Post op valve surgery problems

- SOB S/P
- Suspect IE
- Abnormal murmur
- Hemolysis
- CVA
- Chest pain
Caged ball valve

- First design
- Higher gradient
- More turbulence
- More RBC damage

Starr - Edwards
Single tilt disk

- Blood flow through 2 unequal (major and minor) orifices
- Open angle 60 - 80°
Bileaflet

- Two semicircular pyrolytic carbon discs
- Most popular
- Extremely durable
- Disc travel from $25^\circ$ to $80^\circ$

St. Jude
Carbomedics
Omni
Sorin
Stented bioprostheses

- Low rate of thrombogenicity
- Anticoagulation not required
- Inaudible

Carpentier-Edwards porcine

Carpentier-Edwards perimount pericardium
Carpentier Edwards Porcine
Carpentier Edwards Porcine
Calcific degeneration

- Rate of degeneration for porcine valve: 3.3% per patient-year
- At ten year, freedom from valve failure:
  - 49% AV
  - 32% MV
- Faster in the young and CRF
Stented

Stentless

Percutaneous TAVI
An “unusually” high gradient

Is the valve stenosed? Technical consideration

• Peak instantaneous VS peak to peak
• Pressure recovery
• Simplified Bernoulli – too simplified
• Intrinsic to valve design
Pressure recovery

Echo Doppler $\Delta P = 4 \left( V_2^2 - V_1^2 \right)$

Catheterization $\Delta P = 4 \left( V_3^2 - V_1^2 \right)$

$V_2 > V_3 > V_1$

$P_1 >> P_3 > P_2$
Localized high velocity flow in bi-leaflet mechanical valve

Large lateral orifices

Central slit-like orifice
Transvalvular gradient

- cage ball > single tilting disc ~ bileaflet > stented porcine tissue > stentless tissue
- valve position
  - aortic > mitral > tricuspid
Doppler parameter of prosthetic mitral valve function

<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;1.9</td>
<td>1.9-2.5</td>
<td>≥2.5</td>
</tr>
<tr>
<td>Mean gradient (mm Hg)† §</td>
<td>≤5</td>
<td>6-10</td>
<td>&gt;10</td>
</tr>
<tr>
<td>$VTI_{PrMv}/VTI_{LVO}$† §</td>
<td>&lt;2.2</td>
<td>2.2-2.5</td>
<td>&gt;2.5</td>
</tr>
<tr>
<td>EOA (cm²)</td>
<td>≥2.0</td>
<td>1-2</td>
<td>&lt;1</td>
</tr>
<tr>
<td>PHT (ms)</td>
<td>&lt;130</td>
<td>130-200</td>
<td>&gt;200</td>
</tr>
</tbody>
</table>
Source of error: need to average multiple measurements
Velocity ratio or DVI = \( \frac{LVOT \text{ VTI}}{AV \text{ VTI}} \)

\( \text{dimensionless velocity index} \)
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
  - >100
  - <100

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

EOA Index

- High Flow
- PPM

Normal PrAV

Suggests PrAV Stenosis

Consider Improper LVOT velocity

ASE Guidelines on Prosthetic valves 2008
AV Patient-prosthesis mismatch

- All artificial valve have inherent functional stenosis
- Indexed effective orifice area (EOA / BSA)
  - Significant < 0.85 cm²/m²
  - Severe < 0.65 cm²/m²
- Reduced short-term and long-term survival, particularly if associated with LV dysfunction

Diagnosis by exclusion
High Gradient after AVR

**STEP 1 - Calculate:**
- Predicted Indexed EOA < 0.85 cm²/m²

**Normal reference EOA**: and Patient’s BSA

**STEP 2 - Assess Presence of:**
- Abnormal leaflet morphology/mobility
- EOA < reference EOA* (difference † > 0.35 cm²)
- DVI < 0.35
- Gradient increased during FU (Δ > 10 mmHg)
- EOA & DVI decreased during FU
- AT/ET > 0.37

Cine-fluoro MDCT

Consider:
- High Flow state/subvalvular obstruction
- Technical error
- Localized high gradient (bileaflet valve)
Ventricular edge of stent below aortic annulus
- balloon expandable valve (Edwards Sapien) : 2-4 mm
- self-expanding valve (CoreValve): 4-6 mm (second generation 3-5 mm)

Circumferential extent of PVR (%)
Assessment for paravalvular regurgitation severity

<table>
<thead>
<tr>
<th>Type</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>mild</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>mild-mod</td>
<td>10-20</td>
</tr>
<tr>
<td>mod</td>
<td>20-30</td>
</tr>
<tr>
<td>mod-severe</td>
<td>&gt;30</td>
</tr>
<tr>
<td>severe</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>

Pitarot et al. JACC Img 2015;8:340–60
Normal values for TAV

- Mean gradient <20 mm Hg
- EOA >1.1 cm²
- DVI >0.35
# Approach to Differential Diagnosis of Elevated TAV Gradients

<table>
<thead>
<tr>
<th></th>
<th>Obstruction</th>
<th>High Flow</th>
<th>PPM</th>
<th>Pressure Recovery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gradient</strong></td>
<td>Elevated</td>
<td>Elevated</td>
<td>Elevated</td>
<td>Elevated</td>
</tr>
<tr>
<td><strong>DVI</strong></td>
<td>Reduced</td>
<td>Normal</td>
<td>Normal</td>
<td>Reduced</td>
</tr>
<tr>
<td><strong>EOA</strong></td>
<td>Reduced</td>
<td>Normal</td>
<td>Normal</td>
<td>Reduced</td>
</tr>
<tr>
<td><strong>EOA index</strong></td>
<td>Reduced</td>
<td>Normal</td>
<td>Reduced</td>
<td>Reduced</td>
</tr>
<tr>
<td>Δ in EOA/DVI</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Abnormal Cusp Motion</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

Pibarot et al. JACC Img 2015;8:340–60
71 y/o woman S/P MVR (St.Jude)  Readmitted with ADHF
High mitral prosthetic gradient

Mean gradient 16 mmHg! Is this MV prosthesis stenosed?

1 yes    2 no
High mean MV gradient

- High initial gradient
- High LA pressure
- MR / MS
- Diastolic dysfunction
- Poor LA compliance
- High flow
- Persistently high gradient (slow pressure decay with residual gradient at the end diastole)
- MS
PROSTHETIC MECHANICAL MITRAL VALVE

BEST CLUES FOR DYSFUNCTION

- Peak E velocity $\geq 1.0$ m/s
- $TVI_{MV}/TVI_{LVO} \geq 2.2$

PHT < 130 ms
Regurgitation

PHT $\geq 130$ ms
Stenosis

VTI MV / VTI LVOT

diastole

systole
High mitral prosthetic gradient

Mean gradient 16 mmHg! Is this MV prosthesis stenosis?
Paravalvular leak

TEE
An “unusually” high gradient
Is the valve stenosed? Technical consideration

- Peak instantaneous VS peak to peak
- Pressure recovery
- Simplified Bernoulli – too simplified
- Intrinsic to valve design
- Physiologic conditions – high output state
  - anemia, fever, anxiety, exercise, paravalvular leakage, pregnancy

If the patient is well, so is the valve.
Changes over time

Always compare with the previous study

non immediate

A routine post op echo as base line data is vital.
A 44 years old woman RHD S/P AVR, MVR 20 years ago presented with progressive DOE and peripheral edema due to severe primary TR TS.
Scheduled for redo TV surgery.
Moderately high AV gradient was also found.
Peak 56, mean 34 mmHg
AV velocity ratio 0.3   EOA 1.1 cm$^2$
Prosthesis-patient mismatch was suggested.
(No immediate post op echo was available)

AV Accel Time 110 ms

Should we redo AVR as well?
Peak gradient: 21.8 ± 7.5 mm Hg
Mean gradient: 13.4 ± 5.6 mm Hg
EOA: 1.6 ± 0.4 cm²
Fluoroscopy:

Incomplete opening of one disc of AV bileaflet prosthesis
Fluoroscopy:

Incomplete opening of one disc of AV bileaflet prosthesis
Extensive pannus narrowing the EOA and interfering with disc movement.
♀ 36 years RHD severe MS mild AR mod AS
S/P MVR AVR 1 year ago with regular follow up NYHA I
3 days PTA dyspneic orthopneic NYHA IV frank heart failure valve click +ve SEM grade II LUSB DRM grade III apex

Intermittent failure of MV opening
♀ 53 y S/P MVR sub therapeutic INR due to recent history of UGIH

Presented with progressive dyspnea

Prosthetic valve thrombosis
Clinical presentations

- Dyspnea
- Shock
- Cardiac arrest
- Cerebral, coronary and peripheral embolization
Prosthetic Valve Thrombosis

Surgery or fibrinolysis
Relationship of thrombus area by TEE to overall complication rate and death rate

3.4 cm²

Thrombocardia

Warfarin stopped due to recent ICH

Ventricular side

Atrial side
No valve click
Severe AS
Severe AR
dense
• A 40 year old woman S/P MVR (Bjork Shiley) 20 years ago
• Virtually asymptomatic after MVR with regular follow up and stable INR in therapeutic range
• Progressive dyspnea since 6 months ago
• 3 days ago - dyspneic at rest with signs of severe left and right heart failure

Pulsus interruptus

“Intermittent PEA”
intermittent failure to open
very long PHT

very high LAP

Faint MV inflow signal
intermittent failure to open Fluoroscopy
<table>
<thead>
<tr>
<th></th>
<th>Thrombus</th>
<th>Pannus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of symptoms</td>
<td>&lt; 1 month</td>
<td>&gt; 1 month</td>
</tr>
<tr>
<td>Duration after Sx</td>
<td>Any time</td>
<td>many months to years</td>
</tr>
<tr>
<td>Anticoagulation status</td>
<td>Inadequate</td>
<td>Therapeutics range</td>
</tr>
<tr>
<td>TEE</td>
<td>Soft mass Mobile</td>
<td>Small dense echo mass</td>
</tr>
<tr>
<td></td>
<td></td>
<td>along the plane of valve (suture line)</td>
</tr>
</tbody>
</table>
• Immediate response from CVT team
• Patient was rushed to OR
• PEA cardiac arrest at OR
• 2 hours CPR was done before CP bypass was started
Ventricular side

Pannus
Why intermittent opening

Opening pressure threshold created by pannus resistant

MV prosthetic opening

LA filling

MV prosthetic opening

LA filling

LV filling

Rapid drop in LAP

LA filling

LA filling

LA filling

LA filling
• A 18-year-old girl with history of MV repair 2 months ago revisit for her routine post op follow-up.
• She was fine and afebrile.

Paravalvular abscess
Mr K 34 years old carpenter with severe AR
6 weeks ago - AVR St Jude # 27 complicated by infected wound
2 weeks ago developed low grade fever and progressive shortness of breath, now NYHA IV
RT 3D TEE
Dehisced mitral valve annuloplasty ring

View from left atrium

View from left ventricle

PVE

- Mechanical - paravalvular infection
- Rocking motion $\rightarrow$ dehiscence more than 30-40% of valve ring circumference
- Paravalvular leak
  - may be obscured by reverberation
  - pay attention the proximal flow convergence (PISA)
- Perivalvular abscess *may be echo dense or echo lucent*
PVE: TTE or TEE?

Both! complimentary
Severe anemia

Mr. S NL 38 years old RHD severe MR severe TR
10 years ago – MVR Medtronic Hall #29
- TV repair # 33 Duran’s ring
Regular F/U - NYHA II
1 month PTA progressive dyspnea , easily fatigue
NYHA IV
PE: marked pale , tachycardic
valve click +ve
splenomegaly 3 FB ↓ RCM
Hematocrit 14 %

RBC fragmentation (MAHA)
Leakage backflow

- “Built-in” regurgitation
- Prevent thrombus formation by a “washing” mechanism

Bi-leaflet

Single tilt disc
Leakage backflow in bileaflet valve

- Perpendicular to the leaflet opening plane → diverging jets
- Parallel to the leaflet opening plane → two crisscross jets
<table>
<thead>
<tr>
<th>Jet feature</th>
<th>Physiologic leakage</th>
<th>Pathologic regurgitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration</td>
<td>Short</td>
<td>Pansystole</td>
</tr>
<tr>
<td>Width</td>
<td>Narrow</td>
<td>Large</td>
</tr>
<tr>
<td>Direction</td>
<td>central</td>
<td>Eccentric or paravalvular</td>
</tr>
<tr>
<td>Velocity</td>
<td>Low (no aliasing)</td>
<td>High (aliasing)</td>
</tr>
<tr>
<td>Length</td>
<td>Short (&lt; 3 cm)</td>
<td>May extend far into the receiving chamber</td>
</tr>
</tbody>
</table>
Essential parameters in the comprehensive evaluation of prosthetic valve function

- Clinical information
- Date of valve replacement
- Type and size of the prosthetic valve
- Height, weight, body surface area
- Symptoms and related clinical findings
- Blood pressure and heart rate
- Hct
Doppler echocardiography of the valve

- Contour of the jet velocity signal
- Peak velocity and gradient
- Mean pressure gradient
- DVI
- Pressure half-time in MV and TV.
- EOA*
- Presence, location, and severity of regurgitation
- Comparison with previous post op data
Slightly *imperfect* patient’s own valve is better than *perfect* prosthetic valve.