradient AS with reduced LVEF (&lt;50%)</td>
<td>• D2: AVA $\leq 1$ cm$^2$ with $V_{\text{max}} &lt; 4$ m/s or mean $\Delta P &lt; 40$ mmHg; dobutamine stress echocardiography shows AVA $\leq 1$ cm$^2$ with $V_{\text{max}} \geq 4$ m/s at any flow rate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• D3: Symptomatic severe low-gradient AS with normal LVEF (&gt;$50%) or paradoxical low-flow severe AS</td>
<td>• D3: AVA $\leq 1$ cm$^2$ with $V_{\text{max}} &lt; 4$ m/s or mean $\Delta P &lt; 40$ mmHg AND stroke volume index $&lt; 35$ mL/m$^2$ measured in a normotensive patient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• D1, D2, and D3 may show:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Severe leaflet calcification/fibrosis with reduced leaflet motion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: AR indicates aortic regurgitation; AS aortic stenosis; AVA, aortic valve area circulation; AVAi, aortic valve area indexed to body surface area; LVEF, left ventricular ejection fraction; $\Delta P$, pressure gradient between the left ventricle and aorta; and $V_{\text{max}}$, maximum velocity.
**Figure 2. Timing of Intervention for Aortic Stenosis**

**Abnormal Aortic Valve With Reduced Systolic Opening**

**Symptoms due to AS**
- **Severe AS Stage D1**
  - $V_{max} > 4 \text{ m/s}$
  - $\Delta P_{mean} > 40 \text{ mmHg}$
  - $LVEF \leq 50\%$
- **Severe AS Stage D2**
  - $DSE V_{max} \geq 4 \text{ m/s}$
- **Severe AS Stage D3**
  - $AVA < 0.6 \text{ cm}^2/\text{m}^2$
  - $SVI < 35 \text{ ml/m}^2$
- **AS most likely cause of symptoms**

**No AS Symptoms**
- **AS Stage C**
  - $V_{max} \geq 4 \text{ m/s}$
  - $LVEF \leq 50\%$
  - **Other Cardiac Surgery**
- **AS Stage B**
  - $V_{max} \geq 3.9 \text{ m/s}$
  - **Other Cardiac Surgery**

**Abbreviations**: AS indicates aortic stenosis; AVA, aortic valve area; cm, centimeter; AVR, aortic valve replacement; BNP, B-type natriuretic peptide; DSE, dobutamine stress echocardiography; ETT, exercise treadmill test; LVEF, left ventricular ejection fraction; mmHg, millimeters of mercury; $\Delta P_{mean}$, average change in pressure; SAVR, surgical aortic valve replacement; SVI, stroke volume index; TAVI, transcatheter aortic valve implantation; and $V_{max}$, maximum transvalvular velocity.

*See section 3.2.4.2*
Figure 3. Choice of SAVR versus TAVI for AVR in Valvular AS

Indication for AVR*

Shared Decision-making with patient and Heart Valve Team with discussion of SAVR or TAVI (1)

Not high or Prohibitive Risk

Surgical Risk Assessment

High or Prohibitive Risk

• STS>8%
• > 2 frailty measures or
• < 2 organ systems or
• Procedural impediment

YES

NO

Life expectancy with acceptable QOL >1 year?

YES

NO

Valve and vascular anatomy suitable for TF TAVI?

YES

NO

Palliative Care (1)

Amenable for VKA Anticoagulation?

YES

NO

Bioprosthetic (1)

Symptomatic severe AS (D1, D2, D3) OR asymptomatic severe AS with LVEF < 50% and anatomy suitable for TF TAVI? (Individualize)

YES

NO

Age 65 to 80

Age >80

SAVR (1)

TF TAVI (1)

SAVR (1)

TAVI (1)

SAVR (2a)

Pulmonic autograft (2b)

Mechanical or Bioprosthetic (2a)

Mechanical AVR (2a)

SAVR (1)

SAVR (1)

TF TAVI (1)

TF TAVI (1)

SAVR (2a)

Age >80

Age 65 to 80

SAVR (1)

TF TAVI (1)

SAVR (2a)

*See section 3.2.3

Indication for AVR:

1. Shared Decision-making with patient and Heart Valve Team with discussion of SAVR or TAVI.

Surgical Risk Assessment:

- Not high or Prohibitive Risk
  - Amenable for VKA Anticoagulation?
    - YES
    - NO
    - Age
      - <50
      - 50-65
      - >65
      - Bioprosthetic (2a)
      - Mechanical or Bioprosthetic (2a)
      - Pulmonic autograft (2b)
      - Mechanical AVR (2a)
      - SAVR (1)

- High or Prohibitive Risk
  - STS>8%
  - > 2 frailty measures or
  - < 2 organ systems or
  - Procedural impediment

Life expectancy with acceptable QOL >1 year?

Valve and vascular anatomy suitable for TF TAVI?

*Abbreviations: AS indicates aortic stenosis; AVR, aortic valve replacement; LVEF, left ventricular ejection fraction; QOL, quality of life; SAVR, surgical aortic valve replacement; STS, Society of Thoracic Surgeons; TAVI, transcatheter aortic valve implantation; TF, transfemoral; and VKA, vitamin K antagonist.
Acute Aortic Regurgitation

Abnormalities of the Valve
- Most often due to IE

Abnormalities of the Aorta
- Aortic Dissection
- Iatrogenic complication of a transcatheter procedure
- Blunt chest trauma

Acute volume overload in the LV
- Severe pulmonary congestion
- Low forward cardiac output
- Urgent diagnosis and rapid intervention are lifesaving

Abbreviations: AR indicates aortic regurgitation; IE, infective endocarditis; and TAVR, transcatheter aortic valve replacement.
## Table 15. Stages of Chronic AR

<table>
<thead>
<tr>
<th>STAGE</th>
<th>VALVE ANATOMY</th>
<th>VALVE HEMODYNAMICS</th>
<th>SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> At risk of AS</td>
<td>• Bicuspid aortic valve</td>
<td>• Echocardiography: None or trace AR.</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>• Aortic valve sclerosis</td>
<td>• Angiography: Grade 0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Diseases of the Aortic sinuses or ascending aorta</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rheumatic Heart disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Infective Endocarditis</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>B</strong> Progressive AS</td>
<td>• Mild to Moderate Calcification</td>
<td>• Mild AR by Echocardiography</td>
<td>None</td>
</tr>
<tr>
<td></td>
<td>• Bicuspid aortic valve</td>
<td>• Jet width &lt;25% of LVOT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dilated Aortic Sinuses</td>
<td>• Vena contracta &lt;0.3 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rheumatic Valve Changes</td>
<td>• Regurgitant volume &lt;30 mL/beat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Previous Infective Endocarditis</td>
<td>• Regurgitant fraction &lt;30%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ERO &lt;0.10 cm²</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Angiography: grade 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>C</strong> Asymptomatic</td>
<td>• Calcific valve disease</td>
<td>• Moderate AR by Echocardiography</td>
<td>None</td>
</tr>
<tr>
<td>Severe AS</td>
<td>• Bicuspid aortic valve</td>
<td>• Jet width 25%–64% of LVOT</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Dilated Aortic Sinuses or ascending aorta.</td>
<td>• Vena contracta 0.3–0.6 cm</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rheumatic Valve Changes</td>
<td>• Regurgitant volume 30–59 mL/beat</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Previous infective endocarditis with abnormal leaflet closure or perforation</td>
<td>• Regurgitant fraction 30% to 49%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• ERO 0.10–0.29 cm²</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Angiography: Grade 2</td>
<td></td>
</tr>
<tr>
<td><strong>D</strong> Symptomatic</td>
<td></td>
<td></td>
<td>Exertional dyspnea or</td>
</tr>
<tr>
<td>Severe AS</td>
<td></td>
<td></td>
<td>angina or more severe</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HF symptoms</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Abbreviations:** AR indicates aortic regurgitation; cm, centimeter; ERO, effective regurgitant orifice; HF, heart failure; IE, infective endocarditis; LV, left ventricle; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic diameter; LVOT, left ventricular outflow tract; mm, millimeter; and TAVR, transcatheter aortic valve replacement.
Figure 4. Timing of intervention for AR

Aortic Regurgitation

Severe AR
(VC>0.6 cm, holodiastolic aortic flow reversal, RVol > 60mL, RF> 50%, ERO > 0.3 cm²)

Symptomatic
(Stage D)

Asymptomatic
(Stage C)

LVEF < 55%
(Stage C2)

Other cardiac surgery

LVEF >55% and/or
LVESD>50
(LVESD > 25 mm/m²)

Progressive decrease in LVEF to <55%-60% or increase in size to >65 mm on at least 3 studies

Low surgical risk

AVR (1)

AVR (2a)

AVR (2b)

Moderate AR

Asymptomatic
(Stage C)

Symptomatic
(Stage D)

Other cardiac surgery

AVR (2a)

Abbreviations: AR indicates aortic regurgitation; AVR, aortic valve replacement; EDD, end-diastolic dimension; ERO, effective regurgitant orifice; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic dimension; RF, regurgitant fraction; RVol, regurgitant volume; and VC, vena contracta.
# Timing of Intervention in Chronic Aortic Regurgitation

<table>
<thead>
<tr>
<th>COR</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
</table>
| 1   | 1. In symptomatic patients with severe AR (Stage D), aortic valve surgery is indicated regardless of LV systolic function.  
2. In asymptomatic patients with chronic severe AR and LV systolic dysfunction (LVEF ≤55%) (Stage C2), aortic valve surgery is indicated if no other cause for systolic dysfunction is identified.  
3. In patients with severe AR (Stage C or D) who are undergoing cardiac surgery for other indications, aortic valve surgery is indicated. |
| 2a  | 4. In asymptomatic patients with severe AR and normal LV systolic function (LVEF >55%), aortic valve surgery is reasonable when the LV is severely enlarged (LVESD >50 mm or indexed LVESD >25 mm/m²) (Stage C2).  
5. In patients with moderate AR (Stage B) who are undergoing cardiac or aortic surgery for other indications, aortic valve surgery is reasonable. |
| 2b  | 6. In asymptomatic patients with severe AR and normal LV systolic function at rest (LVEF >55%; Stage C1) and low surgical risk, aortic valve surgery may be considered when there is a progressive decline in LVEF on at least 3 serial studies to the low-normal range (LVEF 55% to 60%) or a progressive increase in LV dilation into the severe range (LV end-diastolic dimension [LVEDD] >65 mm). |
| 3 HARM | 7. In patients with isolated severe AR who have indications for SAVR and are candidates for surgery, TAVI should not be performed. |

**Abbreviations:** AR indicates aortic regurgitation; COR classification of recommendation; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic diameter; mm, millimeter; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve implantation.
Diagnosis & Treatment: Bicuspid Aortic Valve

Figure 5. Diagnosis
Aortopathy is present in 20-40% of patients with BAV

Bicuspid Aortic Valve

TEE including measurement of aortic sinuses and ascending aorta (1)
CMR or CTA if TTE not adequate for aortic measurement (1)
TTE screening of 1st degree relatives (2b)

Aortic diameter (sinuses or ascending aorta) 24.0 cm
BAV with prior aortic valve replacement
Periodic imaging by TTE, CMR or CTA with interval determined by:
  • Degree and rate of progression of aortic dilation
  • Family history of aortic dissection (2a)
Continued lifelong periodic imaging if aortic diameter is 24.0 cm (2a)

Figure 6. Treatment

Bicuspid Aortic Valve

Aortic sinus or ascending aortic diameter >5.5 cm
Indications for surgical AVR and aortic sinus or ascending aortic diameter ≥4.5 cm
Aortic sinus or ascending aortic diameter 5.0-5.5 cm with risk factors for dissection*
Aortic sinus or ascending aortic diameter 5.0-5.5 cm without risk factors for dissection*

Replace aortic sinuses and/or ascending aorta at CVC (2a)
Replace aortic sinuses and/or ascending aorta if performed in low risk patients at CVC (2b)
Valve-sparing surgery may be considered at a CVC (2b)

*Family history of aortic dissection, aortic growth rate ≥0.5 cm/y, and/or presence of aortic coarctation.
Abbreviations: BAV indicates bicuspid aortic valve; CMR, cardiac magnetic resonance imaging; CTA, computed tomography angiography; CVC, comprehensive valve center; and TTE, transthoracic echocardiography.
# Table 16. Stages of Mitral Stenosis

<table>
<thead>
<tr>
<th>STAGE</th>
<th>DEFINITION/ETIOLOGY</th>
<th>DIAGNOSTICS*</th>
<th>SYMPTOMS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> At risk of MS</td>
<td>• Mild valve doming during diastole</td>
<td>• Normal transmitral flow velocity</td>
<td>None</td>
</tr>
</tbody>
</table>
| **B** Progressive MS| • Rheumatic valve changes with commissural fusion and diastolic doming of the mitral valve leaflets  
• Planimetered mitral valve area >1.5 cm² | • Increased transmitral flow velocities  
• Mitral valve area >1.5 cm²  
• Diastolic pressure half-time <150 milliseconds  
• Mild to moderate LA enlargement  
• Normal pulmonary pressure at rest | None                                          |
| **C** Asymptomatic Severe MS | • Rheumatic valve changes with commissural fusion and diastolic doming of the mitral valve leaflets  
• Planimetered mitral valve area ≤ 1.5 cm² | • Mitral valve area ≤1.5 cm²  
• Diastolic pressure half-time ≥150 milliseconds  
• Severe LA enlargement  
• Elevated PASP >50 mm Hg | None                                          |
| **D** Symptomatic Severe MS |                                                                                         |                                                                              | Exertional dyspnea or angina or more severe HF symptoms |
Figure 7. Recommendations for Mitral Stenosis

**Rheumatic Mitral Stenosis**

- **Severe MS**
  - MVA <1.5cm²
    - **Symptomatic Stage D**
      - Pliable valve
        - No clot
          - <2+MR
            - **NO**
            - **Severe symptoms NYHA III-IV**
              - **NO**
              - **Surgical candidate**
                - **YES**
                  - **PBMC at CVC (1)**
                  - **MV surgery* (1)**
                - **NO**
                  - **PBMC at CVC (2b)**
    - **NO**
    - **PBMC at CVC (2b)**

- **Progressive MS**
  - MVA >1.5cm²
    - **Asymptomatic Stage C**
      - **Exertional symptoms**
        - **Stress test Hemodynamically Significant MS**
          - **Pliable valve**
            - No clot
              - <2+MR
                - **NO**
                - **PASP >50mm HG**
                  - **NO**
                  - **New AF**
                    - **NO**
                    - **Pliable valve**
                      - No clot
                        - <2+MR
                          - **NO**
                          - **PBMC at CVC (2b)**

*Repair, commissurotomy, or valve replacement.

**Abbreviations:** AF indicates atrial fibrillation; CVC, Comprehensive Valve Center; MR, mitral regurgitation; MS, mitral stenosis; MV, mitral valve; MVA, mitral valve area; MR, Mitral Regurgitation; NYHA, New York Heart Association; PASP, pulmonary artery systolic pressure; +, plus; and PMBC, percutaneous mitral balloon commissurotomy.
### Table 17. Stages of Chronic Primary MR

<table>
<thead>
<tr>
<th>STAGE</th>
<th>VALVE ANATOMY</th>
<th>VALVE HEMODYNAMICS*</th>
<th>HEMODYNAMIC CONSEQUENCES</th>
<th>SYMPTOMS</th>
</tr>
</thead>
</table>
| **A** | At risk of MR | • Mild mitral valve prolapse with normal coaptation  
  • Mild valve thickening and leaflet restriction | • No MR jet or small central jet area <20% LA on Doppler  
  • Small vena contracta <0.3 cm | None |
| **B** | Progressive MR | • Moderate to severe mitral valve prolapse with normal coaptation  
  • Rheumatic valve changes with leaflet restriction and loss of central coaptation  
  • Prior IE | • Central jet MR 20%–40% LA or late systolic eccentric jet MR  
  • Vena contracta <0.7 cm  
  • Regurgitant volume <60 mL  
  • Regurgitant fraction <50%  
  • ERO <0.40 cm²  
  • Angiographic grade 1–2 | • Mild LA enlargement  
  • No LV enlargement  
  • Normal pulmonary pressure | None |
| **C** | Asymptomatic Severe MR | • Severe mitral valve prolapse with loss of coaptation or flail leaflet  
  • Rheumatic valve changes with leaflet restriction and loss of central coaptation  
  • Prior IE | • Central jet MR >40% LA or holosystolic eccentric jet MR  
  • Vena contracta ≥0.7 cm  
  • Regurgitant volume ≥60 mL  
  • Regurgitant fraction ≥50%  
  • ERO ≥0.40 cm²  
  • Angiographic grade 3 to 4 | • Mod. or severe LA enlargement  
  • LV enlargement  
  • Pulmonary hypertension may be present at rest or with exercise  
  • C1: LVEF >60% and LVESD <40 mm  
  • C2: LVEF =60% and/or LVESD ≥40 mm | None |
| **D** | Symptomatic Severe MR | • Thickening of leaflets with radiation heart disease | | | • Decreased exercise tolerance  
  • Exertional dyspnea |

*Valve Hemodynamics measured by echocardiography (doppler) or cardiac catheterization.

Abbreviations: cm indicates centimeter; ERO, effective regurgitant orifice; IE, infective endocarditis; LA, left atrium/atrial; LV, left ventricular; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic dimension; mL, milliliter; mm, millimeter; and MR, mitral regurgitation.
# Diagnostic Testing of Primary Mitral Regurgitation

<table>
<thead>
<tr>
<th>COR</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1. For asymptomatic patients with severe primary MR (Stages B and C1), TTE is indicated every 6 to 12 months for surveillance of LV function (estimated by LVEF, LVEDD, and LVESD) and assessment of pulmonary artery pressure.</td>
</tr>
<tr>
<td>2b</td>
<td>2. In asymptomatic patients with severe primary MR (Stages B and C1), use of serum biomarkers and novel measurements of LV function, such as global longitudinal strain, may be considered as an adjunct to guide timing of intervention.</td>
</tr>
</tbody>
</table>

**Abbreviations:** CMR indicates cardiac magnetic resonance; COR, classification of recommendation; GDMT, guideline directed medical therapy; LV, left ventricle; LVEDD, left ventricular end-diastolic dimension; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic dimension; MR, mitral regurgitation; PET, positron emission tomography; and TTE, transthoracic echocardiography.
Figure 8. Management of Primary Mitral Regurgitation

Severe MR (VC > 0.7 cm, RVol > 60 mL, RF > 50%, ERO > 0.40 cm²)

- Symptoms due to MR (Stage D) (regardless of LV function)
  - Degenerative MV disease
    - Successful and durable repair possible
  - Rheumatic MV disease
    - Successful and durable repair possible

- No symptoms due to MR (Stage C)
  - Normal LV systolic Function (Stage C1) (LVEF > 60% or ESD < 40 mm)
  - LV systolic dysfunction (Stage C2) (LVEF < 60% or ESD > 40 mm)

- MV surgery (1)
  - Transcatheter edge-to-edge MV Repair (2a)
  - MV surgery* at Primary or CVC (1)
  - MV repair at CVC (2b)
  - MV repair at primary or CVC (2a)
  - MV repair or replacement (2b)

- High or prohibitive Surgical risk with anatomy favorable for transcatheter approach and life expectancy > 1 year

- Expected surgical mortality <1% with >95% likelihood of successful and durable repair without residual MR

- Progressive increase in LV size or decrease in LVEF on at least 3 studies

Abbreviations: CVC indicates comprehensive valve center; ERO, effective regurgitant orifice; ESD, end-systolic dimension; LVEF, ejection fraction; MR, mitral regurgitation; MV, mitral valve; MVR, mitral valve replacement; RF, regurgitant fraction; RVol, regurgitant volume; and VC, vena contracta.

*See Prosthetic Valve section (11.1.2) for choice of mitral valve replacement if mitral valve repair is not possible.
## Diagnostic Testing Chronic Secondary Mitral Regurgitation

<table>
<thead>
<tr>
<th>COR</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1. In patients with chronic secondary MR (Stages B to D), TTE is useful to establish the etiology and to assess the extent of regional and global LV remodeling and systolic dysfunction, severity of MR, and magnitude of pulmonary hypertension.</td>
</tr>
<tr>
<td></td>
<td>2. In patients with chronic secondary MR (Stages B to D), noninvasive imaging (stress nuclear/ PET, CMR, or stress echocardiography), coronary CT angiography, or coronary arteriography is useful to establish etiology of MR and to assess myocardial viability.</td>
</tr>
<tr>
<td></td>
<td>3. In patients with chronic secondary MR with severe symptoms (Stage D) that are unresponsive to GDMT who are being considered for transcatheter mitral valve interventions, TEE is indicated to determine suitability for the procedure.</td>
</tr>
<tr>
<td></td>
<td>4. In patients with chronic secondary MR undergoing transcatheter mitral valve intervention, intraprocedural guidance with TEE is recommended.</td>
</tr>
</tbody>
</table>

**Abbreviations:** CMR indicates cardiac magnetic resonance; COR, classification of recommendation; GDMT, guideline directed medical therapy; LV, left ventricle; LVEDD, left ventricular end-diastolic dimension; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic dimension; MR, mitral regurgitation; PET, positron emission tomography; TEE, transesophageal echocardiography; and TTE, transthoracic echocardiography.
### Table 18. Stages of Secondary MR

<table>
<thead>
<tr>
<th>STAGE</th>
<th>VALVE ANATOMY</th>
<th>VALVE HEMODYNAMICS*</th>
<th>ASSOCIATED CARDIAC FINDINGS</th>
<th>SYMPTOMS</th>
</tr>
</thead>
</table>
| **A** | At risk of MR | • Normal valve leaflets, chords, and annulus in a patient with CAD or cardiomyopathy | • No MR jet or small central jet area <20% LA on Doppler  
• Small vena contracta <0.30 cm | • Normal or mildly dilated LV size with fixed (infarction) or inducible (ischemia) regional wall motion abnormalities  
• Primary myocardial disease with LV dilation and systolic dysfunction | Attributable to coronary ischemia or HF may be present that respond to revascularization & approp. Medical therapy |
| **B** | Progressive MR | • Regional wall motion abnormalities with mild tethering of mitral leaflet  
• Annular dilation with mild loss of central coaptation of the mitral leaflets | • ERO <0.40 cm²†  
• Regurgitant volume <60 mL  
• Regurgitant fraction <50% | • Regional wall motion abnormalities with reduced  
• LV systolic function  
• LV dilation and systolic dysfunction attributable to primary myocardial disease | |
| **C** | Asymptomatic  
Severe MR | • Regional wall motion abnormalities and/or LV dilation with severe tethering of mitral leaflet  
• Annular dilation with severe loss of central coaptation of the mitral leaflets | • ERO ≥0.40 cm²†  
• Regurgitant volume ≥60 mL‡  
• Regurgitant fraction ≥50% | • HF symptoms attributable to MR persist even after revasc. & optimization of medical therapy  
• Decreased exercise tolerance  
• Exertional dyspnea | |
| **D** | Symptomatic  
Severe MR | • HF symptoms attributable to MR persist even after revasc. & optimization of medical therapy  
• Decreased exercise tolerance  
• Exertional dyspnea |

*Several valve hemodynamic criteria are provided for assessment of MR severity, but not all criteria for each category will be present in each patient. Categorization of MR severity as mild, moderate, or severe depends on data quality and integration of these parameters in conjunction with other clinical evidence. †The measurement of the proximal isovelocity surface area by 2D TTE in patients with secondary MR underestimates the true ERO because of the crescentic shape of the proximal convergence. ‡May be lower in low-flow states.

**Abbreviations:** 2D indicates 2-dimensional; CAD, coronary artery disease; ERO, effective regurgitant orifice; HF, heart failure; LA, left atrium; LV, left ventricular; MR, mitral regurgitation; and TTE, transthoracic echocardiogram.
Figure 9. Secondary MR

**Management of Secondary Mitral Regurgitation**

GDMT supervised by an HF specialist (1)

**Severe MR Stage D (RVol >60mL, RF>50%, ERO>0.40 cm²)**

- LVEF > 50%
  - Persistent Symptoms on Optimal GDMT and AF Rx
    - MV surgery (2b)
  - LVEF < 50%
    - Persistent Symptoms on optimal GDMT
      - Mitral anatomy favorable
        - LVEF 20%-50%
        - LVESD < 70mm
        - PASP < 70mm Hg
      - Transcatheter edge-to-edge repair (2a)
- NO
  - Severe Symptoms
    - MV surgery (2b)
    - MV surgery* (2a)

*Chordal-sparing MV replacement may be reasonable to choose over downsized annuloplasty repair.

**Abbreviations:**
GDMT indicates guideline directed medical therapy; HF, heart failure; LVEF, left ventricular ejection fraction; LVESD, left ventricular end-systolic dimension; MR, mitral regurgitation; MV, mitral valve; PASP, pulmonary artery systolic pressure; RF, regurgitant fraction; RVol, regurgitant volume; and Rx, medication.
### Table 19. Classification of TR

<table>
<thead>
<tr>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Rheumatic</td>
<td>• Pulmonary hypertension with RV remodeling (primary or secondary to left-sided heart disease)</td>
</tr>
<tr>
<td>• Infective endocarditis</td>
<td>• Dilated cardiomyopathy</td>
</tr>
<tr>
<td>• Iatrogenic (device leads, endomyocardial biopsy)</td>
<td>• Annular dilation (associated with AF)*</td>
</tr>
<tr>
<td>• Congenital (eg, Ebstein’s, levo-transposition of the great arteries)</td>
<td>• RV volume overload (shunts/high output)</td>
</tr>
<tr>
<td>• Other (eg, trauma, carcinoid, drugs, irradiation)</td>
<td></td>
</tr>
</tbody>
</table>

*Isolated TR is associated with AF and has LVEF >60%, pulmonary artery systolic pressure <50 mm Hg, and no left-sided valve disease, with normal appearing tricuspid valve leaflets.

**Abbreviations:** AF indicates atrial fibrillation; LVEF, left ventricular ejection fraction; RV, right ventricular; and TR, tricuspid regurgitation.
Figure 10. Management of Tricuspid Regurgitation

Tricuspid Regurgitation

Severe TR (Stage C and D)

- Right heart failure (Stage D)
  - Primary TR
  - Secondary TR
  - Prior left-sided valve surgery
    - Poorly responsive to GDMT
      - Annular dilation >4.0 cm
      - Absences of severe PH or RV systolic dysfunction
    - TV surgery (1)
  - TV surgery (2a)
  - TV surgery (2b)

- Asymptomatic (Stage C)
  - Primary TR with progressive RV dilation or systolic dysfunction
  - TV surgery (2a)
  - TV surgery (2b)

Progressive TR (Stage B)

- At time of left-sided valve surgery
  - Annular dilation >4.0 cm or prior right HF
  - TV surgery (2a)

Abbreviations: GDMT indicates guideline-directed management and therapy; HF, heart failure; PAP, pulmonary artery pressure; PH, pulmonary hypertension; RV, right ventricular; TR, tricuspid regurgitation; and TV, tricuspid valve.
### Mixed Valve Disease: Diagnosis and Follow up

**Mitral Stenosis**
- Mostly associated with rheumatic valve disease

**PATHOPHYSIOLOGY**

<table>
<thead>
<tr>
<th>MR</th>
<th>AR</th>
<th>AS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MS protects LV from overload due to severe MR</td>
<td>MS limits LV filling (\rightarrow) reduction in SV (\rightarrow) Underestimation of AR</td>
<td>If either lesion is severe, CO is reduced, leading to underestimation of severity of coexisting valve lesions</td>
</tr>
</tbody>
</table>

**DIAGNOSIS**

- LA enlargement, high transmural gradient, elevated LA or PAWP suggestive of patient’s symptom
- Contrast aortography directly visualizes AR flow
- Invasive hemodynamic measurements

**TREATMENT**

- Diuretic or in severe limiting symptoms, mitral valve replacement
- Diuretic or intervention with surgery: PMBC for MS and AVR/SAVR and open mitral commissurotomy
- Appropriate individual intervention with AVR/mitral valve surgery

**Abbreviations:** AR indicates aortic regurgitation; AS, aortic stenosis; AVR, aortic valve replacement; CO, cardiac output; LA, left atrium; MR, mitral regurgitation; MS, mitral stenosis; PAWP, pulmonary artery wedge pressure; PMBC, percutaneous mitral balloon commissurotomy; SAVR, surgical aortic valve replacement; SV, stroke volume; and TTE transthoracic echocardiogram.

Mixed Valve Disease: Decision-Making

**Aortic stenosis**

**Symptomatic patients**
- With a peak transvalvular velocity of at least 4.0m/s or a mean transvalvular gradient of at least 40mmHg

**Asymptomatic patients**
- With peak transvalvular velocity of at least 4.0m/s with an LVEF <50%

**Abbreviations:** AVR indicates aortic valve replacement; LVEF, left ventricle ejection fraction; MR, mitral regurgitation; SAVR, surgical aortic valve replacement; TAVI, transcatheter aortic valve implantation; and TEER, transcatheter edge-to-edge repair.

**Aortic Regurgitation**
- **Primary MR**
  - Repairable Valve
    - SAVR Candidate
    - SAVR and Surgical Mitral Valve Repair
  - Not repairable valve
    - TAVI Candidate
    - TAVI/Mitral TEER

**Mitral Regurgitation**
- **Secondary MR**
  - Low-Intermediate Risk
    - SAVR & surgical mitral valve repair/replacement
    - Or TAVR/Mitral TEER
  - High-Prohibitive Risk
    - TAVI/Mitral TEER

**Requires multidisciplinary team with shared decision making with patients recommended. Limited data to support COR**
**Figure 12. Antithrombotic Therapy for Prosthetic Valves**

### Mechanical Valve

**VKA anticoagulation (1)**

- Mechanical AVR with no other risk factors
  - INR goal 2.5† (1)
  - If antiplatelet Rx indicated, add ASA 75-100mg (2b)
- Mechanical AVR with other risk factors
  - INR goal 3.0 (1)
- Mechanical mitral valve

- If VKA therapy interrupted for noncardiac procedures, minimize time subtherapeutic INR
- No bridging needed † (1)
- Bridging anticoagulation during time when INR is subtherapeutic (2a)

### Bioprosthetic Valve

- Surgical bioprosthetic AVR or MVR
  - Initial 3-6 month
  - Lifelong
  - VKA anticoagulation INR goal 2.5 (2a)
  - ASA 75-100mg Daily (2a)
- TAVI
  - Initial 3-6 month
  - Low risk of bleeding
  - ASA 75-100mg daily PLUS clopidogrel 75 mg (2b)
  - OR
  - VKA anticoagulation INR goal 2.5 (2b)

*Thromboembolic risk factors include an older-generation valve, AF, previous thromboembolism, hypercoagulable state, and LV systolic dysfunction. †For a mechanical On-X AVR and no thromboembolic risk factors, a goal INR of 1.5–2.0 plus aspirin 75–100 mg daily may be reasonable starting ≥3 months after surgery.

**Abbreviations:** ASA indicates aspirin; AVR, aortic valve replacement; INR, international normalized ratio; MVR, mitral valve replacement; Rx, medication; TAVI, transcatheter aortic valve implantation; and VKA, vitamin K antagonist.
Management of Prosthetic Valve Complications

### Serious Bleeds:

For mechanical valves, use of four-factor prothrombin complex is reasonable (2a).

If bleeding is not controlled despite four-factor prothrombin complex, intravenous Vitamin K is reasonable to consider if use of a VKA is not anticipated for 7 days (2a).

For patients with bioprosthetic valves or anuloplasty rings who are receiving a DOAC and who require immediate reversal of anticoagulation because of uncontrollable bleeding, treatment with idarucizumab (for dabigatran) or andexanet alfa (for anti-Xa agents) is reasonable (2a).

For patients with a mechanical prosthetic valve and supratherapeutic INR (>5.0) who are not actively bleeding, the benefit of individualized treatment with oral vitamin K, in addition to temporary withdrawal of the VKA, is uncertain (2b).

### Thromboembolic Events:

For a mechanical AVR, increase the INR from 2.5 to 3 or add Aspirin 75-100 mg (2a).

For a mechanical MVR, increase the INR from 3 to 4 or add Aspirin 75-100 mg (2a).

For a bioprosthetic valve, VKA anticoagulation can be considered in place of an antiplatelet regimen (2b).

### Acute Valve Thrombosis:

For mechanical valves, urgent TTE, TEE, fluro, and/or CT imaging is recommended for suspected valve thrombosis (1).

For a thrombosed left sided mechanical valve, slow infusion, low dose fibrinolytic therapy or emergency surgery is recommended (1).

In a suspected bioprosthetic valve thrombosis, 3D or 4D CT imaging is reasonable (2a).

In a suspected bioprosthetic valve thrombosis, initial treatment with a VKA is reasonable (2a).

Abbreviations: AVR indicates aortic valve replacement; DOAC, direct oral anticoagulant; INR, international normalized ratio; MVR, mitral valve replacement; and VKA, vitamin K antagonist.
Figure 14. Management of Prosthetic Valve Stenosis

**Patient with Prosthetic Valve**

Suspected valve stenosis

TTE and TEE for all valve types (1)  
Fluoroscopy or cine-CT for mechanical valves (1)  
3D TEE or 4D CT imaging (2a)

Symptomatic severe stenosis

**Mechanical valve**

**Bioprosthetic valve**

High prohibitive surgical risk

**Surgical Intervention (1)**

**Transcatheter ViV at CVC (2a)**

---

**Abbreviations:** 3D indicates 3-dimensional; 4D, 4-dimensional; CT, computed tomography; CVC, Comprehensive Valve Center; HF, heart failure; TEE, transesophageal echocardiography; TTE, transthoracic echocardiography/echocardiogram; and ViV, valve-in-valve.
Suspected prosthetic valve regurgitation

2D or 3D TTE and TEE (1)

Intractable Hemolysis or HF

High prohibitive surgical risk

NO

YES

Paravalvular regurgitation

Bioprosthetic valve regurgitation

Percutaneous repair at CVC (2a)

Transcatheter ViV at CVC (2a)

Surgical Intervention (1)

Surgical Intervention (2a)

Asymptomatic with severe regurgitation and low surgical risk

Abbreviations: 3D indicates 3-dimensional; 4D, 4-dimensional; CT, computed tomography; CVC, Comprehensive Valve Center; HF, heart failure; TEE, transesophageal echocardiography; TTE, transthoracic echocardiography/echocardiogram; and ViV, valve-in-valve.
**Infective Endocarditis: Diagnostic Evaluation**

**Patients At risk OR with suspected NVE or PVE**

- **Blood Cultures (1)**

**Purpose of TTE (1)**
- Identify vegetations
- Hemodynamic severity of valvular lesions
- Assess ventricular function and pulmonary pressures
- Detect complications

**Utilize TEE (1)**
- If TTE non-diagnostic
- Complication suspected or present
- Intra-cardiac leads present

**Heart Valve Team (1)**
- Cardiology
- Cardiac Surgery
- Infectious Disease
- If surgery - cardiac anesthesia
- If neurological event - neurology

**At Risk:**
- Congenital or acquired VHD
- Previous IE
- Prosthetic heart valves
- Certain congenital or heritable cardiac malformations
- Immunodeficiency state
- Injection drug use

**Abbreviations:** IE indicates infective endocarditis; NVE, native valve endocarditis; PVE, prosthetic valve endocarditis; TTE, trans-thoracic echocardiography; and TEE, trans-esophageal echocardiography.
Figure 15. Diagnosis of Infective Endocarditis

**Patient at Risk or with Suspected NVE or PVE**

Blood cultures Modified Duke Criteria Heart Valve Team (1)

**TTE (1)**

- TTE nondiagnostic
- IE complications suspected
- Intracardiac leads present
- IE with change in signs or symptoms
- High risk complications
- Staph, enterococci, or fungal infection
- Stable IE being considered for change to oral antibiotics

- Undergoing valve surgery for IE

**OR**

- S. aureus without known source
- Prosthetic valve with persistent fever without bacteremia or new murmur

**OR**

- Intraoperative TTE (1)
- Echo images not adequate with suspected paravalvular abscess

- Cardiac CT (2a)
- TEE (2b)
- \(^{18}\)FDG PET/CT (2a)

**Possible IE by Modified Duke Criteria**

- Nosocomial S. aureus bacteremia with known portal

**Abbreviations:** CT indicates computed tomography; IE, infective endocarditis; \(^{18}\)FDG, \(^{18}\)fluorodeoxyglucose; NVE, native valve endocarditis; PET, positron emission tomography; PVE, prosthetic valve endocarditis; S, staph; TEE, transesophageal echocardiography; and TTE, transthoracic echocardiography.

**Infective Endocarditis: Medical Therapy**

### Antibiotics

- Antibiotics should be initiated after blood cultures are obtained, with guidance from infectious disease plus antibiotic sensitivity data (1)

  *In stable left-sided IE - consider changing to oral antibiotics if:
  - No paravalvular infection on TEE
  - Follow-up can be assured
  - Follow-up TEE can be performed 1-3 days prior to antibiotics completion (2b)

- Patients with known VHD and unexplained fever should NOT receive antibiotics before blood cultures are obtained (3:Harm)

### Anticoagulation

- If there is evidence of cerebral embolism or stroke, irrespective of other indications for anticoagulation, it is reasonable to temporarily hold anticoagulation (2a)

  In patients on VKA anticoagulation at the time of IE diagnosis, temporary discontinuation of VKA may be considered (2b)

### Addiction Rx

- If IE is a consequence of injection drug use, the patient should be referred to addiction treatment for opioid substitution therapy (1)

---

*IE caused by streptococcus, E. faecalis, S. aureus, or coagulase-negative staphylococci deemed stable by the Heart Valve Team.

**Abbreviations:** IE indicates infective endocarditis; Rx, treatment; TEE, trans-esophageal echocardiography; VHD, valvular heart disease; and VKA, vitamin K antagonists.
Figure 17. Preconception Management of Women with NVD

All women with suspected valve disease who are considering pregnancy should undergo a clinical evaluation & TTE before pregnancy (1)

Severe valve disease?

Pre-pregnancy counseling by cardiologist with expertise in managing VHD during pregnancy (1)

Exercise testing is reasonable before pregnancy (2a)

Clinical symptoms?

Intervention before pregnancy (1)

Prosthetic valve required?

Balloon commissurotomy before pregnancy (2a)

Valve intervention before pregnancy is reasonable (2a)

Valve repair may be considered after detailed discussion with patient (2b)

Severe rheumatic MS amenable to balloon commissurotomy?

Severe AS?

Severe MR and valve suitable for repair?

Monitor with dedicated Multidisciplinary Heart Valve Team with expertise in management of high-risk cardiac conditions during pregnancy (1)

Abbreviations: AS indicates aortic stenosis; MR, mitral regurgitation; MS, mitral stenosis; TTE, transthoracic echocardiography; and VHD, valvular heart disease.
Figure 18. Anticoagulation for Prosthetic Mechanical Heart Valves in Pregnancy

Women with Mechanical Heart Valve

Pregnant women with a mechanical prosthesis should receive therapeutic anticoagulation with frequent monitoring (1)

Can woman maintain therapeutic anticoagulation with frequent monitoring?

YES

NO

Counsel against pregnancy (1)

Patient counseled that there is no anticoagulation strategy that is safe for mother and fetus. Shared decision-making (1)

Warfarin dose >5mg/dl?

YES

NO

Dose-adjusted LMWH with monitoring of Xa levels available?

YES

NO

1st, 2nd, 3rd trimesters

Continuous warfarin in all trimesters (2a) OR Dose-adjusted LMWH* for 1st trimester then warfarin for 2nd & 3rd (2b)

Dose-adjusted LMWH* for all trimesters (2b)

At least 1 week before delivery

Discontinue warfarin, switch to continuous IV UFH or dose-adjusted LMWH* (1)

At least 36 hours before delivery

Switch to continuous IV UFH* (1)

4-6 hours before planned delivery

Stop IV heparin (1)

If labor begins or urgent delivery is requested in a woman therapeutically anticoagulated with a VKA, cesarean section should be performed after reversal of anticoagulation (1)

Warfarin dose >5mg/dl?

YES

NO

Continuous dose-adjusted UFH* for 1st trimester then warfarin for 2nd & 3rd (2a)

Dose-adjusted LMWH* for all trimesters (2b)

Abbreviations: aPTT indicates activated partial thromboplastin time; IV, intravenous; LMWH, low-molecular-weight heparin; UFH, unfractionated heparin; and VKA, vitamin K antagonist.

*Dose-adjusted LMWH should be given at least 2 times per day, with close monitoring of anti-Xa levels. Target to Xa level of 0.8 to 1.2 U/mL, 4 to 6 hours after dose. Trough levels may aid in maintaining patient in therapeutic range. Continuous UFH should be adjusted to aPTT 2 times control.

Figure 19. Valve Intervention in CAD

Patients undergoing valve interventions

TAVI

Low risk of CAD

YES

NO

Coronary CT angiography (1)

Coronary angiography (1)

Left main or proximal CAD

Complex bifurcation left main and/or multivessel CAD with a SYNTAX score >33

PCI prior to TAVI (2a)

Surgical AVR and CABG (2a)

Valve Surgery

Chronic severe secondary MR

Angina, decreased LV systolic function, history of CAD, or CAD risk factors*

Coronary angiography (1)

Coronary CT angiography (2a)

Abnormal

Low to intermediate risk of CAD

YES

Coronary angiography (1)

Significant proximal CAD or left main disease

CABG (2a)

Abbreviations: AVR indicates aortic valve replacement; CAD, coronary artery disease; CABG, coronary artery bypass graft; CT, computed tomography; LV, left ventricular; MR, mitral regurgitation; PCI, percutaneous coronary intervention; SYNTAX, Synergy Between Percutaneous Coronary Intervention With Taxus and Cardiac Surgery; and TAVI, transcatheter aortic valve implantation.

*Including men age >40 years and postmenopausal women.
Figure 20. Intervention for AF in patients with VHD

Patients Undergoing Surgical Valve Intervention

Atrial Fibrillation

YES

Discuss benefits/risks of adjunctive AF Procedure (1)

NO

LAA ligation or excision may be harmful (3 Harm)

Surgical pulmonary vein isolation or maze procedure (2a)

LAA ligation or excision (2a)

Anticoagulation therapy for at least 3 months after the procedure regardless of CHA2DS2-VASc risk score (2a)

Discontinuation of anticoagulant despite these procedures associated with late stroke.

VKA preferred over others for first 3 months in patients receiving bioprosthetic device.
**Recommendations for Noncardiac Surgery in Patients with VHD**

### Diagnosis in Patients With VHD Undergoing Noncardiac Surgery

<table>
<thead>
<tr>
<th>COR</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In patients with clinically suspected moderate or greater degrees of valvular stenosis or regurgitation who are undergoing noncardiac surgery, preoperative echocardiography is recommended.</td>
</tr>
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</table>

### Management of the Symptomatic Patient

<table>
<thead>
<tr>
<th>COR</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In patients who meet standard indications for intervention for VHD (replacement and repair) on the basis of symptoms and disease severity, intervention should be performed before elective noncardiac surgery to reduce perioperative risk if possible, depending on the urgency and risk of the noncardiac procedure.</td>
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</tbody>
</table>

### Management of the Asymptomatic Patient

<table>
<thead>
<tr>
<th>COR</th>
<th>RECOMMENDATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In asymptomatic patients with moderate or greater degrees of AS and normal LV systolic function, it is reasonable to perform elective noncardiac surgery.</td>
</tr>
<tr>
<td>2a</td>
<td>In asymptomatic patients with moderate or greater degrees of rheumatic MS with less than severe pulmonary hypertension (pulmonary artery systolic pressure &lt;50 mm Hg), it is reasonable to perform elective noncardiac surgery.</td>
</tr>
<tr>
<td>3</td>
<td>In asymptomatic patients with moderate or greater degrees of MR and normal LV systolic function with less than severe pulmonary hypertension (pulmonary artery systolic pressure &lt;50 mm Hg), it is reasonable to perform elective noncardiac surgery.</td>
</tr>
<tr>
<td>4</td>
<td>In asymptomatic patients with moderate or greater degrees of AR and normal LV systolic function, it is reasonable to perform elective noncardiac surgery.</td>
</tr>
</tbody>
</table>

**Abbreviations:** AR indicates aortic regurgitation; AS, aortic stenosis; COR, classification of recommendation; LV, left ventricular; mm Hg, millimeters of mercury; MR, mitral regurgitation; MS, mitral stenosis; and VHD valvular heart disease.

# Evidence Gaps and Future Directions in VHD

## STAGE A
**Prevention of VHD:**
- Disease mechanism and risk factors: Ca++ in BAV, Lp(a)
- Primary & secondary prevention of risk factors

## STAGE B
**Medical therapy to prevent VHD progression:**
- Disease mechanism and targets
- Understanding the interplay between severity of VHD and LV modulation and vascular dysfunction

## STAGE C
**Timing of intervention:**
- Improvement in measures of disease severity and impact on LV
- Patient-centered research and diverse patient groups

## STAGE D
**Better management options:**
- Prosthetic valve durability and long-term management
- Optimal anti-thrombotic regimen
- Prevention of complications
- Promoting equity in care of pts with VHD

**Abbreviations:** Ca++ in BAV indicates calcium in bicuspid aortic valve; Lp(a), lipoprotein (a); LV indicates left ventricle; pts, patients; and VHD, valvular heart disease.
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