# Prosthetic Valves

**Moderator:** S. Lester

<table>
<thead>
<tr>
<th>Time</th>
<th>Session</th>
<th>Presenter(s)</th>
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</thead>
<tbody>
<tr>
<td>11:00 AM</td>
<td>Echocardiographic Evaluation of an Aortic Prosthesis</td>
<td>S. Wilansky</td>
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<tr>
<td>11:25 AM</td>
<td>Echocardiographic Evaluation of a Mitral Prosthesis</td>
<td>V. Rigolin</td>
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<tr>
<td>11:50 AM</td>
<td>Question and Answer</td>
<td>All Faculty</td>
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<tr>
<td>12:00 PM</td>
<td>Lunch and Visit Exhibits</td>
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<tr>
<td>1:00 – 4:30 PM</td>
<td>TAVR Workshop: Echo Measurements Pre, Post, and Intra Procedure</td>
<td>B. Khandheria, C. Kramer, M. Saric, M. Umland</td>
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<tr>
<td>4:30 PM</td>
<td>Refreshment Break and Visit Exhibits</td>
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<tr>
<td>4:45 – 5:45 PM</td>
<td>Echo Jeopardy</td>
<td>Chair: S. Mankad</td>
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<td></td>
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<td>Team 1 S. Lester, V. Rigolin</td>
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<td>Team 2 R. Lang, S. Wilansky</td>
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<tr>
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<td></td>
<td>Team 3 B. Khandheria, M. Saric</td>
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TAVR: Echo Measurements Pre, Post And Intra Procedure

Muhamed Sarić MD, PhD, MPA
Director of Noninvasive Cardiology | Echo Lab
Associate Professor of Medicine

2017 SOTA, Tucson, AZ
February 19, 2017 | 11:15 – 11:40 AM | 25 min
Disclosures

Speakers Bureau (Philips, Medtronic)
Advisory Board (Siemens)
IMAGING IN PATIENTS UNDERGOING TAVR

Role of various imaging modalities before, during and after TAVR procedure

Role of **echocardiography** relative to other imaging modalities in TAVR cases

Echo

CT

Fluoroscopy

Chest CT: Primary means of TAVR valve sizing.

**Before TAVR Procedure**

**During TAVR Procedure**

Echocardiography: Primary means of assessing for paravalvular leak, overall valve function and possible complications.

Fluoroscopy/Cine: Primary means of AVR valve implantation guidance.

**After TAVR Procedure**

Echocardiography: Primary means of assessing for prosthetic and overall cardiac function.

Echocardiography Prior to TAVR
ROLE OF ECHO PRIOR TO TAVR

- Establish whether indications for TAVR are present
  - Severity of aortic stenosis
  - Subtype of aortic stenosis (high vs. low-gradient)
- Assess LV ejection fraction
- Assist in TAVR valve sizing
PRIMARY INDICATIONS FOR SURGICAL OR PERCUTANEOUS TREATMENT OF AORTIC STENOSIS

SYMPTOMS
Dyspnea, angina, syncope

Severe symptomatic AS irrespective of LVEF

LV FUNCTION
Diminished LVEF

Severe AS with diminished LVEF irrespective of symptoms

SEVERE Aortic Stenosis
Types of Aortic Stenosis

- **Classic High-Gradient AS**
  - 65-85%

- **Low-Gradient AS with Preserved EF**
  - 10-25%

- **Low-Gradient AS with Diminished EF**
  - 5-10%
Additional Roles of Echo Prior to TAVR

Assessment of the aortic valve complex
TAVR-related Aortic Root Measurements

- Systolic size of the aortic annulus
- Diastolic sinus of Valsalva width & height
- Diastolic annulo-coronary distance

These measurements help select TAVR prosthesis size.

A: Aortic Annulus

B: Sinus of Valsalva Width

C: Ascending Aorta Width

D: Annulo-coronary Distance

E: Sinus of Valsalva Height
1º Generation Edwards Sapien

Available in Two Sizes

23 mm  26 mm

14.3 mm  16.1 mm

Annulus Range
18-22 mm  21-25 mm

1º Generation Medtronic CoreValve
AORTIC ANNULUS SIZING BY TTE
Aortic Annulus & LVOT

- Both typically OVOID rather than circular shape
- Have major and minor axis diameters
- Diameter measure by 2D echo (anteroposterior diameter) is typically the minor diameter
- By measuring the minor diameter, echo may underestimate the annular and LVOT size
- Aortic root sizing (including annular diameter, perimeter and area) is best done using a 3D method (CT or 3D TEE)
3D TEE: MULTIPLE RECONSTRUCTION (MPR)

Long Axis #1

Short Axis

Long Axis #2
It looks like a true LVOT diameter... ... but it's a chord (a line that connects 2 points on a circle but does not go through the center)
Even a perfectly measured LVOT diameter on echo may not be good enough...

... echo measured diameter is the sagittal (antero-posterior) diameter which is typically smaller than the coronal (medio-lateral) diameter.
3D TEE MPR: Ovoid Shape of LVOT

LVOT D1 = 1.9 cm (Calculated AVA 2.8 cm²)
LVOT D2 = 2.5 cm (Calculated AVA 4.9 cm²)
-----------------------------------------------
LVOT Area = 3.3 cm²
Some interventionalists prefer **CT measurements** of aortic root over echocardiographic measurements...

...because calcifications may interfere with echo but not CT imaging.
Aortic Annular Sizing | CT

Aortic annular diameter, perimeter and area by CT
Aortic Annular Sizing | 3D TEE

Aortic annular diameter, perimeter and area by semi-automated 3D TEE
Aortic Annular Sizing | 3D TEE

Aortic annular diameter, perimeter and area by automated 3D TEE
AORTIC ANNULAR SIZING | 3D TEE

Ann Min Diam: 16.8 mm
Ann Max Diam: 26.1 mm
Aortic Annular Sizing | 3D TEE

Aortic annular diameter, perimeter and area by automated 3D TEE
Echocardiography During TAVR Procedure
Question | Echo Type

Should I use transesophageal echo (TEE) or transthoracic echo (TTE) during TAVR procedures?
These recommendations support the use of TEE for TAVR.
Optimal Imaging for Guiding TAVR: Transesophageal or Transthoracic Echocardiography, or Just Fluoroscopy?

Itzhak Kronzon, MD, Vladimir Jelnin, MD, Carlos E. Ruiz, MD, PhD, Mahamed Saric, MD, PhD, Mathew Russell Williams, MD, Albert M. Kasel, MD, Anupama Shivaraju, MD, Antonio Colombo, MD, Adnan Rastiati, MD

Section Editor: Partho P. Sengupta, MD

**THE FOLLOWING IPUM DEBATE FEATURES 3 VIEWPOINTS** related to the most practical and effective imaging strategy for guiding transcatheter aortic valve replacement (TAVR). Kronzon, et al. provide evidence that enhanced analysis of aortic valve anatomy and improved appreciation of complications mandate the use of transesophageal echocardiography as front-line imaging modality for ALL patients undergoing TAVR. On the other hand, Saric and colleagues compare and contrast the approach of performing TAVR under transapical guidance. Lastly, Kasel and co-workers provide preliminary evidence that TAVR could be performed under fluoroscopic guidance without the need for additional imaging technique. Although the use of less-intensive sedation or anesthesia might reduce the procedural time, we need more randomized data to establish the most cost-effective approach in guiding TAVR.

# Evolution of Anesthesia & Echo Imaging for TAVR

<table>
<thead>
<tr>
<th>INITIAL TAVR EXPERIENCE</th>
<th>SUBSEQUENT TAVR EXPERIENCE</th>
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<tbody>
<tr>
<td>General anesthesia</td>
<td>Moderate sedation</td>
</tr>
<tr>
<td>Endotracheal intubation</td>
<td>No endotracheal intubation</td>
</tr>
<tr>
<td>TEE guidance</td>
<td>TTE guidance</td>
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A Practical Approach to Managing Transcatheter Aortic Valve Replacement With Sedation

Peter J. Neuburger, MD, Muhamed Saric, MD, PhD, Conan Huang, BS, and Mathew Russell Williams, MD

Abstract
Transcatheter aortic valve replacement is increasingly performed as a minimally invasive treatment option for aortic valve disease. The typical anesthetic management for this procedure was traditionally similar to surgical aortic valve replacement and involved general anesthesia and transesophageal echocardiography. In this review, we discuss the technological advances in transcatheter valve systems that have improved outcomes and allow for use of sedation instead of general anesthesia. We describe an anesthetic protocol that avoids general anesthesia and utilizes transthoracic echocardiography for procedural guidance.

NYU TAVR Program | TEE vs. TTE

Sep 1, 2011 – Nov 30, 2016
What to Look For During TAVR on Echo?

- TAVR Valve Function
- Paravalvular Leak
- Complications
When...

• Proper preprocedural TAVR valve sizing is done, and
• When newer generation TAVR valves are used,
• By a an experienced TAVR team

... TAVR procedure is typically uneventful
... Complications are relatively rare
TAVR Valve Function
TAVR: Markers of Good Implantation

Valve Shape & Location
- Short axis: Circular rather than ovoid
- Long axis: Proximal end just a few millimeters in the LVOT

Valve Gradient
- Vmax typically < 2.0 m/sec

Valve Regurgitation
- No significant paravalvular or transvalvular aortic regurgitation

If one or more suboptimal, consider:
- Repositioning TAVR valve (for self-expanding valves)
- Post-dilatation of TAVR valve with a balloon
- Implantation of another TAVR valve (valve-in-valve procedure)
TAVR Valve Shape
TAVR Valve Shape

Optimal Shape
Circular
TAVR Valve Shape

**Suboptimal Shape**

Ovoid
TAVR Valve Location

**Optimal Location**
No excessive protrusion into LVOT
TAVR Valve Location

**Suboptimal Location**

Too deep into LVOT
Most Common TAVR Valves at Present

**Balloon Expandable**
- Sapien 3

**Self-Expanding**
- CoreValve Evolut R
TAVR Valve Gradients
Aortic Valve Gradients | Pre & Post TAVR

Before TAVR
(Severe native valve stenosis)

$V_{\text{max}} = 4.3 \text{ m/sec}$

Peak/Mean Gradient $74/43 \text{ mm Hg}$

Time to peak gradient $140 \text{ msec (late peaking)}$

After TAVR
(Minimal aortic valve gradients)

$V_{\text{max}} = 1.4 \text{ m/sec}$

Peak/Mean Gradient $9/3 \text{ mm Hg}$

Time to peak gradient $95 \text{ msec (early peaking)}$
TAVR Valve Gradients

**Optimal Gradient**

Vmax < 2.0 m/sec

Vmax = 1.4 m/sec
Peak/Mean Gradient 9/3 mm Hg
Time to peak gradient 95 msec (early peaking)

**Suboptimal Gradient**

Vmax > 2.0 m/sec

Vmax = 2.6 m/sec
Peak/Mean Gradient 27/17 mm Hg
Time to peak gradient > 100 msec (late peaking)
Paravalvular Leak Evaluation
1 Month Moderate & Severe PVL
Echo Core Lab Adjudicated Clinical Trials

% Patients with Mod/Severe PVL

<table>
<thead>
<tr>
<th>Design</th>
<th>N</th>
<th>%</th>
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<tbody>
<tr>
<td>sapien XT</td>
<td>236</td>
<td>24.2</td>
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<tr>
<td>sapien XT, inop</td>
<td>225</td>
<td>16.9</td>
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<tr>
<td>CoreValve ADVANCE</td>
<td>639</td>
<td>14.2</td>
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<td>CoreValve extreme risk</td>
<td>418</td>
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<tr>
<td>CoreValve high risk</td>
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<td>sapien 3'</td>
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<td>2.6</td>
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<td>Direct flow DISCOVER</td>
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<td>1.7</td>
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<tr>
<td>LOTUS REPRISE II</td>
<td>103</td>
<td>1.0</td>
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**Older TAVR Designs**

**Newer TAVR Designs**
FIGURE 3  Location of the PVR Jets in the Different Transthoracic Echocardiographic Views

A

B

C

D

CoreValve inserted too deep into LVOT
Significant Paravalvular Aortic Regurgitation
Significant Paravalvular Aortic Regurgitation
Significant Paravalvular Aortic Regurgitation
Significant Paravalvular Aortic Regurgitation
## Paravalvular Aortic Regurgitation Post TAVR

No easy way to grade it

### Table 4: VARC II Recommendations for Evaluation of Aortic and/or Paravalvular Regurgitation After TAVR

<table>
<thead>
<tr>
<th>Table 4: VARC II Recommendations for Evaluation of Aortic and/or Paravalvular Regurgitation After TAVR</th>
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<tbody>
<tr>
<td><strong>Semiquantitative parameters</strong></td>
</tr>
<tr>
<td>Diastolic flow reversal in the descending aorta—pulsed wave</td>
</tr>
<tr>
<td>Circumferential extent of prosthetic valve paravalvular regurgitation (%)</td>
</tr>
</tbody>
</table>

| **Quantitative parameters†** |
| Regurgitant volume (ml/beat) | <30 | 30–59 | ≥60 |
| Regurgitant fraction (%) | <30 | 30–49 | ≥50 |
| Effective regurgitant orifice area (cm²) | 0.10 | 0.10–0.29 | ≥0.30 |

*Not well validated and may overestimate severity compared with quantitative Doppler. †For LVOT >2.5 cm, significant stenosis criteria is <0.20. Adapted with permission from Kappetein et al. (66). VARC = Valve Academic Research Consortium; other abbreviations as in Table 1.

### VARC II Criteria

An expert consensus without empiric validation
POST TAVR | TRANSESOPHAGEAL ECHO

AR occupies > 30% of prosthetic circumference

Consistent with severe aortic regurgitation
Pressure Half-time = 63 msec

Consistent with acute aortic regurgitation
Holodiastolic Flow Reversal in Descending Aorta

Consistent with severe aortic regurgitation
Echocardiography
Post TAVR Procedure
What to Look For Post TAVR on Echo?

Assess for TAVR complications

- Pericardial effusion
  - LV rupture [LV wire related]
  - RV rupture [Pacing wire related]

- Annular rupture
Case #1

Pericardial Effusion Post LV Wire Removal
Prior to CoreValve Insertion

6:49:59 PM
No pericardial effusion
Post CoreValve Insertion But Wire Still in LV

7:23:03 PM
First TEE image of CoreValve

7:26:036 PM
Still no effusion
Post TAVR Insertion, LV Wire Removed

7:31:06 PM  
First appearance of effusion

7:39:01 PM  
Massive effusion
Case #2
Pericardial Effusion Post RV Wire Removal
Day 0 | Uneventfully implantation of a TAVR valve

No pericardial effusion
Day 1
Hypotension minutes post removal of temporary RV pacing wire

New hemorrhagic pericardial effusion
Day 1
Hypotension minutes post removal of temporary RV pacing wire

Mitral Inflow

Marked respiratory variations indicative of tamponade
Day 1 | Post Pericardiocentesis

Resolution of pericardial effusion
Case #3

Annular Rupture After CoreValve Post Dilation
**Annular Rupture Post TAVR**

- Annular rupture is a rare event, but is associated with a mortality rate of ~50%.
- It is typically associated with balloon expansion, and is therefore very uncommon with self-expanding valves.

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Rare but Catastrophic

- **SAPIEN PARTNER IB**
  - N=271
  - 0.7%

- **SAPIEN XT PARTNER IB**
  - N=282
  - 0.4%

- **SAPIEN 3 PARTNER II S3 HR**
  - N=583
  - 0.3%

- **SAPIEN 3 PARTNER II S3i**
  - N=1076
  - 0.2%

- **CoreValve Extreme Risk**
  - N=489
  - 0.2%

- **ADVANCE**
  - N=1,015
  - 0.0%

- **CoreValve High Risk**
  - N=390
  - 0.0%

- **Evolut R CE Study**
  - N=60
  - 0.0%

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Several Weeks Post CoreValve | Severe new-onset heart failure with normal LVEF

Bilateral pleural effusions
Aorto-RV Fistula:
Transthoracic
Echocardiography
Several Weeks Post CoreValve | Severe new-onset heart failure with normal LVEF

Abnormal color Doppler jet at caudal end of CoreValve
Several Weeks Post CoreValve | Severe new-onset heart failure with normal LVEF

Abnormal color Doppler jet from CoreValve region to RVOT
Several Weeks Post CoreValve | Severe new-onset heart failure with normal LVEF

Systolic AND diastolic flow
TTE Study Conclusions

Peri-annular rupture with ascending aorta to RVOT communication
CONTRAST CT CONFIRMS ANNULAR RUPTURE

RVOT

RV

Defect

Annulus

LV
CONTRAST CT CONFIRMS ANNULAR RUPTURE
TEE & Fluoroscopy Guided Closure

Aorta-to-RV communication closed using an 8-mm Amplatzer Vascular Plug (AVP)
Aorto-RV Fistula: Transesophageal Echocardiography
Cine Fluoroscopy:
Aorto-RV Fistula Closure
Transesophageal Echocardiography

Aorto-RV Fistula Closure
A Team Approach for Replacing Heart Valves

One of the procedures made possible by NYU Langone Medical Center’s state-of-the-art hybrid OR—equipped for both surgery and catheterization—is transcatheter aortic valve replacement (TAVR). TAVR allows a narrowed, narrowed valve to be replaced through a catheter, a minimally invasive approach requiring no cardiopulmonary bypass and two small incisions. About 350,000 Americans are estimated to suffer from severe aortic stenosis, which limits blood flow from the heart. Without a valve replacement, half will not survive more than two years after the onset of symptoms.
Thank You!

New York University Langone Medical Center