Cases of Abnormal Prosthetic Valves

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DISCLOSURE

Relevant Financial Relationship(s)
None

Off Label Usage
None
“At the annual meeting of the AHA in California (late 1960’s), a patient who had received the Huffnagel artificial valve was being questioned. He was asked the usual question by a member of the audience, i.e. if the loud heart sounds bothered him. He replied, “No.” Then after a second thought, he said, “Well occasionally they do. I like to play poker and when I get an unusually good hand, the sounds get louder and faster, and gives me away.”
30 yo Woman With Ebstein’s Anomaly

- **2009** TVR, MV repair
- **2010** Endocarditis (*S. aureus*)
  Redo MVR (St. Jude Epic)
- **2012** Worsening fatigue, dyspnea
  - **Physical Exam**
    - HR 77 BPM, BP 110/76 mmHg, Afebrile
    - JVP at earlobe sitting upright, prominent V-wave
    - Heart: RRR, S4, faint systolic murmur + diastolic rumble at LLSB. Faint diastolic rumble at the apex
    - Lungs: clear
    - Abdomen: Shifting dullness
    - Extremities: 1+ edema
Mitral Prosthesis

- Diastolic mean gradient: 8 mmHg (HR: 69 BPM)
- Blood cultures negative
What would you recommend?

1. Redo surgery (MVR)
2. Valve-in-valve mitral
3. Fibrinolytic therapy
4. Warfarin
Bioprosthetic Valve Thrombosis: Diagnosis

- Challenging
- TTE: no set criteria
  - Increased gradients
  - Thickened cusps, thrombus
- TEE
  - Soft echodensity in cusps
- CT
Bioprosthetic Valve Thrombosis
Mayo Clinic Experience
Misconceptions, diagnostic challenges and treatment opportunities in bioprosthetic valve thrombosis: lessons from a case series

Sorin V. Pislaru, Imad Hussain, Patricia A. Pellikka, Joseph J. Maleszewski, Richard D. Hanna, Hartzell V. Schaff and Heidi M. Connolly

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Abstract

OBJECTIVES: Bioprosthetic valve thrombosis (BPVT) is a rare but potentially life-threatening complication. Current guidelines favour surgery or thrombolysis as initial treatment. We set forth to characterize timing, diagnostic criteria and treatment strategies in BPVT.

METHODS: A free-text search tool was used to identify patients diagnosed with BPVT at Mayo Clinic between 1997 and 2013. We compared patients treated initially with vitamin K antagonists (VKA group; N = 15) versus surgery/thrombolysis (non-VKA group; N = 17).

RESULTS: Peak incidence of BPVT was 13–24 months after implantation in both groups. VKA and surgery/thrombolysis decreased prosthetic mean gradients to a similar extent (VKA group: 13 ± 5 to 6 ± 2 mmHg in mitral position, 9 ± 3 to 5 ± 1 mmHg in tricuspid position and 39 ± 3 to 24 ± 7 mmHg in aortic/pulmonary position; non-VKA group: 16 ± 12 to 5 ± 1 mmHg in mitral, 10 ± 5 to 4 ± 1 mmHg in tricuspid and 57 ± 9 to 18 ± 6 mmHg in aortic position; P = 0.59 for group effect). NYHA class improved in 11 of 15 patients in the VKA group and 10 of 17 patients in the non-VKA group (P = 0.39). There were no deaths, strokes or recognized embolic events; 1 patient in each group experienced gastrointestinal bleeding requiring transfusion. Index transthoracic echocardiogram formally identified BPVT in a minority of patients.

CONCLUSIONS: BPVT may occur late after surgical implantation. VKA therapy resulted in haemodynamic and clinical improvement with minimal risk, and should be considered the first-line therapy in haemodynamically stable patients. Echocardiographic criteria for improving BPVT diagnosis are proposed.

Keywords: Bioprosthetic valves • Prosthetic valve thrombosis • Anticoagulant therapy
Misconceptions in BPVT

• How good was TTE?
  • Abnormal findings: all patients
  • Possibility of BPVT: **6 of 32**
  • *BPVT not suspected: 8 of 15 undergoing surgery*

• TEE
  • Thrombus seen in all mitral / tricuspid
  • Challenging imaging for aortic BPV; thrombus described in 9/12 patients
Misconceptions in BPVT

Peak incidence second year
Longest interval: 6.5 years
Misconceptions in BPVT

VKA as effective as surgery / lytics
Our patient: One Month VKA

Diastolic mean gradient:
3 mmHg (HR 66 BPM)
Bioprosthetic Valve Thrombosis Versus Structural Failure
Clinical and Echocardiographic Predictors

Alexander C. Egbe, MD, MPH,* Sorin V. Pislaru, MD, PhD,† Patricia A. Pellikka, MD,* Joseph T. Poterucha, DO,* Hartzell V. Schaff, MD,† Joseph J. Maleszewski, MD,† Heidi M. Connolly, MD*

ABSTRACT

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 reliable diagnosis.

OBJECTIVES  This study sought to determine the diagnostic features of BPVT and to formulate a diagnostic model for BPVT.
BPVT: Mayo Surgical Experience

- All bioprosthetic re-operations 1994-2014

- 46 BPVT (11% of all reoperations)

- 92 structural failure (2:1 for age, gender, prosthetic position, and year of implantation)

Egbe et al. JACC 2015.
A: Freedom From Explantation

- **BPVT**
- **Structural Failure**
- Log-rank p < 0.0001

B: Time to Explantation by Position

- **BPV Position**
  - Aortic
  - Mitral
  - Tricuspid
  - Pulmonary

- At risk:
  - 46 13 5 1 0
  - 92 73 35 13 3

Egbe et al. JACC 2015.
Proposed Echo Criteria

1. Increased gradient > 50% over baseline, especially within first 5 years post-implant

2. Thickened, non-calcified leaflets

3. Restricted leaflet mobility

All 3 parameters: 72% sensitivity, 90% specificity for BPVT

Egbe et al. JACC 2015.
Bioprosthetic Valve Thrombosis
TAVR: A Bigger Problem?
Possible Subclinical Leaflet Thrombosis in Bioprosthetic Aortic Valves

Symptomatic TAVR-related thrombosis is rare (<1%)
CT reconstruction – Portico TAV

Corresponding TEE

Makkar et al, NEJM 2015
BPVT: Take Home Points

- BPVT diagnosis is **challenging**

- **What we know:**
  - BPVT may occur late after implantation
  - TTE increased gradient, may not show mechanism

- **When to suspect:**
  - BPV gradient > 50% over baseline, restricted cusp mobility, thickened leaflets

- **TEE/CT when in doubt**
Case: 58 Year-Old Woman

• Progressive Dyspnea (NYHA III)
• Rheumatic heart disease
• 2010
  • Medtronic Mosaic (21mm) AVR
  • MV Repair (27mm Duran ring)
• Obesity
  • BNP not elevated
AV Prosthetic Gradient
The gradient across the prosthesis most likely reflects:

A. Patient-prosthesis mismatch
B. Prosthetic obstruction
C. Normal function for this prosthesis
D. Pressure recovery
E. Cannot tell; need more information
Normal Valve-Specific Parameters

Appendix A. Normal Doppler Echocardiographic Values for Prosthetic Aortic Valves

<table>
<thead>
<tr>
<th>Valve</th>
<th>Size</th>
<th>Peak gradient (mm Hg)</th>
<th>Mean gradient (mmHg)</th>
<th>Effective orifice area (cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Medtronic Mosaic</td>
<td>21</td>
<td>23.8± 11.0</td>
<td>14.2± 5.0</td>
<td>1.4± 0.4</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td>23.8 ± 11.0</td>
<td>14.2 ± 5.0</td>
<td>1.4 ± 0.4</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td>22.5 ± 10.0</td>
<td>13.7 ± 4.8</td>
<td>1.5 ± 0.4</td>
</tr>
<tr>
<td></td>
<td>27</td>
<td>22.5 ± 10.0</td>
<td>11.7 ± 5.1</td>
<td>1.8 ± 0.5</td>
</tr>
<tr>
<td></td>
<td>29</td>
<td></td>
<td>10.4 ± 4.3</td>
<td>1.9 ± 0.1</td>
</tr>
<tr>
<td>Stented porcine</td>
<td>21</td>
<td>22.5 ± 10.0</td>
<td>11.1 ± 4.3</td>
<td>2.1 ± 0.2</td>
</tr>
<tr>
<td></td>
<td>23</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>25</td>
<td></td>
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<tr>
<td></td>
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</tr>
<tr>
<td></td>
<td>29</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The Differential Diagnosis

Elevated Prosthetic Aortic Valve Gradient

- Obstruction
  - Dysfunction, thrombus, vegetation, pannus, degeneration
- Patient-prosthesis mismatch
  - EOA too small for body size
- High output state
- Pressure Recovery
## Interpretation of Elevated Aortic PV Gradients

<table>
<thead>
<tr>
<th>Doppler parameter</th>
<th>Expected*</th>
<th>Stenosis</th>
<th>PPM</th>
<th>High Output</th>
<th>Pressure Recovery</th>
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<tbody>
<tr>
<td>Gradient (mmHg)</td>
<td>14 ± 5</td>
<td>High</td>
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<td>High</td>
</tr>
</tbody>
</table>

*Prosthesis-specific: Medtronic Mosaic 21mm
Ejection Time (ET) = 331 msec

Acceleration Time (AT) = 88 msec

\[
\frac{AT}{ET} = 0.27
\]
AT = 88 msec
AT / ET = 0.27

These AV systolic time intervals are most consistent with a:

A. Obstructed prosthesis
B. Normal prosthesis
C. I have no idea
# Acceleration Time and Ejection Time

## Table 2. ROC Analysis: Differentiation of PAV Stenosis From Controls and PPM

<table>
<thead>
<tr>
<th>Parameter</th>
<th>AUC (95% CI)</th>
<th>Value</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Accuracy (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AT, ms</td>
<td>0.92 (0.83–1.00)</td>
<td>100</td>
<td>86</td>
<td>86</td>
<td>85</td>
<td>66</td>
<td>95</td>
</tr>
<tr>
<td>ET, ms</td>
<td>0.73 (0.60–0.86)</td>
<td>275</td>
<td>73</td>
<td>68</td>
<td>74</td>
<td>48</td>
<td>85</td>
</tr>
<tr>
<td>AT/ET</td>
<td>0.88 (0.78–0.97)</td>
<td>0.37</td>
<td>96</td>
<td>82</td>
<td>85</td>
<td>64</td>
<td>98</td>
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<tr>
<td>Accel Time (msec)</td>
<td>≤ 100</td>
<td>&gt; 100</td>
<td>≤ 100</td>
<td>≤ 100</td>
<td>≤ 100</td>
</tr>
<tr>
<td>AT / ET</td>
<td>≤ 0.37</td>
<td>&gt; 0.37</td>
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*Prosthesis-specific: Medtronic Mosaic 21mm
**Dimensionless Index**

- **Mean Gradient** = 56 mmHg
- **LVSVI** = 54 cc / m² (normal 32-58)
- **Effective Orifice Area (EOA)** = 0.97 cm²
- **EOA Index** = 0.57 cm² / m² (BSA 1.7 m²)
- **Dimensionless Index (DI)** = 0.28
What is the most likely cause of the elevated gradient in this case?

A. Patient-prosthesis mismatch
B. Prosthetic obstruction
C. High output state
D. Pressure recovery
E. Need more information
## Interpretation of Elevated Aortic PV Gradients

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<tr>
<td>Abn Leaflet Motion</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>EOA (cm²)</td>
<td>1.4 ± 0.4</td>
<td>Low</td>
<td>Expected</td>
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<td>Varies</td>
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<td>EOA Index (cm²/m²)</td>
<td>&gt; 0.85</td>
<td>Low</td>
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<td>DVI</td>
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<tr>
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<td>≤ 0.25</td>
<td>&gt; 0.25</td>
<td>&gt; 0.25</td>
<td>Varies</td>
</tr>
<tr>
<td>∆ in EOA &amp; DVI from baseline</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

*Prosthesis-specific: Medtronic Mosaic 21mm

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Slide adapted from Darryl Burstow, M.D.
Left Ventricle and Aorta

Mean Gradient: 26 mmHg
Surgical Consultation

- AVR not advised
- Medical Rx
Sinotubular Junction Diameter: 2.1 cm
Discrepancies Between Catheter and Doppler Estimates of Valve Effective Orifice Area Can Be Predicted From the Pressure Recovery Phenomenon

Practical Implications With Regard to Quantification of Aortic Stenosis Severity

\[ \text{AVA}_{\text{predict}} = \frac{\text{AAA} \times \text{AVA}_{\text{Dop}}}{\text{AAA} - \text{AVA}_{\text{Dop}}} \]

Routine Adjustment of Doppler Echocardiographically Derived Aortic Valve Area Using a Previously Derived Equation to Account for the Effect of Pressure Recovery

Daniel M. Spevack, MD, Khalid Almuti, MD, Robert Ostfeld, MD, Ricardo Bello, MD, PhD, and Garet M. Gordon, MD, \textit{Bronx, New York}
Take Home Points

• Use Doppler data to identify the cause for a high prosthetic AV gradient (remember AT and AT/ET)

• **Pressure recovery** may occasionally lead to significant Doppler overestimate of cath gradient

• **Pressure recovery** is most likely when the aorta is \( \leq 3\text{cm} \) or in bileaflet **mechanical prostheses** (19 or 21mm)

• Correct for pressure recovery with the **Energy Loss Index**; this may improve risk stratification in AS
Question

For a Patient with Mechanical Mitral Prosthesis, Which of the Following is NOT a sign of Significant Regurgitation?

1. Mitral E velocity 2.3 m/sec
2. Mitral $T_{1/2}$ 150 msec
3. Mitral diastolic mean gradient 10 mmHg
4. IVRT 60 msec
5. MV prosthesis TVI / LVOT TVI ratio 2.6
Doppler Clues to Severe Mechanical MVR Regurgitation

- Mitral E velocity $\geq 2.0$ m/sec
- Increased prosthesis mean gradient
- Normal pressure half-time
- Decreased IVRT
- Dense MR CW velocity profile
Mitral St. Jude Medical Prosthesis
CW Doppler

E = 2.9 m/s

IVRT = 55 msec

t/2 = 55 msec

Severe Periprosthetic Regurgitation
Mechanical MVR
Peak Early Diastolic Velocity Rather Than Pressure Half-Time Is the Best Index of Mechanical Prosthetic Mitral Valve Function

Valerian Fernandes, MD, Leopoldo Olmos, MD, Sherif F. Nagueh, MD, Miguel A. Quiñones, MD, and William A. Zoghbi, MD

Reliable screening of mechanical prosthetic mitral valve (PMV) dysfunction by transthoracic echocardiography (TTE) is mandatory because transesophageal echocardiography (TEE) cannot be routinely used. However, acoustic shadowing seriously hampers detection of PMV dysfunction with TTE, particularly regurgitation. To identify TTE indexes that can detect PMV dysfunction (regurgitation or obstruction), 134 patients (age 60 ± 12 years, 64 men) with PMV who underwent TTE and TEE within 3 ± 5 days were assessed. There were 73 normal and 61 dysfunctional valves (40 regurgitant, 21 obstructive). By multivariate analysis, peak E velocity was the best predictor of a dysfunctional valve. Both peak E velocity (E ≥1.9 m/s; sensitivity 92%, specificity 78%) and the ratio of velocity-time integrals of flow through the prosthesis to that of the left ventricular outflow (VTI\textsubscript{PMV}/VTI\textsubscript{LVO} ≥2.2; sensitivity 91%, specificity 74%) were successful in detecting PMV dysfunction. Although pressure half-time (PHT) readily identified PMV obstruction, it did not detect regurgitation. Logistic models including peak E velocity and VTI\textsubscript{PMV}/VTI\textsubscript{LVO} or PHT were equally successful in detecting PMV dysfunction. However, all 3 variables were needed to best distinguish among normal, obstructed, and regurgitant valves. A peak E velocity ≥1.9 m/s and VTI\textsubscript{PMV}/VTI\textsubscript{LVO} ratio ≥2.2 predicted valve regurgitation in 83% of valves when PHT was <130 ms, and valve stenosis in 95% when PHT was >130 ms. Importantly, a peak E velocity <1.9 m/s, VTI\textsubscript{PMV}/VTI\textsubscript{LVO} ratio <2.2, and a PHT <130 ms had a predictive accuracy for a normal valve of 98%. Thus, TTE Doppler indexes can be used as screening parameters of PMV dysfunction and help select patients for further diagnostic evaluation with TEE. ©2002 by Excerpta Medica, Inc.

(Am J Cardiol 2002;89:704–710)
# Mechanical Prosthetic Mitral Valve Dysfunction

<table>
<thead>
<tr>
<th>Doppler index</th>
<th>Sens (%)</th>
<th>Spec (%)</th>
<th>PPV (%)</th>
<th>NPV (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>E ≥1.9 m/sec</td>
<td>92</td>
<td>78</td>
<td>83</td>
<td>90</td>
</tr>
<tr>
<td>VTI_{PMV}/VTI_{LVO} ≥ 2.2</td>
<td>91</td>
<td>74</td>
<td>80</td>
<td>87</td>
</tr>
<tr>
<td>PHT ≥130 msec</td>
<td>38</td>
<td>99</td>
<td>96</td>
<td>57</td>
</tr>
</tbody>
</table>

Fernandes V: Am J Cardiol 89, 3/15/02
Mechanical MVR with ↑ Gradient

- Increased T1/2: Obstructed
- Normal T1/2: Significant MR or High Output

Prosthesis TVI / LVOT TVI ratio > 2.2
Case

- 53 year old female
  - Hx of CABG, Redo CABG & ST Jude MVR
  - CHF (LV EF 30%)
    - NYHA class II
  - Chronic Atrial Fibrillation
- Coumadin held for colonoscopy
  - No LMWH bridging!
- Sudden onset severe dyspnea
  - SBP 85 mmHg
  - Muffled S1
  - Diastolic murmur
No Change in Baseline EKG

- INR 1.7
- CXR
- Cardiomegaly
- Pulmonary Edema
Emergent TEE

Mean Gradient 20 mmHg
Severe LV Systolic Dysfunction
Cardiac Cath

Total Occlusion of LAD, LCx, and RCA
Only One Patent Graft

Significant Collaterals
What would you recommend now?

1. Immediate CT Surgery
2. Thrombolysis
3. Heparin and Prayer

Can TEE help decide?
PRO-TEE Registry

PRO-TREE Registry

Complication Rate

* $p = 0.003$
$\phi \ p = 0.03$

Death Rate

- Thrombus $< 0.8 \text{ cm}^2$
- Thrombus $\geq 0.8 \text{ cm}^2$

NYHA CLASS

Tong, A. T. et al. *J Am Coll Cardiol* 2004;43:77-84
Follow-up TEE After Thrombolysis
Follow-up at 1 year: NYHA Class III-IV

Mean Gradient 9 mmHg (INR 3.5-4.5)
More Follow-up

• Worsening angina in addition to HF
• Inferolateral and anterior ischemia on vasodilator stress testing
• Placed on Plavix in anticipation of cardiac cath & possible PTCA/Stent
  • Known single patent SVG to LCx
  • All native vessels occluded proximally but LAD and RCA filled via collaterals
• Not candidate for 3rd CT surgery
• Not candidate for Heart Transplant
Sudden Onset Improvement in Symptoms

TTE Performed
Mean Gradient 4 mmHg

Another Miraculous “CURE”
Prosthetic Valve Thrombosis: Medical Therapy

### Recommendations

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>COR</th>
<th>LOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibrinolytic therapy is reasonable for patients with a thrombosed left-sided prosthetic heart valve, recent onset (&lt;14 days) of NYHA class I to II symptoms, and a small thrombus</td>
<td>Ila</td>
<td>B</td>
</tr>
<tr>
<td>Fibrinolytic therapy is reasonable for thrombosed right-sided prosthetic heart</td>
<td>Ila</td>
<td>B</td>
</tr>
</tbody>
</table>

# Prosthetic Valve Thrombosis: Intervention

<table>
<thead>
<tr>
<th>Recommendations</th>
<th>COR</th>
<th>LOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Emergency surgery is recommended for patients with a thrombosed left-sided prosthetic heart valve with NYHA class III to IV symptoms</td>
<td>I</td>
<td>B</td>
</tr>
<tr>
<td>Emergency surgery is reasonable for patients with a thrombosed left-sided prosthetic heart valve with a mobile or large thrombus (&gt;0.8 cm²)</td>
<td>IIA</td>
<td>C</td>
</tr>
</tbody>
</table>

Evaluation and Management of Suspected Prosthetic Valve Thrombosis

Suspected Prosthetic Valve Thrombosis

TTE to evaluate hemodynamic severity (I)

CT or fluoroscopy to evaluate valve motion (IIa)

Left-sided prosthetic valve thrombosis

TEE for thrombus size (I)

NYHA class III-IV symptoms

Emergency Surgery (I)

Mobile or large (≥0.8 cm²) thrombus

Emergency Surgery (IIa)

Right-sided prosthetic valve thrombosis

TEE for thrombus size (I)

Recent onset (<14 d)

NYHA class I-II symptoms

Small thrombus (<0.8 cm²)

Fibrinolytic Rx if persistent valve thrombosis after IV heparin therapy* (IIa)

Class I

Class IIa

Helping Cardiovascular Professionals Learn. Advance. Heal.
Thank You!
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