Echocardiographic Evaluation of Aortic Valve Prosthesis

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Philadelphia, PA

Pre Questions (1)

• Regarding Aortic Prosthetic Valves
  – A. A routine echocardiogram is required very two years after AVR
  – B. An elevated gradient with a decreased EOA is always suggestive of valvular stenosis
  – C. Transthoracic echocardiogram alone is always sufficient to diagnose valvular stenosis
  – D. It is more challenging to quantify para-valvular versus valvular aortic regurgitation.
Pre Questions (2)

• Patients with Prosthesis-Patient Mismatch
  – A. Have abnormal prosthetic valve function
  – B. Progressively worsen with time
  – C. Have a small valve compared to the demands of their body and cardiac output
  – D. Have a benign condition
Topics of Discussion

• Types and Flow Profiles of Prosthetic Valves
• Echocardiographic Evaluation: Key Points
• Challenges for Evaluation
• Prosthetic Valves Evaluation
  – Elevated gradients
  – Regurgitation
  – Endocarditis
  – Thrombosis versus pannus

Types & Flow Profiles of Prosthetic Valves
Mechanical Vs. Bioprosthetic Vs. Autografts
Types & Flow Profiles of Prosthetic Valves
Mechanical Vs. Bioprosthetic Flow

Localized Pressure Loss and High Gradient in Central Orifice of Bileaflet Mechanical Valve
(?Pressure Recovery)

• Fluoroscopy
## ECHO EVALUATION Guidelines

### CLASS I
- Initial TTE after AVR (2-4 weeks or sooner if concern for follow up and transfer)
- Repeat TTE for AVR if there is a change in clinical symptoms or signs suggesting dysfunction
- TEE for AVR if there is a change in clinical symptoms or signs suggesting dysfunction

### CLASS II
- Annual TTE in bioprosthetic valves after the first 10 years (5 years in prosthetic statement 2008) but not mechanical valves

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### ECHO EVALUATION: Key Points

- Clinical picture
- Baseline study
- Type and size of valve
- LV chamber
- BP/HR
- Height/weight/BSA
- Exercise echo may be helpful
- Cinefluoroscopy, CT, MRI
ECHO EVALUATION:
Key Points

- Opening and Closing of leaflets or occluders
- Abnormal densities (calcium/mass/vegetation)
- Stability versus rocking motion
- May use Modified versus Simplified Bernoulli
  - $4V_2^2 - 4V_1^2$ Vs. $4V_2^2$
- Attention to flow states & adequate Doppler signals

Echo Evaluation:
Key Points

- Adequate Doppler Signals
  - LVOT obtained away from flow acceleration (0.5 to 1 cm below sewing ring)
  - Multiple planes
  - Off axis view in parasternal view to obtain LVOT diameter/TAVR versus SAVR
  - Eccentric aortic regurgitant jets may require different angles to Doppler
Evaluation of Prosthetic Valves: Challenges

- Large range in what is considered normal
- Mean Gradients produced depend on size and type of valve.
- For any particular patient... it is difficult to differentiate normal from abnormal, hence the need for comparison to older studies
- Shadowing may interfere with assessment of location and amount of regurgitation

Bioprosthetic Valve Abnormalities

- Elevated Gradients
- Regurgitation
- Endocarditis
- Thrombosis
- Pannus
Echocardiographic Evaluation of Elevated Prosthetic Valve Gradients

Comprehensive Evaluation

Peak aortic prosthesis velocity > 3m/s

Jet contour
AT (ms)

DVI ≥0.30
Jet contour >100
Consider PrAV stenosis with:
- Sub-valve narrowing
- Underestimated gradient
- Improper LVOT velocity

Normal PrAV
EOA index
High flow

DVI 0.25 – 0.29
Jet contour <100
Suggests prosthetic aortic valve stenosis

DVI <0.25
Jet contour >100
Consider improper LVOT velocity

PPM

JASE 2009;22(9):975
Parameters Utilized

• Peak prosthetic aortic velocity

- Normal < 3 m/sec
- Abnormal > 3 m/sec

Parameters Utilized

• Doppler Velocity Index

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

1.1/2.8 = 0.39  
Normal > 0.3

1/5.5 = 0.18  
Abnormal < 0.25

Parameters Utilized

• Jet Contour

Triangular  Rounded
Parameters Utilized

• Acceleration Time

<table>
<thead>
<tr>
<th>Time</th>
<th>Normal (&lt; 100 msec)</th>
<th>Abnormal (&gt; 100 msec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 msec</td>
<td><img src="image1.png" alt="Image" /></td>
<td><img src="image2.png" alt="Image" /></td>
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<tr>
<td>150 msec</td>
<td><img src="image3.png" alt="Image" /></td>
<td><img src="image4.png" alt="Image" /></td>
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</tbody>
</table>

Parameters Utilized

• Acceleration time/ ejection time
• AT/ET > 0.4: Prosthetic valve obstruction

<table>
<thead>
<tr>
<th>AT/ET</th>
<th>No Obstruction</th>
<th>Obstruction</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.290</td>
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<td><img src="image6.png" alt="Image" /></td>
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<tr>
<td>0.31</td>
<td><img src="image7.png" alt="Image" /></td>
<td><img src="image8.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Parameters Utilized

• Effective Orifice Area and iEOA

\[ A_2 \text{(EOA)} = \frac{A_1 \times V_1}{V_2} \]

\[ \text{iEOA} = \frac{AVA}{BSA} \]

Normal > 1.2 cm\(^2\)
Abnormal < 0.8 cm\(^2\)
Abnormal < 0.6 cm\(^2/m^2\)

Cause of Elevated Gradients Across Aortic Prosthesis

• Errors in Measurement
  – Improper LVOT Velocity
    • Taken too far from flow acceleration
  – Improper AV Velocity (Gradient) Assessment

• Increased Flow
• Pressure Recovery
• Prosthesis patient mismatch
• Prosthesis stenosis
NORMAL PROSTHESIS FUNCTION

Pulsed Doppler LVO

Normal

CW Doppler Prosthetic AV

MG = 22 mmHg
DVI = 0.4
AT = 75 ms
PROSTHETIC STENOSIS

Obstructed

Pulsed Doppler
LVO

CW Doppler
Prosthetic AV

MG = 80 mmHg
DVI = 0.18
AT = 180 ms
Doppler of Prosthetic Aortic Valve Function

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Possible Stenosis</th>
<th>Suggests Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Velocity</td>
<td>&lt; 3 m/s</td>
<td>3-4 m/sec</td>
<td>&gt; 4 m/s</td>
</tr>
<tr>
<td>Mean Gradient</td>
<td>&lt; 20 mmHg</td>
<td>20-35 mmHg</td>
<td>&gt; 35 mmHg</td>
</tr>
<tr>
<td>Doppler Velocity Index</td>
<td>&gt; 0.3</td>
<td>0.29-0.25</td>
<td>&lt; 0.25</td>
</tr>
<tr>
<td>Effective Orifice area</td>
<td>&gt; 1.2 cm²</td>
<td>1.2 – 0.8 cm²</td>
<td>&lt; 0.8 cm²</td>
</tr>
<tr>
<td>Contour of Jet</td>
<td>Triangular</td>
<td>Triangular to</td>
<td>Rounded Symmetrical contour</td>
</tr>
<tr>
<td></td>
<td>Early Peaking</td>
<td>intermediate</td>
<td></td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>80-100 ms</td>
<td>&gt; 100 ms</td>
</tr>
</tbody>
</table>

Mechanisms of Prosthetic Valve Dysfunction

- Wear and tear
- Calcification
- Pannus
- Endocarditis
- Thrombus
CASE PRESENTATIONS

- CASE PRESENTATION (1):
- 81 Y/O with progressive DOE
- PMHx: Rheumatic valve disease, CABG + Mechanical AVR 2003 (19 St Jude Regent Valve)
- TTE: Difficult to visualize mechanical AV
AV VEL=3.2
DI=0.58/3.2=0.18
AT=150msec
Jet Contour: Circular

An approach to prosthetic AV stenosis
An approach to prosthetic AV stenosis

Doppler Parameters of Prosthetic Aortic Valve Function

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</tr>
</thead>
<tbody>
<tr>
<td>Peak Velocity</td>
<td>&lt; 3 m/s</td>
<td>&gt; 4 m/s</td>
</tr>
<tr>
<td>Mean Gradient</td>
<td>&lt; 20 mmhg</td>
<td>&gt; 35 mmhg</td>
</tr>
<tr>
<td>Doppler Velocity Index</td>
<td>&gt;= 0.3</td>
<td>&lt; 0.25</td>
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<tr>
<td>Effective Orifice area</td>
<td>&gt; 1.2 cm²</td>
<td>&lt; 0.8 cm²</td>
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<td>Contour of Jet</td>
<td>Triangular</td>
<td>Rounded</td>
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<tr>
<td></td>
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<td>Symmetrical contour</td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>&gt; 100 ms</td>
</tr>
</tbody>
</table>
What is your diagnosis?

• A) Normal Prosthetic Valve Function
• B) Prosthesis – Patient Mismatch
• C) High Flow State
• D) Prosthetic Valve Stenosis
• E) Errors of Measurement: Improper LVOT Velocity

Additional Studies Needed?
TEE
Helpful with high gradients and normal motion by Fluoro
• CASE PRESENTATION (2):
  • 67 Y/O F Hx AVR (Bi-Leaflet Mechanical Valve 1998)
  • On Coumadin, difficulty maintaining therapeutic INR
  • Progressive DOE 6 mos
AV VEL = 3.6
DVI = 1.19 / 3.60
DVI = 0.33

Acceleration Time 0.11 sec
### Doppler Parameters of Prosthetic Aortic Valve Function

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal</th>
<th>Suggests Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Velocity</td>
<td>&lt; 3 m/s</td>
<td>3.6 &gt; 4 m/s</td>
</tr>
<tr>
<td>Mean Gradient</td>
<td>&lt; 20 mmhg</td>
<td>26 &gt; 35 mmhg</td>
</tr>
<tr>
<td>Doppler Velocity Index</td>
<td>&gt;= 0.3</td>
<td>0.33 &lt; 0.25</td>
</tr>
<tr>
<td>Effective Orifice area</td>
<td>&gt; 1.2 cm²</td>
<td>&lt; 0.8 cm²</td>
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<tr>
<td>Contour of Jet</td>
<td>Triangular</td>
<td>Rounded Symmetrical contour</td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>110 ms &gt; 100 ms</td>
</tr>
</tbody>
</table>

### An approach to prosthetic AV stenosis

- **Peak Prosthetic Aortic Jet Velocity > 3 m/s**
  - **DVI ≥ 0.30**
  - Jet Contour : >100
  - AT (ms) : >100
  - **DVI 0.25 – 0.29**
  - Jet Contour : <100
  - AT (ms) : <100
  - **DVI < 0.25**
  - Jet Contour : >100
  - AT (ms) : <100
An approach to prosthetic AV stenosis

**Peak Prosthetic Aortic Jet Velocity > 3 m/s**

- **DVI ≥ 0.30**
  - Jet Contour
    - AT (ms) >100
  - Consider PrAV stenosis with
    - Sub-valve narrowing
    - Underestimated gradient
    - Improper LVOT velocity

- **DVI 0.25 – 0.29**
  - AT (ms) <100

- **DVI < 0.25**
  - AT (ms) >100

Original LVOT Velocity Taken Too Close to the AV Prosthesis (*region of sub-valvular acceleration*)
DVI = **Velocity** LVO / AV Jet
DVI = 0.82 / 3.60
DVI = 0.22

Original LVOT Velocity
Taken Too Close to the AV Prosthesis

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**Doppler Parameters of Prosthetic Aortic Valve Function**

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<tr>
<td><em>Early Peaking</em></td>
<td></td>
<td>Symmetrical contour</td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>&gt; 100 ms</td>
</tr>
<tr>
<td><strong>0.22</strong></td>
<td></td>
<td><strong>3.6</strong></td>
</tr>
<tr>
<td><strong>110 ms</strong></td>
<td></td>
<td><strong>26</strong></td>
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An approach to prosthetic AV stenosis

Peak Prosthetic Aortic Jet Velocity > 3 m/s

- DVI ≥ 0.30
  - Jet Contour
    - AT (ms) >100
      - Consider PrAV stenosis with
        - Sub-valve narrowing
        - Underestimated gradient
        - Improper LVOT velocity*
    - AT (ms) <100
      - Normal PrAV
  - AT (ms) <100
    - Consider improper LVOT velocity**

- DVI 0.25 – 0.29
  - Normal PrAV
  - EOA Index
    - High Flow
    - PPM

- DVI < 0.25
  - Suggests PrAV Stenosis†
  - High Flow
  - PPM
Surgical Findings
Well seated valve with a large amount of tissue ingrowth beneath the valve resulting in a frozen leaflet

An approach to prosthetic AV stenosis
What is your diagnosis?

• A) Patient – Prosthesis Mismatch
• B) Normal Prosthetic Valve Function
• C) High Flow State
• D) Prosthetic Valve Stenosis
• E) Improper LVOT Velocity

What is your diagnosis?

• A) Patient – Prosthesis Mismatch
• B) Normal Prosthetic Valve Function
• C) High Flow State
• D) Prosthetic Valve Stenosis
• E) Improper LVOT Velocity (Prosthetic valve stenosis)
• CASE PRESENTATION (3):
  • 66 Y/O F Hx AVR (St Jude Valve Conduit 2002 for AR)
  • Progressive DOE
• DVI = 0.85/3.4 = 0.25
• AVA VELOCITY = 3.4 m/s

AT = 0.09 sec
## Doppler Parameters of Prosthetic Aortic Valve Function

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<tr>
<td><strong>Peak Velocity</strong></td>
<td>&lt; 3 m/s</td>
<td>&gt; 4 m/s</td>
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<tr>
<td><strong>Mean Gradient</strong></td>
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<td>Triangular Early Peaking</td>
<td>Rounded Symmetrical contour</td>
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<tr>
<td><strong>Acceleration Time</strong></td>
<td>&lt; 80 ms</td>
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## Doppler Parameters of Prosthetic Aortic Valve Function

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<td><strong>Peak Velocity</strong></td>
<td>&lt; 3 m/s</td>
<td>3.4</td>
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<td><strong>Mean Gradient</strong></td>
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<td>30</td>
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</tr>
<tr>
<td><strong>Acceleration Time</strong></td>
<td>&lt; 80 ms</td>
<td>90 ms</td>
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</tbody>
</table>
An approach to prosthetic AV stenosis

Peak Prosthetic Aortic Jet Velocity > 3 m/s

Jet Contour
- DVI ≥ 0.30
  - AT (ms) >100
    - Consider PrAV stenosis with:
      - Sub-valve narrowing
      - Underestimated gradient
      - Improper LVOT velocity
    - Normal PrAV
  - AT (ms) <100
    - DVI 0.25 – 0.29
      - Suggests PrAV stenosis
    - DVI < 0.25
      - Consider Improper LVOT velocity

High Flow PPM

EOA Index

An approach to prosthetic AV stenosis

Peak Prosthetic Aortic Jet Velocity > 3 m/s

Jet Contour
- DVI ≥ 0.30
  - AT (ms) >100
    - Consider PrAV stenosis with:
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      - Underestimated gradient
      - Improper LVOT velocity
    - Normal PrAV
  - AT (ms) <100
    - DVI 0.25 – 0.29
      - Suggests PrAV stenosis
    - DVI < 0.25
      - Consider Improper LVOT velocity

High Flow PPM

EOA Index
An approach to prosthetic AV stenosis

Indexed EOA = 0.78
PPM occurs when:
iEOA < 0.85
Severe if iEOA < 0.65

Prosthetic Aortic Jet Velocity > 3 m/s

DVI 0.25 – 0.29
DVI < 0.25

<100
>100
<100

Normal PrAV
Suggests PrAV Stenosis
Consider Improper LVOT velocity

EOA Index

PPM

High Flow
What is your diagnosis?

• A) **Prosthesis – Patient Mismatch**
• B) Normal Prosthetic Valve Function
• C) High Flow State
• D) Prosthetic Valve Stenosis
• E) Improper LVOT Velocity (Prosthetic valve stenosis)

**Patient Prosthesis Mismatch**

- AVA velocity: 4.6
- DVI: 1.14/4.6 = 0.25, AVA = 0.4 cm²
- Acceleration Time: 60 msec
### Doppler Parameters of Prosthetic Aortic Valve Function

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<td>&lt; 80 ms</td>
<td>&gt; 100 ms</td>
</tr>
</tbody>
</table>

### Patient Prosthesis Mismatch
Patient Prosthesis Mismatch

- $\Delta P = Q^2/(K \times EOA^2)$
- $Q =$ Flow, $K =$ Constant
- For gradients to remain low, EOA has to accommodate and be proportionate to flow
- At rest, $Q$ is determined by BSA, bigger people have bigger flow
- In patients with large BSA and increased flow, a “too small of a valve” with a small EOA will produce a high gradient:
- Small valves + Big people = High gradients

Patient Prosthesis Mismatch

- Moe common in SAVR versus TAVR
  - PARTNER 28% vs 20%
  - In smaller annulus even more pronounced
    - 36% Vs 19%
CASE PRESENTATION

69 Y/O F Hx AVR (BIOPROSTHETIC BIOCOR 23 MM 2006)

SOB, FATIGUE, NEVER FELT MUCH BETTER AFTER SAVR

BSA 2.2, 6’ 2”

Doppler Parameters of Prosthetic Aortic Valve Function

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</tr>
</tbody>
</table>
An approach to prosthetic AV stenosis

Indexed EOA = 0.5
PPM occurs when:
iEOA < 0.85
Severe if iEOA < 0.65

TEE
MRI

SURGERY PRE
Echocardiographic Evaluation of Prosthetic Valve Regurgitation

Types of Regurgitation

• Regurgitation may be
  — Physiological
  — Pathological
• Physiological regurgitation
  — Closing volume (blood displacement by occluder motion)
  — At the hinges of occluder
Types of Regurgitation

• Pathological
  — Central
    • Mostly with bioprosthetic
    • Technical or infection related
  — Paravalvular
    • Either type, usually the site with mechanical
    • Mild is common after surgery (5-20%) and likely insignificant in the absence of infection
    • Usually after calcium debridement, redo, older patients
    • Hemolytic anemia
    • TAVR

Central Aortic Regurgitation
Central Aortic Regurgitation
Paravalvular Aortic Regurgitation

Paravalvular Aortic Regurgitation
Assessment of Prosthetic Aortic Valve Regurgitation: TTE

- Challenging due to
  - Shadowing
  - Eccentric Jet
  - Difficult to quantify paravalvular leak
- Width of vena contracta may be difficult to measure
- Off axis views may be required

Assessment of Prosthetic Aortic Valve Regurgitation

- Jet diameter/LVO diameter <25% in PS views
- Pressure Half Time < 200 ms
- Holodiastolic flow reversal in Descending aorta
- Neck in the short axis view
  - < 10% of sewing ring is mild
  - 10-20% moderate
  - > 20% severe
  - > 40% rocking motion
Assessment of Prosthetic Aortic Valve Regurgitation

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Valve structure and motion</td>
<td>Usually normal</td>
<td>Abnormal&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Abnormal&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>Mechanical or bioprosthetic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Structural parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV size</td>
<td>Normal&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Normal or mildly dilated&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Dilated&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Doppler parameters (qualitative or semiquantitative)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet width in central jets (% LVO diameter): color&lt;sup&gt;4&lt;/sup&gt;</td>
<td>Narrow (&lt;25%)</td>
<td>Intermediate (26%-64%)</td>
<td>Large (&gt;65%)</td>
</tr>
<tr>
<td>Jet density: CW Doppler</td>
<td>Incomplete or faint</td>
<td>Dense</td>
<td>Dense</td>
</tr>
<tr>
<td>Jet deceleration rate (PHT, ms): CW Doppler&lt;sup&gt;5&lt;/sup&gt;</td>
<td>Low (&lt;500)</td>
<td>Dense</td>
<td>Dense</td>
</tr>
<tr>
<td>LVO flow vs pulmonary flow: PW Doppler</td>
<td>Slightly increased</td>
<td>Variable (200-500)</td>
<td>Greatly increased</td>
</tr>
<tr>
<td>Diastolic flow reversal in the descending aorta: PW Doppler</td>
<td>Absent or brief early diastolic</td>
<td>Intermediate</td>
<td>Prominent, holodiastolic</td>
</tr>
</tbody>
</table>

Doppler parameters (quantitative)

- Regurgitant volume (mL/breath): <30, 30-59, >60
- Regurgitant fraction (%): <30, 30-50, >50

PROSTHETIC VALVE REGURGITATION

- DT
  - DT: 800, 230
  - DT: 300, 90
Assessment of Prosthetic Aortic Valve Regurgitation

NORMAL

Assessment of Prosthetic Aortic Valve Regurgitation

AORTIC REGURGITATION

R Volume = 120 - 70 = 50 mL
R Fraction = 50/120 = 42%
Assessment of Prosthetic Aortic Valve Regurgitation: TEE

- Identifies:
  - Location,
  - Mechanism,
  - AR width to LVOT width,
  - Posterior jets may be identified
- LVOT obscured by accompanied MV prosthesis
- 3D: value? Especially for transcatheter repair, challenging for AV versus MV
Trans-Catheter Valves

Technical Points

• PW at inferior border of stent
• LVOT diameter
  – Use baseline numbers prior to TAVR
  – BE TAVR: inferior border of stent
  – SE TAVR: inferior border of stent/5 mm below leaflets
Echocardiographic Outcomes
Mean Gradient and Aortic Valve Area

- Mean Gradient
- Aortic Valve Area

Mean ± SD

- PARTNER I B (TF)
- PARTNER I A (All)
- PARTNER I A (TF)
- PARTNER II B (TF)
- PARTNER II HR (TF)

All-Cause Mortality Has Decreased Overall

ALL-CAUSE MORTALITY at 30 DAYS
PARTNER I Trial and PARTNER II Trial

- PARTNER I B (TF)
- PARTNER I A (All)
- PARTNER I A (TF)
- PARTNER II B (TF)
- PARTNER II HR (TF)

SAPIEN Valve
SAPIEN XT Valve
SAPIEN 3 Valve
PARAVALVULAR REGURGITATION

Assessment of Paravalvular Regurgitation Following TAVR
A Proposal of Unifying Grading Scheme

Philipppe Pibarot, DVM, PhD,* Rebecca T. Hahn, MD,† Neil J. Weissman, MD,† Mark J. Monaghan, PhD*
Determinants of PVR after TAVR

**Patient Characteristics:**
Tissue characteristics such as calcium burden and location, annular dimensions, etc.

**Assessment Modality:**
Echo, angiography, hemodynamics, and cardiac MR

**Procedural Factors:**
Sizing Algorithm; deployment technique (positioning and post-dilatation)

**Valve Design**

Impact of Aortic Regurgitation on Mortality: PARTNER Trial

12-19% of patients with ≥ moderate AR
Moderate/Severe PVL at 30 Days
Edwards SAPIEN Valves

PARTNER I and II Trials

P1B (TF) 179
P1A (Overall) 344
P2B (TF) 276
P2B XT (TF) 284
S3HR (Overall) 583
S3i (Overall) 1076

PARTNER I and II Trials

INVASIVE ASSESSMENT

Aortic Regurgitation Index = \[ \frac{(DBP - LVEDP) \times 100}{SBP} \]
= \[ \frac{(40-20) \times 100}{120} \] = 16.7

Aortic Regurgitation Index = \[ \frac{(DBP - LVEDP) \times 100}{SBP} \]
= \[ \frac{(50-10) \times 100}{130} \] = 30.8
ECHOCARDIOGRAPHIC ASSESSMENT
ECHOCARDIOGRAPHIC ASSESSMENT

TAVR PVR ASSESSMENT

<table>
<thead>
<tr>
<th>3-Class Grading Scheme</th>
<th>Trace</th>
<th>Mild</th>
<th>Mild to Moderate</th>
<th>Moderate</th>
<th>Moderate to Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color Doppler</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Absent</td>
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<td></td>
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<tr>
<td>Present</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Proximal flow convergence visible</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Present</td>
<td>Present</td>
</tr>
<tr>
<td>Absent</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Present</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vena contracta width (mm)</td>
<td>Narrow (1-5)</td>
<td>Narrow (5-10)</td>
<td>Intermediate (5-10)</td>
<td>Intermediate (10-20)</td>
<td>Large (&gt;20)</td>
</tr>
<tr>
<td>Vena contracta area (mm²)</td>
<td>Normal (1-5)</td>
<td>Normal (5-10)</td>
<td>Intermediate (5-10)</td>
<td>Intermediate (10-20)</td>
<td>Large (&gt;20)</td>
</tr>
</tbody>
</table>

Color Doppler
- Absent
- Present
- Proximal flow convergence visible
- Absent
- Present
- Vena contracta width
  - Narrow (1-5)
  - Narrow (5-10)
  - Intermediate (5-10)
  - Intermediate (10-20)
  - Large (>20)
- Vena contracta area
  - Normal (1-5)
  - Normal (5-10)
  - Intermediate (5-10)
  - Intermediate (10-20)
  - Large (>20)
ECHOCARDIOGRAPHIC ASSESSMENT

OTHER TAVR ISSUES

• Infective endocarditis 1.1%
  – 62% 60 days-1 year
  – RF: DM, CKD, infections, Performance in cathlab
  – ABX, Surgical survival (38-75%)

• Thrombosis 0.8%
  – RF Cancer, incomplete expansion, overhanging leaflets
  – Anticoagulation

• Structural failure 13 cases
  – 24 months (up to 5 years
  – Valve in valve
Echocardiographic Evaluation of Prosthetic Valve Endocarditis

Endocarditis

- Incidence < 1% and has declined with perioperative antibiotics
- Form in valve ring and extend to and spread to stent, occluder, or leaflet
- Irregular and independently mobile
- Can not adequately differentiate between vegetations, thrombus, pledgets, sutures, etc
Endocarditis

- TEE has better sensitivity and specificity for
  - Vegetations
  - Abscess in the posterior but not anterior location
- Combined TEE and TTE have a NPV of 95%
- If clinical suspicion high and studies negative, repeat studies in 7-10 days

Parasternal Long
Color

TEE Short
TEE Long

Doppler
Pathology

Echocardiographic Evaluation of Prosthetic Valve Thrombosis/Pannus
Thrombus versus Pannus

**Thrombus**
- Larger
- Soft density similar to myocardium
- More likely to encounter abnormal valve motion
- Short duration of symptom
- Poor anticoagulation
- Size $< 0.85$ cm$^2$ less likely to embolize
- More with mechanical

**Pannus**
- Small
- Dense, 30% may not be visualized
- Longer duration
- More common in aortic

---

**Pannus**

**TEE**
11.6 Prosthetic Valve Thrombosis

Suspect Prosthetic Valve Thrombosis

TTE to evaluate hemodynamic severity

CT or fluoroscopy to evaluate valve motion

Left Sided Prosthetic Valve Thrombosis

TEE for thrombosis size

NYHA III-IV symptoms

Emergency Surgery

Mobile or large (>0.8cm²) thrombus

Emergency Surgery

Right Sided Prosthetic Valve Thrombosis

Recent onset (<14d) NYHA II
Small thrombus (<0.8cm²)

Fibrinolytic Rx if persistent valve thrombosis after IV heparin therapy

Class I

Class IIa
Pre Questions (1)

• Regarding Aortic Prosthetic Valves
  – A. A routine echocardiogram is required very two years after AVR
  – B. An elevated gradient with a decreased EOA is always suggestive of valvular stenosis
  – C. Transthoracic echocardiogram alone is always sufficient to diagnose valvular stenosis
  – D. It is more challenging to quantify para-valvular versus valvular aortic regurgitation.

Answer (1)

• D. It is more challenging to quantify para-valvular versus valvular aortic regurgitation.
Pre Questions (2)

• Patients with Prosthesis-Patient Mismatch
  – A. Have abnormal prosthetic valve function
  – B. Progressively worsen with time
  – C. Have a small valve compared to the demands of their body and cardiac output
  – D. Have a benign condition

Answer (2)

C. Have a small valve compared to the demands of their body and cardiac output
Conclusions

- Elevated gradients across prosthetic aortic valves may be due to other factors besides stenosis
- Regurgitation may be physiological or pathological and may be valvular or paravalvular
- Endocarditis, pannus, and thrombosis may be difficult to distinguish based solely on echocardiographic findings
- TAVR has its unique problems