Evaluation of Prosthetic Valve Function

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No conflicts to report
Prosthetic Valves
Types of Prosthetic Heart Valves

**Biological**

*Stented*
- Porcine xenograft
- Pericardial xenograft

*Stentless*
- Porcine xenograft
- Pericardial xenograft
- Homograft (allograft)
- Autograft

*Percutaneous*

**Mechanical**

- Bileaflet
- Single tilting disk
- Caged-ball

25 Different Brand names worldwide…

> 44 Different Models!

Sizes: 17 - 35 mm
Normal Prosthetic Valves

Determinants of Velocity / Gradient:

- Valve size
- Valve Type
- Flow Rate
Different Flow Profiles and Effective Orifice Areas For Similar “Size”
Recommendations For Evaluation Of Prosthetic Valves With Echocardiography And Doppler Ultrasound

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Parameters in the Comprehensive Evaluation of Prosthetic Valve Function

**Clinical information**

- Date of valve replacement
- Type and size of the prosthetic valve
- Height/Weight/Body surface area
- Symptoms and related clinical findings
- Blood pressure and heart rate
Prosthetic Aortic Valve CW Recording

? Normal or Abnormal
St Jude Medical Valve

ANOVA p=0.002
* p<0.05

Chafizadeh E. Circ 83:213, 1991
Derivation of Effective orifice Area

Effective Orifice Area \( = \frac{CSA_{LVO} \times VTI_{LVO}}{VTI_{JET}} \)
St Jude Medical Valve

Doppler Valve Area (cm²)
(D_{LV0-Echo})

Valve Size (mm)

(n=9) (14) (16) (14) (6) (5) (3)

19 21 23 25 27 29 31

Chafizadeh E. Circ 83:213, 1991
Doppler Velocity Index

\[
\text{Doppler Velocity Index} = \frac{\text{Velocity}_{LVO}}{\text{Velocity}_{jet}}
\]

(Normal > 0.25)
DOPPLER VELOCITY INDEX

St. Jude Valve

\[ \frac{P_{kV_{LVO}}}{P_{kV_{jet}}} \]

- Normal
- Obstructed

Valve Size (mm):
- (n=9) 19
- (14) 21
- (16) 23
- (14) 25
- (6) 27
- (5) 29
- (3) 31

Chafizadeh: Circulation 83: 213, 1991
Percutaneous Aortic Valves (TAVR)

**Excellent Flow Profile**

DVI is Normally close to 0.5

LVO

1 m/s

AV

2 m/s
### Pulsed Doppler
- **Normal**
  - MG = 22 mmHg
  - DVI = 0.4
  - AT = 75 ms

- **Obstructed**
  - MG = 80 mmHg
  - DVI = 0.18
  - AT = 180 ms

### CW Doppler
- **Prosthetic AV**
  - Normal: 1.1 m/s
  - Obstructed: 1.0 m/s

  - Normal: AT = 75 ms
  - Obstructed: AT = 180 ms

### Flow Speeds
- Normal: 2.8 m/s
- Obstructed: 5.5 m/s
Comparison with post-operative studies is essential in cases of high gradient
Prosthetic Mitral Valve

Normal

Mean Gr = 4 mmHg
PHT = 123 ms
EOA = 2.5 cm²

Obstructed

Mean Gr = 13 mmHg
PHT = 200 ms
EOA = 1.1 cm²
Prosthetic Mitral Valve

Traditional Doppler Parameters

• Maximal Velocity
• Mean gradient: Importance of heart rate
• Pressure half-time
• Effective orifice area (continuity equation)
### Doppler Parameters of Prosthetic MV Function

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity</td>
<td>$\geq 2.5$ m/s</td>
</tr>
<tr>
<td>Mean gradient</td>
<td>$&gt; 10$ mmHg</td>
</tr>
<tr>
<td>EOA (continuity)</td>
<td>$&lt; 1$ cm$^2$</td>
</tr>
<tr>
<td>Pressure Half-time</td>
<td>$&gt; 200$ ms</td>
</tr>
</tbody>
</table>

Suggests Significant Stenosis

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Zoghbi W et al. JASE 22: 975, September 2009
Indications of TEE
In Prosthetic Valve Obstruction

- Non-diagnostic or borderline cases by transthoracic Echo / Doppler
- Assessment of concomitant regurgitation
- Patients with known severe obstruction: Candidates for thrombolysis
Fluoroscopy May be Need to Assess Valve Mobility in *Mechanical Aortic* valves
CT Scan in Prosthetic Valves

Normal

Obstructed-Thrombus
Normal, “Physiologic” Regurgitation
Shadowing & Flow Masking

Mitral prosthesis

Aortic prosthesis

Parasternal

Apical

Zoghbi W et al. JASE 22: 975, September 2009
58 M with Prosthetic Mitral Valve
Clues from the Transthoracic Study for Significant MR in Mechanical Valves

- High E mitral velocity (> 1.9 m/s)
- High mean gradient (> 5 mmHg)
- Elevated $\frac{VTI_{MV}}{VTI_{LVO}}$ ratio (> 2.2)
- Good LV function but low systemic output (VTI)
- Pulmonary hypertension (TR velocity > 3 m/s)
Prosthetic Aortic Regurgitation
Prosthetic Aortic Regurgitation

Indicators of Severity

• Aortic Valve/ LV enlargement

• Color Doppler: Proximal jet width/CSA; Vena Contracta > PISA; Beware of eccentric jets

• Intensity of jet by CW

• Pressure half-time

• Regurgitant Volume/Fraction

• Diastolic retrograde flow in aorta
Prosthetic Aortic Regurgitation

TEE helps Identify Etiology & Complications
TAVR

...How severe is the Regurgitation?
Paravalvular Regurgitation after TAVR
A Lingering challenge


<table>
<thead>
<tr>
<th></th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Prosthetic aortic valve regurgitation</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Semiquantitative parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diastolic flow reversal in the descending aorta—PW</td>
<td>Absent or brief early diastolic</td>
<td>Intermediate</td>
<td>Prominent, holodiastolic</td>
</tr>
<tr>
<td>Circumferential extent of prosthetic valve paravalvular regurgitation (%)**</td>
<td>&lt;10%</td>
<td>10%-29%</td>
<td>≥30%</td>
</tr>
<tr>
<td>Quantitative parameters‡</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regurgitant volume (mL/beat)</td>
<td>&lt;30 mL</td>
<td>30-59 mL</td>
<td>≥60 mL</td>
</tr>
<tr>
<td>Regurgitant fraction (%)</td>
<td>&lt;30%</td>
<td>30-49%</td>
<td>≥50%</td>
</tr>
<tr>
<td>EROA (cm²)</td>
<td>0.10 cm²</td>
<td>0.10-0.29 cm²</td>
<td>≥0.30 cm²</td>
</tr>
</tbody>
</table>
Comprehensive Evaluation of Prosthetic Valve Function

• Clinical evaluation, know valve Type and Size

• Baseline echo/Doppler study after surgery

• Transthoracic 2D/Doppler evaluation of structure and function is the first line diagnostic method

• In cases with high velocity jet/gradient and suspected stenosis or regurgitation
  • Compare previous studies
  • TEE, (fluoroscopy if needed for Aortic mechanical PrV, ?CT)
  • CMR in some cases of PrV regurgitation