Prosthetic Valve Dysfunction
Advanced Echocardiography
Heidi M. Connolly

Prosthetic Valves - Outline
• Prosthesis types
  • Types of dysfunction
• High AVR gradient
  • Differential and clues to diagnosis
• Others
  • PV thrombosis
  • Infection
  • Calcification
  • Pannus
  • Structural deterioration

What year was the first prosthetic valve placed?
1. 1952
2. 1960
3. 1962
4. 1965
5. 1970

Hufnagel Valve Prosthesis - 1952
In 1954, Charles Hufnagel and his colleagues described 23 patients with aortic insufficiency who had been treated during the previous 2 years by rapid insertion of an acrylic ball valve into the descending aorta. “...the noise generated by the valve was disconcerting — reminiscent, according to some, of a ticking time bomb.”

Mechanical Prostheses
St. Jude Conduit

St. Jude Valve Conduit
Stan-Edwards 1960
St. Jude Carbomedics
Bjork-Shiley Medtronic Hall
Mechanical Valve Dysfunction

- Endocarditis
- Thrombosis
- Pannus

Elevated AVR Velocity and Gradient
What is the Cause?

Increased PV Gradients
- Valve geometry/pressure recovery
  - Small bi-leaflet prosthesis
- Prosthesis-patient mismatch
- Hemodynamically significant regurgitation
- High flow states
- Obstruction – thrombosis, infection
  - Structural degeneration

Hemodynamic Profiles Differ by Prosthesis Type and Size

<table>
<thead>
<tr>
<th>Prosthesis type</th>
<th>Prosthesis size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autograft</td>
<td>33 mm</td>
</tr>
<tr>
<td>Homograft</td>
<td>31 mm</td>
</tr>
<tr>
<td>Caged Ball</td>
<td>29 mm</td>
</tr>
<tr>
<td>Mechanical</td>
<td>27 mm</td>
</tr>
<tr>
<td>Bileaflet</td>
<td>25 mm</td>
</tr>
<tr>
<td>Stentless</td>
<td>23 mm</td>
</tr>
<tr>
<td>Porcine</td>
<td>21 mm</td>
</tr>
<tr>
<td>Transcatheter</td>
<td>19 mm</td>
</tr>
</tbody>
</table>

Doppler Parameters of Prosthetic Aortic Valve Function in Mechanical and Stented Biologic Valves

<table>
<thead>
<tr>
<th></th>
<th>Normal</th>
<th>Possible stenosis</th>
<th>Suggests significant 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>MG (mmHg)*</td>
<td>&lt;20</td>
<td>20-35</td>
<td>&gt;35</td>
</tr>
<tr>
<td>DI / DVI</td>
<td>≥0.30</td>
<td>0.29-0.25</td>
<td>&lt;0.25</td>
</tr>
<tr>
<td>EOA (cm²)</td>
<td>&gt;1.2</td>
<td>1.2-0.8</td>
<td>&lt;0.8</td>
</tr>
<tr>
<td>Contour jet velocity</td>
<td>Triangular, early peaking</td>
<td>Triangular to Intermediate</td>
<td>Rounded</td>
</tr>
<tr>
<td>AT (ms)</td>
<td>&lt;80</td>
<td>80-100</td>
<td>&gt;100</td>
</tr>
</tbody>
</table>

19-mm St. Jude Mechanical AVP

Pathologic Stenosis
- Peak velocity: 4.0 m/s
- MG: 40 mm Hg
- DVI: 0.30
- EOA: 0.85 cm²
- iEOA: 0.48 cm²/m²

Functional Stenosis
- Peak velocity: 4.1 m/s
- MG: 40 mm Hg
- DVI: 0.32
- EOA: 1.25 cm²
- iEOA: 0.47 cm²/m²

Aortic Valve Prostheses
With High Peak Velocity and/or High MG

Pathologic obstruction
- Pannus
- Thrombus
- Degenerative stenosis (bioprostheses)

Functional obstruction
- High flow state
- Pressure recovery (small mechanical bileaflet prostheses)
- Prosthesis-patient mismatch (PPM)

Pathologic regurgitation

75-Year-Old Man
Early Postop 25-mm SJ Mechanical AVR
Echo-Doppler MG 50 mmHg, INR 3

What would you recommend?
1. CT
2. TEE
3. Fluoroscopy
4. Observe

Evaluation of Abnormal Disc Motion

• Clinical assessment
• TTE to assess hemodynamic severity
• TOE to assess valve motion and echodensity
• Fluoroscopy or CT
  Assess disc motion
  Mechanism of dysfunction

Evaluation of Mechanical Valve Dysfunction

19-mm Bileaflet Mechanical AVR
Other Examples

28-Year-Old Female CarboMedics MVR
30 weeks pregnant, recent dyspnea
Weight-based LMWH during pregnancy

MVR MG 16 mmHg
Baseline MG 4 mmHg

28-Year-Old Female CM MVR
• 30 weeks pregnant, recent dyspnea
• LMWH during pregnancy

What would you recommend?
1. Operation
2. Adjust anticoagulation
3. Lytic therapy
4. Observation

Prosthetic Valve Fibrinolysis
• Effective in 70-90% of patients
• Acute mortality 4-12%
• Complications
  - Thromboembolism 15%
  - Major bleed 5%
  - Non-disabling bleed 14%
  - Recurrent thrombosis 10-20%

ESC suggested regimens:
- Recombinant tPA 10 mg bolus + 90 mg in 90 min with UFH or
- Streptokinase 1.5 MU in 60 min without UFH
Biological Prostheses

- Homograft Autograft (Ross)
- Xenograft Porcine/Bovine
- Percutaneous Melody and Sapien

Biological Prostheses Valved Conduit

- Hancock Percine-Valved Conduit
- Contegra graft Glutaraldehyde-preserved valve-containing bovine jugular vein

Bioprosthetic Valve Dysfunction

- Endocarditis
- Thrombosis (BPVT)
- Wear and tear
- Calcification
- Pannus

STRUCTURAL VALVE DEGENERATION (SVD)

Another Case

55-Year-Old Man

- Mitral valve replacement
  - 33-mm Edwards Magna tissue valve
- 6 month later progressive dyspnea, orthopnea
- Near syncope with activity

MG 9 mmHg
(Baseline 4 mmHg)
**Increased Bioprosthetic Gradients**

**Differential Diagnosis**
- Prosthetic valve degeneration
  - Pannus ingrowth, calcification, wear and tear
- Infection
- Increased cardiac output
  - Anemia, sepsis, thyrotoxicosis, A-V fistula
- Patient-prosthesis mismatch
- Pressure recovery – aortic prosthesis
- Bioprosthetic thrombosis

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**55-Year-Old Man with Dyspnea**

- Bioprosthetic MVR MG 9 mmHg
  - Baseline MG 4 mmHg, 6 months ago

What would you recommend?
1. Anticoagulation
2. Surgical re-replacement
3. Percutaneous valve-in-valve

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**55-Year-Old Man with Dyspnea**

- Suspected bioprosthetic MV thrombosis
- Anticoagulation with VKA 2 months
- Follow up
  - Clinically improved

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MG 4 mmHg
Continues on VKA

MG 9 mmHg

MG 4 mmHg on VKA
Identify BPVT in all explanted BPV between 1997-2013 using Mayo Clinic Pathology Database (397 cases)

**Echo Features of BPVT**
- Gradient >50% baseline
- Restricted cusp mobility
- Thickened leaflets
- TOE when in doubt

**Clinical Predictors of BPVT**
- Paroxysmal atrial fibrillation
- Sub-therapeutic or no warfarin therapy

**Other Examples**
63-Year-Old Male
12 months after Freestyle AVR

63-Year-Old Male
6 months after Freestyle AVR

12 Month postop echo
After 6 weeks of VKA

Year Old Male
6 months after Freestyle AVR

3D echocardiography
Tricuspid Prosthesis

58-Year Old Female with Carcinoid Heart Disease
18 Months Postop – TVR MG 10 mmHg (Baseline 3 mmHg)

VKA Therapy 4 Months
TVR MG 3 mmHg

Still functioning normally >10 years postop

What is new in the 2017 Valvular Heart Disease Guidelines?

2017 New recommendations

Management of prosthetic valve dysfunction
New recommendations:

Reoperation using a VKA and/or LPR is recommended in bioprosthetic valve thrombosis before considering reversion.

Baumgartner H, et al. EHJ VHD Guidelines 2017
**Bioprosthetic Valve Thrombosis**

**Things to Remember**

- May occur early or late after implantation
- When to suspect
  - BPV gradient >50% over baseline
  - Restricted cusp mobility, thickened leaflets
  - Prosthesis regurgitation
- Findings may be subtle
- TEE or CT when in doubt
- Early screening may be beneficial

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**31-Year-Old dTGA, Rastelli**

Status Post 22 mm Contegra Graft

Mean Gradient 34 mmHg

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**Bioprosthetic Valve Dysfunction**

- Endocarditis
- Thrombosis (BPVT)
- Wear and tear
- Pannus
- Calcification

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**What is new in the 2017 Vahrular Heart Disease Guidelines?**

**2017 New recommendations**

Management of prosthetic valve dysfunction

New recommendations:

- IE: Treatment is recommended if atheroma described.

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**Infection**

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**European Heart Journal - Cardiovascular Imaging Advance Access published May 8, 2016**

Prosthetic pulmonary valve and pulmonary conduit endocarditis: clinical, microbiological and echocardiographic features in adults

William R. Miranda, Heidi M. Connolly, Crystal R. Breslin, Daniel C. DeSimone, Joseph A. DeRosa, Joseph J. Malezewski, Kevin L. Greason, Walter R. Wilson, and Larry M. Balduzzi

1. PPV IE – morbidity, mortality and high risk of reoperation
2. TTE and TEE – complementary diagnostic techniques
3. PPV stenosis more common than regurg; consider IE in new obstruction

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Baumgartner H, et al. EHJ VHD Guidelines 2017
Homograft Calcification and Obstruction

"Valve heavily calcified and severely obstructed – calcified valve cusps were excised and debrided with a rongeur…"

Another Case

69-Year-Old-Female AVR for AS

- AVR 23-mm Mitroflow bovine pericardial
- DM, dyslipidemia, obesity, HTN
- 2 years postop → DOE, NYHA III
- New murmur on examination
Early Structural Valve Degeneration (SVD)

- Operative findings – severe SVD with calcification of Mitroflow valve leaflets
- Redo AVR 21-mm CarboMedics TopHat valve
- Pathology – moderate commissural calcification without cusp tear, thrombus, pannus or vegetation

Accelerated Structural Valve Degeneration

- Wear and tear – accelerated calcification
- Host metabolic factors and specific valve design
- Risk factors
  - Diabetes
  - Young females
  - Patient prosthesis mismatch
  - Small prosthesis size
  - Metabolic syndrome
  - Mitral position
  - CKD, abnormal Ca²⁺ metabolism

75-Year-Old Male

- Severe degenerative calcific AS
- AVR 25 mm CarboMedics Mitroflow prosthesis
- Increasing AV gradient noted postop

<table>
<thead>
<tr>
<th>Year</th>
<th>Mean gradient</th>
<th>iEOA</th>
<th>EF</th>
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<tbody>
<tr>
<td>2010</td>
<td>8</td>
<td>1.00</td>
<td>63%</td>
</tr>
<tr>
<td>2011</td>
<td>12</td>
<td>0.84</td>
<td>62%</td>
</tr>
<tr>
<td>2013</td>
<td>24</td>
<td>0.66</td>
<td>64%</td>
</tr>
<tr>
<td>2015</td>
<td>37</td>
<td>0.47</td>
<td>60%</td>
</tr>
</tbody>
</table>

One More Case

- Severe degenerative calcific AS
- AVR 25 mm CarboMedics Mitroflow prosthesis
- Increasing AV gradient noted postop

What is the diagnosis?
1. Bioprosthentic AV thrombosis
2. Accelerated degeneration
3. Pannus

Pannus Overgrowth

Lorusso et al. Circulation 2011
Pannus
• Difficult to differentiate from thrombus
  ∘ Failure of anticoagulation may be initial clue
• Host healing response to prosthesis
• Surgical injury → thrombus → inflammation → fibrosis/collagen deposition
• Pannus overgrowth → pathology
  ∘ Subvalvular thickening, stiffness → stenosis (majority)
  ∘ Can occur in isolated annuloplasty ring

Bioprosthetic Pannus - Histopathology
Thrombus and pannus often coexist
Cremer et al. JACC: CV Imaging, 2015

Prosthetic Valve Choice
• Every valve prosthesis introduces new disease process
• Randomized trials comparing mechanical vs bioprostheses:
  ∘ Similar survival
  ∘ No significant difference in rates of valve thrombosis and thromboembolism
  ∘ Higher rates of bleeding with mechanical prostheses
  ∘ Higher rates of reintervention with bioprostheses

Patient with Prosthetic Heart Valve
• Lifelong follow-up
  ∘ Baseline TTE within 30 days
  ∘ TTE at 1 year, and annually thereafter
• Repeat TTE for new symptoms or suspected complications
• TOE when TTE is poor quality and for all suspected prosthetic dysfunction or endocarditis
• Cine-fluoroscopy and MSCT for mechanical valves useful if valve thrombus or pannus are suspected

Prosthetic Valve Dysfunction
Take Home Points
Know Prosthesis Type and Size
Infection, Calcification, Thrombus, Pannus
Structural Deterioration, Regurgitation
Multimodality Assessment Options

Questions & Discussion
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