Quantifying Aortic Regurgitation

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No Disclosures
European Association of Echocardiography recommendations for the assessment of valvular regurgitation. Part 1: aortic and pulmonary regurgitation (native valve disease)

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Approaches

- Color Jet
  - Dimensions
  - Vena Contracta
- Spectral Doppler
  - Density
  - Pressure half time
  - Flow reversal (descending and/or abdominal aorta)
  - Quantitative Doppler
  - PISA
Color Jet Characteristics

• Length

Indexed Width vs. LVOT diameter

• <25% = mild
• 25-45% = mild to moderate
• 46-64% = moderate to severe
• ≥ 65% = severe
Color Jet Characteristics
Indexed CSA

vs. LVOT CSA

• <5% = mild
• 5-20% = mild to moderate
• 21-59% = moderate to severe
• ≥ 60% = severe
Pros

1) Easy
2) Easy
3) Easy
4)  

Cons

• Setting dependent
  – Jet dimension
    • Directly related to gain, transmit power
    • Inversely related to Nyquist limit
• (Wall constraints)
• May not be constant flow rate
• BP dependent
• Reference to LVOT dimension may be inappropriate
• The color jet volume is not the same as the regurgitant volume
Vena Contracta

- the point in a fluid stream where the diameter (and cross-sectional area) of a fluid stream moving through a narrowing is the least, and fluid velocity is at its maximum.
- the maximum contraction takes place at a section slightly downstream of the orifice, where the jet is more or less horizontal.
Why does this happen?

- Fluid streamlines cannot abruptly change direction.
- In the case of a sudden change in orifice diameter, the streamlines are unable to closely follow the sharp angle into the orifice.
- Instead, the converging streamlines follow a smooth path, which results in the narrowing of the jet.
Vena Contracta

< 0.3 = mild
0.3-0.6 = moderate
>0.6 = severe

Semi-quantitative assessment of aortic regurgitation severity using the vena contracta (VC) width.

Problems

• Imprecision of the measurement
  – Spatial resolution
• Spatial variation (noncircular)
  – Assumes sphericity
• Temporal variability
• Multiple jets??
• Large gray zone

Spectral Doppler

Density problematic with eccentric jets
Pressure Half Time

> 500 = mild
200-500 = moderate
<200 = severe

What Is the Validity of Continuous Wave Doppler Grading of Aortic Regurgitation Severity? A Chronic Animal Model Study

Masahiro Ishii, MD, Michael Jones, MD, Takahiro Shiota, MD, Izumi Yamada, MD, Russell S. Heinrich, BS, Scott R. Holcomb, MS, Tahir El-Kadi, MD, Ajit P. Yoganathan, PhD, and David J. Sahn, MD, Portland, Oregon, Bethesda, Maryland, and Atlanta, Georgia

Fig. 3

AR Halftime vs RF

Contrasting Effect of ROA and SVR


With thanks to Jim Thomas
PHT not very helpful

Flow Reversal
### Table 4: Qualitative and quantitative parameters useful in grading aortic regurgitation severity

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Structural parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LA size</td>
<td>Normal*</td>
<td>Normal or dilated</td>
<td>Usually dilated**</td>
</tr>
<tr>
<td>Aortic leaflets</td>
<td>Normal or abnormal</td>
<td>Normal or abnormal</td>
<td>Abnormal/flail, or wide coaptation defect</td>
</tr>
<tr>
<td><strong>Doppler parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet width in LVOY - Color flow</td>
<td>Small in central jet</td>
<td>Intermediate</td>
<td>Large in central jet; variable in eccentric jet</td>
</tr>
<tr>
<td>Jet density - CW</td>
<td>Incomplete or faint</td>
<td>Dense</td>
<td>Dense</td>
</tr>
<tr>
<td>Jet acceleration - CW</td>
<td>Flow &gt; 500</td>
<td>Medians 500-200</td>
<td>Slope &lt; 200</td>
</tr>
<tr>
<td><strong>Diastolic flow reversal at descending aorta - CW</strong></td>
<td>Breif, early diastolic reversal</td>
<td>Intermediate</td>
<td>Prominent holodiastolic reversal</td>
</tr>
<tr>
<td><strong>Quantitative parameters</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VC width, cm²</td>
<td>&lt; 0.3</td>
<td>0.2-0.60</td>
<td>&gt; 0.6</td>
</tr>
<tr>
<td>Jet width / LVOY width, %²</td>
<td>&lt; 25</td>
<td>25-45</td>
<td>45-64</td>
</tr>
<tr>
<td>Jet CSA / LVOY CSA, %²</td>
<td>&lt; 8</td>
<td>8-20</td>
<td>21-39</td>
</tr>
<tr>
<td>R Vol, ml/beat</td>
<td>&lt; 30</td>
<td>30-44</td>
<td>45-59</td>
</tr>
<tr>
<td>RE, %</td>
<td>&lt; 30</td>
<td>30-29</td>
<td>40-49</td>
</tr>
<tr>
<td>EROA, cm²</td>
<td>&lt; 0.10</td>
<td>0.10-0.19</td>
<td>0.20-0.29</td>
</tr>
</tbody>
</table>

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- AR = aortic regurgitation; CW = continuous-wave; LA = left atrium; EROA = effective regurgitant orifice area; LVOY = left ventricle; R Vol = regurgitant volume; VC = vena contracta.
- * AT a nyquist limit of 50-60 cm/s.
- ** PMT is shortened with increasing LV diastolic pressure, vasodilator therapy, and in patients with a dilated compliant aorta or lengthened in chronic AR.
- Grading of the severity of AR is classified as mild, moderate or severe and subclassifies the moderate regurgitation group into ‘mild-to-moderate’ (EROA of 12-19 mm or an R Vol of 30-44 ml) and ‘moderate-to-severe’ (EROA of 20-29 mm or an R Vol of 45-59 ml).
<table>
<thead>
<tr>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal/Abnormal</td>
<td>Normal/Abnormal</td>
<td>Abnormal/Abnormal/Coaptation defect</td>
</tr>
<tr>
<td>Small in central jets</td>
<td>Intermediate</td>
<td>Large in central jet, variable in eccentric jets</td>
</tr>
<tr>
<td>Incompletely filled</td>
<td>Dense</td>
<td>Dense</td>
</tr>
<tr>
<td><strong>Brief, protodiastolic flow reversal</strong></td>
<td><strong>Intermediate</strong></td>
<td><strong>Holodiastolic flow reversal (end-diastolic velocity &gt;20 cm/s)</strong></td>
</tr>
</tbody>
</table>

- `<3`: Intermediate
- `>6`: Severe
- `<10`: 10–19
- `>30`: 30–44
- `<30`: 30–44

wave; LA, left atrium; EROA, effective regurgitant orifice area; LV, left ventricle; R Vol, regurgitant volume; VC, venous congestion of the liver; CRT, cardiac resynchronization therapy; AR, aortic regurgitation; PHT, portal hypertension.

...and in patients with a dilated compliant aorta and lengthened in chronic AR.
Limitations

• Noise
• Default wall filters
• Impact of vascular compliance on accuracy still unknown
Quantitative Doppler

- Regurgitant volume
  - <30 = mild
  - 30-44 = mild to moderate
  - 45-59 = moderate to severe
  - ≥ 60 = severe

- Regurgitant fraction
  - <30 = mild
  - 30-39 = mild to moderate
  - 40-49 = moderate to severe
  - ≥ 50 = severe
Pros

- Only way we have to get at regurgitant fraction
- Measures the same thing as MRI
- Echo methods of measuring forward flow are robust
- Handles multiple jets
Limitations

- Limited validation
- Using mitral inflow as reference makes lots of assumptions
- Using pulmonic flow as reference is difficult
- Concomitant aortic stenosis may create problems

PISA
Proximal Convergence Method

Flow thru any isovelocity shell is equal to instantaneous orifice flow

Quantitative assessment of aortic regurgitation (AR) severity using the proximal isovelocity surface area (PISA) method.

• Regurgitant volume (cc)
  <30 = mild
  30-44 = mild to moderate
  45-59 = moderate to severe
  ≥ 60 = severe

• EROA (cm²)
  <0.10= mild
  .10-.19 = mild to moderate
  .20-.29 = moderate to severe
  ≥ .30 = severe

**Limitations**

• Spatial resolution
• Geometric assumptions
• Limited validation
  – Other echo methods (quantitative Doppler, 2D)
Can 3D help with quantitation?

Maybe
Accuracy of Three-Dimensional Versus Two-Dimensional Echocardiography for Quantification of Aortic Regurgitation and Validation by Three-Dimensional Three-Directional Velocity-Encoded Magnetic Resonance Imaging


Am J Cardiol 2013;112:560e566
3D still research tool

Summary

• Use an integrated approach
• Every method has pitfalls
Thank you!