Case Studies: Evaluating Post-TAVR PVL

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Trans-catheter Heart Valves

Edwards Sapien Valve
Medtronic CoreValve
SJM Portico Valve
Procedural Success?

VARC – 2 Definitions: PVL Quantification

- Adapted from the guidelines for surgical AVR
- Does not consider the height of the PVR jet
- <10% mild PVR
- 10–20% moderate PVR
- >20% severe PVR

*Adapted from the guidelines for surgical AVR
Does not consider the height of the PVR jet

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

Philippe Pifarot, DVM, PaD,* Rebecca T. Hahn, MD,† Neil J. Weissman, MD,‡ Mark J. Monaghan, PaD§

PVR severity: 5 Grades
- <5%, trace PVR (A);
- 5% to 15%, mild PVR (B);
- 15% to 25%, mild-to-moderate PVR (C and D);
- 15% to 25% but larger jet width, moderate PVR (E);
- >30%, moderate-to-severe PVR (F)
Assessment of Paravalvular Regurgitation Following TAVR: A Proposal of Unifying Grading Scheme

Doppler Echo
- Color (VCA, circumferential extent, jet length)
- Pulse wave (Holodiastolic flow reversal, LVOT/RVOT SV)
- Beware the many limitations (shielding, Doppler angle)

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Paravalvular Regurgitation Severity?

Mid-Esophagus

Deep Trans-gastric

Steep Pressure ½ Time

Severe PVL
Location of the PVR jets in different views

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Balloon Expansion of the self-expanding valve
Final Result

Trace PVL

92 yr male; Post-TAVR

Balloon Inflation for PVL?
77 yr male, severe symptomatic AS. History of CABG and liver dysfunction

LVEF 35%
AV peak velocity 3.8 m/s
AV mean gradient 35 mmHg
AVA 0.7cm²
Intra-Procedural TTE

29mm Sapien 3 implantation
No acute complications
Transvalvular mean systolic gradient 6mmHg
Possible mild PVL

Persistent dyspnea after TAVR

TEE done prior to hospital discharge
Mild to moderate PVL reported
Severity of PVR at 30 Days and All-cause Mortality at 2 Years (VI)

Overall Log-Rank p = 0.001

Moderate/Severe (reference = None/Trace)

Mild (reference = None/Trace)

Number at risk:

<table>
<thead>
<tr>
<th>Category</th>
<th>0</th>
<th>3</th>
<th>6</th>
<th>9</th>
<th>12</th>
<th>15</th>
<th>18</th>
<th>21</th>
<th>24</th>
<th>27</th>
<th>30</th>
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<tbody>
<tr>
<td>Moderate/Severe</td>
<td>76</td>
<td>32</td>
<td>32</td>
<td>26</td>
<td>26</td>
<td>24</td>
<td>22</td>
<td>22</td>
<td>22</td>
<td>18</td>
<td>18</td>
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<tr>
<td>Mild</td>
<td>210</td>
<td>204</td>
<td>199</td>
<td>194</td>
<td>188</td>
<td>184</td>
<td>182</td>
<td>180</td>
<td>175</td>
<td></td>
<td></td>
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<tr>
<td>None/Trace</td>
<td>701</td>
<td>676</td>
<td>664</td>
<td>647</td>
<td>628</td>
<td>621</td>
<td>612</td>
<td>605</td>
<td>565</td>
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Overall Log-Rank p = 0.001

Moderate/Severe (reference = None/Trace)
p (Log-Rank) < 0.001

Mild (reference = None/Trace)
p (Log-Rank) = 0.82

None/Trace

PVR at 30 Days and All-cause Mortality at 2 Years (VI)

Hazard Rate

Estimated Hazard Rate

Days Post Procedure

HR Pivotal TAVR

HR Pivotal SAVR

Periprocedural Elevated Hazard

Delayed Recovery

Constant Hazard
Valve-in-Valve procedure successfully treated PVL

After TAVR #1

After TAVR #2

No change in symptoms.
Persistent restrictive diastolic filling indices

• 25 studies reported on predictors of post TAVR PVL
• Implant depth, valve under sizing, and calcium score were identified as important predictors

Incidence, Predictors, and Outcomes of Aortic Regurgitation After Transcatheter Aortic Valve Replacement
Meta-Analysis and Systematic Review of Literature

Ganesh Athappan, MD,‡ Eshan Patwardhan, MD,§ E. Murat Tuzcu, MD,¶ Lars Georg Svensson, MD, PhD; Pedro A. Lemos, MD,§ Chiara Fraccaro, MD, PhD;‡ Giuseppe Tarantino, MD, PhD; Ján-Malte Sinning, MD;¶ Georg Nickeni, MD;¶ Davide Capodanno, MD, PhD; Corrado Tamburino, MD, PhD; Azeen Latib, MD;¶ Antonius Colombo, MD,‡ Samir R. Kapadia, MD

Cleveland, Ohio; São Paulo, Brazil; Padova, Genoa, and Milan, Italy; and Bern, Germany

Athappan et al. JACC 2013
Importance of Correct Valve Size

CT Data:

**Aortic annulus:**
- 84 mm perimeter
- \( \frac{29 \text{ mm}}{84 \text{ mm}} = 0.35 \) perimeter

**29 mm CoreValve:**
- 29 mm inflow diameter
- Perimeter = 29 x 3.14 = 91 mm
- 91 mm/84 mm = 1.08
- 8% cover index

**15-20% is ideal**

<table>
<thead>
<tr>
<th>Valve Size</th>
<th>Aortic Annulus Diameter</th>
<th>Ascending Aorta Diameter</th>
<th>Sinus of Valsalva Diameter</th>
<th>Native Leaflet to Sinotubular Junction Length</th>
<th>Perimeter Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>23</td>
<td>18 mm – 20 mm</td>
<td>34 mm</td>
<td>25 mm</td>
<td>15 mm</td>
<td>56.5 mm – 62.8 mm</td>
</tr>
<tr>
<td>26</td>
<td>20 mm – 23 mm</td>
<td>40 mm</td>
<td>27 mm</td>
<td>15 mm</td>
<td>62.8 mm – 72.3 mm</td>
</tr>
<tr>
<td>29</td>
<td>23 mm – 27 mm</td>
<td>43 mm</td>
<td>29 mm</td>
<td>15 mm</td>
<td>72.3 mm – 84.8 mm</td>
</tr>
<tr>
<td>31</td>
<td>26 mm – 29 mm</td>
<td>43 mm</td>
<td>29 mm</td>
<td>15 mm</td>
<td>81.6 mm – 91.1 mm</td>
</tr>
</tbody>
</table>

The Dynamic Annulus

4D multidetector CT image of the aortic annulus in a patient with severe aortic stenosis shows change in measurements during the cardiac cycle.

**3D Imaging Considerations**

- Under sizing increases the risk of PVL.
- The “virtual” annulus is non-circular.
- Single linear measurements (whether directly measured or derived) are less accurate.
- Sizing algorithms for each valve have been defined.
- 3D imaging techniques must be used to accurately measure the annulus.

**It’s less important which 3D imaging tool is used!**
Para-Valvular Regurgitation after TAVR

Correlation of Device Landing Zone Calcification and Acute Procedural Success in Patients Undergoing Transcatheter Aortic Valve Implantations With the Self-Expanding CoreValve Prosthesis

Daniel John, MD, Lutz Buellesfeld, MD, Seyrani Yuecel, MD, Ralf Mueller, MD, Georg Latsios, MD, Harald Beucher, MD, Ulrich Gerecke, MD, Eberhard Grube, MD

Siegburg, Germany

Methods:
• 100 pts with CoreValve TAVR
• MSCT to assess calcium load in valve and adjacent LVOT
• Calcium levels correlated with PVL by angio and TTE (2 weeks later)
Landing Zone Concerns

Immediately after Valve deployment
Asymmetric Root Calcium

CoreValve System: sealing can occur along the 12mm sealing skirt—in the aortic root, annulus, and LVOT—including above and below calcification.

Sealing at Multiple Levels

Patient Example of 3D Sealing at Multiple Levels

CT Images Courtesy of Dr. Piazza and Prof. Lange, German Heart Center Munich Germany

Bright green = CoreValve in contact with tissue
Red = blood volume
White = calcification
Implantation Depth

- PVL is influenced significantly by implant depth.
- A low CoreValve implantation associated with an OR of 3.67 for moderate or severe AR. (Takagi et al.)

- Sherif et al. optimal device depth 9.5mm (from the NCC)
- Jilaihawi et al. optimal device depth 5- to 10-mm

Valve positioning is based mainly on fluoroscopy with or without echo guidance. Choosing the correct fluoroscopic plane is critical.

Guiding the Procedure

*Confirm the Pig-Tail Catheter Location within the Non-Coronary Cusp (NCC)*
Clinical Presentation

91 year old man with severe AS
- TAVR 1 month prior
- Now with new onset DOE, NYHA 3

PMHx:
- CAD, Dyslipidemia, HTN, Atrial fibrillation, Pacemaker (prior to TAVR)

Medications:
- Furosemide, simvastatin, digoxin, apixaban
Clinical Presentation

Physical Exam:

- BP 154/64, HR 67, RR 18, T 96.7, O2 97% R/A
- No Jugular venous distension, ascites, or peripheral edema
- Decreased breath sounds to bases
- 2/4 diastolic murmur
Transthoracic Echocardiogram

Findings
LV: LV size is normal. LV function is normal. Overall wall motion is normal. Estimated EF is 60-64%.
RV: RV size is normal. RV function is normal.
LA: LA size is enlarged.
RA: RA size is enlarged.
AO: Aortic root is mildly enlarged.
PERI: No pericardial effusion.
PLE: Pleural effusion is present.
AV: Bioprosthetic aortic valve. Normal prosthetic valve velocity and gradient. Doppler velocity index is 0.57. Mild paravalvular aortic regurgitation.
MV: Moderate thickening and calcification of mitral leaflets. Moderate mitral annular calcification. Thickened and/or calcified chordae. Mild mitral regurgitation.
PV: Pulmonic valve not well seen. A trace of pulmonic regurgitation.
TV: No structural TV abnormalities noted. A trace of tricuspid regurgitation.
Other: Estimated PA systolic pressure is 30 mmHg, assuming a mean RAP of 5 mmHg.

<table>
<thead>
<tr>
<th>2D Measurements</th>
<th>Doppler Measurements</th>
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<tbody>
<tr>
<td>Parasternal Long Axis</td>
<td>AV For Flow Max</td>
</tr>
<tr>
<td>IVSD</td>
<td>1.1 cm</td>
</tr>
<tr>
<td>LVDd</td>
<td>5.6 cm</td>
</tr>
<tr>
<td>LVEDd</td>
<td>2.5 cm</td>
</tr>
<tr>
<td>AV Max</td>
<td>2.0 cm/s</td>
</tr>
<tr>
<td>AV Max VE</td>
<td>113.9 cm/s</td>
</tr>
<tr>
<td>AV Max GP</td>
<td>16 m/s</td>
</tr>
<tr>
<td>AV Max G</td>
<td>6.6 m/s</td>
</tr>
<tr>
<td>AV AC</td>
<td>79 m/sec</td>
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<tr>
<td>AV ET</td>
<td>203 m/sec</td>
</tr>
<tr>
<td>LVOT For Flow</td>
<td></td>
</tr>
<tr>
<td>LVOT Area</td>
<td>5.8 cm²</td>
</tr>
<tr>
<td>LVOT Arterial</td>
<td>115.6 cm³</td>
</tr>
<tr>
<td>LVOT AreaO</td>
<td>5.2 cm²</td>
</tr>
<tr>
<td>LVOT TVI</td>
<td>2.7 mmHg</td>
</tr>
<tr>
<td>LVOT TVI</td>
<td>23.2 cm</td>
</tr>
</tbody>
</table>

TEE for PVL severity
### Transesophageal Echocardiogram

<table>
<thead>
<tr>
<th>LV</th>
<th>LV size is normal. LV function is normal. Overall wall motion is normal. 3D volumetric LVEF is 62%.</th>
</tr>
</thead>
<tbody>
<tr>
<td>RV</td>
<td>RV size is normal. RV function is normal.</td>
</tr>
<tr>
<td>LA</td>
<td>LA size is enlarged. No thrombus or mass is visualized in the LA or LA appendage. Spontaneous echo contrast is seen in the LA/LA appendage.</td>
</tr>
<tr>
<td>RA</td>
<td>RA size is enlarged.</td>
</tr>
<tr>
<td>AO</td>
<td>Mild atherosclerotic changes seen in the aortic arch and descending aorta.</td>
</tr>
<tr>
<td>PERIC</td>
<td>No pericardial effusion.</td>
</tr>
<tr>
<td>IAS</td>
<td>Atrial septum is normal.</td>
</tr>
<tr>
<td>AV</td>
<td>Bioprosthetic Core Valve is visualized. Placement appears lower in LVOT. Mild paravalvular aortic regurgitation with 2 jets located anterior and posteriorly (view 37).</td>
</tr>
<tr>
<td>MV</td>
<td>Moderate thickening and calcification of mitral leaflets. Mild mitral annular calcification. Mild to moderate mitral regurgitation.</td>
</tr>
<tr>
<td>PV</td>
<td>No structural PV abnormalities noted.</td>
</tr>
<tr>
<td>TV</td>
<td>No structural TV abnormalities noted.</td>
</tr>
</tbody>
</table>
**Cardiac Magnetic Resonance**

LV
- End Diastolic Volume: 152.1 ml
- End Systolic Volume: 29 ml
- Cardiac Output: 8.62 L/min
- Myocardial Mass: 154.7 g
- Stroke Volume: 123.10 ml
- Ejection Fraction: 80.93 %
RF = Rvol (50 mL) / AOFF (100 mL) = 50%
Cardiac Magnetic Resonance Report

1. Normal LV and RV sizes. Severe bi-atrial enlargement. No thrombus in LA or RA appendages.
2. Hyperdynamic LV and normal RV systolic function (LVEF 81%, RVEF 50%).
3. Subendocardial scarring in the basal-mid anterolateral wall, total scar burden 2%.
4. Self expanding transcatheter valve in low aortic/LVOT position. Severe paravalvular aortic regurgitation (RV 50 ml, RF 50%) with holodiastolic flow reversal in the descending aorta. Position of bioprosthesis limits anterior mitral leaflet excursion resulting in mild mitral stenosis (planimetered MVA 2.0 cm²). Mild-moderate mitral regurgitation (RV 2.3 ml, RF 32%).
5. Enlarged ascending aorta (4.5 cm) without dissection. Enlarged pulmonary artery (MPA 3.0 cm). Normal pulmonary venous anatomy.

FINAL IMPRESSION: SELF EXPANDING TRANSCATHETER IN LOW AORTIC/LVOT POSITION WITH SEVERE PARAVALVULAR AORTIC REGURGITATION. MILD-MODERATE MITRAL REGURGITATION.

Clinical Decision Making

Clinical Summary
- 91M NYHA III
- Post-TAVR (Core Valve) 1 month ago

CMR Findings
- Low implant in LVOT
- Severe (RF 50%) paravalvular AI with holodiastolic reversal
- Mild-moderate mitral regurgitation
Interventional Lab

Post redo TAVR

PREDICTIONS FOR 2020

All risk categories will be TAVR candidates

Both dividing lines moving to the left
• Underestimation of PAR with may be significant.
• Accurate annulus sizing is a key step to prevent PVR.
• 3D imaging is superior to 2-D imaging techniques.
• Innovations designed to improve sealing.
• Improvement in the range of available device sizes, accurate annular sizing, and precise positioning will help minimize AR after TAVR.