Valvular Heart Disease: Diagnosis and Management

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Cardiologist, Central Utah Clinic

Objectives:
• Identify the pathophysiology of common disorders such as aortic stenosis and mitral regurgitation
• Relate how to differentiate chronic stable valve disease from decompensated valve disease causing heart failure
• Summarize the indications for noninvasive and invasive diagnostic testing and endocarditis prophylaxis
AORTIC STENOSIS- A REVIEW AND UPDATE OF RECENT GUIDELINES

MARV ALLEN MD, FACC

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PATHOPHYSIOLOGY

- DEGENERATIVE
  - MOST COMMON
  - ELDERLY
- CONGENITAL
  - BICUSPID
- RHEUMATIC
  - ALMOST ALWAYS ASSOCIATED WITH MITRAL VALVE DISEASE
- MISCELLANEOUS
PATHOPHYSIOLOGY

A. Valve Histology Showing Progression of the Disease

- **Initiating factors:**
  - Bicuspid valve
  - Genetic factors
  - Shear stress

- **Disease Progression:**
  - Age and sex
  - Increased serum lipids
  - Increased blood pressure
  - Diabetes and metabolic syndrome
  - Smoking

B. Aortic-Valve Anatomy

- Normal
- Aortic sclerosis
- Mild-to-moderate aortic stenosis
- Severe aortic stenosis

C. Doppler Aortic-Jet Velocity

- Normal
- Aortic sclerosis
- Mild-to-moderate aortic stenosis
- Severe aortic stenosis

**Calcification**
- Increased alkaline phosphatase
- Increased BMP-2
- Increased osteocalcin
## Pathophysiology

<table>
<thead>
<tr>
<th>Normal leaflets</th>
<th>Aortic sclerosis</th>
<th>Aortic stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>At risk</strong></td>
<td><strong>Disease initiation</strong></td>
<td><strong>Progressive disease</strong></td>
</tr>
<tr>
<td>• Risk genotype</td>
<td>• Shear stress</td>
<td>• Oxidative stress</td>
</tr>
<tr>
<td>• Risk valve morphology</td>
<td>• Inflammation</td>
<td>• Increased angiotensin II</td>
</tr>
<tr>
<td>• Older age, male sex</td>
<td>• Lipid infiltration</td>
<td>• Procalcific stimuli</td>
</tr>
<tr>
<td>• Dyslipidemia</td>
<td>• Myofibroblast differentiation</td>
<td>• OPG–RANKL</td>
</tr>
<tr>
<td>• Diabetes or metabolic syndrome</td>
<td></td>
<td>• Wnt–LRP</td>
</tr>
<tr>
<td>• Hypertension</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Renal insufficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Increased serum phosphate</td>
<td></td>
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</tr>
</tbody>
</table>

### Leaflet calcification

- **10–15%**
- **100%**

- Hydroxypatite nodules
- Cartilage and bone formation

### Inflammation

- Risk genotype
- Risk valve morphology
- Older age, male sex
- Dyslipidemia
- Diabetes or metabolic syndrome
- Hypertension
- Smoking
- Renal insufficiency
- Increased serum phosphate

### Age

- Normal leaflets
- Aortic sclerosis
- Aortic stenosis

### Disease initiation

- Shear stress
- Inflammation
- Lipid infiltration
- Myofibroblast differentiation

### Progressive disease

- Oxidative stress
- Increased angiotensin II
- Procalcific stimuli
- OPG–RANKL
- Wnt–LRP

### Valve obstruction

- Hydroxypatite nodules
- Cartilage and bone formation
HEMODYNAMICS

Aortic Valve Doppler

Apical Sample

SSN Sample
HEMODYNAMICS

Catheterization vs. Echo Assessment of Valvular Stenosis

- Maximum pressure difference: 40 mm Hg
- Peak-peak pressure difference: 27 mm Hg
- Flow velocity: 3.2 m/s
- Pressure difference: 41 mm Hg
PHYSICAL EXAM

- DIMINISHED A2
- SYSTOLIC EJECTION MURMUR RIGHT UPPER STERNAL BORDER
- CRESCENDO-DECRESCENDO (DIAMOND SHAPE)
- DELAYED AND DECREASED CAROTID UPSTROKE (PARVUS/TARDUS)
- PROMINENT APICAL IMPULSE
IMAGING/DIAGNOSIS

- ECG
- ECHO
- CATH
- MRI
- TEE
- CT
- CXR
DIAGNOSIS
ECHO DIAGNOSIS

Continuity Equation

\[ A_{AV} \cdot \overline{V}_{AV} = A_{LVOT} \cdot \overline{V}_{LVOT} \]

\[ A_{AV} = 0.785 \times (D)^2 \times \frac{\overline{V}}{LVOT} \]
ECHO DIAGNOSIS
<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>At risk</td>
<td>Patients with risk factors for the 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>
</tbody>
</table>
| C     | Asymptomatic severe | Asymptomatic patients who have reached the criteria for severe VHD  
C1: Asymptomatic patients with severe VHD in whom the left or right ventricle remains compensated  
C2: Asymptomatic patients who have severe VHD, with decompensation of the left or right ventricle |
| D     | Symptomatic severe | Patients who have developed symptoms as a result of VHD                                         |
### Stages of Valvular Heart Disease

<table>
<thead>
<tr>
<th>Stage</th>
<th>Definition</th>
<th>Valve Anatomy</th>
<th>Valve Hemodynamics</th>
<th>Hemodynamic Consequences</th>
<th>Symptoms</th>
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</table>
| A     | At risk of AS | • Bicuspid aortic valve (or other congenital valve anomaly)  
• Aortic valve sclerosis | • Aortic $V_{\text{max}} < 2 \text{ m/s}$ | • None | • None |
| B     | Progressive AS | • Mild-to-moderate leaflet calcification of a bicuspid or trileaflet valve with some reduction in systolic motion or  
• Rheumatic valve changes with commissural fusion | • Mild AS: Aortic $V_{\text{max}} 2.0–2.9 \text{ m/s or mean } \Delta P < 20 \text{ mm Hg}$  
• Moderate AS: Aortic $V_{\text{max}} 3.0–3.9 \text{ m/s or mean } \Delta P 20–39 \text{ mm Hg}$ | • Early LV diastolic dysfunction may be present  
• Normal LVEF | • None |
# STAGES OF VALVULAR HEART DISEASE

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<tr>
<td>C - Asymptomatic severe AS</td>
<td>Asymptomatic severe AS</td>
<td>Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</td>
<td>Aortic $V_{\text{max}} \geq 4 \text{ m/s}$ or mean $\Delta P \geq 40 \text{ mm Hg}$</td>
<td>LV diastolic dysfunction</td>
<td>None—exercise testing is reasonable to confirm symptom status</td>
</tr>
<tr>
<td>C1</td>
<td>Asymptomatic severe AS</td>
<td></td>
<td></td>
<td>Mild LV hypertrophy</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Normal LVEF</td>
<td></td>
</tr>
<tr>
<td>C2</td>
<td>Asymptomatic severe AS with LV dysfunction</td>
<td>Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</td>
<td>Aortic $V_{\text{max}} \geq 4 \text{ m/s}$ or mean $\Delta P \geq 40 \text{ mm Hg}$</td>
<td>LVEF &lt;50%</td>
<td>None</td>
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<tr>
<td>D - Symptomatic severe AS</td>
<td></td>
<td></td>
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<tr>
<td>D1</td>
<td>Symptomatic severe high-gradient AS</td>
<td>Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</td>
<td>Aortic $V_{\text{max}} \geq 4$ m/s, or mean $\Delta P \geq 40$ mm Hg</td>
<td>LV diastolic dysfunction</td>
<td>Exertional dyspnea or decreased exercise tolerance</td>
</tr>
<tr>
<td></td>
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<td>AVA typically is $\leq 1$ cm$^2$ (or AVAi $\leq 0.6$ cm$^2$/m$^2$), but may be larger with mixed AS/AR</td>
<td>LV hypertrophy</td>
<td>Exertional angina</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Pulmonary hypertension may be present</td>
<td>Exertional syncope or presyncope</td>
</tr>
<tr>
<td>D2</td>
<td>Symptomatic severe low-flow/low-gradient AS with reduced LVEF</td>
<td>Severe leaflet calcification with severely reduced leaflet motion</td>
<td>AVA $\leq 1$ cm$^2$ with resting aortic $V_{\text{max}} &lt; 4$ m/s or mean $\Delta P &lt; 40$ mm Hg</td>
<td>LV diastolic dysfunction</td>
<td>HF, Angina,</td>
</tr>
<tr>
<td></td>
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<td></td>
<td>Dobutamine stress echo shows AVA $\leq 1$ cm$^2$ with $V_{\text{max}} \geq 4$ m/s at any flow rate</td>
<td>LV hypertrophy</td>
<td>Syncpe or presyncope</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>LVEF $&lt;50%$</td>
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<tr>
<td>D3</td>
<td>Symptomatic severe low-gradient AS with normal LVEF or paradoxical low-flow severe AS</td>
<td>• Severe leaflet calcification with severely reduced leaflet motion</td>
<td>• AVA ≤1 cm² with aortic $V_{max} &lt; 4$ m/s, or mean $\Delta P &lt; 40$ mm Hg • Indexed AVA ≤0.6 cm²/m² and • Stroke volume index &lt;35 mL/m² • Measured when the patient is normotensive (systolic BP &lt;140 mm Hg)</td>
<td>• Increased LV relative wall thickness • Small LV chamber with low-stroke volume. • Restrictive diastolic filling • LVEF ≥50%</td>
<td>• HF, • Angina, • Syncope or presyncope</td>
</tr>
</tbody>
</table>
Aortic stenosis symptoms
Initial
- Decreased exercise tolerance
- Dyspnea on exertion
Early
- Exertional dizziness
- Angina
Late
- Syncope
- Heart failure

Aortic stenosis signs
- Systolic murmur
- Single second heart sound
- Delayed carotid upstroke

Echocardiography
- Valve anatomy
- $V_{max}$, mean $\Delta P$, AVA
- LV function

Cardiac catheterization
- Symptomatic
- Inconclusive echocardiogram or discrepant echocardiogram and physical examination

Severe aortic stenosis
- $V_{max} \geq 4$ m/sec or mean $\Delta P \geq 40$ mm Hg

Symptomatic stage D1
- Evaluate for aortic-valve replacement

Asymptomatic stage C
- Echocardiogram every 6–12 mo

Equivocal symptoms
- Exercise testing
- Provoked symptoms
- Change in blood pressure
- Decrease in exercise duration

Ejection fraction < 50%
- Severe aortic stenosis (stage D2)
- $V_{max} \geq 4$ m/sec or mean $\Delta P \geq 40$ mm Hg with AVA $\leq 1.0$ cm$^2$

Severe aortic stenosis (stage D3)
- Indexed AVA $\leq 0.6$ cm$^2$
- SV index $< 35$ ml/m$^2$
- Mean $\Delta P \geq 40$ mm Hg

Ejection fraction $\geq 50%$
- and symptomatic

Moderate aortic stenosis
- (stage B)
- $V_{max} = 3.0–3.9$ m/sec

Echocardiogram every 1–2 yr

Mild aortic stenosis
- (stage B)
- $V_{max} = 2.0–2.9$ m/sec

Echocardiogram every 3–5 yr
Transthoracic echocardiogram

Aortic root or ascending aorta ≤40 mm
- Valvular indication
  - No
    - Serial transthoracic echocardiography
      - May consider CT or MRI in patients with aortic root or ascending aorta dimensions of 35–39 mm
  - Yes
    - Yearly echocardiography, CT, or MRI to evaluate ascending aorta
      - Yearly echocardiography, CT, or MRI to evaluate ascending aorta
      - If rapid progression (≥5 mm/yr), consider surgery

Aortic root or ascending aorta 40–44 mm
- Valvular indication
  - No
    - Baseline CT or MRI
  - Yes
    - Yearly echocardiography, CT, or MRI to evaluate ascending aorta

Aortic root or ascending aorta 45–49 mm
- Valvular indication
  - No
    - Evaluate the presence of risk modifiers
      - Family history of aortic dissection, aneurysm, rupture, or sudden death
      - Growth rate ≥5 mm/yr
      - Ratio of aortic area to body height >10
  - Yes
    - Tailored surgical approach based on type of aortopathy pattern, perioperative risk assessment, and patient preference (e.g., aortic valve replacement with suprarenal replacement of ascending aorta, hemiarch, total arch replacement, aortic valve repair, sparing root replacement, or valved conduit repair)

Aortic root or ascending aorta 50–55 mm
- Valvular indication
  - No
    - May consider surgery
  - Yes
    - Tailored surgical approach based on type of aortopathy pattern, perioperative risk, and surgeon or center experience

Consider surgery
TREATMENT

- **MEDICAL**
  - No current effective therapy

- **SURGICAL**
  - Best option for most patients
  - Mechanical, bioprosthetic, homograft

- **TAVR**
  - Patients who meet criteria for surgery
  - High risk
  - Life expectancy >12 months
CASES

Aortic-valve stenosis

Symptoms from aortic stenosis

$V_{max} \leq 4$ m/sec

Ejection fraction $< 50\%$

DSE with $V_{max} > 4$ m/sec and AVA $\leq 1.0 \text{ cm}^2$ at any flow rate

Yes

No

No

Periódic monitoring

Yes

AVR (IIa)

AVR (IIa)

AVR (IIa)

AVR (II)

AVR (IIa)

AVR (IIb)

Surgical risk

Low or intermediate

High

Prohibitive

Surgical AVR

Candidate for TAVR with expected benefit
CONCLUSIONS

- Untreated, severe aortic stenosis has a high 2 year mortality.
- New guidelines are available to help clarify treatment and follow-up options.
- ECHO is the cornerstone of initial evaluation and guiding treatment.
- Be aware of severe, symptomatic low flow / low gradient AS and paradoxical low flow AS with a normal EF.
- Recognize the association between bicuspid aortic valve and aortopathy.
- TAVR is an option for symptomatic, severe AS with high surgical risk.