2017 ASE Florida, Orlando, FL

October 10, 2017 | 8:00 – 8:25 AM | 25 min

TAVR: Echo Measurements Pre, Post And Intra Procedure

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NYU Langone MEDICAL CENTER

Disclosures

Speakers Bureau (Philips, Medtronic)
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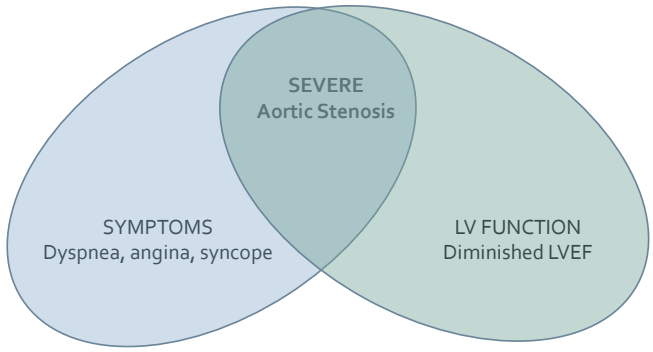
Primary Indications for Surgical Or Percutaneous Treatment of Aortic Stenosis



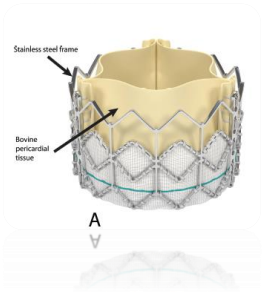
Severe symptomatic AS irrespective of LVEF

Severe AS with diminished LVEF irrespective of symptoms

TAVR Indications Based on STS Risk Score

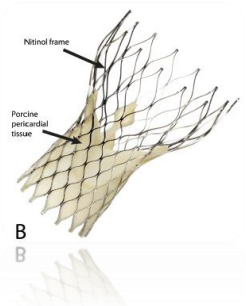
Low Risk (< 4 %)	Intermediate (4 – 8 %)	High Risk (> 8 %)
TAVR vs. surgical AVR trials in progress	TAVR is a safe and effective alternative to surgical AVR	

TAVR Prostheses Used in United States



Edwards
Sapien Valves

Balloon-expandable
bovine pericardial aortic valve prosthesis



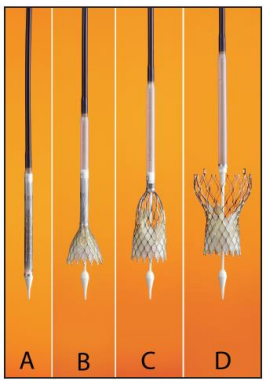
Medtronic
CoreValves

Self-expandable
porcine pericardial aortic valve prosthesis

TAVR Prostheses Used in United States

Edwards
Sapien Valve

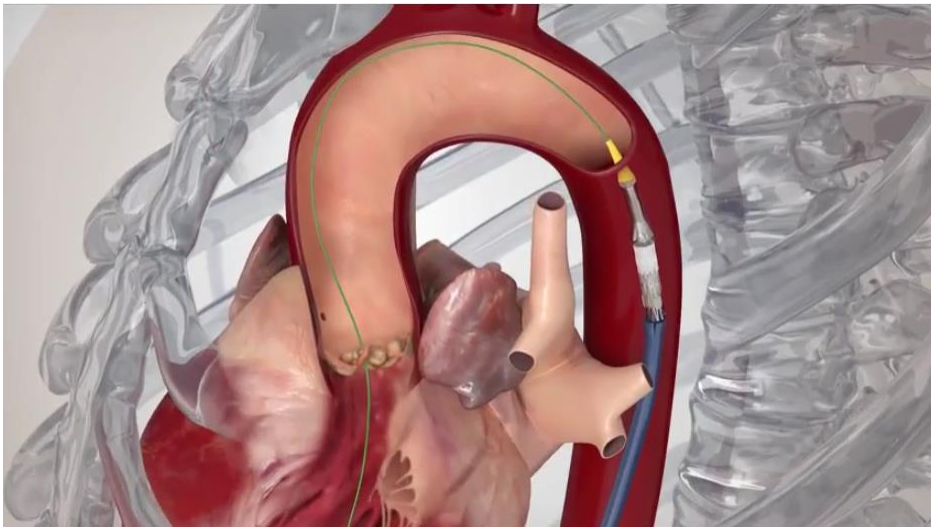
Balloon Expandable



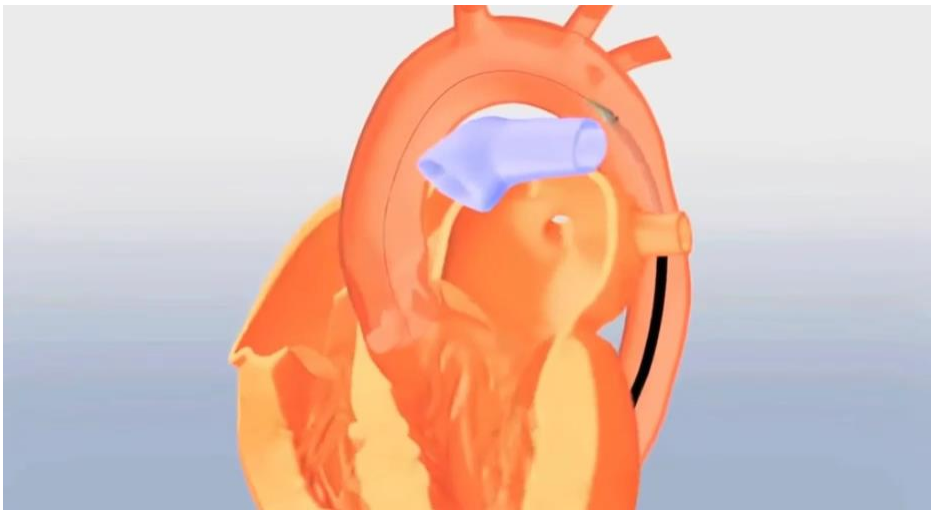
Medtronic
CoreValve

Self Expanding

Sapien Valve Implantation



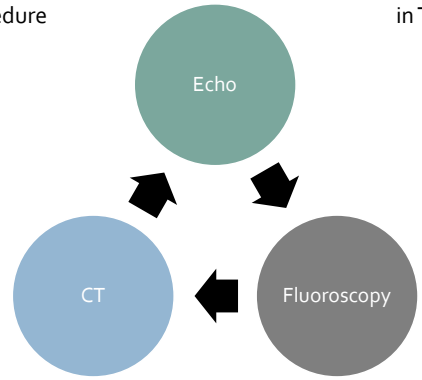
CoreValve Implantation



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



IMAGING IN PATIENTS UNDERGOING TAVR

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

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.

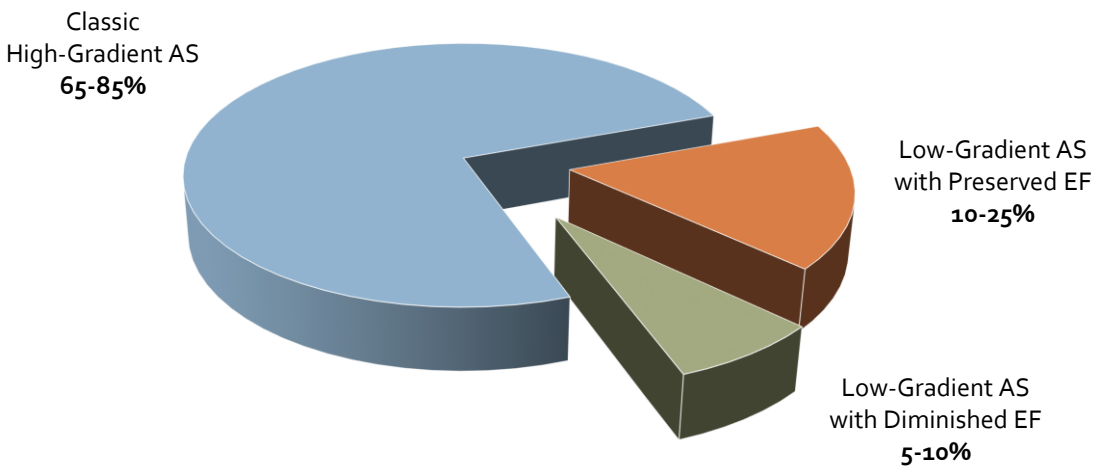
Saric M, Williams MR. **Transthoracic echocardiography guidance for TAVR.** *J Am Coll Cardiol Img.* 2015;8(3):363-67.

Echocardiography Prior to TAVR

Role of Echo Prior to TAVR

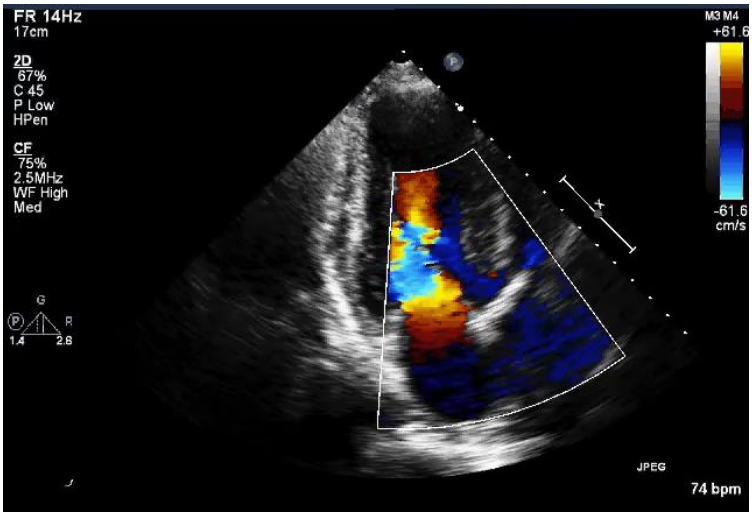
- Establish whether indications for TAVR are present
  - Severity of aortic stenosis
  - Subtype of aortic stenosis (high vs. low-gradient)
- Asses LV ejection fraction
- Assist in TAVR valve sizing

Types of Aortic Stenosis

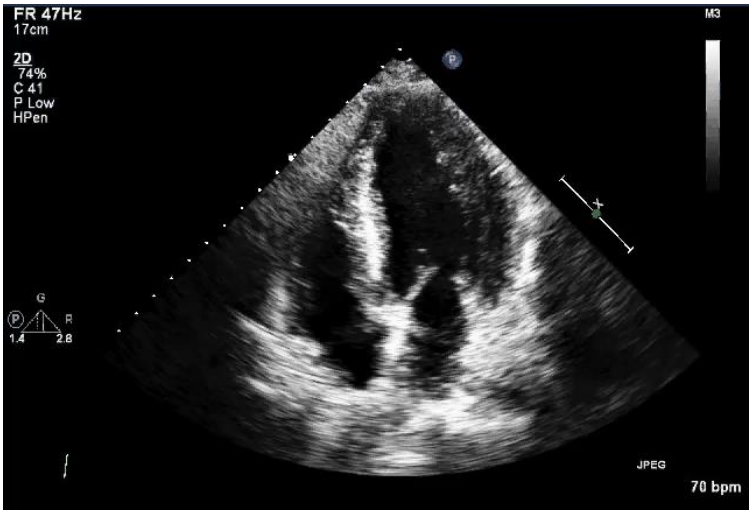


Severe Aortic Stenosis | TTE Apical 3-Chamber

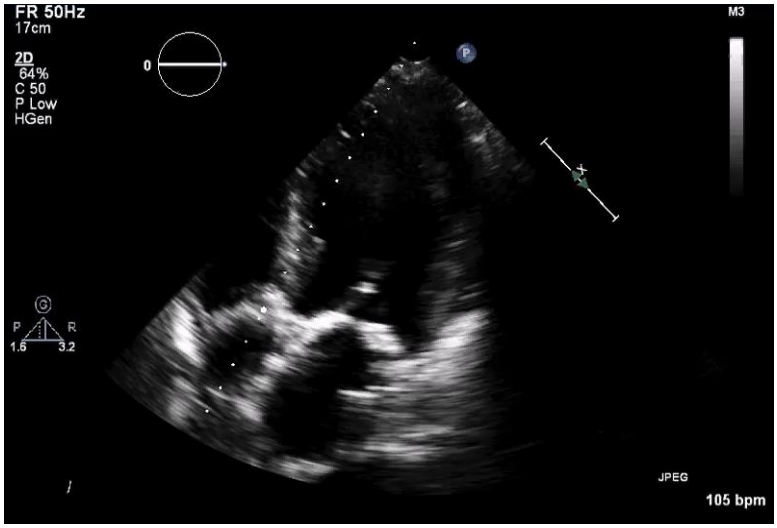
Severe Aortic Stenosis | TTE Apical 3-Chamber



Severe Aortic Stenosis | TTE Apical 4-Chamber

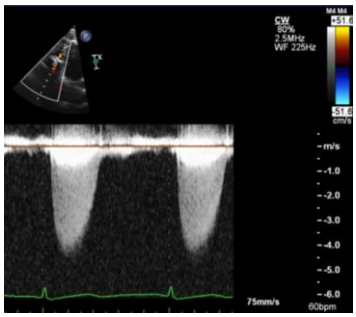


Severe Aortic Stenosis | TTE Apical 5-Chamber



SEVERE AORTIC STENOSIS

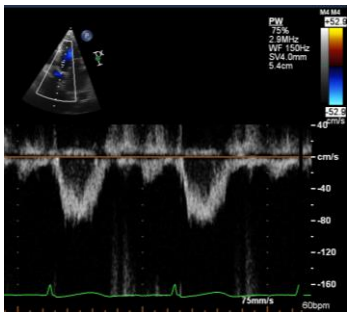
Continuous Wave (CW) Doppler



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

	Severe Aortic Stenosis	Our Patient
Peak velocity (V_{max})	≥ 4 m/sec	4.3 m/sec
Mean gradient (ΔP_{mean})	≥ 40 mm Hg	43 mm Hg
Dimensionless Index	≤ 0.25	0.18
Aortic valve area (AVA)	≤ 1.0 cm^2	0.6 cm^2
AVA Index	≤ 0.6 cm^2/m^2	0.3 cm^2/m^2

ASE/EAE Guidelines on Valvular Stenosis
J Am Soc Echocardiogr. 2009 May;22(5):442.

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

	Severe Aortic Stenosis	Our Patient
Peak velocity (V_{max})	≥ 4 m/sec	3.1 m/sec
Mean gradient (ΔP_{mean})	≥ 40 mm Hg	26 mm Hg
Dimensionless Index	≤ 0.25	0.26
Aortic valve area (AVA)	≤ 1.0 cm^2	0.6 cm^2
AVA Index	≤ 0.6 cm^2/m^2	0.3 cm^2/m^2

ASE/EAE Guidelines on Valvular Stenosis
J Am Soc Echocardiogr. 2009 May;22(5):442.

Aortic Stenosis

2014 ACC/AHA Valvular Heart Disease Guidelines

	C: Asymptomatic severe AS					
	C1 **Asymptomatic severe AS**	• Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening	• Aortic V_{max} ≥4 m/s or mean ΔP ≥40 mm Hg • AVA typically is ≤1.0 cm^2 (or AVAi ≤0.6 cm^2/m^2) • Very severe AS is an aortic V_{max} ≥5 m/s or mean ΔP ≥60 mm Hg	• LV diastolic dysfunction • Mild LV hypertrophy • Normal LVEF	• None: Exercise testing is reasonable to confirm symptom status	
	C2 **Asymptomatic severe AS with LV dysfunction**	• Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening	• Aortic V_{max} ≥4 m/s or mean ΔP ≥40 mm Hg • AVA typically ≤1.0 cm^2 (or AVAi ≤0.6 cm^2/m^2)	• LVEF <50%	• None	
	D: Symptomatic severe AS					
	D1 **Symptomatic severe high-gradient AS**	• Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening	• Aortic V_{max} ≥4 m/s or mean ΔP ≥40 mm Hg • AVA typically ≤1.0 cm^2 (or AVAi ≤0.6 cm^2/m^2) but may be larger with mixed AS/AR	• LV diastolic dysfunction • LV hypertrophy • Pulmonary hypertension may be present	• Exertional dyspnea or decreased exercise tolerance • Exertional angina • Exertional syncope or presyncope	
Low Gradient AS	**D2** **Symptomatic severe low-flow/low-gradient AS with reduced LVEF**	• Severe leaflet calcification with severely reduced leaflet motion	• AVA ≤1.0 cm^2 with resting aortic V_{max} <4 m/s or mean ΔP <40 mm Hg • Dobutamine stress echocardiography shows AVA ≤1.0 cm^2 with V_{max} ≥4 m/s at any flow rate	• LV diastolic dysfunction • LV hypertrophy • LVEF <50%	• HF • Angina • Syncope or presyncope	Low LVEF
	D3 **Symptomatic severe low-gradient AS with normal LVEF or paradoxical low-flow severe AS**	• Severe leaflet calcification with severely reduced leaflet motion	• AVA ≤1.0 cm^2 with aortic V_{max} <4 m/s or mean ΔP <40 mm Hg • Indexed AVA ≤0.6 cm^2/m^2 and • Stroke volume index <35 mL/m^2 • Measured when patient is normotensive (systolic BP <140 mm Hg)	• Increased LV relative wall thickness • Small LV chamber with low stroke volume • Restrictive diastolic filling • LVEF >50%	• HF • Angina • Syncope or presyncope	Normal LVEF

AORTIC STENOSIS

2014 ACC/AHA Valvular Heart Disease Guidelines

C: Asymptomatic severe AS					
C1	**Asymptomatic severe AS**	• Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening	• Aortic V_{max} ≥4 m/s or mean ΔP ≥40 mm Hg • AVA typically is ≤1.0 cm^2 (or AVAi ≤0.6 cm^2/m^2) • Very severe AS is an aortic V_{max} ≥5 m/s or mean ΔP ≥60 mm Hg	• LV diastolic dysfunction • Mild LV hypertrophy • Normal LVEF	• None: Exercise testing is reasonable to confirm symptom status
C2	**Asymptomatic severe AS with LV dysfunction**	• Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening	• Aortic V_{max} ≥4 m/s or mean ΔP ≥40 mm Hg • AVA typically ≤1.0 cm^2 (or AVAi ≤0.6 cm^2/m^2)	• LVEF <50%	• None
D: Symptomatic severe AS					
D1	**Symptomatic severe high-gradient AS**	• Severe leaflet calcification or congenital stenosis with severely reduced leaflet opening	• Aortic V_{max} ≥4 m/s or mean ΔP ≥40 mm Hg • AVA typically ≤1.0 cm^2 (or AVAi ≤0.6 cm^2/m^2) but may be larger with mixed AS/AR	• LV diastolic dysfunction • LV hypertrophy • Pulmonary hypertension may be present	• Exertional dyspnea or decreased exercise tolerance • Exertional angina • Exertional syncope or presyncope
Low Gradient AS	**D2**	**Symptomatic severe low-flow/low-gradient AS with reduced LVEF**	• Severe leaflet calcification with severely reduced leaflet motion	**DOBUTAMINE STRESS ECHO** (LV Contractile Reserve)	Low LVEF
	D3	**Symptomatic severe low-gradient AS with normal LVEF or paradoxical low-flow severe AS**	• Severe leaflet calcification with severely reduced leaflet motion	**EXERCISE STRESS TESTING** (Symptoms)	Normal LVEF

Echocardiography During TAVR Procedure

Question | Echo Type

Should I use **transesophageal** echo (TEE) or **transthoracic** echo (TTE) during TAVR procedures?

JACC: CARDIOVASCULAR IMAGING
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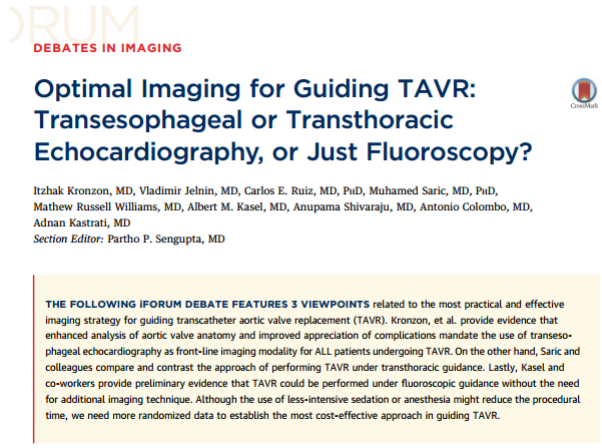
Recommendations for Comprehensive Intraprocedural Echocardiographic Imaging During TAVR

Rebecca T. Hahn, MD,* Stephen H. Little, MD,† Mark J. Monaghan, PhD,‡ Susheel K. Kodali, MD,* Mathew Williams, MD,§ Martin B. Leon, MD,* Linda D. Gillam, MD, MPH‖

ABSTRACT

Recent multicenter trials have shown that transcatheter aortic valve replacement is an alternative to surgery in a high risk population of patients with severe, symptomatic aortic stenosis. Echocardiography and multislice computed tomographic imaging are accepted tools in the pre-procedural imaging of the aortic valve complex and vascular access. Transesophageal echocardiography can be valuable for intraprocedural confirmation of the landing zone morphology and measurements, positioning of the valve and post-procedural evaluation of complications. The current paper provides recommendations for pre-procedural and intraprocedural imaging used in assessing patients for transcatheter aortic valve replacement with either balloon-expandable or self-expanding transcatheter heart valves. (J Am Coll Cardiol Img 2015;8:261-87) © 2015 by the American College of Cardiology Foundation.

These recommendations support the use of TEE for TAVR.



DEBATES IN IMAGING

Optimal Imaging for Guiding TAVR: Transesophageal or Transthoracic Echocardiography, or Just Fluoroscopy?

Itzhak Kronzon, MD, Vladimir Jelnin, MD, Carlos E. Ruiz, MD, PhD, Muhamed Saric, MD, PhD, Mathew Russell Williams, MD, Albert M. Kasel, MD, Anupama Shivaraju, MD, Antonio Colombo, MD, Adnan Kastrati, MD
Section Editor: Partho P. Sengupta, MD

THE FOLLOWING iFORUM 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 transthoracic 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.

J Am Coll Cardiol Img. 2015;8(3):363-67.

Evolution of Anesthesia & Echo Imaging for TAVR

INITIAL TAVR EXPERIENCE	SUBSEQUNT TAVR EXPERIENCE
General anesthesia	Moderate sedation
Endotracheal intubation	No endotracheal intubation
TEE guidance	TTE guidance

Review

A Practical Approach to Managing Transcatheter Aortic Valve Replacement With Sedation

Seminars in Cardiothoracic and Vascular Anesthesia
1–11

DOI: 10.1177/1089253215625111
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Peter J. Neuburger, MD[1], Muhamed Saric, MD, PhD[1], Conan Huang, BS[1], and Mathew Russell Williams, MD[1]

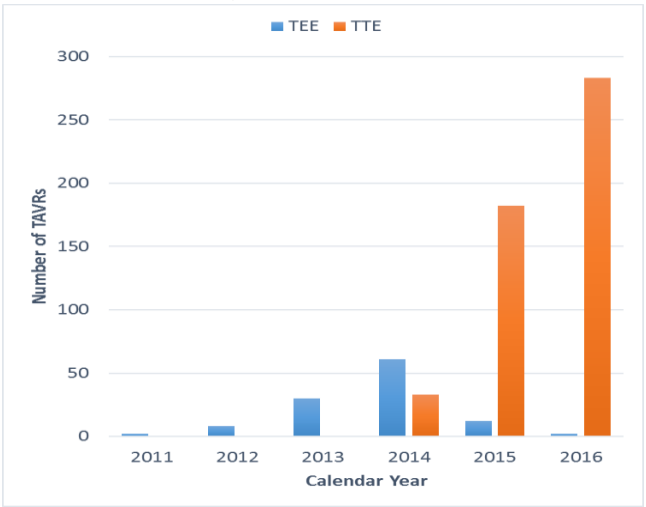
Abstract

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.

Semin Cardiothorac Vasc Anesth. **2016**;20(2):147-57.

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

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

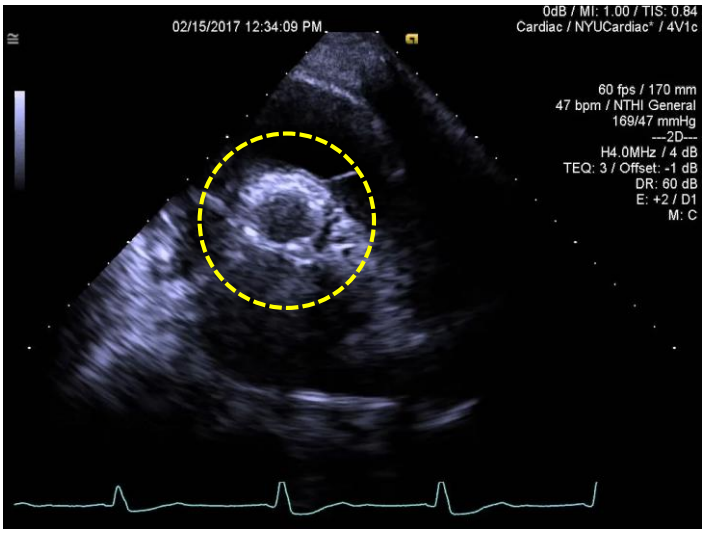
If one or more suboptimal, consider:

- **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

TAVR Valve Shape

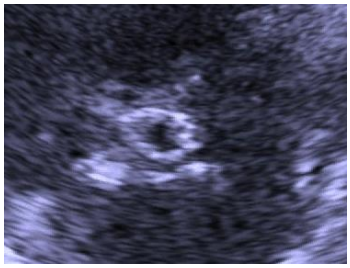
Optimal Shape
Circular

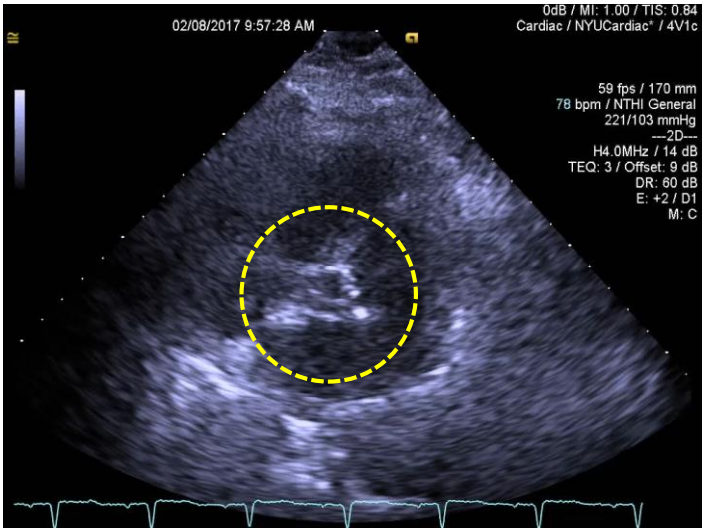


TAVR Valve Shape

SUBOPTIMAL SHAPE

Ovoid

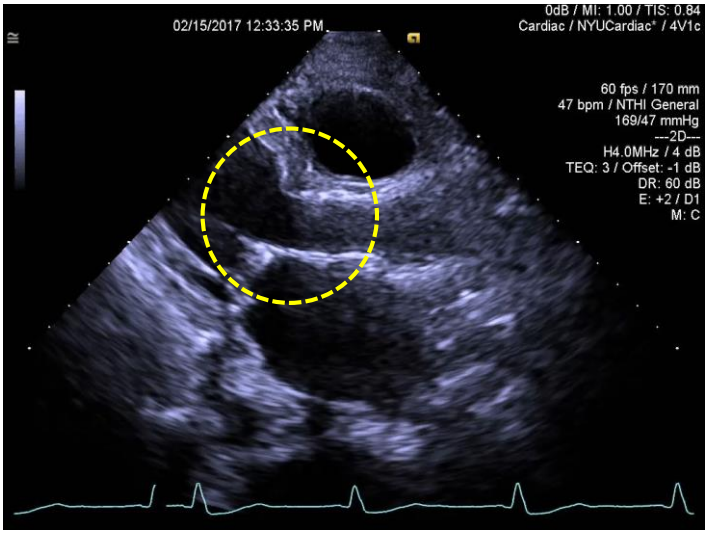




TAVR Valve Location

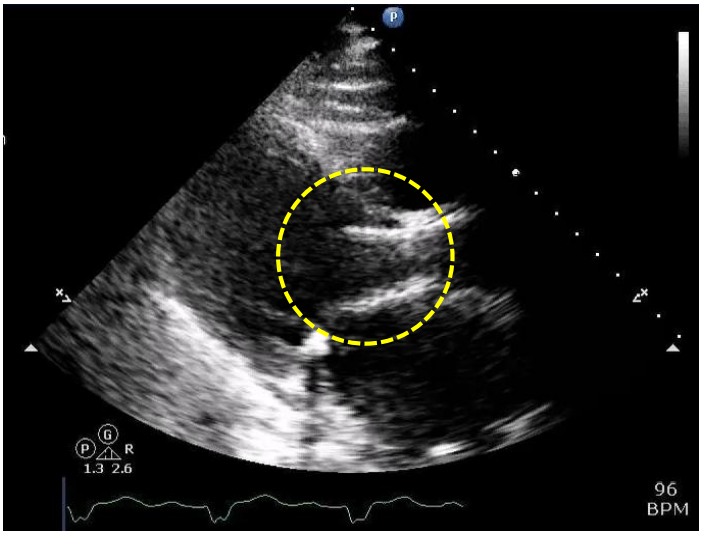
OPTIMAL LOCATION

No excessive protrusion into LVOT

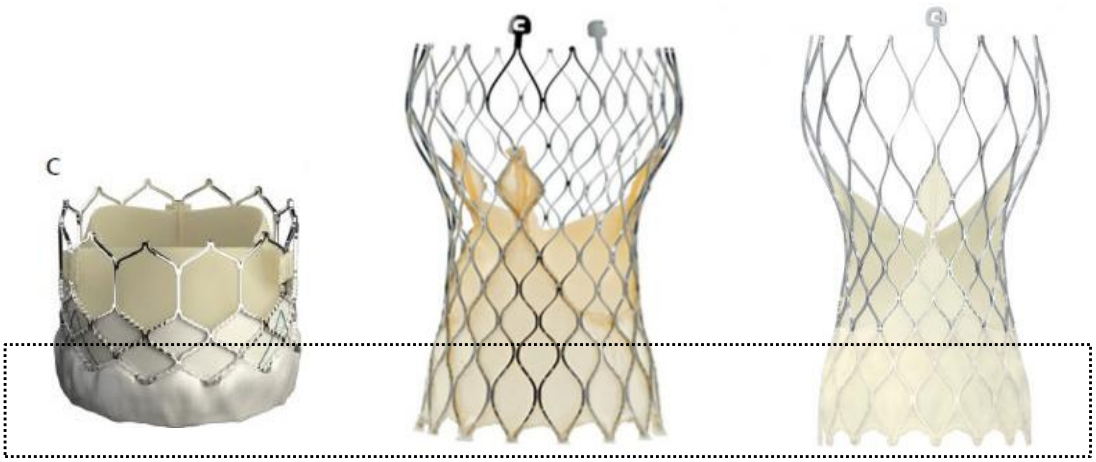


TAVR Valve Location

SUBOPTIMAL LOCATION
Too deep into LVOT



Most Common TAVR Valves at Present



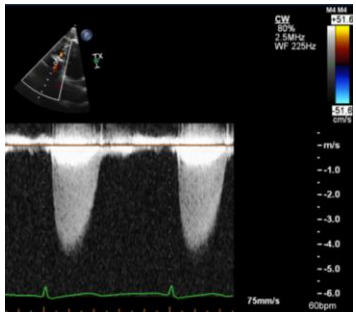
BALLOON EXPANDABLE
Sapien 3

SELF-EXPANDING
CoreValve Evolut R

SELF-EXPANDING
CoreValve Evolut Pro

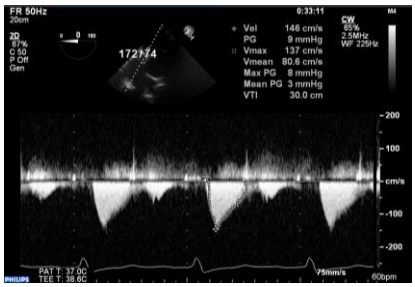
TAVR Valve Gradients

Aortic Valve Gradients | Pre & Post TAVR



Before TAVR
(Severe native valve stenosis)

Vmax = **4.3** m/sec
Peak/Mean Gradient **74/43** mm Hg
Time to peak gradient
140 msec (late peaking)

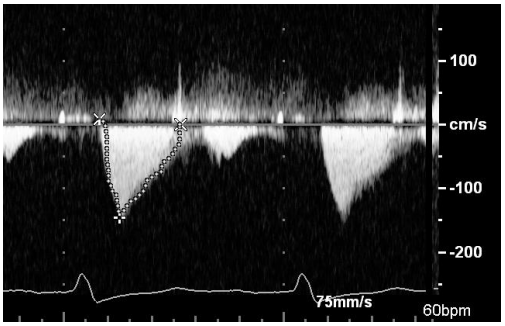


After TAVR
(Minimal aortic valve gradients)

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

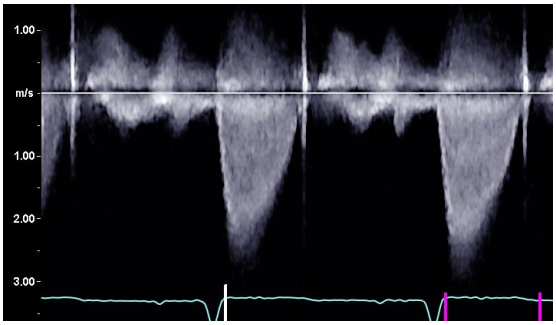
TAVR Valve Gradients

OPTIMAL GRADIENT
Vmax ≤ 2.0 m/sec



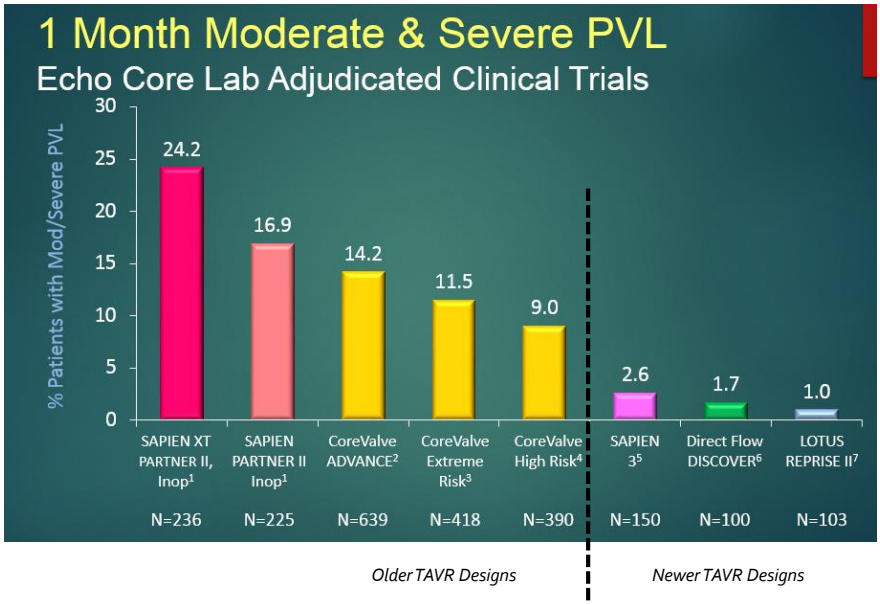
Vmax = **1.4** m/sec
Peak/Mean Gradient **9/3** mm Hg
Time to peak gradient
95 msec (early peaking)

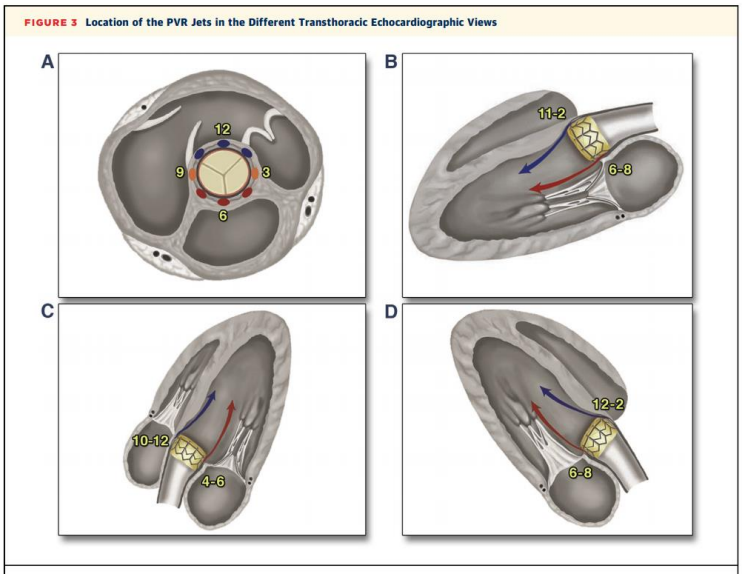
SUBOPTIMAL GRADIENT
Vmax > 2.0 m/sec



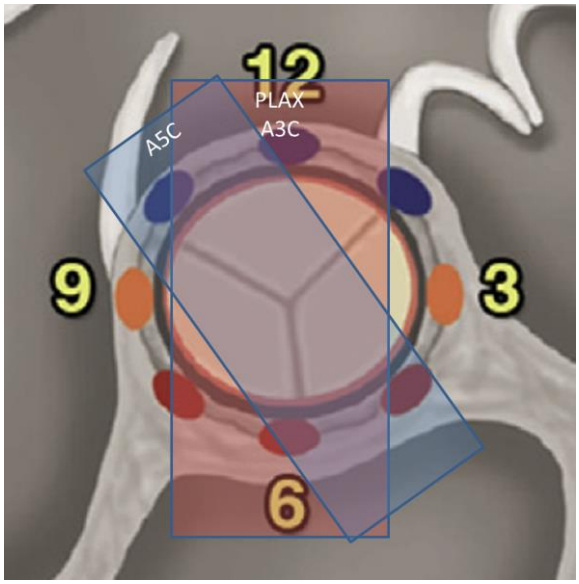
Vmax = **2.6** m/sec
Peak/Mean Gradient **27/17** mm Hg
Time to peak gradient
> 100 msec (late peaking)

Paravalvular Leak Evaluation

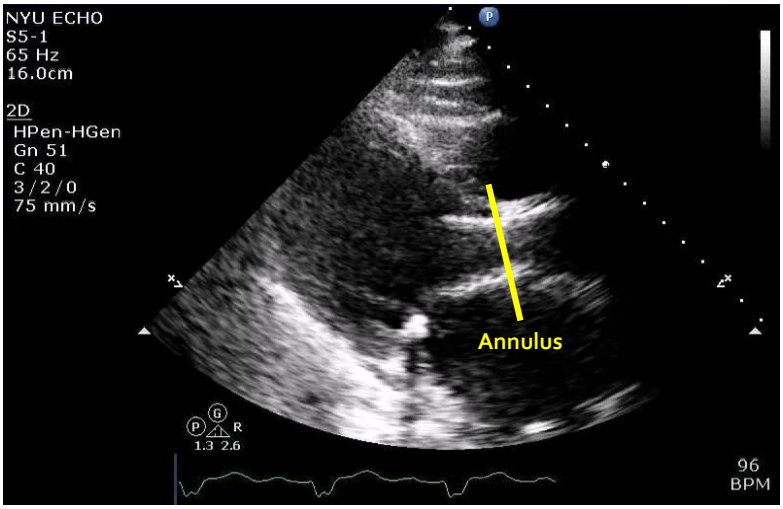




JACC Cardiovasc Imaging. 2015 Mar;8(3):340-60.

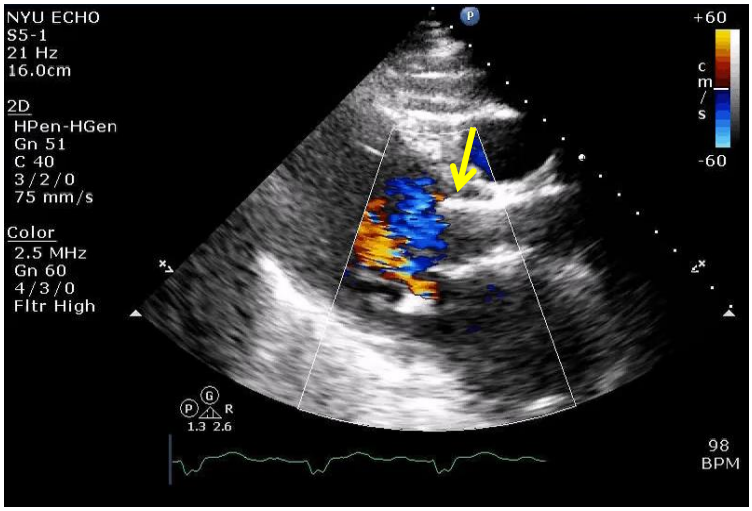


TAVR PROCEDURE | TRANSTHORACIC ECHO



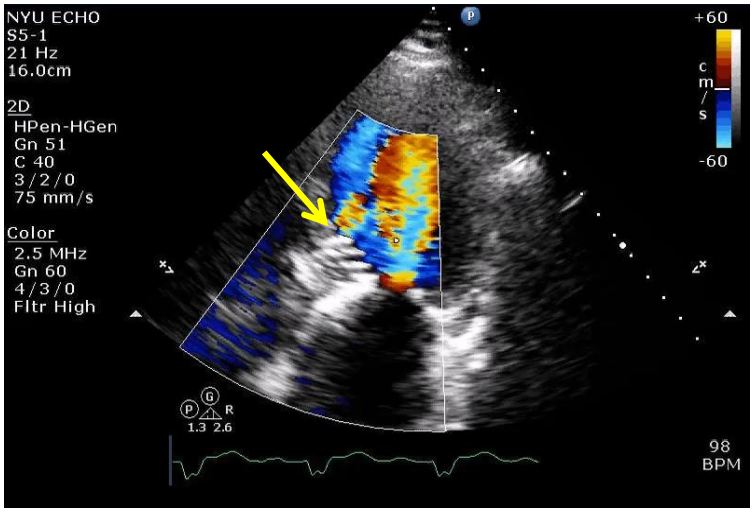
CoreValve inserted too deep into LVOT

TAVR PROCEDURE | TRANSTHORACIC ECHO



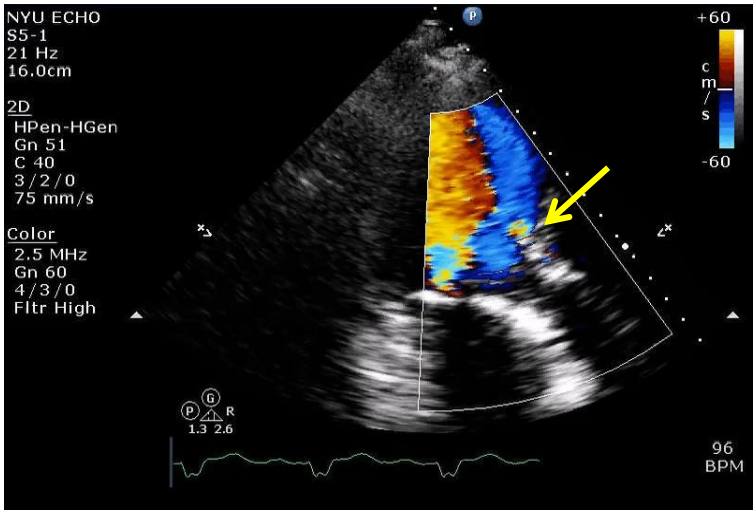
Significant Paravalvular Aortic Regurgitation

TAVR PROCEDURE | TRANSTHORACIC ECHO



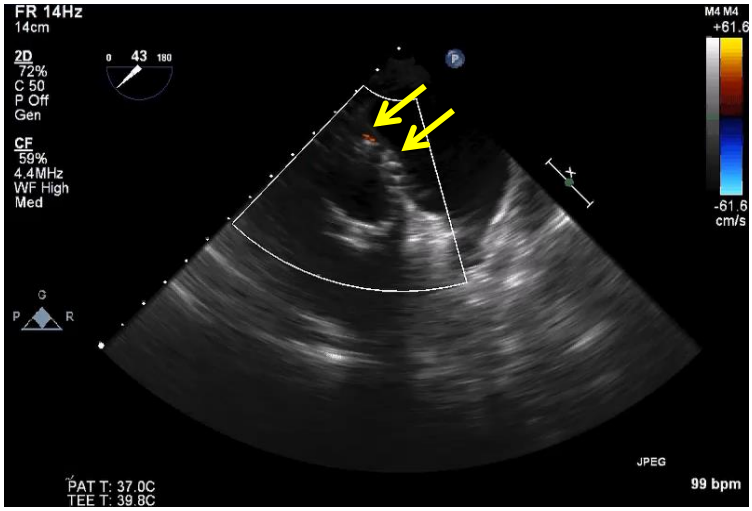
Significant Paravalvular Aortic Regurgitation

TAVR Procedure | Transthoracic Echo



Significant Paravalvular Aortic Regurgitation

Post TAVR | Transesophageal Echo



Significant Paravalvular Aortic Regurgitation

Paravalvular Aortic Regurgitation Post TAVR

No easy way to grade it

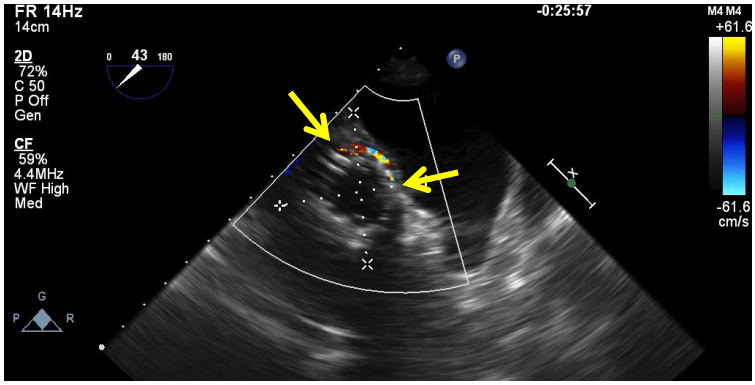
Table 4 VARC II Recommendations for Evaluation of Aortic and/or Paravalvular Regurgitation After TAVR

	Mild	Moderate	Severe
Semiquantitative parameters			
Diastolic flow reversal in the descending aorta—pulsed wave	Absent or brief early diastolic	Intermediate	Prominent, holodiastolic
Circumferential extent of prosthetic valve paravalvular regurgitation (%)*	<10	10–29	≥30
Quantitative parameters†			
Regurgitant volume (ml/beat)	<30	30–59	≥60
Regurgitant fraction (%)	<30	30–49	≥50
Effective regurgitant orifice area (cm^2)	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

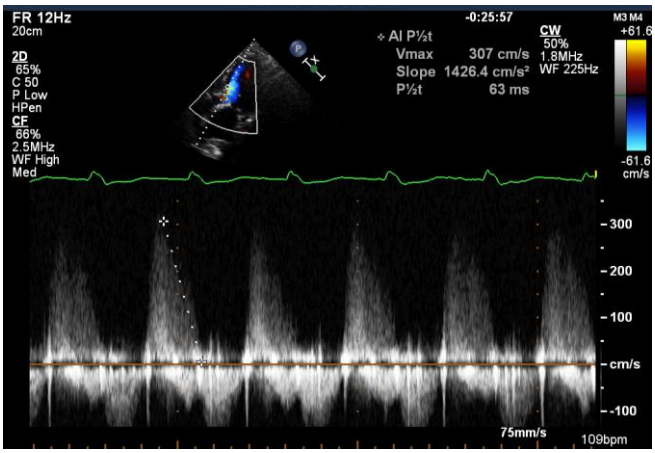
Post TAVR | Transesophageal Echo



AR occupies > 30% of prosthetic circumference

Consistent with severe aortic regurgitation

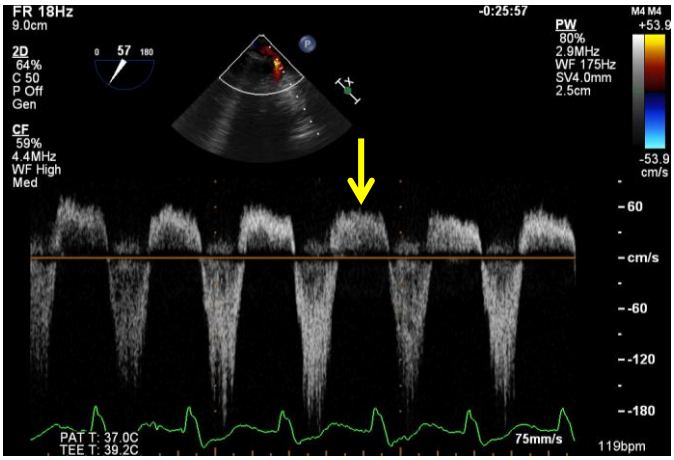
TAVR Procedure | Transthoracic Echo



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

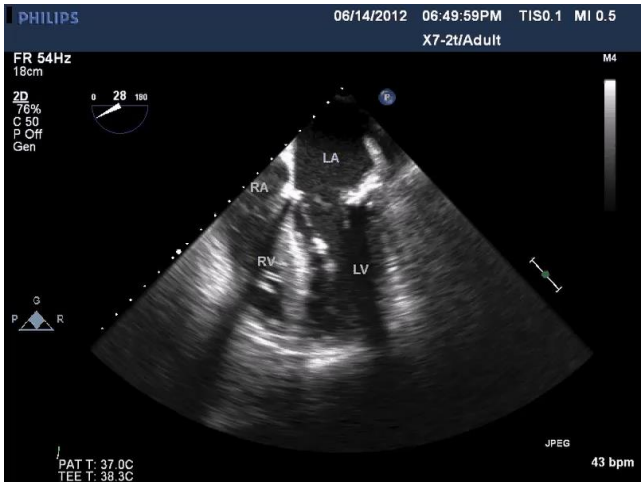
Thank you!

New York University Langone Medical Center

Case #1

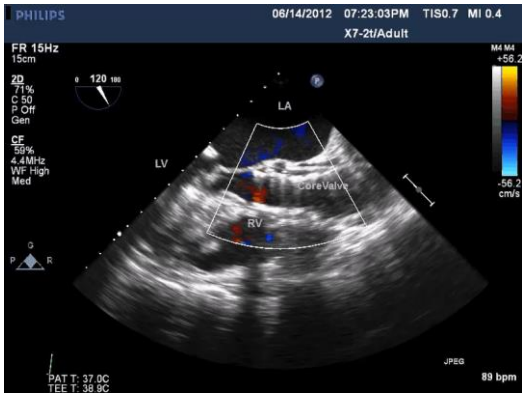
Pericardial Effusion Post LV Wire Removal

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

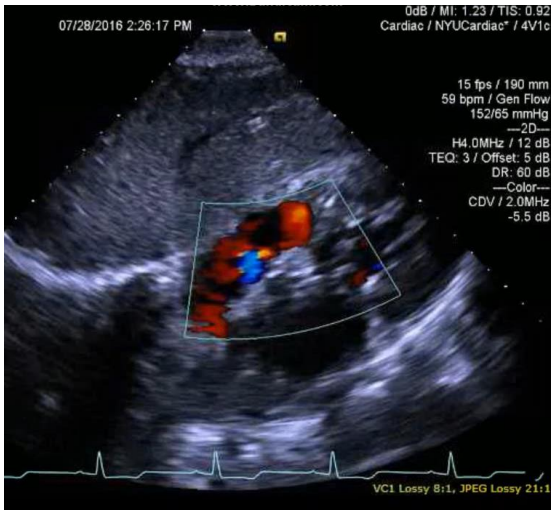
7:31:06 PM
First appearance of effusion

7:39:01 PM
Massive effusion

Case #2

Pericardial Effusion Post RV Wire Removal

Day 0 | Uneventfully implantation of a TAVR valve

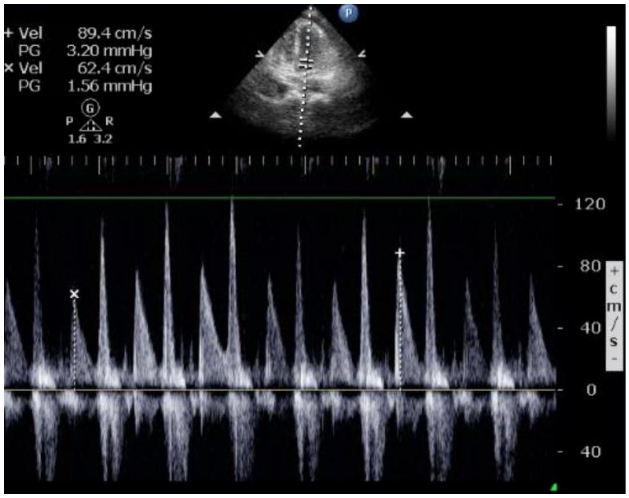


No pericardial effusion

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

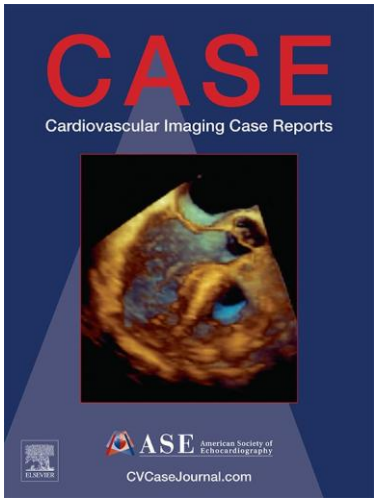
Marked respiratory variations indicative of tamponade

Day 1 | Post Pericardiocentesis

Resolution of pericardial effusion

Case #3

Annular Rupture After CoreValve Post Dilation



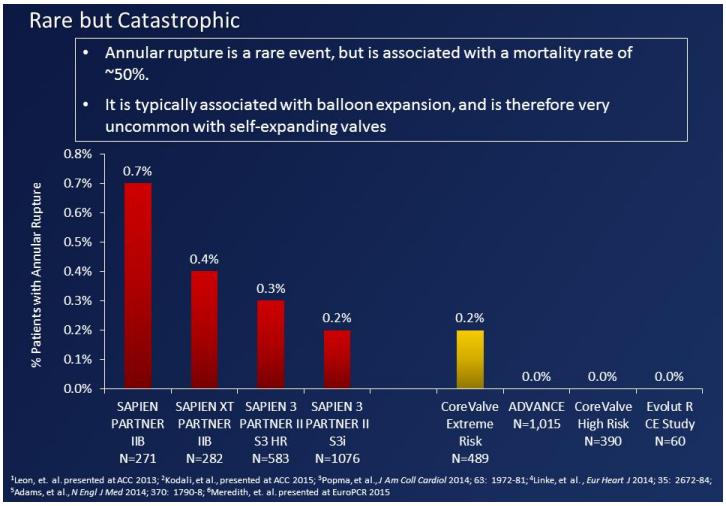
PERCUTANEOUS PERILS

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

Alan F. Vainrib, MD, Homam Ibrahim, MD, Kazuhiro Hisamoto, MD, Cezar S. Staniloae, MD, Hasan Jilaihawi, MD, Ricardo J. Benenstein, MD, Larry Latson, MD, Mathew R. Williams, MD, and Muhamed Saric, MD, PhD, *New York, New York*

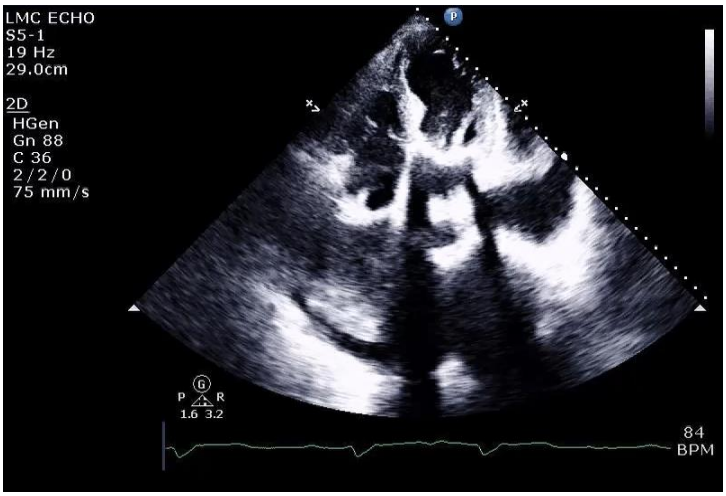
CASE 2017;1(2):70-74

ANNULAR RUPTURE POST TAVR



Balloon Expandable TAVR Self-expanding TAVR

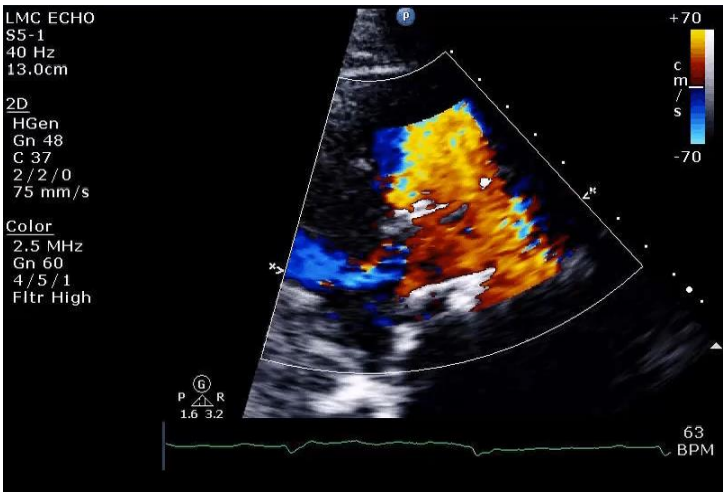
Several Weeks Post CoreValve | Severe new-onset heart failure with normal LVEF



Bilateral pleural effusions

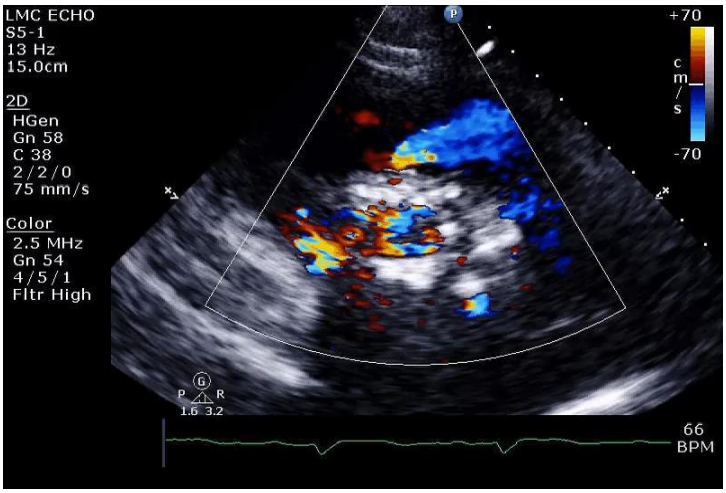
Aorto-RV Fistula: Transthoracic Echocardiography

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



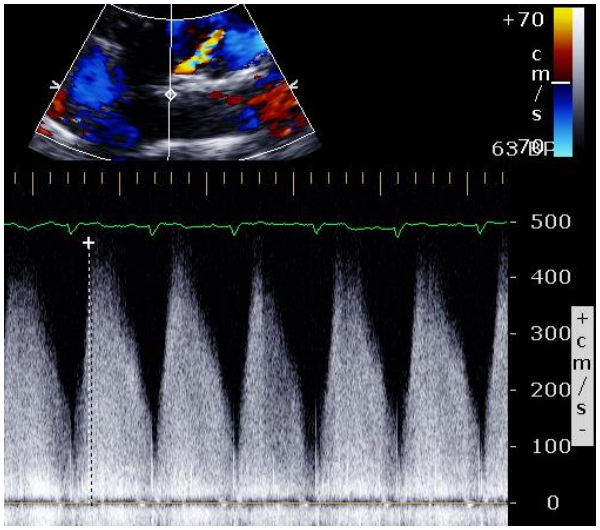
Abnormal color Doppler jet at caudal end of CoreValve

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



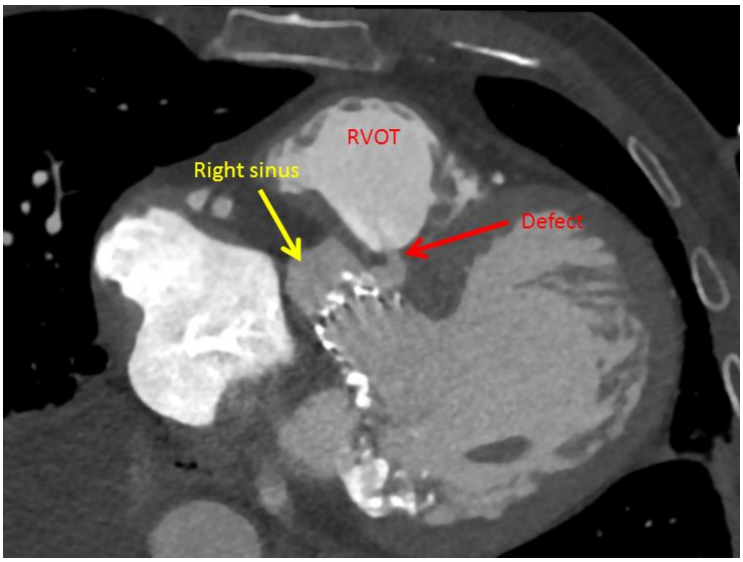
Systolic AND diastolic flow

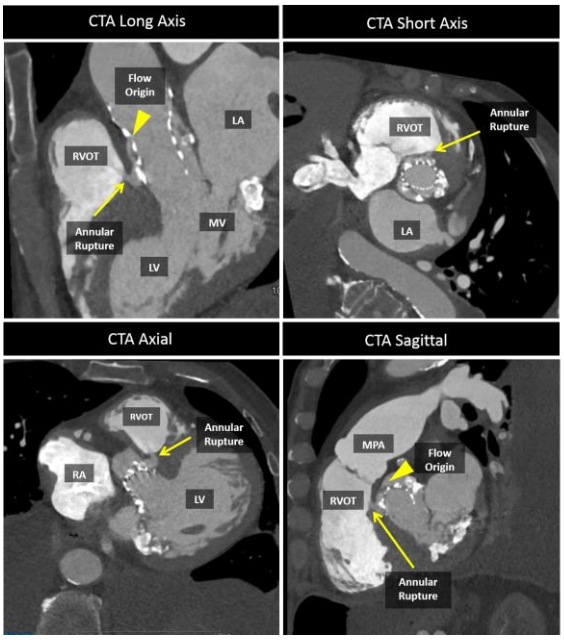
TTE Study Conclusions

Peri-annular rupture with ascending aorta to RVOT communication

CONTRAST CT CONFIRMS ANNULAR RUPTURE

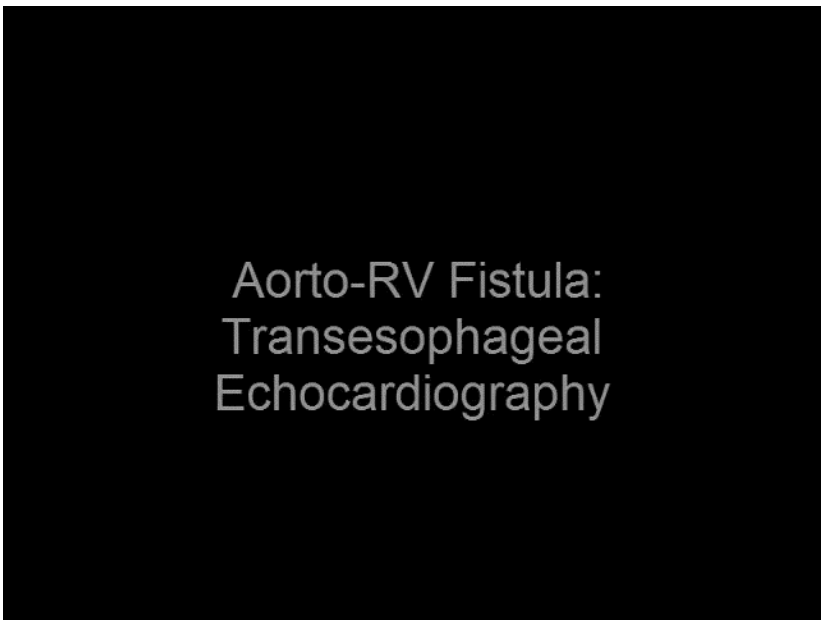
CONTRAST CT CONFIRMS ANNULAR RUPTURE



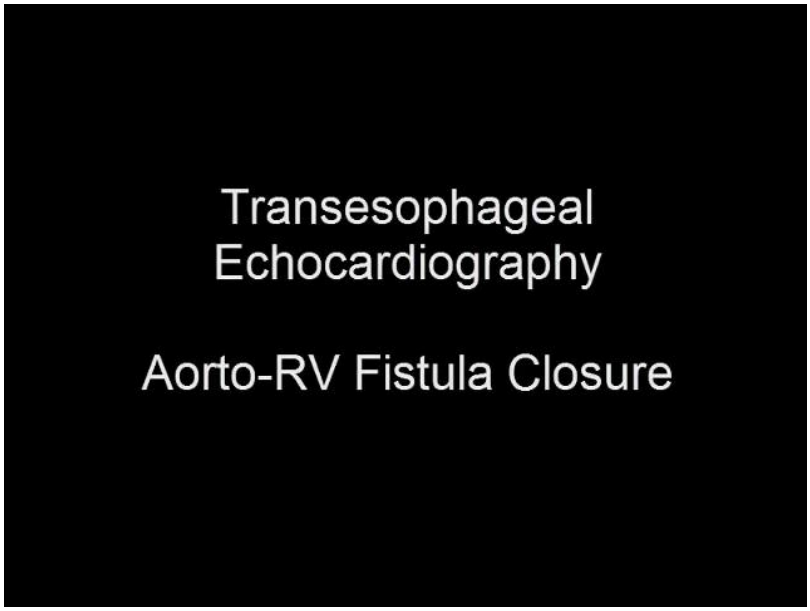


TEE & Fluoroscopy Guided Closure

Aorta-to-RV communication closed using an 8-mm Amplatzer Vascular Plug (AVP)




Cine Fluoroscopy:
Aorto-RV Fistula Closure


Transesophageal
Echocardiography
Aorto-RV Fistula Closure

NYU TAVR TEAM

Thank You!

New York University Langone Medical Center