Aortic Stenosis
Echocardiographic Evaluation of Hemodynamic Severity

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DISCLOSURE

Relevant Financial Relationship(s)
None

Off Label Usage
None
VHD in the 21\textsuperscript{th} century
A re-emerging public-health problem

- Increasing prevalence
- Mostly degenerative
- Affecting the elderly
- Requiring new approaches

Prevalence of Aortic Stenosis
Moderate to Severe

Population Based Studies: CARDIA, ARIC, CHS
Olmstead County

Nkomo et al. Lancet 2006; 368: 1005–11
VHD in the 21st century
A re-emerging public-health problem

- Increasing prevalence
- Mostly degenerative
- Affecting the elderly
- Requiring new approaches

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

Developed in Collaboration With the American Association for Thoracic Surgery, American Society of Echocardiography, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

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2/16/2017
Stages of Progression of 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 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>
<tr>
<td>C</td>
<td>Asymptomatic</td>
<td>Severe asymptomatic patients with criteria for severe VHD</td>
</tr>
<tr>
<td>C1</td>
<td></td>
<td>Left and right ventricles remain compensated</td>
</tr>
<tr>
<td>C2</td>
<td></td>
<td>Decompensation of left or right ventricle</td>
</tr>
<tr>
<td>D</td>
<td>Symptomatic</td>
<td>Patients who have developed symptoms as a result of VHD</td>
</tr>
</tbody>
</table>

Severe AS

- Symptomatic (stage D1)
- Symptoms with Exercise testing
- LVEF <50% (stage C2)
- Asymptomatic (stage C)
- Other cardiac surgery
- \( V_{\text{max}} \geq 5 \text{ m/s} \)
- \( \Delta P_{\text{mean}} \geq 60 \text{ mmHg} \)
- Low surgical risk
- Abnormal ETT
- \( \Delta V_{\text{max}} > 3 \text{ m/s/yr} \)
- Low surgical risk

AVR (I)
AVR (Ila)
AVR (IIb)
## Aortic Stenosis

### Hemodynamic Severity

<table>
<thead>
<tr>
<th>Category</th>
<th>(V_{max}) (m/s)</th>
<th>Mean Gradient (mmHg)</th>
<th>Valve Area (cm(^2))</th>
<th>Valve Area Index (cm(^2)/m(^2))</th>
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</thead>
<tbody>
<tr>
<td>Mild</td>
<td>2.0-2.9</td>
<td>&lt;20</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>3.0-3.9</td>
<td>20-39</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>(\geq 4.0)</td>
<td>(&gt;40)</td>
<td>(\leq 1.0)</td>
<td>(\leq 0.6)</td>
</tr>
</tbody>
</table>

Nishimura, et al, 2014

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### Survival in Asymptomatic Aortic Stenosis

![Graph showing survival rates for different Vmax categories](attachment:graph.png)

- Vmax <3 m/s
- 3.0-4.0 m/s
- \(\geq 4.0\) m/s

Otto CM et al: Circ 95(9):2262, 1997
### Aortic Stenosis
#### Hemodynamic Severity

<table>
<thead>
<tr>
<th>Severity</th>
<th>$V_{\text{max}}$ (m/s)</th>
<th>Mean Gradient (mmHg)</th>
<th>Valve Area (cm²)</th>
<th>Valve Area Index (cm²/m²)</th>
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Nishimura, et al, 2014

### Echocardiographic Evaluation of Aortic Stenosis

- **Doppler**
- **2D**
- **3D**

- Valve Morphology
- Vmax, Valve Area and Gradient
- Ventricular Size & Function, RVSP
Blood Flow Velocity

Positive Frequency Shift

\[(fr - fo) = 2fo \times \frac{v \times (\cos \theta)}{c}\]

C = average speed of sound in tissue (1540 m/sec)

Importance of Doppler Angle

• Goal: parallel to flow
• Skilled in non-guided CW transducer
Aortic Stenosis

**CW Doppler**

Apical

- \( V_{\text{max}} = 4.1 \text{ m/s} \)
- \( \text{TVI} = 92 \text{ cm} \)
- \( \text{MG} = 34 \text{ mmHg} \)

Right parasternal

- \( V_{\text{max}} = 4.8 \text{ m/s} \)
- \( \text{TVI} = 148 \text{ cm} \)
- \( \text{MG} = 68 \text{ mmHg} \)
Rule #1: CW Doppler from multiple windows

Echocardiographic Evaluation of Aortic Stenosis

Aortic Valve Area Continuity Equation

LVOT flow = AV flow

\[ A_{LVOT} \times TVI_{LVOT} = A_{AV} \times TVI_{AV} \]

\[ A_{AV} = \frac{(A_{LVOT} \times TVI_{LVOT})}{TVI_{AV}} \]
LVOT area = (0.785) x (d^2)
LVOT Diameter

LVOT Diameter
Rule #2:
When measuring the LVOT diameter you should see the base of the anterior or right coronary cusp but may not clearly see the posterior cusp.
Differential Left Ventricular Outflow Tract Remodeling and Dynamics in Aortic Stenosis

Methods: In 54 patients with aortic stenosis, left ventricular outflow tract (LVOT) remodeling and stiffness was measured relative to changes in LVOT wall thickness and peak systolic LVOT planimetry was compared to control subjects.

Results: At end-diastole, patients with AS had lower LVOT wall thickness and distensibility compared to control subjects, and peak systolic LVOT wall thickness and distensibility was lower in patients with AS compared to normal control subjects. Patients with AS had lower peak systolic LVOT ellipticity index compared to control subjects, and higher posterior LVOT ellipticity index was associated with AS when assessing these changes relative to normal controls. (J Am Soc Echo-

Where To Measure the LVOTd? At the Annulus or Below the Annulus?

LaBounty et al. JACC Cardiovasc Imaging 2014;7:1065-6
Echocardiographic Evaluation of Aortic Stenosis

Rule #2a:
When measuring the LVOT diameter this measurement should be made at the hinge point of the aortic valve leaflets in mid-systole.

Aortic Stenosis
Measure $LVOT_{TVI}$
If as in the LVOT, the flow proximal to the obstruction is accelerated, the velocity profile at level A is flattened. Velocities representing the spatial mean velocity should therefore be recorded at this level.

Skjaerpe T. Circulation 72(4), 1085
Normal LVOT TVI: 18-22 cm
**Echocardiographic Evaluation of Aortic Stenosis**

**Rule #3:**
When measuring the $\text{LVOT}_{TVI}$ the pulsed wave sample volume should be placed in the blue flow.
Stroke volume = 79 cc  
TVI = 19 cm

Stroke volume = 141 cc  
TVI = 34 cm

2D Biplane SV = 80 cc  
LVEF = 67%

3D Echocardiography
Stroke Volume & Ejection Fraction

SV = 81 cc
**Echocardiographic Evaluation of Aortic Stenosis**

**Rule #4:**
Check for concordance between Doppler with 2D &/or 3D calculations of stroke volume and compare to LV size and ejection fraction.

**Rule #5:**
Check for concordance between the calculated valve area and mean gradient or explain discordance.
Echocardiographic Evaluation of Aortic Stenosis