Aortic Valve Disease (Aortic Stenosis)

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Disclosures

Academic Echo Core Lab with multiple pharmaceutical and device commercial sponsors

No direct COI with this lecture

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ACC/AHA/ASE GUIDELINE

ACC/AHA/ASE 2003 Guideline Update for the Clinical Application of Echocardiography:
Summary Article

Recommendations for Echocardiography in Valvular Stenosis

Class I
1. Diagnosis/assessment of hemodynamic severity.
2. Assessment of LV and right ventricular (RV) size, function, and/or hemodynamics.
3. Re-evaluation of patients with known valvular stenosis with changing symptoms or signs.
5. Re-evaluation of asymptomatic patients with severe stenosis.

Class IIa
1. Assessment of the hemodynamic significance of mild to moderate valvular stenosis by stress Doppler echocardiography.
2. Re-evaluation of patients with mild to moderate aortic stenosis with LV dysfunction or hypertrophy even without clinical symptoms.
Valvular Aortic Stenosis
Comprehensive Echo Evaluation

- Imaging of valve to determine etiology
- Quantitation of stenosis severity
- Evaluation of co-existing valve lesions
- Assessment of LV function, hypertrophy

Qualitative Assessment

Aortic Stenosis: Etiology

1. Congenital (Unicuspid, bicuspid)
2. Rheumatic and other systemic dz
3. Degenerative (Sclerosis of previously normal valve)
Senile Calcific Aortic Valve Stenosis

- Nodular calcific masses on aortic side of cusps
- No commissural fusion
- Free edges of cusps are not involved

Congenital Bicuspid Aortic Valve

- Arrow points to median raphe

Qualitative Evaluation

- Thin and delicate cusps
- May be difficult to visualize
- Unrestricted opening: in systole = Ao walls
Qualitative Evaluation

- Cusps visualized in diastole
- Lines of coaptation: Benz Sign
- No fusion of commissures
- No restriction of motion

Aortic Stenosis
Pathophysiology

- Obstruction to LV outflow
- Requires high LV pressure to maintain systolic BP
- High LV pressure leads to hypertrophy
- Hypertrophy leads to elevation of LVEDP
- High LV pressure assoc'd with increased MVO₂
- Fibrosis may extend into conduction system
Aortic Stenosis
2D-Echo Findings

- Increased thickness of leaflets
- Decreased excursion of leaflets (< 15 mm)
- Post-stenotic dilatation of ascending aorta
- Left ventricular hypertrophy
- Increased left ventricular mass
- Left atrial enlargement
- Decreased LV function (late in course)

Quantitative Assessment

Grading the Degree of Stenosis

<table>
<thead>
<tr>
<th>Grade</th>
<th>Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>$\leq 3.0$ to $4.0 , \text{cm}^2$</td>
</tr>
<tr>
<td>Mild</td>
<td>$&gt;1.5 , \text{cm}^2$</td>
</tr>
<tr>
<td>Moderate</td>
<td>$1.0$ to $1.5 , \text{cm}^2$</td>
</tr>
<tr>
<td>Severe</td>
<td>$&lt;1.0 , \text{cm}^2$</td>
</tr>
</tbody>
</table>


*Historically severe AS $<0.75 \, \text{cm}^2$
Quantitation of Aortic Stenosis
Echo-Doppler Assessment

- Peak instantaneous gradient
- Mean pressure gradient
- Aortic valve area (continuity equation)
- Velocity ratio (dimensionless index)
- LV size & function, aortic root and other valves

Gradients in Aortic Stenosis

Stenotic Aortic Valve
Quantitative Evaluation

AoV Velocity
- Smooth curve
- Well-defined peaks
- High frequency signal
- $V_{\text{max}}$ measured at the outer edge of envelope

Peak Instantaneous Gradient

$$\Delta P_{\text{max}} = 4V^2$$

Mean Gradient

$$\Delta P_{\text{mean}} = \frac{4V_1^2 + 4V_2^2 + 4V_3^2 + \ldots + 4V_n^2}{n}$$
Aortic Stenosis
Pitfalls of Doppler-Derived Gradients

- Comparison with cath gradients
- Poor alignment of Doppler beam
- High LVOT velocity (Sub-aortic stenosis)
- High velocity systolic jets that can mimic AS
  - MR
  - TR
  - VSD
  - PA Stenosis

Quantitative Evaluation

AS
Sub-aortic Membrane
HCM

Mitral Regurgitation
Aortic Valve Area
Continuity Equation

Continuity Equation

AVA by Continuity Equation

Weakest link is LVOT D
LVOT\textsubscript{D} Measurement

Limitations

• Poor image quality
• Annular calcification
• Sigmoid septum

Quantitative Evaluation

LVOT Diameter

• Parasternal long axis
• Measure in mid-systole
• Proximal and parallel to plane of stenotic aortic valve
• From inner-edge of septal endocardium to edge of AMVL
• CSA= \pi r^2

LVOT Velocity Measurement

• Apical 5 chamber or ApLAX
• Use small sample volume
• With PW, start apically & advance \rightarrow LVOT until well-defined laminar peak velocity curve is obtained (if broadens, back out apically)
• LVOT Diameter and Velocity signals need to be recorded at the same anatomic site
Doppler in Aortic Stenosis
Ultrasonic Windows

1. Apex
2. Suprasternal notch
3. Right sternal edge
4. Subxiphoid

Quantitative Evaluation

AoV Velocity
- Choose view allowing highest Velocity
- CW Doppler transducer – Vmax
- Highest signal-to-noise ratio
- Imperative use of Pedoff transducer

Grading the Severity of Aortic Stenosis

<table>
<thead>
<tr>
<th>Grade</th>
<th>Antegrade Jet Velocity</th>
<th>Aortic Valve Area</th>
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<tr>
<td>Normal</td>
<td>&lt;2.5 m/s</td>
<td>≈3.0 to 4.0 cm²</td>
</tr>
<tr>
<td>Mild</td>
<td>2.5 - &lt;3.0 m/s</td>
<td>&gt;1.5 cm²</td>
</tr>
<tr>
<td>Moderate</td>
<td>3.0 - &lt;4.0 m/s</td>
<td>1.0 to 1.5 cm²</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;4.0 m/s</td>
<td>&lt;1.0 cm²</td>
</tr>
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*Historically severe AS <0.75 cm²
Grading the Severity of Aortic Stenosis

<table>
<thead>
<tr>
<th>Grading</th>
<th>Dimensionless Index</th>
<th>Aortic Valve Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&gt; 0.50</td>
<td>&gt;1.5 cm²</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.50-0.25</td>
<td>1.0 to 1.5 cm²</td>
</tr>
<tr>
<td>Severe</td>
<td>&lt; 0.25</td>
<td>&lt;1.0 cm²</td>
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*Historically severe AS <0.75 cm²*


Aortic Stenosis
Complete Echo Evaluation

- Quantitation of stenosis severity
- LV response to pressure overload
  - Quantitation of coexisting AI & MR
  - Estimation of PA pressures
  - Assessment of LV diastolic function
  - Presence & extent of aortic root dilation