Echocardiographic Evaluation of Aortic Valve Prosthesis

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Boston, MA

GUIDELINES AND STANDARDS
Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound

A Report From the American Society of Echocardiography’s Guidelines and Standards Committee and the Task Force on Prosthetic Valves, Developed in Conjunction With the American College of Cardiology Cardiovascular Imaging Committee, Cardiac Imaging Committee of the American Heart Association, the European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography and the Canadian Society of Echocardiography, Endorsed by the American College of Cardiology Foundation, American Heart Association, European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography, and Canadian Society of Echocardiography

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JASE September 2009
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

Pibarot P, Dumesnil J G Circulation 2009;119:1034-1048

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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

Nishimura et al 2014

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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
  \[ 4V_2^2 - 4V_1^2 \text{ Vs. } 4V_2^2 \]
- 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
  - 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

Echocardiographic Evaluation of Elevated Prosthetic Valve Gradients

Comprehensive Evaluation

Peak aortic prosthesis velocity > 3m/s

Jet contour
AT (ms)

DVI ≥0.30

DVI 0.25–0.29

DVI <0.25

Consider PrAV stenosis with:
• Sub-valve narrowing
• Underestimated gradient
• Improper LVOT velocity

Normal PrAV

EOA index

High flow

PPM

Suggests prosthetic aortic valve stenosis

Consider improper LVOT velocity

JASE 2009;22(9):975
Parameters Utilized

• Peak prosthetic aortic velocity

\[ V_{LVO} \quad V_{jet} \]

Doppler Velocity Index

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

Parameters Utilized

- Jet Contour
  - Triangular
  - Rounded

Normal > 0.3
1.1/2.8 = 0.39

Abnormal < 0.25
1/5.5 = 0.18
Parameters Utilized

• Acceleration Time

<table>
<thead>
<tr>
<th>Normal &lt; 100 msec</th>
<th>Abnormal &gt; 100 msec</th>
</tr>
</thead>
<tbody>
<tr>
<td>80 msec</td>
<td>150 msec</td>
</tr>
</tbody>
</table>

• Acceleration time/ ejection time

• AT/ET > 0.4: Prosthetic valve obstruction

No Obstruction: 0.31

Obstruction: 0.5
Parameters Utilized

• Effective Orifice Area and iEOA

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

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

Normal > 1.2 cm²
Abnormal < 0.8 cm²
Abnormal < 0.6 cm²/m²

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

CW Doppler Prosthetic AV

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

**Obstructed**

- Pulsed Doppler
  - LVO
  - 1.0 m/s

- 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 Early Peaking</td>
<td>Triangular to intermediate</td>
<td>Rounded Symmetrical contour</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

- **A** Wear and tear
- **B** Calcification
- **C** Pannus
- **D** Endocarditis
- **E** 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
An approach to prosthetic AV stenosis

- **AV VEL=3.2**
- **DI=0.58/3.2=0.18**
- **AT=150msec**
- **Jet Contour: Circular**
An approach to prosthetic AV stenosis

Doppler Parameters of Prosthetic Aortic Valve Function

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Suggests Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Velocity</td>
<td>&lt; 3 m/s</td>
<td>&gt; 4 m/s</td>
</tr>
<tr>
<td></td>
<td>3.2</td>
<td></td>
</tr>
<tr>
<td>Mean Gradient</td>
<td>&lt; 20 mmhg</td>
<td>&gt; 35 mmhg</td>
</tr>
<tr>
<td></td>
<td>24</td>
<td></td>
</tr>
<tr>
<td>Doppler Velocity Index</td>
<td>&gt;= 0.3</td>
<td>&lt; 0.25</td>
</tr>
<tr>
<td></td>
<td>0.18</td>
<td></td>
</tr>
<tr>
<td>Effective Orifice area</td>
<td>&gt; 1.2 cm²</td>
<td>&lt; 0.8 cm²</td>
</tr>
<tr>
<td>Contour of Jet</td>
<td>Triangular Early Peaking</td>
<td>Rounded Symmetrical contour</td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>&gt; 100 ms</td>
</tr>
<tr>
<td></td>
<td>150 ms</td>
<td></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>
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<tbody>
<tr>
<td>Peak Velocity</td>
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<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>&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
      - AT (ms) > 100
  - **DVI 0.25 – 0.29**
    - Jet Contour
      - AT (ms) < 100
  - **DVI < 0.25**
    - Jet Contour
      - AT (ms) > 100
      - AT (ms) < 100
An approach to prosthetic AV stenosis

Peak Prosthetic Aortic Jet Velocity > 3 m/s

- DVI ≥ 0.30
- DVI 0.25 - 0.29
- DVI < 0.25

Jet Contour

AT (ms)

>100

<100

Consider PrAV stenosis with
- Sub-valve narrowing
- Underestimated gradient
- Improper LVOT velocity

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

**Doppler Parameters of Prosthetic Aortic Valve Function**

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<tr>
<td>Effective Orifice area</td>
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<td>Rounded</td>
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<td>Acceleration Time</td>
<td>&lt; 80 ms</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
      - EOA Index
        - Normal PrAV
        - Suggests PrAV Stenosis
        - Consider Improper LVOT velocity
    - EOA Index
      - High Flow
      - PPM

- DVI 0.25 – 0.29
  - Jet Contour
    - AT (ms) < 100
      - Normal PrAV
      - EOA Index
        - Suggests PrAV Stenosis
      - EOA Index
        - High Flow
        - PPM

- DVI < 0.25
  - Jet Contour
    - AT (ms) > 100
      - Consider Improper LVOT velocity
    - EOA Index
      - Normal PrAV
      - Suggests PrAV Stenosis
      - EOA Index
        - 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

- Peak Prosthetic Aortic Jet Velocity > 3 m/s
- DVI ≥ 0.30
- DVI 0.25 – 0.29
- DVI < 0.25

Jet Contour
- AT (ms)
  - >100
  - <100

DVI
- >100
- <100

Suggests PrAV 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

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
Doppler Parameters of Prosthetic Aortic Valve Function

<table>
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<tr>
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<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>&gt; 100 ms</td>
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AT = 0.09 sec
Doppler Parameters of Prosthetic Aortic Valve Function

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<td>&lt; 0.25</td>
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<td>&lt; 0.8 cm²</td>
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</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>&gt; 100 ms</td>
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</tbody>
</table>

An approach to prosthetic AV stenosis

Peak Prosthetic Aortic Jet Velocity > 3 m/s

DVI ≥ 0.30

DVI 0.25 - 0.29

DVI < 0.25

Jet Contour

AT (ms)

>100

<100

Consider PrAV stenosis with:
- Sub-valve narrowing
- Underestimated gradient
- Improper LVOT velocity*

Normal PrAV

EOA Index

High Flow

PPM

Suggests PrAV Stenosis*

Consider Improper LVOT velocity**
An approach to prosthetic AV stenosis

Indexed EOA = 0.78

PPM occurs when:
  iEOA < 0.85
  Severe if iEOA < 0.65
An approach to prosthetic AV stenosis

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 cm$^2$
• Acceleration Time: 60 msec

Doppler Parameters of Prosthetic Aortic Valve Function

<table>
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<tr>
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<th>Normal</th>
<th>Suggests Stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak Velocity</td>
<td>&lt; 3 m/s</td>
<td>4.6</td>
</tr>
<tr>
<td>Mean Gradient</td>
<td>&lt; 20 mmHg</td>
<td>51</td>
</tr>
<tr>
<td>Doppler Velocity Index</td>
<td>&gt;= 0.3</td>
<td>0.25</td>
</tr>
<tr>
<td>Effective Orifice area</td>
<td>&gt; 1.2 cm$^2$</td>
<td>0.4</td>
</tr>
<tr>
<td>Contour of Jet</td>
<td>Triangular Early Peaking</td>
<td>TRI Symmetrical contour</td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>60 ms</td>
</tr>
</tbody>
</table>
Patient Prosthesis Mismatch

\[ \Delta P = \frac{Q^2}{K \times EOA^2} \]

- \( Q = \text{Flow} \), \( K = \text{Constant} \)
- 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

- More common in SAVR versus TAVR
  - PARTNER 28% vs 20%
  - In smaller annulus even more pronounced
    - 36% vs 19%

TAVR Key Points

- Same as SAVR
- DI > 0.45 is expected and normal after TAVR
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

Central 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(^1)</td>
<td>Abnormal(^1)</td>
</tr>
<tr>
<td>Mechanical or bioprosthetic</td>
<td>Normal(^2)</td>
<td>Normal or mildly dilated(^3)</td>
<td>Dilated(^3)</td>
</tr>
<tr>
<td>Structural parameters</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LV size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Doppler parameters (qualitative or semi-quantitative)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet width in central jets (% LVO diameter; color)</td>
<td>Narrow (≤25%)</td>
<td>Intermediate (26%-64%)</td>
<td>Large (≥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(^5)</td>
<td>Slow (&lt;500)</td>
<td>Variable (200-400)</td>
<td>Steep (&lt;200)</td>
</tr>
<tr>
<td>LVO flow vs pulmonary flow: PW Doppler</td>
<td>Slightly increased</td>
<td>Intermediate</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>
<tr>
<td>Doppler parameters (quantitative)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regurgitant volume (mL/beat)</td>
<td>&lt;30</td>
<td>30-50</td>
<td>&gt;60</td>
</tr>
<tr>
<td>Regurgitant fraction (%)</td>
<td>&lt;30</td>
<td>30-50</td>
<td>&gt;50</td>
</tr>
</tbody>
</table>

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### PROSTHETIC VALVE REGURGITATION

![Diagram of Doppler waves showing assessment parameters](image)

- **DT**
  - PHT: 1500
  - 430

- **DT**
  - PHT: 800
  - 230

- **DT**
  - PHT: 300
  - 90

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Robert D. Safian, MD
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

TAVR ASSESSMENT

FOCUS TOPIC: ECHOCARDIOGRAPHY IN STRUCTURAL HEART DISEASE INTERVENTIONS
STATE-OF-THE-ART REVIEWS

Echocardiographic Imaging for Transcatheter Aortic Valve Replacement

Rebecca T. Hahn, MD, Alina Nicoara, MD, Samir Kapadia, MD, Lars Svensson, MD, PhD, and Randolph Martin, MD,
New York, New York; Durham, North Carolina; Cleveland, Ohio; and Atlanta, Georgia

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

Philippe Pibarot, DVM, PhD,* Rebecca T. Hahn, MD,† Neil J. Weissman, MD,‡ Mark J. Monaghan, PhD§
Trans-Catheter Valves

CORE VALVE SELF EXPANDING

Sapien Balloon Expandable

Trans-Catheter Valves

TAVR Follow-up: What Are We Looking For?

**VISUAL APPEARANCE**
- Stent position
- Cusp mobility, thickness
- Color Doppler

**HEMODYNAMICS**
- Mean gradient, peak velocity
- EOA, EOA
- Regurgitation (circumferential extent, ERG, RV, PHT)

**OTHER STRUCTURES**
- Mitril valve, aorta, coronaries

**CARDIAC FUNCTION**
- LV (size, SV, cardiac index)
- RV (size, function)

Normal
TAVR malposition
TAV thrombosis
TAV obstruction
TAV PPM
TAV regurgitation
Mitril valve impingement
Aortic hemorrhagic dissection
Coronary obstruction
Trans-Catheter Valves

Technical Points

- PW: BE inferior border of stent/ SE leaflet base
- LVOT diameter
  - Use baseline numbers prior to TAVR
  - BE TAVR: inferior border of stent outer to outer stent frame.
  - SE TAVR: inferior border of stent outer to outer stent frame/just below hinge points of leaflets
Measuring The Aortic Annulus with 3D

Echocardiographic Outcomes
Mean Gradient and Aortic Valve Area

- Mean Gradient
- Aortic Valve Area

p < 0.0001
p = NS
All-Cause Mortality Has Decreased Overall

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

<table>
<thead>
<tr>
<th>Group</th>
<th>Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTNER I B (TF) 175</td>
<td>6.3%</td>
</tr>
<tr>
<td>PARTNER I A (All) 344</td>
<td>5.2%</td>
</tr>
<tr>
<td>PARTNER I A (TF) 240</td>
<td>3.7%</td>
</tr>
<tr>
<td>PARTNER II B (TF) 271</td>
<td>4.4%</td>
</tr>
<tr>
<td>PARTNER II B (TF) 282</td>
<td>3.5%</td>
</tr>
<tr>
<td>PARTNER II HR (TF) 491</td>
<td>1.6%</td>
</tr>
</tbody>
</table>

All-Stroke at 30 Days

<table>
<thead>
<tr>
<th>Group</th>
<th>Stroke Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>PARTNER IA</td>
<td>4.6%</td>
</tr>
<tr>
<td>PARTNER IB</td>
<td>6.7%</td>
</tr>
<tr>
<td>CoreValve High Risk</td>
<td>4.9%</td>
</tr>
<tr>
<td>CoreValve Extreme Risk</td>
<td>4.0%</td>
</tr>
<tr>
<td>Sapien S3 Intermediate Risk</td>
<td>2.1%</td>
</tr>
</tbody>
</table>
### 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

12-15% of patients with ≥ moderate AR

Moderate/Severe PVL at 30 Days
Edwards SAPIEN Valves

PARTNER I and II Trials
INVASIVE ASSESSMENT

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

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

ECHOCARDIOGRAPHIC ASSESSMENT
ECHOCARDIOGRAPHIC ASSESSMENT
### TAVR PVR ASSESSMENT

#### Echocardiographic Assessment

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Grade 1</th>
<th>Grade 2</th>
<th>Grade 3</th>
<th>Grade 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple jets</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Jet path visible along the aortic valve</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Proximal flow convergence visible</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Vena contracta width (mm): 2D (5-10 color Doppler)</td>
<td>&gt;10</td>
<td>&gt;10</td>
<td>&gt;10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Jet width at its angle (%AV diameter)</td>
<td>Narrow</td>
<td>Narrow</td>
<td>Intermediate</td>
<td>Large</td>
</tr>
<tr>
<td>Jet density (PW/Doppler)</td>
<td>Incomplete or faint</td>
<td>Incomplete or faint</td>
<td>Variable</td>
<td>Dense</td>
</tr>
<tr>
<td>Aortic valve commissural fusion</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
<tr>
<td>Proximal flow reversal to the descending aorta</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
<td>Absent</td>
</tr>
</tbody>
</table>

#### Diagrams

- **Figure A**: Sample echocardiogram showing aortic valve with jet direction.
- **Figure B**: Close-up view of the aortic valve with jet visualization.
- **Figure C**: Color Doppler image highlighting the jet area.
- **Figure D**: M-mode tracing of the valve.
- **Figure E**: Spectral Doppler tracing showing jet velocity.
- **Figure F**: Imaging of the aortic valve with color flow overlay.

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Robert D. Safian, MD
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, pledges, 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
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 cm² less likely to embolize
- More with mechanical

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

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

11.6 Prosthetic Valve Thrombosis

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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
CASE PRESENTATION

- 69 Y/O F Hx AVR (BIOPROSTHETIC BIOCOR 23 MM 2006)
- SOB, FATIGUE, NEVER FELT MUCH BETTER AFTER SAVR

### 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>&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>
</tr>
<tr>
<td>Effective Orifice area</td>
<td>&gt; 1.2 cm²</td>
<td>&lt; 0.8 cm²</td>
</tr>
<tr>
<td>Contour of Jet</td>
<td>Triangular</td>
<td>Rounded</td>
</tr>
<tr>
<td>Acceleration Time</td>
<td>&lt; 80 ms</td>
<td>&gt; 100 ms</td>
</tr>
</tbody>
</table>

TRI

- Peak Velocity: 4.1
- Mean Gradient: 36
- Doppler Velocity Index: 0.25
- Effective Orifice area: 1
- Contour of Jet: TRI
- Acceleration Time: 74 ms
An approach to prosthetic AV stenosis

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

TEE
CTA SYSTOLE

Distance: 15.9 mm x 13.6 mm
Area: 1.74 cm²
Avg. Diameter: 14.9 mm
Perimeter: 48.0 mm
MRI

SURGERY PRE

23 mm
SURGERY POST

25 mm

ECHO POST
“Please Let Them do Well on the Boards” Zane Abbas