 HOW TO?

Assess the severity of aortic stenosis

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Invasive assessment

- Retrograde catheterization to assess aortic stenosis has a substantial risk of both clinical and silent cerebral infarction.
- Cranial (MRI) and neurologic assessment within two days before and after the procedure revealed evidence of cerebral embolism in 22% of patients who had retrograde catheterization of the aortic valve.
- Conclusion: patients should be informed about the risks, and retrograde catheterization of the stenotic aortic valve reserved to only those with unclear echocardiographic findings and additional information is essential for clinical management.
Transthoracic echocardiography has largely replaced cardiac catheterization as the primary modality for the hemodynamic assessment of valvular heart disease. A comprehensive evaluation of valve structure, function, and hemodynamics is possible through a carefully performed transthoracic study.

Initial severity, etiology, and progression through serial follow up studies are easily obtained.

Aortic Stenosis Etiology

- Age Group < 70 years:
  - Degenerative: 18%
  - Rheumatic: 25%
  - Bicuspid: 50%
  - Other: 7%

- Age Group > 70 years:
  - Degenerative: 48%
  - Rheumatic: 23%
  - Bicuspid: 27%
  - Other: 2%
Leaflet doming is the hallmark of aortic stenosis. Failure of aortic leaflets to open fully (restriction) with ventricular ejection in the setting of adequate cardiac output often signifies some degree of aortic stenosis. Stenotic aortic valves are generally thickened or calcified. + counting the leaflets
2DE normal and AS

2DE bi and quadricuspid
Planimetry

- From a short-axis view at the level of the valve orifice, direct planimetry of the valve area is possible in more than 90% of patients. Limitations of this approach include the three-dimensional nature of the orifice and the shadowing effect of a calcified valve and root.

- As a result, the technical challenges of this approach are considerable and it is not routinely performed.
Doppler measurements across the aortic valve begin with estimation of peak velocity. Entered in the simplified Bernoulli equation, peak instantaneous gradient is obtained. This is well correlated with simultaneous measurements obtained by invasive means. Peak velocity usually occurs in mid systole. As aortic stenosis worsens, velocity tends to peak later in systole, sometimes offering a clue to severity. Late peaking jets are also characteristic of dynamic subaortic stenosis, as occurs in hypertrophic cardiomyopathy.
DOPPLER ASSESSMENT

Continuous-wave (CW) Doppler measurements across the aortic valve should be performed where the ultrasound beam is most parallel to the flow of blood across the valve. Therefore, best measurements are acquired in the apical five-chamber, right parasternal long axis, or suprasternal views to obtain the highest velocities across the valve.

Underestimation is the rule:

1) technically poor recording may fail to display the highest velocity signals,
2) An inability to align the interrogation angle parallel to flow
3) beat to beat, day to day, HR, Arrhyt., loading, BP, inotropic state
Invasive/ echo gradients

DOPPLER ASSESSMENT

- Overestimation of the true pressure gradient is less common but can occur. This is usually the result of mistaken identity of the recorded signal. For example, the mitral regurgitation jet has a contour similar to that of a jet of severe aortic stenosis.
- To avoid this, the two jets should be recorded by sweeping the transducer back and forth to clearly indicate to the interpreter which jet is which. Another helpful clue involves the timing of the two jets.
DOPPLER ASSESSMENT

The calculation of transvalvular pressure gradients is based upon the simplified Bernoulli principle:

CW Doppler:
\[ \Delta P \text{ (in mmHg)} = 4V^2 \]
\[ \Delta P_{\text{mean}} = \Delta p_{\text{max}}/1.45 + 2 \text{ mmHG} \]
(roughly 2/3 Pmax)

mean pressure gradient (P) can ALSO be estimated as: Mean \( \Delta P = 2.4(V_{\text{max}})^2 \)
eliminating the need to trace the Doppler velocity curve.

CALCULATION OF AORTIC VALVE AREA

Based on the principle of conservation of mass, the continuity equation states that the stroke volume proximal to the aortic valve (within the left ventricular outflow tract) must equal the stroke volume through the stenotic orifice. Because stroke volume is the product of the cross-sectional area and time velocity integral (TVI), the continuity equation can be arranged to yield:

\[ \text{Area LVOT} \times (V)_{\text{LVOT}} = \text{AVA} \times (V)_{\text{AS}} \]
( V: V max, or TVI)
ASA SMENT OF STENOSIS SEVERITY

The normal aortic valve orifice area in adults ranges from 2 to 4 cm².
Aortic stenosis can be categorized based on valve area (severe 1.0 cm², moderate 1.0-1.5 cm², and mild 1.5 cm²) according to American College of Cardiology/American Heart Association guidelines.

Transvalvular gradients should not be ignored when assessing severity of aortic stenosis. Overall, when the mean transvalvular gradient exceeds 50 mmHg, severe stenosis is usually present.
Another approach is to delete the outflow tract cross-sectional area from the continuity equation, leaving the ratio of outflow tract velocity to aortic jet velocity. Thus, a ratio close to 1 is normal, a ratio of 0.5 indicates a valve area half normal size, and a ratio of 0.25 is consistent with severe stenosis (i.e., a valve area one quarter normal size).

The British Society of Echocardiography gives clear criteria for classification of disease severity (see box 1), which have to be taken in the context of the clinical state of your patient.

### BOX 1: DISEASE SEVERITY AND PEAK AORTIC GRADIENT

<table>
<thead>
<tr>
<th>Disease severity</th>
<th>Peak aortic gradient</th>
<th>Mean gradient</th>
<th>Maximum velocity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild</td>
<td>&lt;40mmHg</td>
<td>&lt;20mmHg</td>
<td>2-3m/sec</td>
</tr>
<tr>
<td>Moderate</td>
<td>40-65mmHg</td>
<td>20-40mmHg</td>
<td>3-4m/sec</td>
</tr>
<tr>
<td>Severe</td>
<td>&gt;65mmHg</td>
<td>&gt;40mmHg</td>
<td>&gt;4m/sec</td>
</tr>
</tbody>
</table>

Echo machines allow the operator to calculate the valve area, using the continuity equation: >1cm² is considered mild, 0.8-1cm², moderate, and less than 0.8cm², severe.

Pulmonary hypertension is a poor prognostic sign and can be detected using echocardiography.
Using Jet Velocity

- Severe AS: 4.0 m/s, moderate 2.5–4.0 m/s and mild 2.5 m/s) based on concepts of fluid dynamics and on clinical outcome data. However, there is substantial overlap between hemodynamic severity and symptoms, such that the exact jet velocity or valve area at which symptoms occur varies from patient to patient.

<table>
<thead>
<tr>
<th>Components</th>
<th>Measurement</th>
<th>Acquisition site</th>
<th>Echo modality</th>
<th>Utility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continuity equation</td>
<td>LVOT diameter, LVOT VTI, AV VTI mean gradient</td>
<td>PLAX, A5C, A3C, A3C, A2C, SSN, right PLAX</td>
<td>2D, pulsed Doppler, CW Doppler</td>
<td>Accurate, reproducible, flow-dependent</td>
</tr>
<tr>
<td>Doppler velocity index (dimensionless index)</td>
<td>Peak LVOT, Peak AV</td>
<td>A5C, A3C, A2C, right PLAX, SSN</td>
<td>CW or pulsed Doppler</td>
<td>Useful in patients with AF, PVCs, and prostatic valves</td>
</tr>
<tr>
<td>Doppler pressure gradients</td>
<td>Doppler maximum gradient, Doppler mean gradient</td>
<td>A5C, A3C, right PLAX, SSN</td>
<td>CW Doppler</td>
<td></td>
</tr>
<tr>
<td>Maximum aortic jet velocity</td>
<td>Maximum velocity</td>
<td>A5C, A3C, right PLAX, SSN</td>
<td>CW Doppler</td>
<td></td>
</tr>
<tr>
<td>Planimetry</td>
<td>2D planimetry</td>
<td>Midesophageal views</td>
<td>TEE</td>
<td>Planimetry by TEE, when transesophageal study suboptimal</td>
</tr>
</tbody>
</table>

A3C, apical three-chamber view; A5C, apical five-chamber view; AF, atrial fibrillation; CW, continuous wave; 2D, two-dimensional; LVOT, left ventricular outflow tract; PLAX, parasternal long axis; SSN, suprasternal notch; TEE, transesophageal echocardiography; VTI, velocity time integral; PVC, premature ventricular contraction.
LOW-GRADIENT AORTIC STENOSIS

In some situations, patients present with severe aortic stenosis (calculated AVA < 1.0 cm²) and low transvalvular gradients (< 30 mmHg).

These patients have low ejection fractions and low cardiac output.

In this situation, the calculated AVA may be small secondary to the low flow state, and should be interpreted with caution. These patients may benefit from further testing to differentiate true severe aortic stenosis from Pseudo AS owing to a functionally stenotic valve because of the low output state.

DSE in AS
DSE in AS

Dobutamine echocardiography can help to differentiate these two conditions. With the infusion of low-dose dobutamine, stroke volume increases and the calculated AVA increases in those with functionally stenotic valves.

However, in those with true severe aortic stenosis, the calculated AVA remains unchanged. Low-dose dobutamine challenge therefore can assess the “contractile reserve”—a predictor of which patients are more likely to benefit from aortic valve replacement.
Other methods

- SWL = 100 \times \frac{\Delta P_{\text{mean}}}{\Delta P_{\text{mean}} + \text{SBP}} \quad \text{(A cutoff value more than 25% effectively discriminated between patients experiencing a good and poor outcome)}
- AV resistance = \left(\frac{\Delta P_{\text{mean}}}{Q_{\text{mean}}}\right) \times 1333
- Resistance = 28 \sqrt\frac{\Delta P_{\text{mean}}}{\text{AVA}}