TAVR: Echo Measurements Pre, Post And Intra Procedure

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Associate Professor of Medicine

Disclosures

Speakers Bureau (Philips, Medtronic)
Advisory Board (Siemens)
**Primary Indications for Surgical or Percutaneous Treatment of Aortic Stenosis**

Severe symptomatic AS irrespective of LVEF

Severe AS with diminished LVEF irrespective of symptoms

**TAVR Indications Based on STS Risk Score**

<table>
<thead>
<tr>
<th>Low Risk</th>
<th>Intermediate</th>
<th>High Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>(&lt; 4 %)</td>
<td>(4 – 8 %)</td>
<td>(&gt; 8 %)</td>
</tr>
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</table>

TAVR vs. surgical AVR trials in progress

TAVR is a safe and effective alternative to surgical AVR
TAVR Prostheses Used in United States

Edwards Sapien Valve

- Balloon-expandable bovine pericardial aortic valve prosthesis

Medtronic CoreValve

- Self-expandable porcine pericardial aortic valve prosthesis
Sapien Valve Implantation

CoreValve Implantation
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

BEFORE TAVR Procedure

ECHOCARDIOGRAPHY:
- Primary means of establishing
diagnosis, severity and subtype
of aortic stenosis
- Secondary means of TAVR
valve sizing

CHEST CT:
- Primary means of TAVR valve
sizing

AFTE R TAVR Procedure

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

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

FLUOROSCOPY / CINE:
- Primary means of AVR valve
implantation guidance

Saric M, Williams MR. Transthoracic echocardiography guidance for TAVR.
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
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%

**Severe Aortic Stenosis** | TTE Apical 3-Chamber
Severe Aortic Stenosis | TTE Apical 3-Chamber

Severe Aortic Stenosis | TTE Apical 4-Chamber
Severe Aortic Stenosis | TTE Apical 5-Chamber

Severe Aortic Stenosis

Continuous Wave (CW) Doppler

Aortic Valve

VTI = 134 cm
Vmax = 4.3 m/sec
Peak/Mean Gradient 74/43 mm Hg

Pulsed Wave (PW) Doppler

LVOT

VTI = 24 cm
Vmax = 0.8 m/sec
Area 3.14 cm²

Dimensionless Index = 24 / 134 = 0.18 | Aortic Valve Area = 0.6 cm²
SEVERE SENILE CALCIFIC AORTIC STENOSIS
OF A TRILEAFLET AORTIC VALVE

<table>
<thead>
<tr>
<th></th>
<th>Severe Aortic Stenosis</th>
<th>Our Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity ($V_{\text{max}}$)</td>
<td>$\geq 4 \text{ m/sec}$</td>
<td>4.3 m/sec</td>
</tr>
<tr>
<td>Mean gradient ($\Delta P_{\text{mean}}$)</td>
<td>$\geq 40 \text{ mm Hg}$</td>
<td>43 mm Hg</td>
</tr>
<tr>
<td>Dimensionless Index</td>
<td>$\leq 0.25$</td>
<td>0.18</td>
</tr>
<tr>
<td>Aortic valve area (AVA)</td>
<td>$\leq 1.0 \text{ cm}^2$</td>
<td>0.6 cm$^2$</td>
</tr>
<tr>
<td>AVA Index</td>
<td>$\leq 0.6 \text{ cm}^2$/m$^2$</td>
<td>0.3 cm$^2$/m$^2$</td>
</tr>
</tbody>
</table>

ASE/EAE Guidelines on Valvular Stenosis

TTE STUDY CONCLUSIONS

- Severe senile calcific high-gradient aortic stenosis of a trileaflet native aortic valve with preserved LVEF
- If symptoms attributable to aortic stenosis are:
  - Present >>> Refer for TAVR evaluation
  - Absent >>> Consider stress testing
Severe Senile Calcific Aortic Stenosis of a Trileaflet Aortic Valve

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<th>Severe Aortic Stenosis</th>
<th>Our Patient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak velocity ($V_{max}$)</td>
<td>$\geq 4$ m/sec</td>
<td>3.1 m/sec</td>
</tr>
<tr>
<td>Mean gradient ($\Delta P_{mean}$)</td>
<td>$\geq 40$ mm Hg</td>
<td>26 mm Hg</td>
</tr>
<tr>
<td>Dimensionless Index</td>
<td>$\leq 0.25$</td>
<td>0.26</td>
</tr>
<tr>
<td>Aortic valve area (AVA)</td>
<td>$\leq 1.0$ cm$^2$</td>
<td>0.6 cm$^2$</td>
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ASE/EAE Guidelines on Valvular Stenosis

Aortic Stenosis

2014 ACC/AHA Valvular Heart Disease Guidelines

Low LVEF

Normal LVEF
### Aortic Stenosis

#### 2014 ACC/AHA Valvular Heart Disease Guidelines

<table>
<thead>
<tr>
<th>C: Asymptomatic severe AS</th>
<th>D: Symptomatic severe AS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>C1</strong> Asymptomatic severe AS</td>
<td><strong>D1</strong> Symptomatic severe low-flow/low-gradient AS with reduced LVEF</td>
</tr>
<tr>
<td>- Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening</td>
<td>- Severe leaflet calcification with severely reduced leaflet motion</td>
</tr>
<tr>
<td>- Aortic flow &lt; 2.4 m/s or mean JVP ≤ 60 mm Hg</td>
<td>- Dobutamine stress echo (LV contractile reserve)</td>
</tr>
<tr>
<td>- Aortic flow &lt; 2.4 m/s or mean JVP ≤ 60 mm Hg</td>
<td>(Low LVEF)</td>
</tr>
<tr>
<td>- LV diastolic dysfunction</td>
<td>- Exercise stress testing (Symptoms)</td>
</tr>
<tr>
<td>- LV EF &lt; 50%</td>
<td>- Normal LVEF</td>
</tr>
<tr>
<td>- None</td>
<td>-</td>
</tr>
</tbody>
</table>
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.
Evolution of Anesthesia & Echo Imaging for TAVR

<table>
<thead>
<tr>
<th>INITIAL TAVR EXPERIENCE</th>
<th>SUBSEQUENT TAVR EXPERIENCE</th>
</tr>
</thead>
<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>
</tr>
</tbody>
</table>
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

![Graph showing TEE vs. TTE](image)
What to Look For During TAVR on Echo?

- TAVR Valve Function
- Paravalvular Leak
- Complications

TAVR | Intraprocedural Echo Evaluation

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

**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
  - CoreValve Evolut Pro
TAVR Valve Gradients

Aortic Valve Gradients | Pre & Post TAVR

**Before TAVR**
(Severe native valve stenosis)

- $V_{max} = 4.3$ m/sec
- Peak/Mean Gradient $74/43$ mm Hg
- Time to peak gradient $140$ msec (late peaking)

**After TAVR**
(Minimal aortic valve gradients)

- $V_{max} = 1.4$ m/sec
- Peak/Mean Gradient $9/3$ mm Hg
- Time to peak gradient $95$ msec (early peaking)
TAVR Valve Gradients

**Optimal Gradient**

- $V_{max} \leq 2.0 \text{ m/sec}$
- $V_{max} = 1.4 \text{ m/sec}$
- Peak/Mean Gradient $9/3 \text{ mm Hg}$
- Time to peak gradient $95 \text{ msec}$ (early peaking)

**Suboptimal Gradient**

- $V_{max} > 2.0 \text{ m/sec}$
- $V_{max} = 2.6 \text{ m/sec}$
- Peak/Mean Gradient $27/17 \text{ mm Hg}$
- Time to peak gradient $>100 \text{ msec}$ (late peaking)

Paravalvular Leak Evaluation
1 Month Moderate & Severe PVL
Echo Core Lab Adjudicated Clinical Trials

% Patients with Mod/Severe PVL

- SAPION XT PARTNER II, Inop
- SAPION PARTNER II Inop
- CoreValve ADVANCE^2
- CoreValve Extreme Risk^3
- CoreValve High Risk^4
- SAPION 3^5
- Direct Flow DISCOVER^6
- LOTUS REPRISE II^7

N=236  N=225  N=639  N=418  N=390  N=150  N=100  N=103

Older TAVR Designs  Newer TAVR Designs

FIGURE 2 Location of the PVL Jets in the Different Transthoracic Echocardiographic Views

TAVR Procedure | Transthoracic Echo

CoreValve inserted too deep into LVOT
TAVR Procedure | Transthoracic Echo

Significant Paravalvular Aortic Regurgitation

TAVR Procedure | Transthoracic Echo

Significant Paravalvular Aortic Regurgitation
**TAVR Procedure | Transthoracic Echo**

Significant Paravalvular Aortic Regurgitation

**Post TAVR | Transesophageal Echo**

Significant Paravalvular Aortic Regurgitation
PARAVULVAR 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>Parameter</th>
<th>Mild</th>
<th>Moderate</th>
<th>Severe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diastolic flow reversal in the descending aorta—pulsed wave</td>
<td>Absent or brief early diastolic</td>
<td>Intermediate</td>
<td>Prominent, holodiastolic</td>
</tr>
<tr>
<td>Circumferential extent of prosthetic valve paravalvular regurgitation (%)</td>
<td>≤10</td>
<td>10–29</td>
<td>≥30</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. If the LVOT > 2.5 cm, significant aortic criteria is <2.25. Adapted with permission from Kappetein et al. (86), VARC = Valve Academic Research Consortium; other abbreviations as in Table 1.

VARC II Criteria
An expert consensus
without empiric validation

POST TAVR | TRANSSESOPHAGEAL ECHO

AR occupies > 30% of prosthetic circumference

Consistent with severe aortic regurgitation
TAVR Procedure | Transthoracic Echo

Pressure Half-time = 63 msec

Consistent with acute aortic regurgitation

Post TAVR | Transesophageal Echo

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
Thank you!

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

PERCUTANEOUS PERILS

Aorto-Right Ventricular Fistula
Post-Transcatheter Aortic Valve Replacement:
Multimodality Imaging of Successful
Percutaneous Closure

Alan F. Vainrub, MD, Homam Ibrahim, MD, Kazuhiro Hisamoto, MD, Cezar S. Staniloac, MD,
Hasan Jilaihawi, MD, Ricardo J. Benveniste, MD, Larry Latson, MD, Mathew R. Williams, MD,
and Mubayed Saric, MD, PhD, New York, New York

CASE 2017;1(2):70-74
ANNULAR RUPTURE POST TAVR

Rare but Catastrophic

- 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.

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

Bilateral pleural effusions
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

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

Abnormal color Doppler jet from CoreValve region to RVOT

Systolic AND diastolic flow
TTE Study Conclusions

Peri-annular rupture with ascending aorta to RVOT communication

**CONTRAST CT CONFIRMS ANNULAR RUPTURE**
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
Thank You!

New York University Langone Medical Center