Echocardiographic Assessment of Aortic Valve Prosthesis

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DISCLOSURE

Relevant Financial Relationship(s)
None

Off Label Usage
None
Objectives

• Review mechanisms of high gradients across AV prosthesis
• Review approach to high gradients
• Case studies
Bioprosthetic Valve Thrombosis Versus Structural Failure

**BACKGROUND:** Bioprosthetic valve thrombosis (BPVT) is considered uncommon; this may be related to the fact that it is often unrecognized. Recent data suggest that BPVT responds to vitamin K antagonists, emphasizing the need for further assessment.

- 11.6% (n=397); 63% aortic position
- 65% > 12 months post-op
- Median longevity 24 months (vs 108 in controls)
- Independent predictors: >50% increase in mean gradient within 5 years; PAF; subtherapeutic INR; increased cusp thickness and abnormal mobility

**CONCLUSIONS:** BPVT is not uncommon and can occur several years after surgery. A combination of clinical and echocardiographic features can reliably diagnose BPVT. (J Am Coll Cardiol 2015;66:2285-94)

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**Timing of Bioprosthetic Valve Explanation by Position**

<table>
<thead>
<tr>
<th>BPVT</th>
<th>Structural Failure</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aortic</strong></td>
<td>*p&lt;0.05</td>
</tr>
<tr>
<td><strong>Mitral</strong></td>
<td>*</td>
</tr>
<tr>
<td><strong>Tricuspid</strong></td>
<td>*</td>
</tr>
<tr>
<td><strong>Pulmonary</strong></td>
<td></td>
</tr>
</tbody>
</table>

**BPV Position**

JACC 2015; 66(21): 2285
Aortic Prosthesis

43 year old female S/P Bentall with #21 St. Jude AVR

Presents for evaluation of shortness of breath

LV size
LVEDD 50mm, ESD 32mm

Wall thickness
Septum 12mm
Posterior 12mm

LV function
LVEF 60%
CW Aortic prosthesis

5.7 m/s  68 mmHg
High Gradients across aortic prostheses

Obstruction
- Thrombus
- Pannus
- Bioprosthetic degeneration
- Subvalvular narrowing

Functional
- Regurgitation
- High flow states
- Pressure recovery

Patient prosthesis mismatch

Dimensionless Index: DVI

\[
\text{DVI} = \frac{\text{PW}_{\text{LVOT}}}{\text{CW}_{\text{AS}}}
\]

Normal > .30
### Acceleration Time (ms)

<table>
<thead>
<tr>
<th></th>
<th>NORMAL</th>
<th>OBSTRUCTED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gradient (mmHg)</td>
<td>14</td>
<td>68</td>
</tr>
<tr>
<td>DVI</td>
<td>0.52</td>
<td>0.22</td>
</tr>
<tr>
<td>AT (ms)</td>
<td>70</td>
<td>177</td>
</tr>
</tbody>
</table>

### AT/ET

Normal: \( \leq 0.25 \pm 0.05 \)
DVI : 0.22
AT  : 177
AVA: 0.59 cm²

Expected gradients for normal # 21 St. Jude AVR:
Mean gradient 15±5
EOA:2±0.7 cm²

What is wrong with AVR?
1. Patient-prosthesis mismatch
2. Obstructed
3. Severe AI; mild obstruction
4. High flow state
Comprehensive Evaluation
Peak aortic prosthesis velocity > 3m/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
  - Normal PrAV EOA index
    - High flow PPM

- DVI <0.25
  - <100
  - Suggests prosthetic aortic valve stenosis
  - Consider improper LVOT velocity

JASE 2009;22(9):975

Our patient

Peak velocity 5.7m/s
Mean grad 68 mmHg
DVI 0.22
AT: 177 msec
Obstructed AVR
Suspected Prosthetic Valve Thrombosis

- TTE to evaluate hemodynamic severity (Class I)
- Left-sided prosthetic valve thrombosis
- TEE for thrombosis size
- NYHA class III-IV symptoms
- Mobile or larger (≥0.8 cm²) thrombus
- Recent onset (<14 days) NYHA class I-II symptoms; small thrombus (<0.8 cm²)
- Fibrinolytic prescription if persistent valve thrombosis after IV heparin therapy (Class IIa)

- CT or fluoroscopy to evaluate valve motion (Class IIa)
- Right-sided prosthetic valve thrombosis

Emergency surgery (Class I)
Emergency surgery (Class IIa)
JACC 2014;63(22):2438
Case

- 80 year old woman: progressive dyspnea on exertion
- NYHA Class III
- S/P tissue AVR #19 2001

Septum/posterior wall 14 mm

EF 63%
Septum/posterior wall 14 mm
EF 63%

LVOT$_{TVI}$ : 21
AS$_{TVI}$ : 99
DVI: 21
EOA: 0.6 cm$^2$
AT: 100 ms
What is wrong with AVR?

1. Patient-prosthesis mismatch
2. Obstructed
3. Severe AI; mild obstruction
4. High flow state
Case

- 28 year old female ESRD
- S/P AVR 1 year previous
  size/type unknown
- Functional Class I
LVOT: 1 m/s
TVILVOT: 17.6
AV velocity: 3.4 m/s
DI: 0.27
Mean gradient (mmHg): 30
EOA: 1.13 cm²
AT: 100 ms

What to do next?

1. Re-do AVR
2. Get valve size
3. TEE
4. Repeat TTE
Normal ATS #19

- Peak gradient: $47 \pm 12.6 \text{ mmHg}$ (46)
- Mean gradient: $25.3 \pm 8 \text{ mmHg}$ (30)
- EOA: $1.1 \pm 0.3 \text{ cm}^2$ (1.13)

Case

- 36 year old male: fall in EF
- 5 years prior: AV/aortic root endocarditis: homograft and AVR
- The next day: redo homograft due to high gradients
- 2 years later: endocarditis: medical management
- Currently NYHA Class II
- Echo: torn cusp; severe AI; ESD 57mm; EF 50%
In the OR

- “Difficult” case: extensive adhesions
- Excision homograft AVR and replacement with suprannular #21 OnX mechanical valve
- Annual follow up
- Clinically well

Septum 12 mm  Posterior wall 12 mm  EF 66%
Peak Velocity: 3.2 m/s  
Mean gradient 24 mmHg  
AVA: 1.33 cm²  
Indexed AVA: 0.62 cm²/m²  
DI: 0.35  
AT: 76 ms

What is wrong with AVR?

1. Patient-prosthesis mismatch  
2. Obstructed  
3. Significant AI; mild obstruction  
4. High flow state
**Comprehensive evaluation**

DVI

0.25 – 0.29

<100

Normal PrAV

EOA index

High flow

Suggests prosthesis aortic valve stenosis

>100

PPM

*JASE 2009;22(9):975*

**Patient Prosthesis Mismatch**

“Mismatch can be considered to be present when the effective prosthetic heart valve area, after insertion into the patient, is less than that of a human heart valve. All PHV’s are smaller than normal and inherently stenotic.”

*JACC 2012;60(13):1123*
Patient Prosthesis Mismatch for Aortic Valve Replacement

Indexed EOA (cm²/m²)      PPM
≤ 0.85                     Moderate
≤ 0.65                     Severe

JACC 2000;36:1131
PPM Risk Factors

- Small valve size (19, 21 mm)
- Mechanical valves
- Stented Bioprosthesis
- Clinical
  - HT, DM, obesity, female gender, CAD, CKD
- Pre-op AS

JACC 2009; 53(1):39
Freedom from CV Death

![Graph showing freedom from CV death across different years with data points and curves for NS PPM, Mod PPM, and Severe PPM.]

\[ P < 0.001 \]

Doppler Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal</th>
<th>Possible stenosis</th>
<th>Sugg sig stenosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity (m/s)</td>
<td>&lt; 3</td>
<td>3-4</td>
<td>&gt; 4</td>
</tr>
<tr>
<td>Mean grad (mmHg)</td>
<td>&lt; 20</td>
<td>20-35</td>
<td>&gt; 35</td>
</tr>
<tr>
<td>DVI</td>
<td>≥ 0.30</td>
<td>0.29-0.25</td>
<td>&lt; 0.25</td>
</tr>
<tr>
<td>Jet contour</td>
<td>Early peak</td>
<td>Mid peak</td>
<td>Rounded symmetric</td>
</tr>
<tr>
<td>AT (ms)</td>
<td>&lt; 80</td>
<td>80-100</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

JACC 2009; 53(1):39
JASE 2009;22(9):975
<table>
<thead>
<tr>
<th></th>
<th>Accuracy</th>
<th>Sensitivity</th>
<th>Specificity</th>
</tr>
</thead>
<tbody>
<tr>
<td>MG (mmHg)</td>
<td>75%</td>
<td>83%</td>
<td>74%</td>
</tr>
<tr>
<td>DVI</td>
<td>75%</td>
<td>92%</td>
<td>84%</td>
</tr>
<tr>
<td>EOAi (cm²/m²)</td>
<td>67%</td>
<td>83%</td>
<td>66%</td>
</tr>
<tr>
<td>dA (cm²)</td>
<td>87%</td>
<td>92%</td>
<td>86%</td>
</tr>
<tr>
<td>AT (ms)</td>
<td>94%</td>
<td>92%</td>
<td>94%</td>
</tr>
<tr>
<td>AT/ET</td>
<td>89%</td>
<td>83%</td>
<td>90%</td>
</tr>
</tbody>
</table>

**Pressure Recovery**

The increase of pressure downstream from the stenosis caused by a reconversion of kinetic to potential energy which can lead to an “overestimation” of gradients by Doppler in certain situations.

*Circulation 1996;94:1934-1940*
Case

- 31 year old female: S/P tissue AVR (endocarditis) 1 year prior
- 2 weeks prior to transfer: sudden onset chest pain (pneumonia)
- Severe headache: left common carotid occlusion; occluded right renal and celiac arteries: Takayasu’s arteritis
- Grade III/VI holodiastolic murmur
LVEDD: 57 mm  LVESD 35mm  EF 61%
What is wrong with AVR?

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