Echocardiographic Evaluation of Aortic Valve Prosthesis

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Philadelphia, PA

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Pre Questions (1)

- Regarding Aortic Prosthetic Valves
  - A. A routine echocardiogram is required very two years after AVR
  - B. An elevated gradient with a decreased EOA is always suggestive of valvular stenosis
  - C. Transthoracic echocardiogram alone is always sufficient to diagnose valvular stenosis
  - D. It is more challenging to quantify para-valvular versus valvular aortic regurgitation.

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Pre Questions (2)

- Patients with Prosthesis-Patient Mismatch
  - A. Have abnormal prosthetic valve function
  - B. Progressively worsen with time
  - C. Have a small valve compared to the demands of their body and cardiac output
  - D. Have a benign condition

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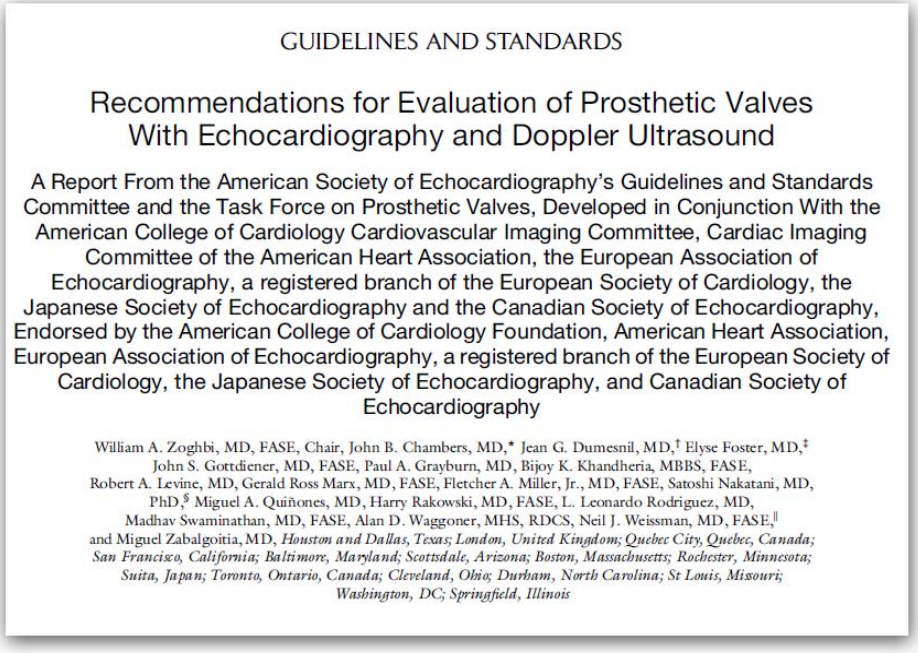

GUIDELINES AND STANDARDS

Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound

A Report From the American Society of Echocardiography's Guidelines and Standards Committee and the Task Force on Prosthetic Valves, Developed in Conjunction With the American College of Cardiology Cardiovascular Imaging Committee, Cardiac Imaging Committee of the American Heart Association, the European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography and the Canadian Society of Echocardiography, Endorsed by the American College of Cardiology Foundation, American Heart Association, European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography, and Canadian Society of Echocardiography

William A. Zoghbi, MD, FASE, Chair, John B. Chambers, MD,* Jean G. Dumesnil, MD,† Elyse Foster, MD,‡ John S. Gottdiener, MD, FASE, Paul A. Grayburn, MD, Bijoy K. Khandheria, MBBS, FASE, Robert A. Levine, MD, Gerald Ross Marx, MD, FASE, Fletcher A. Miller, Jr., MD, FASE, Satoshi Nakatani, MD, PhD,§ Miguel A. Quiñones, MD, Harry Rakowski, MD, FASE, L. Leonardo Rodriguez, MD, Madhav Swaminathan, MD, FASE, Alan D. Waggoner, MHS, RDCS, Neil J. Weissman, MD, FASE,‖ and Miguel Zabalgoitia, MD, *Houston and Dallas, Texas; London, United Kingdom; Quebec City, Quebec, Canada; San Francisco, California; Baltimore, Maryland; Scottsdale, Arizona; Boston, Massachusetts; Rochester, Minnesota; Suita, Japan; Toronto, Ontario, Canada; Cleveland, Ohio; Durham, North Carolina; St Louis, Missouri; Washington, DC; Springfield, Illinois*

JASE September 2009

Topics of Discussion

- Types and Flow Profiles of Prosthetic Valves
- Echocardiographic Evaluation: Key Points
- Challenges for Evaluation
- Prosthetic Valves Evaluation
  - Elevated gradients
  - Regurgitation
  - Endocarditis
  - Thrombosis versus pannus

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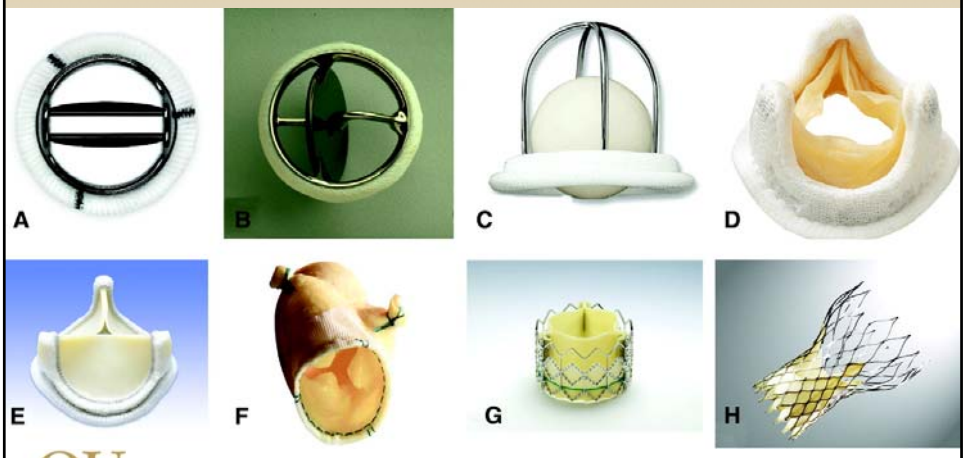
Types & Flow Profiles of Prosthetic Valves

Mechanical Vs. Bioprosthetic Vs. Autografts



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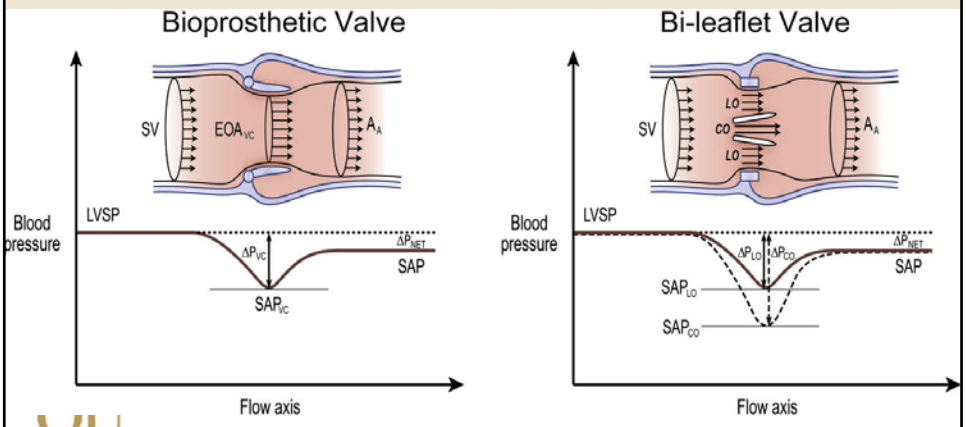
Pibarot P , Dumesnil J G Circulation 2009;119:1034-1048

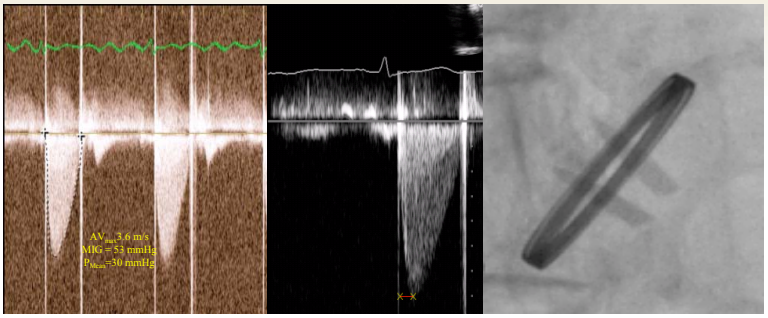
American Heart Association
Learn and Live

Types & Flow Profiles of Prosthetic Valves

Mechanical Vs. Bioprosthetic Flow



Localized Pressure Loss and High Gradient in Central Orifice of Bileaflet Mechanical Valve (?Pressure Recovery)



- **Fluoroscopy**

ECHO EVALUATION Guidelines

- CLASS I
  - Initial TTE after AVR (2-4 weeks or sooner if concern for follow up and transfer)
  - Repeat TTE for AVR if there is a change in clinical symptoms or signs suggesting dysfunction
  - TEE for AVR if there is a change in clinical symptoms or signs suggesting dysfunction
- CLASS II
  - Annual TTE in bioprosthetic valves after the first 10 years (5 years in prosthetic statement 2008) but not mechanical valves

Nishimura et al 2014

ECHO EVALUATION: Key Points

- Clinical picture
- Baseline study
- Type and size of valve
- LV chamber
- BP/HR
- Height/weight/BSA
- Exercise echo may be helpful
- Cinefluoroscopy, CT, MRI

ECHO EVALUATION: Key Points

- Opening and Closing of leaflets or occluders
- Abnormal densities (calcium/mass/vegetation)
- Stability versus rocking motion
- May use Modified versus Simplified Bernoulli
  - $4V_2^2 - 4V_1^2$ Vs. $4V_2^2$
- Attention to flow states & adequate Doppler signals

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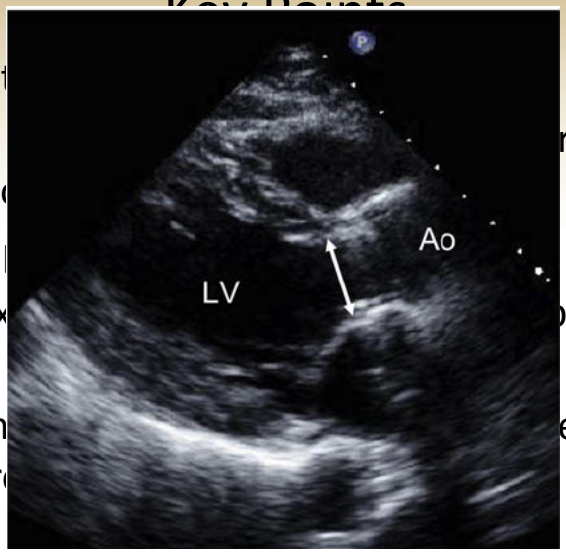
Echo Evaluation: Key Points

- Adequat
  - LVOT ration (0.5 t
  - Multi
  - Off ax btain LVOT
  - Eccen equire differ



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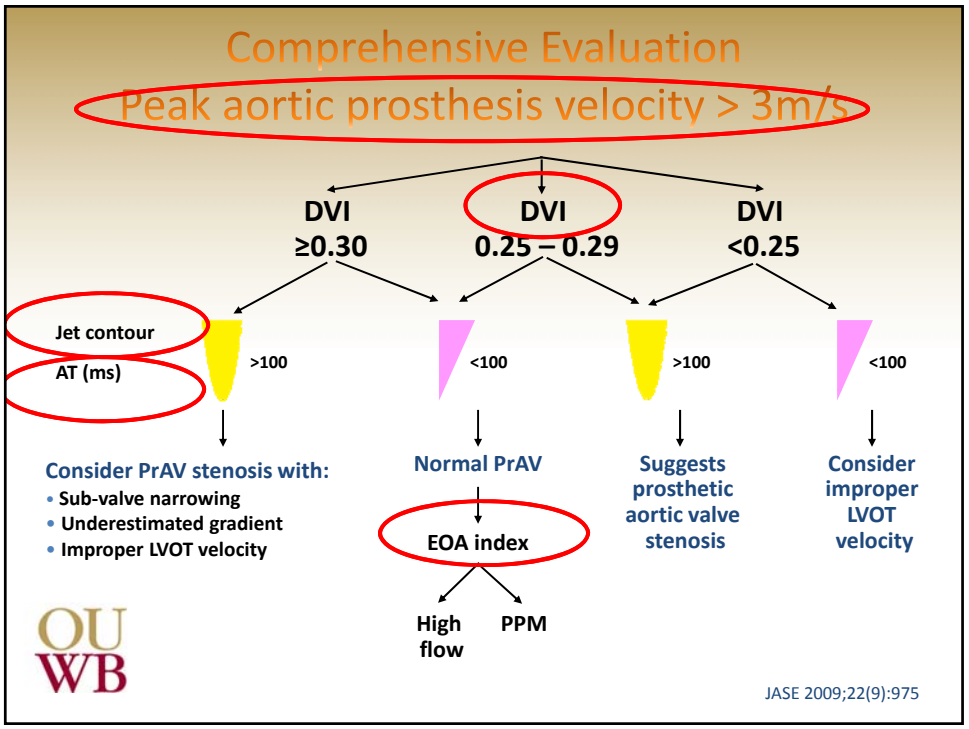
Evaluation of Prosthetic Valves: Challenges

- Large range in what is considered normal
- Mean Gradients produced depend on size and type of valve.
- For any particular patient… it is difficult to differentiate normal from abnormal, hence the need for comparison to older studies
- Shadowing may interfere with assessment of location and amount of regurgitation

Bioprosthetic Valve Abnormalities

- Elevated Gradients
- Regurgitation
- Endocarditis
- Thrombosis
- Pannus

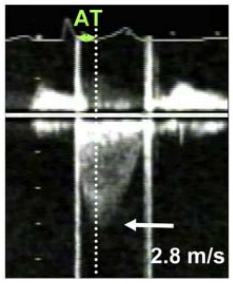
Echocardiographic Evaluation of Elevated Prosthetic Valve Gradients

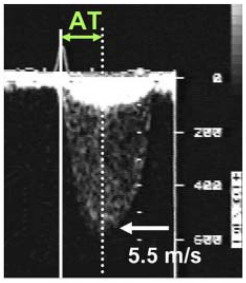


Parameters Utilized

- Peak prosthetic aortic velocity

CW Doppler
Prosthetic AV



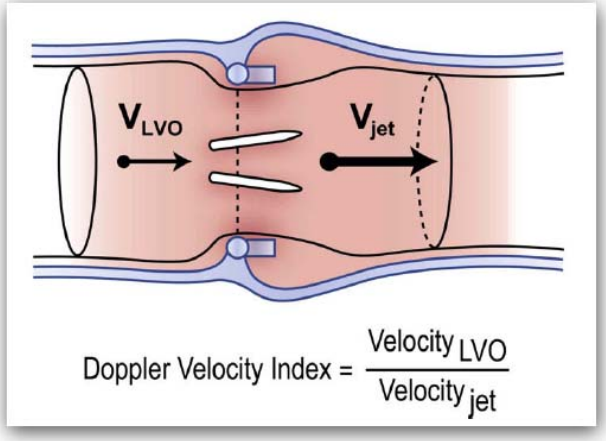


Normal < 3 m/sec

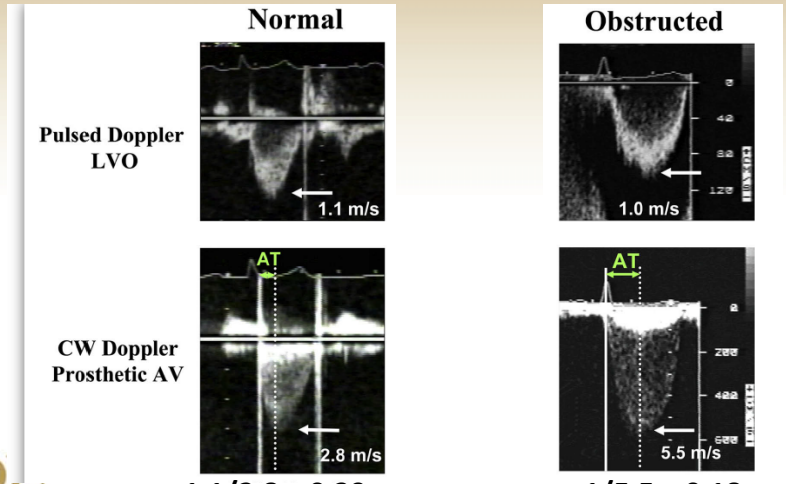
Abnormal > 3 m/sec

Parameters Utilized

- Doppler Velocity Index



Doppler Velocity Index



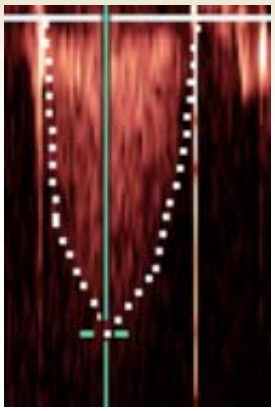
1.1/2.8 = 0.39
Normal > 0.3

1/5.5 = 0.18
Abnormal < 0.25

Parameters Utilized

- Jet Contour

Triangular

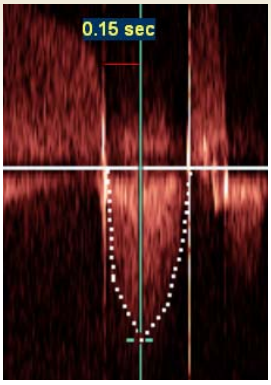


Rounded

Parameters Utilized

- Acceleration Time

80 msec
Normal < 100 msec



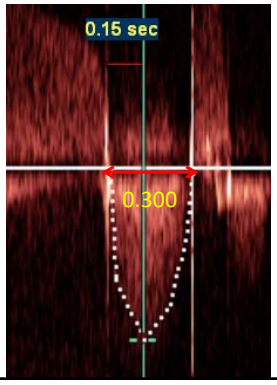
150 msec
Abnormal > 100 msec

Parameters Utilized

- Acceleration time/ ejection time
- AT/ET > 0.4: Prosthetic valve obstruction

No Obstruction:0.31

Obstruction: 0.5



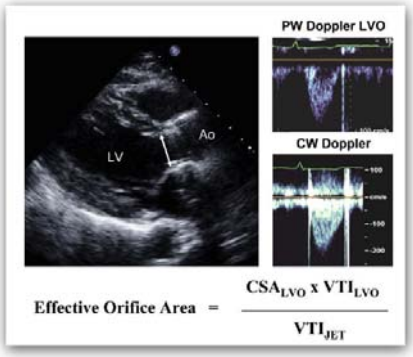
Parameters Utilized

- Effective Orifice Area and iEOA

$$A_2\ (EOA) = \frac{A_1 \times V_1}{V_2}$$

iEOA = AVA/BSA

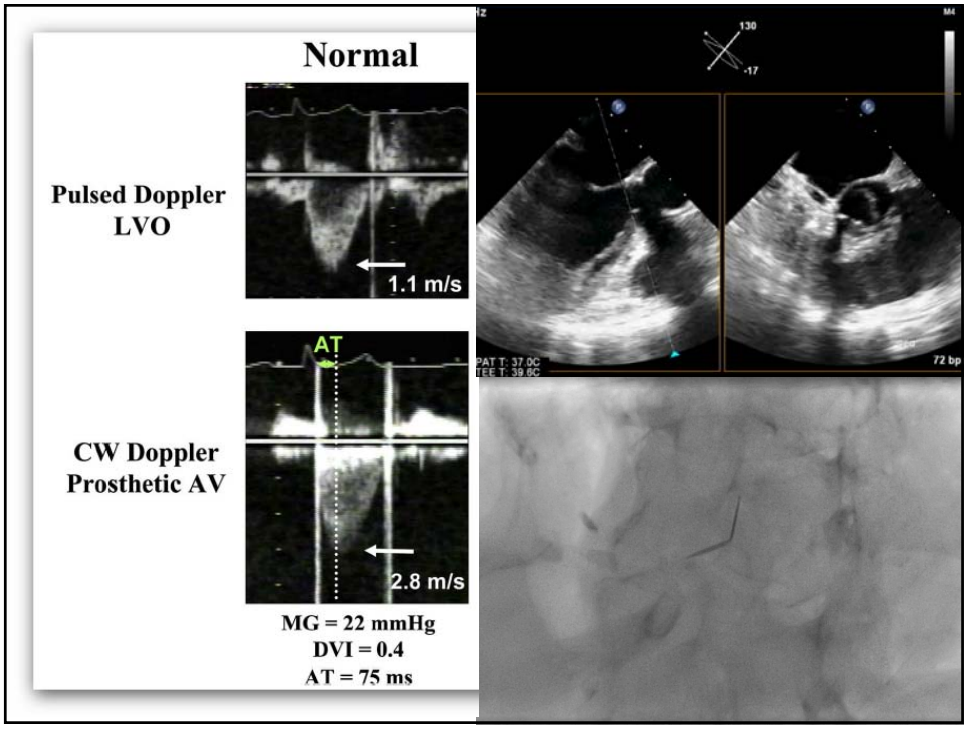
Normal > 1.2 cm²
Abnormal < 0.8 cm²
Abnormal < 0.6 cm²/m²



Cause of Elevated Gradients Across Aortic Prosthesis

- Errors in Measurement
  - Improper LVOT Velocity
    - Taken too far from flow acceleration
  - Improper AV Velocity (Gradient) Assessment
- Increased Flow
- Pressure Recovery
- Prosthesis patient mismatch
- Prosthesis stenosis

NORMAL PROSTHESIS FUNCTION



PROSTHETIC STENOSIS

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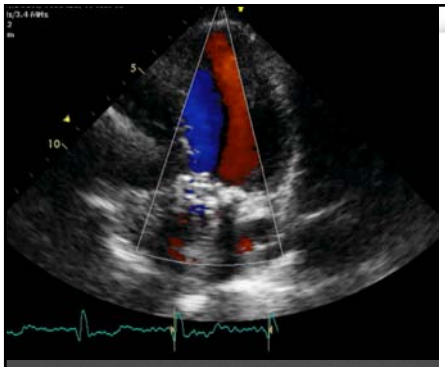
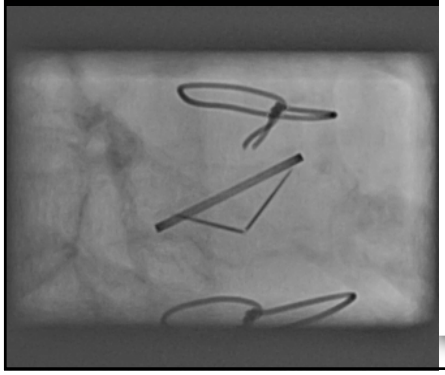
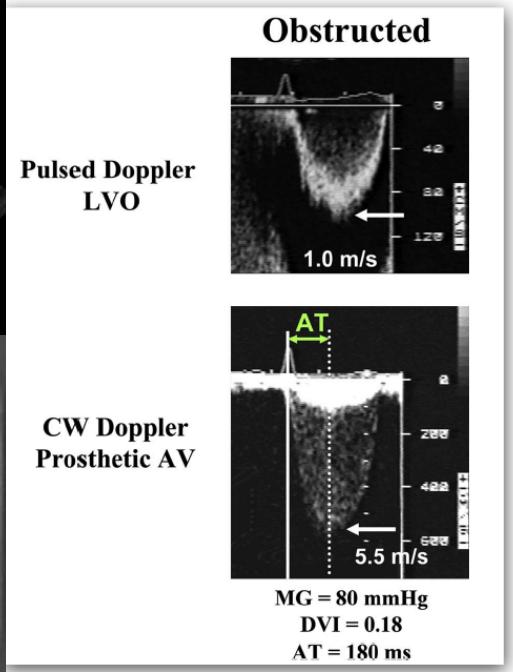


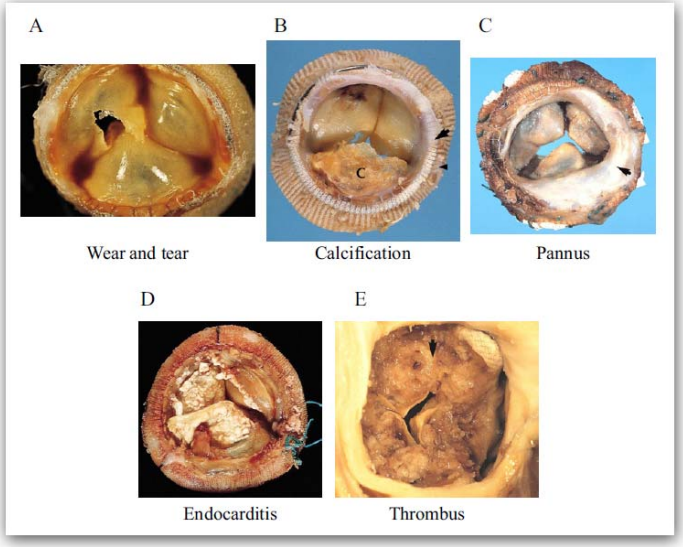




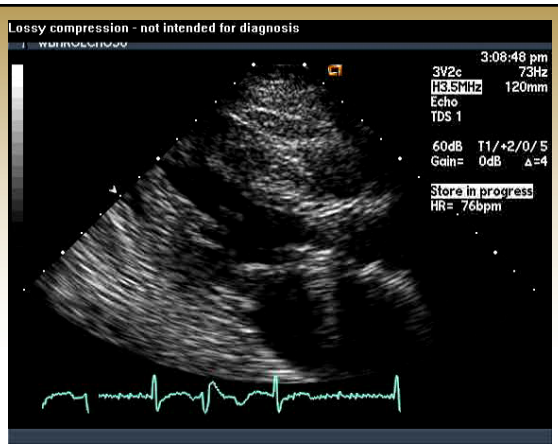
Doppler of Prosthetic Aortic Valve Function

	Normal	Possible Stenosis	Suggests Stenosis
Peak Velocity	< 3 m/s	3-4 m/sec	> 4 m/s
Mean Gradient	< 20 mmHg	20-35 mmHg	> 35 mmHg
Doppler Velocity Index	≥ 0.3	0.29-0.25	< 0.25
Effective Orifice area	> 1.2 cm^2	1.2 – 0.8 cm^2	< 0.8 cm^2
Contour of Jet	Triangular Early Peaking	Triangular to intermediate	Rounded Symmetrical contour
Acceleration Time	< 80 ms	80-100 ms	> 100 ms

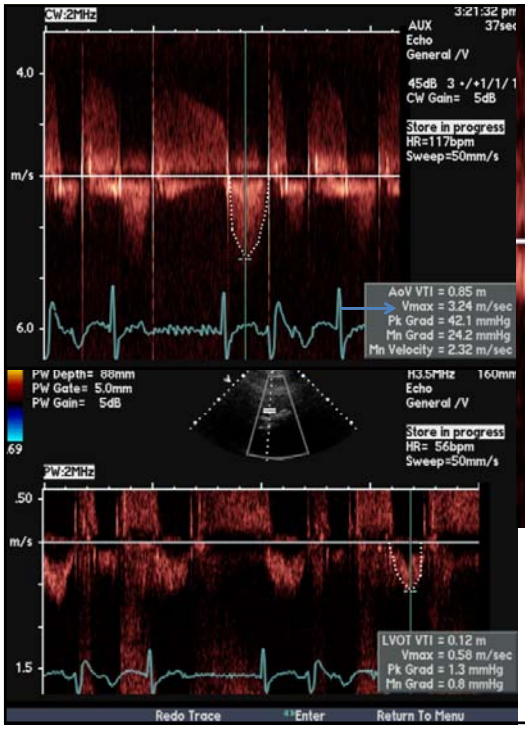
Mechanisms of Prosthetic Valve Dysfunction

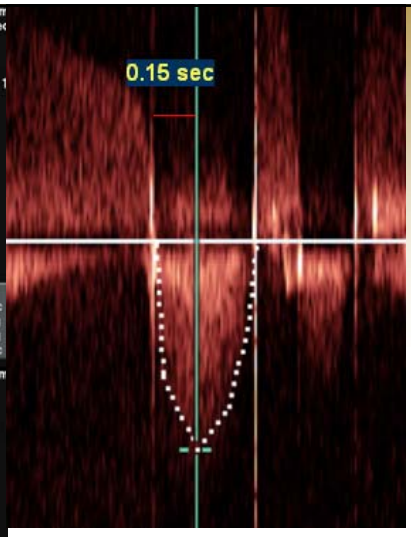


CASE PRESENTATIONS



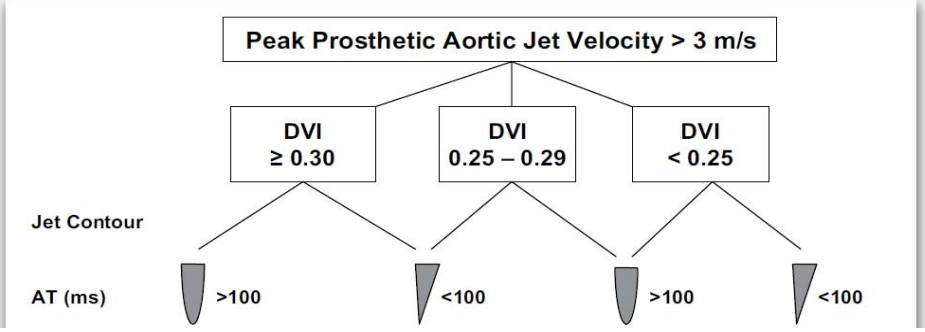
- CASE PRESENTATION (1):
- 81 Y/O with progressive DOE
- PMHx: Rheumatic valve disease, CABG + Mechanical AVR 2003 (19 St Jude Regent Valve)
- TTE: Difficult to visualize mechanical AV



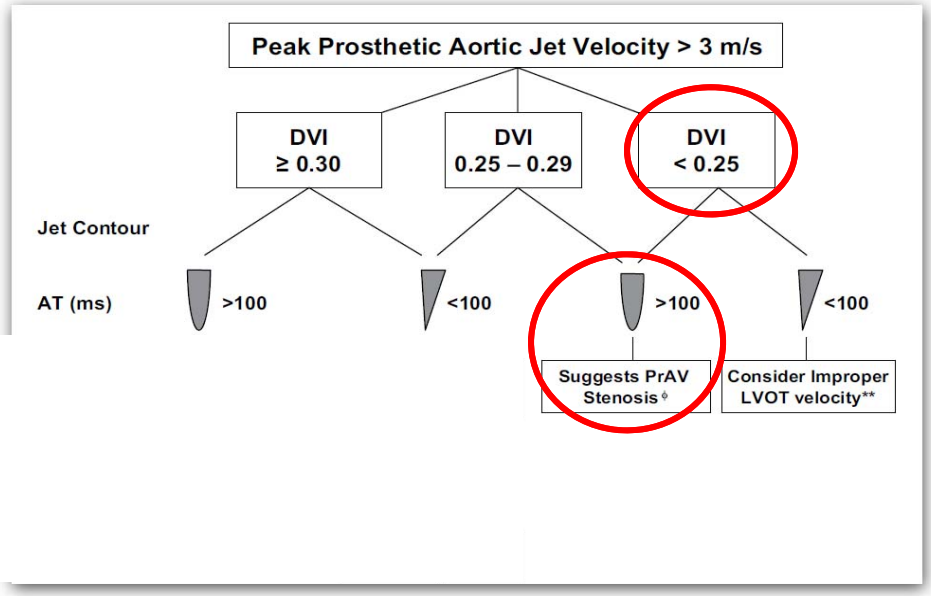


AV VEL=3.2
DI=0.58/3.2=0.18
AT=150msec
Jet Contour: Circular

An approach to prosthetic AV stenosis



An approach to prosthetic AV stenosis



Doppler Parameters of Prosthetic Aortic Valve Function

	Normal	Suggests Stenosis
Peak Velocity	< 3 m/s	> 4 m/s
Mean Gradient	< 20 mmhg	> 35 mmhg
Doppler Velocity Index	>= 0.3	< 0.25
Effective Orifice area	> 1.2 cm2	< 0.8 cm2
Contour of Jet	Triangular Early Peaking	Rounded Symmetrical contour
Acceleration Time	< 80 ms	> 100 ms

3.2

24

0.18

150 ms

What is your diagnosis?

- A) Normal Prosthetic Valve Function
- B) Prosthesis – Patient Mismatch
- C) High Flow State
- D) **Prosthetic Valve Stenosis**
- E) Errors of Measurement: Improper LVOT Velocity

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Additional Studies Needed?

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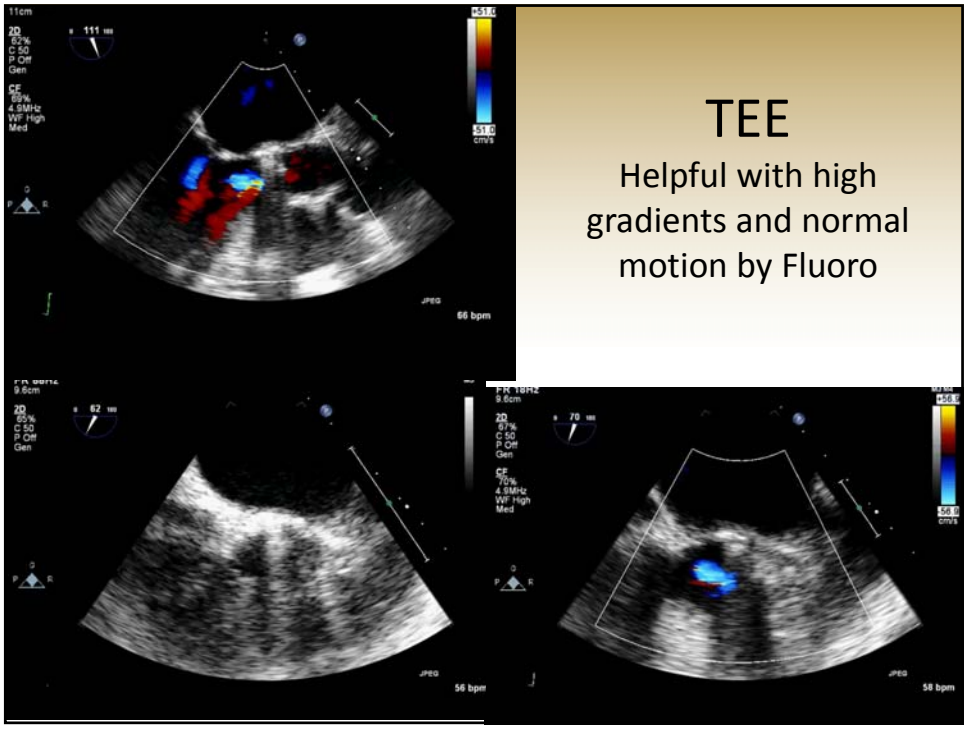
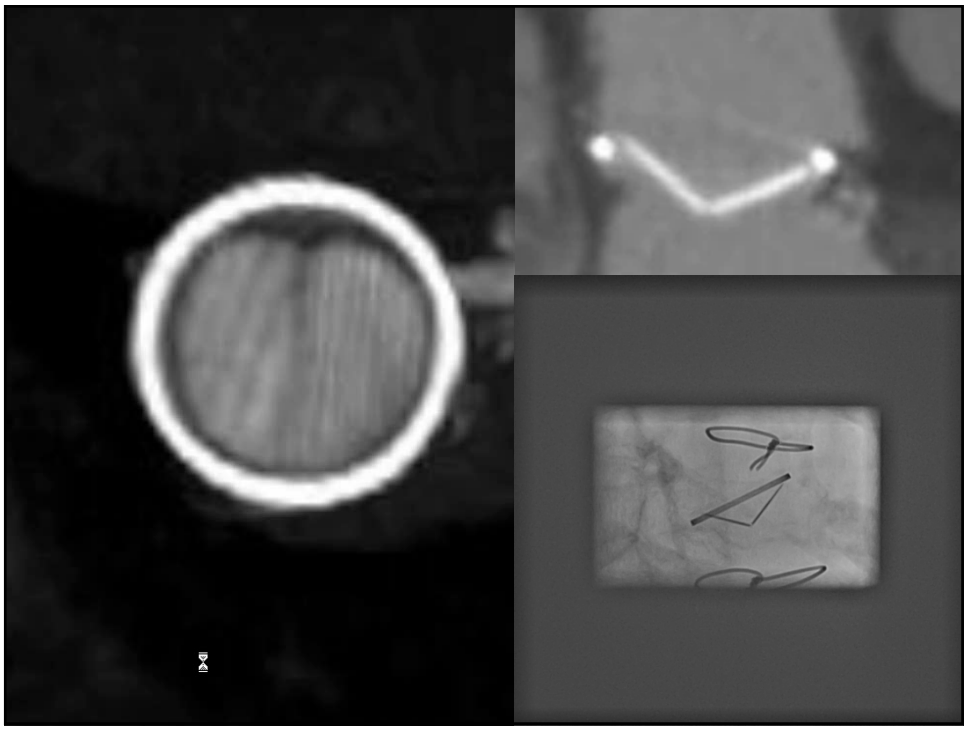
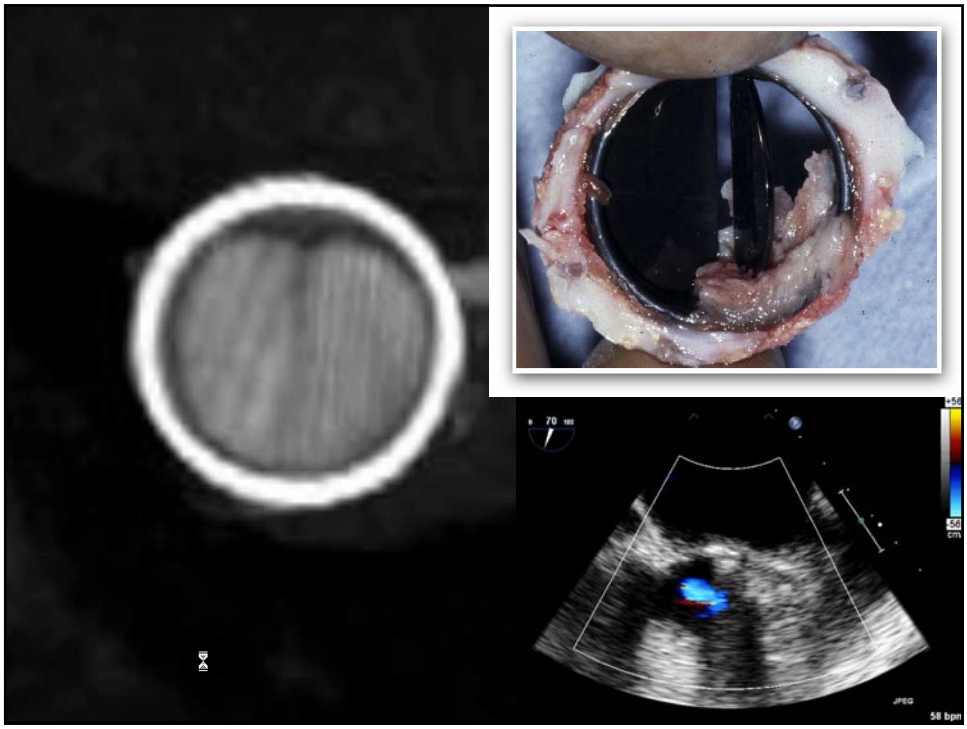
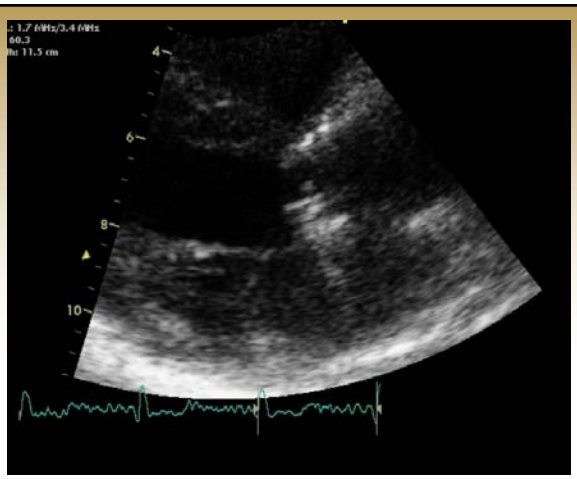


TEE

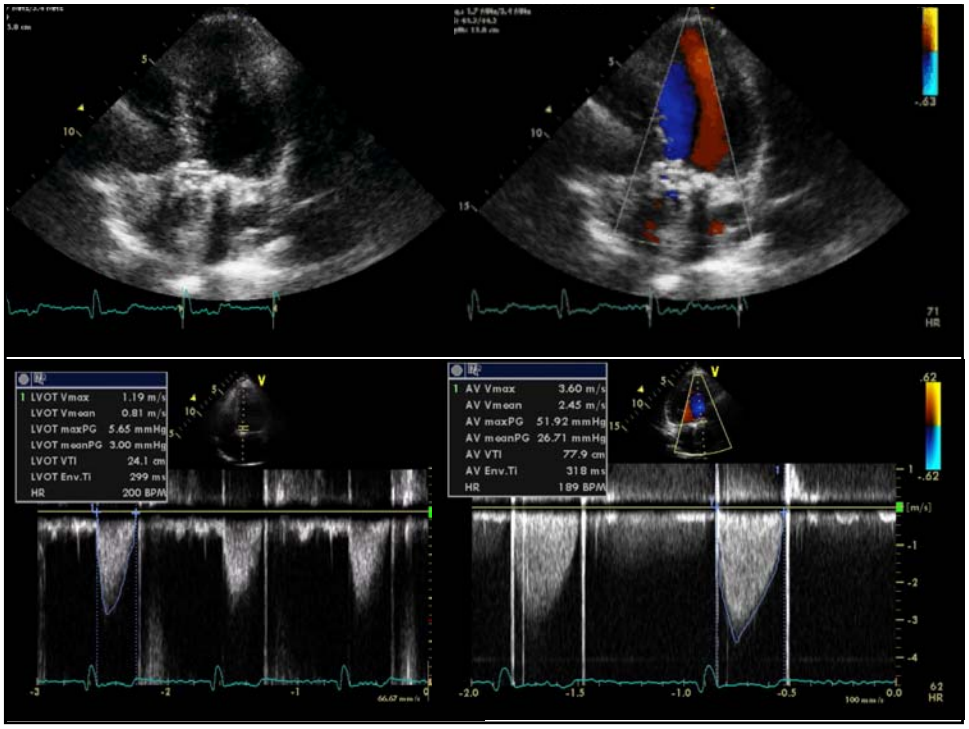
Helpful with high gradients and normal motion by Fluoro





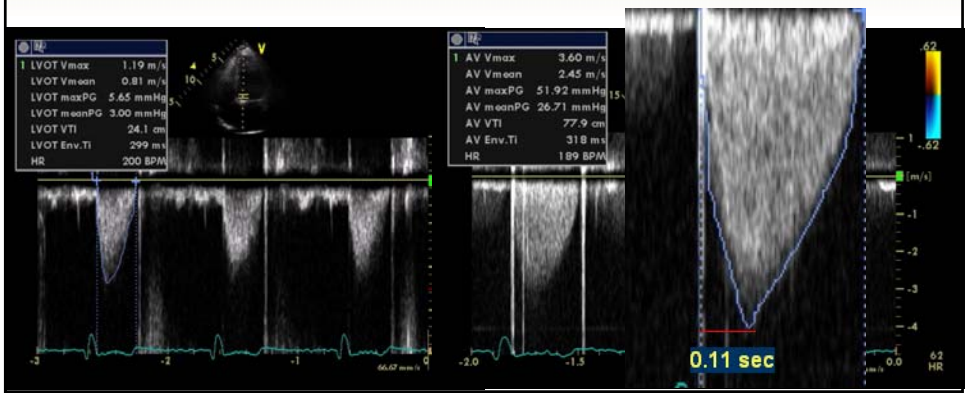


- CASE PRESENTATION (2):
- 67 Y/O F Hx AVR (Bi-Leaflet Mechanical Valve 1998)
- On Coumadin, difficulty maintaining therapeutic INR
- Progressive DOE 6 mos



AV VEL = 3.6
DVI = 1.19 / 3.60
DVI = 0.33

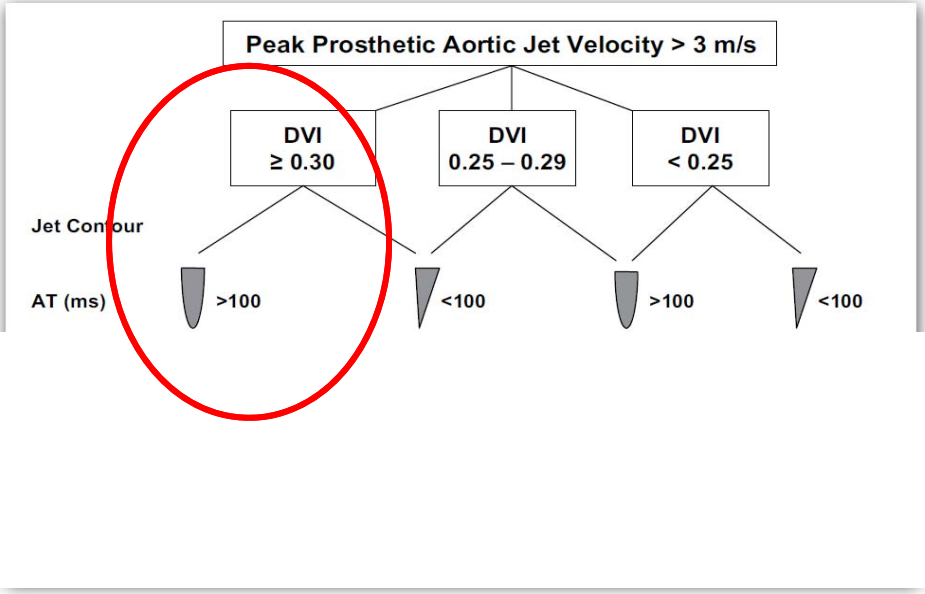
Acceleration Time 0.11 sec



Doppler Parameters of Prosthetic Aortic Valve Function

	Normal		Suggests Stenosis
Peak Velocity	< 3 m/s	3.6	> 4 m/s
Mean Gradient	< 20 mmhg	26	> 35 mmhg
Doppler Velocity Index	>= 0.3	0.33	< 0.25
Effective Orifice area	> 1.2 cm2		< 0.8 cm2
Contour of Jet	Triangular Early Peaking		Rounded Symmetrical contour
Acceleration Time	< 80 ms	110 ms	> 100 ms

An approach to prosthetic AV stenosis



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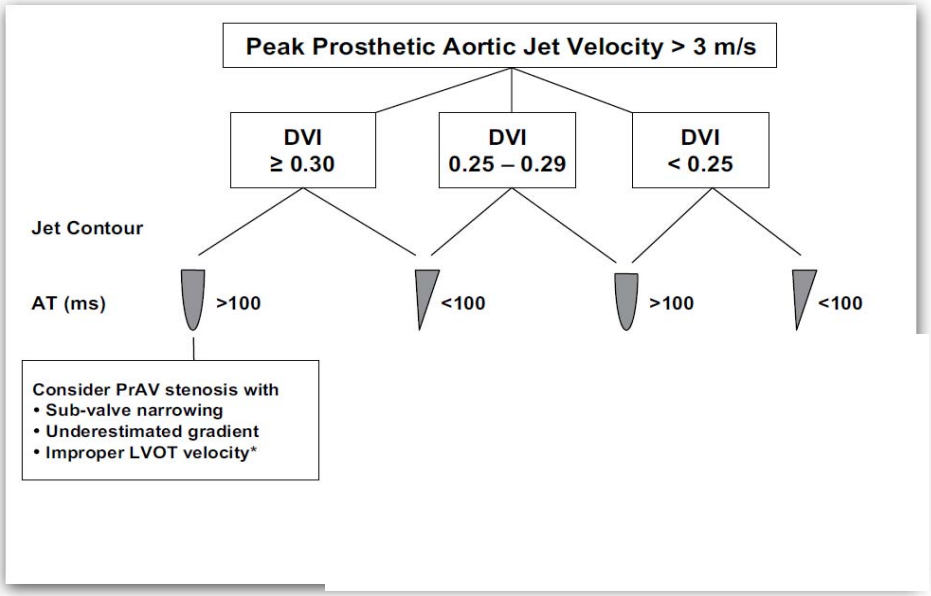
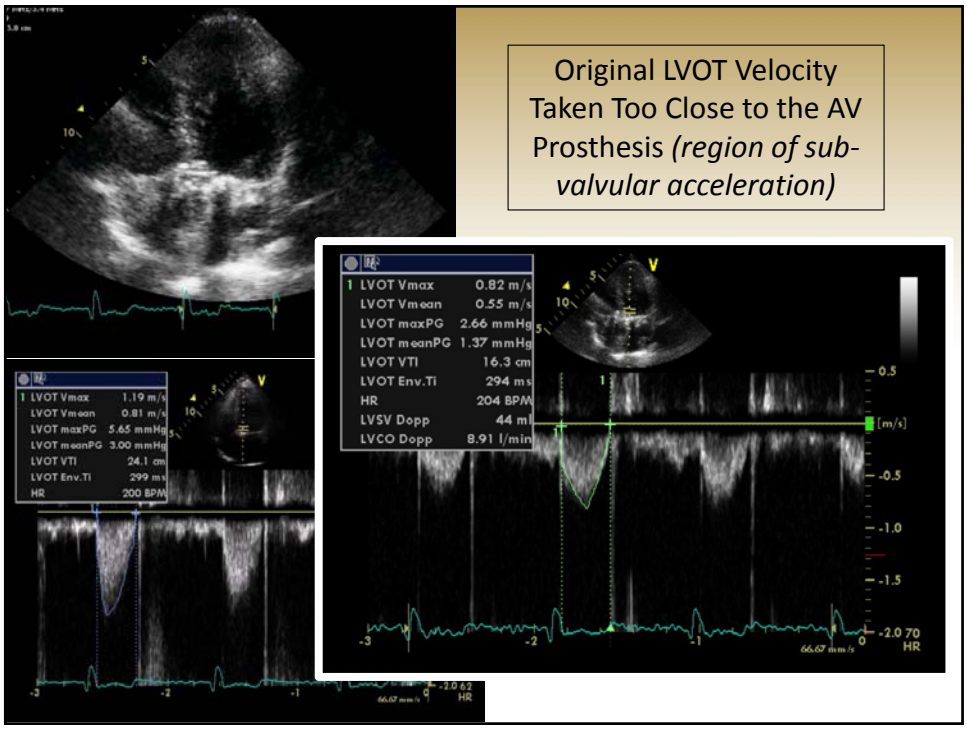
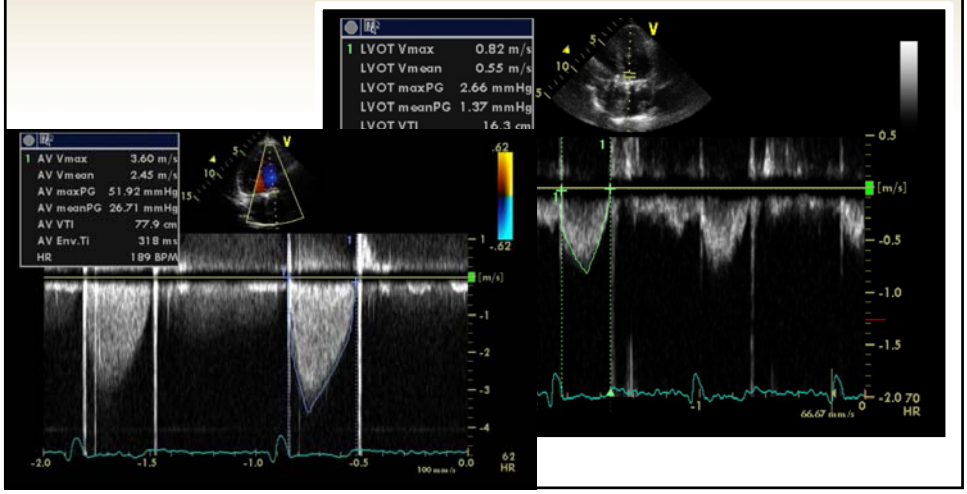




DVI = **Velocity** LVO / AV Jet
DVI = 0.82 / 3.60
DVI = 0.22

Original LVOT Velocity Taken Too Close to the AV Prosthesis



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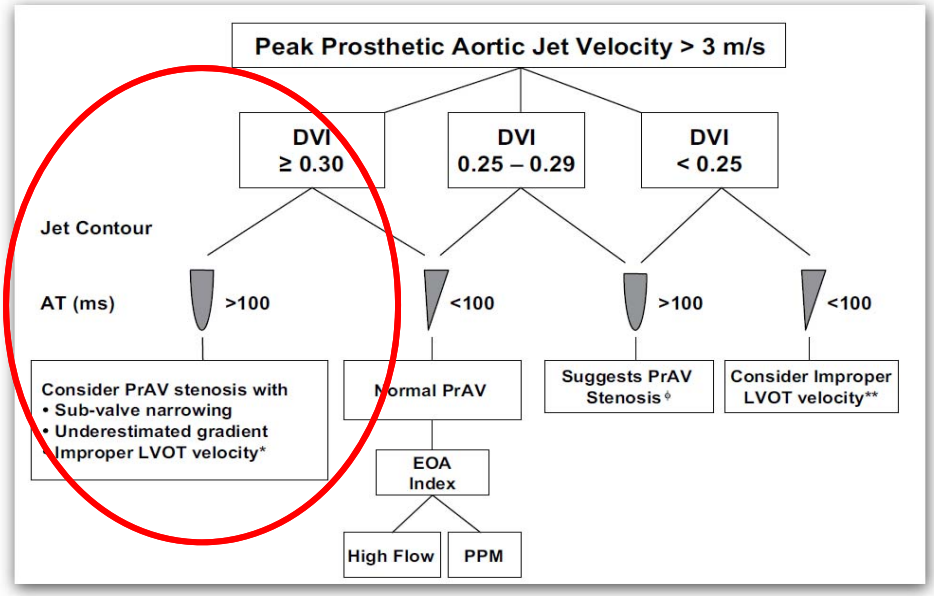
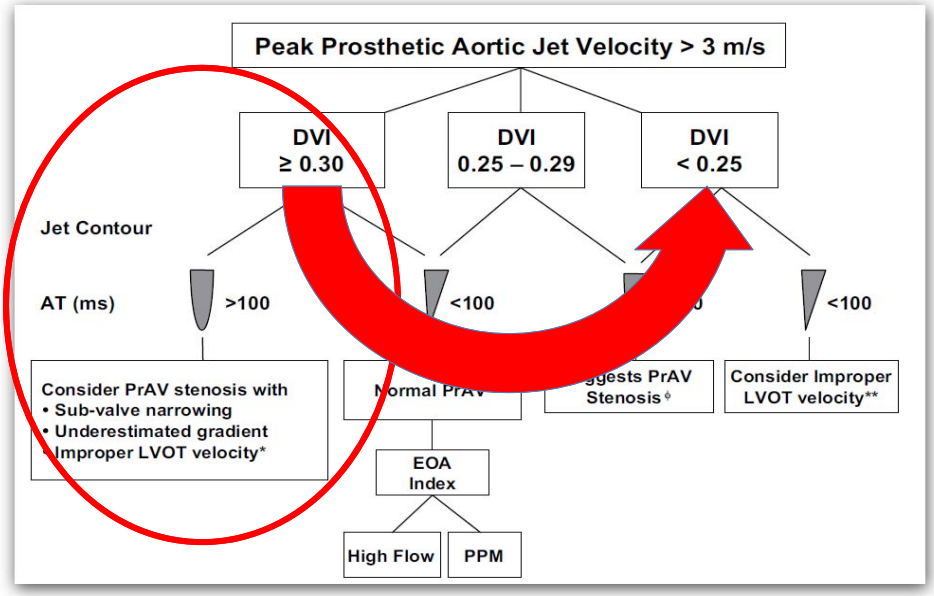
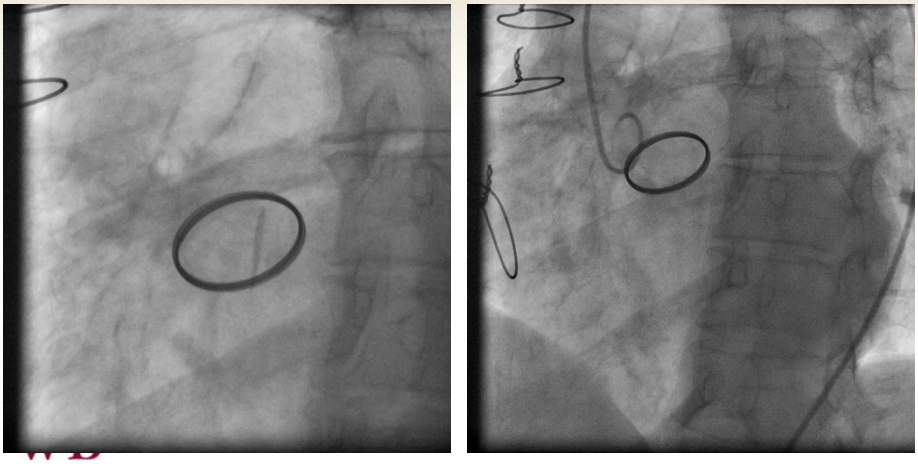


An approach to prosthetic AV stenosis

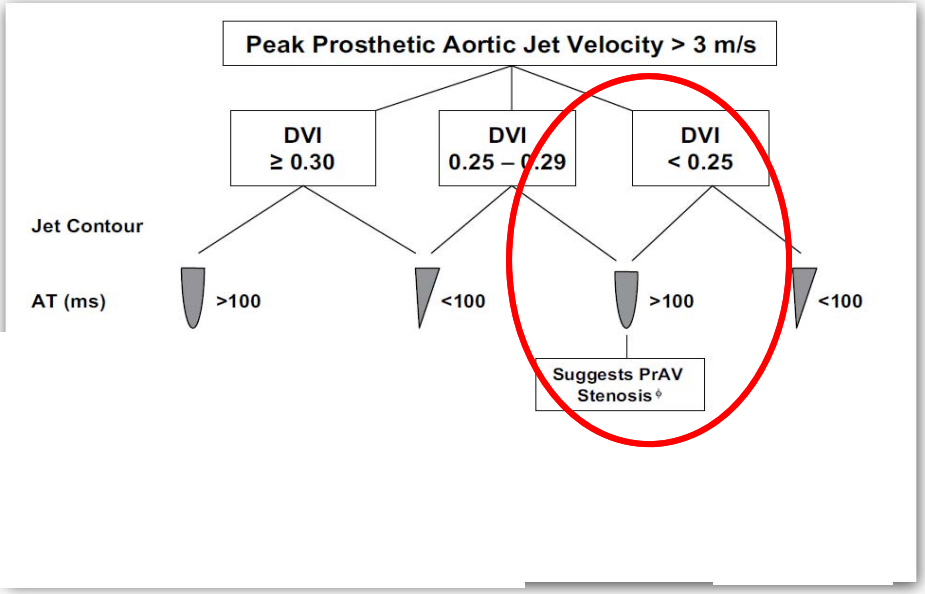


Surgical Findings

Well seated valve with a large amount of tissue ingrowth beneath the valve resulting in a frozen leaflet



An approach to prosthetic AV stenosis



What is your diagnosis?

- A) Patient – Prosthesis Mismatch
- B) Normal Prosthetic Valve Function
- C) High Flow State
- D) Prosthetic Valve Stenosis
- E) Improper LVOT Velocity

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What is your diagnosis?

- A) Patient – Prosthesis Mismatch
- B) Normal Prosthetic Valve Function
- C) High Flow State
- D) Prosthetic Valve Stenosis
- E) Improper LVOT Velocity (Prosthetic valve stenosis)

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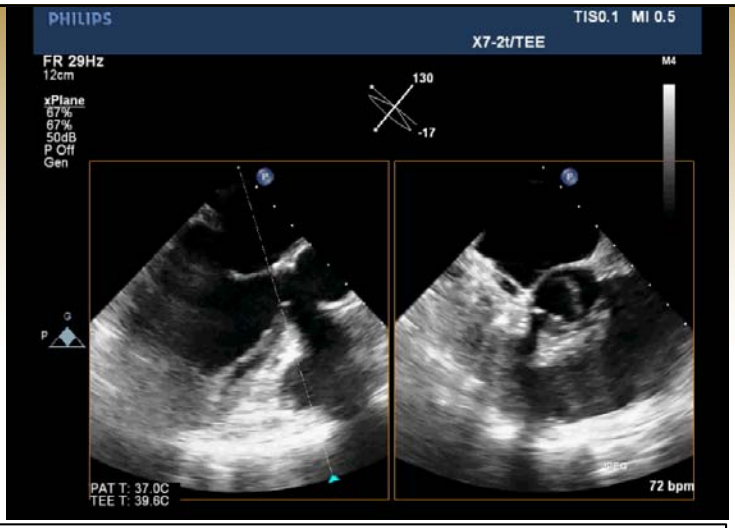
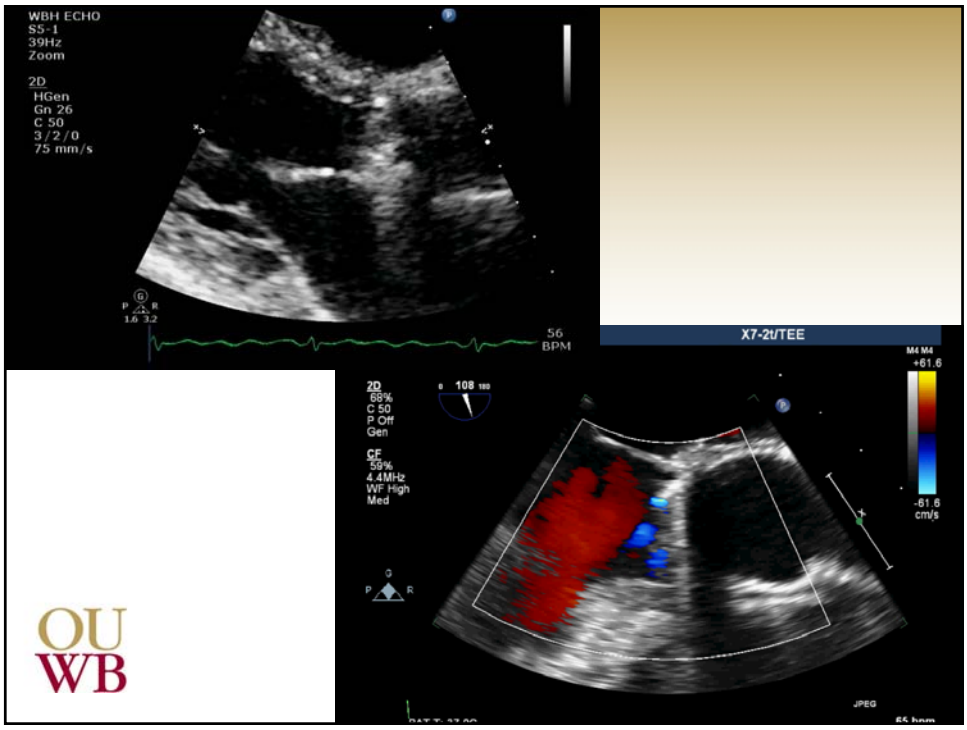
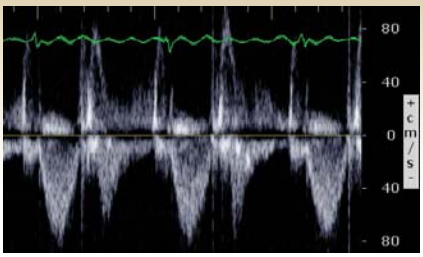
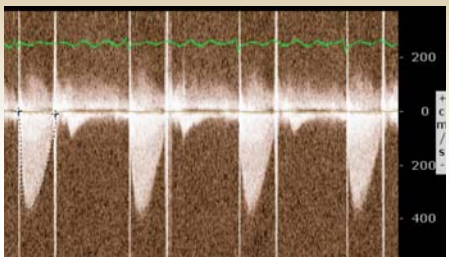


- CASE PRESENTATION (3):
- 66 Y/O F Hx AVR (St Jude Valve Conduit 2002 for AR)
- Progressive DOE





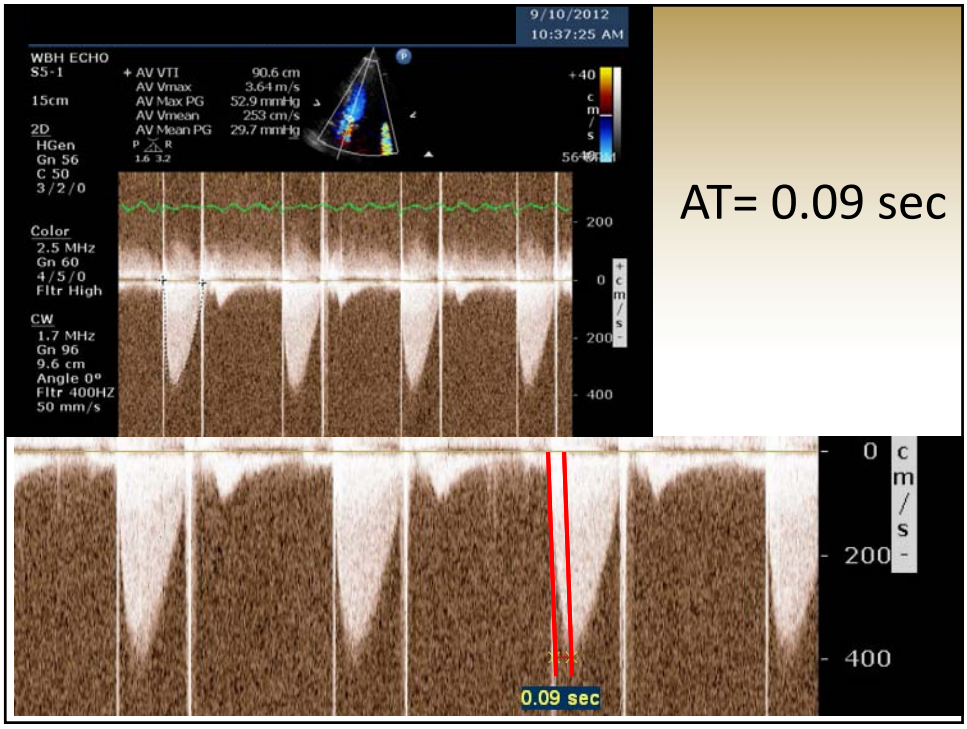
LVOT VELOCITY = 0.85



AVA VELOCITY = 3.4

- DVI= 0.85/3.4 = 0.25
- AVA VELOCITY = 3.4 m/s

OU WB



AT= 0.09 sec

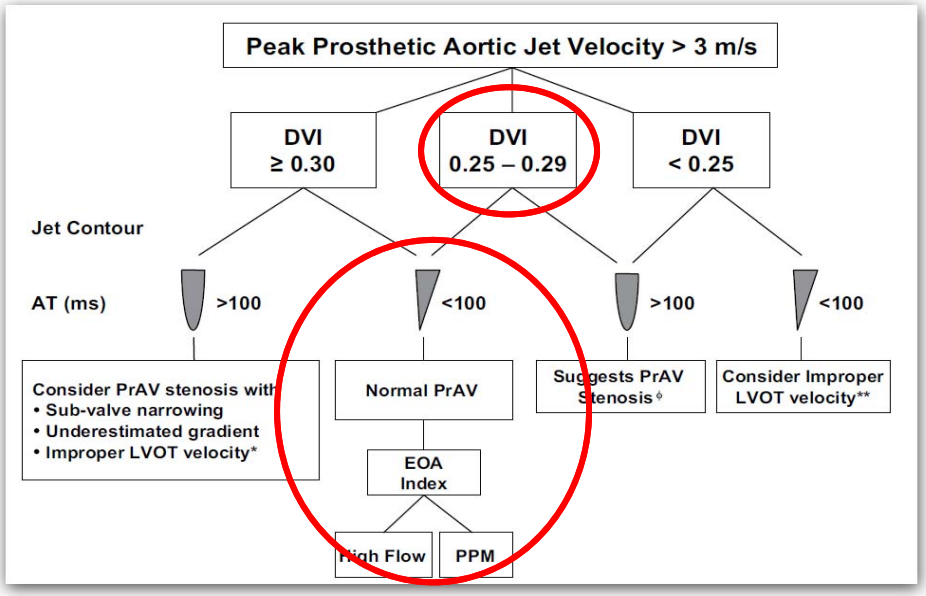
Doppler Parameters of Prosthetic Aortic Valve Function

	Normal	Suggests Stenosis
Peak Velocity	< 3 m/s	> 4 m/s
Mean Gradient	< 20 mmhg	> 35 mmhg
Doppler Velocity Index	>= 0.3	< 0.25
Effective Orifice area	> 1.2 cm2	< 0.8 cm2
Contour of Jet	Triangular Early Peaking	Rounded Symmetrical contour
Acceleration Time	< 80 ms	> 100 ms

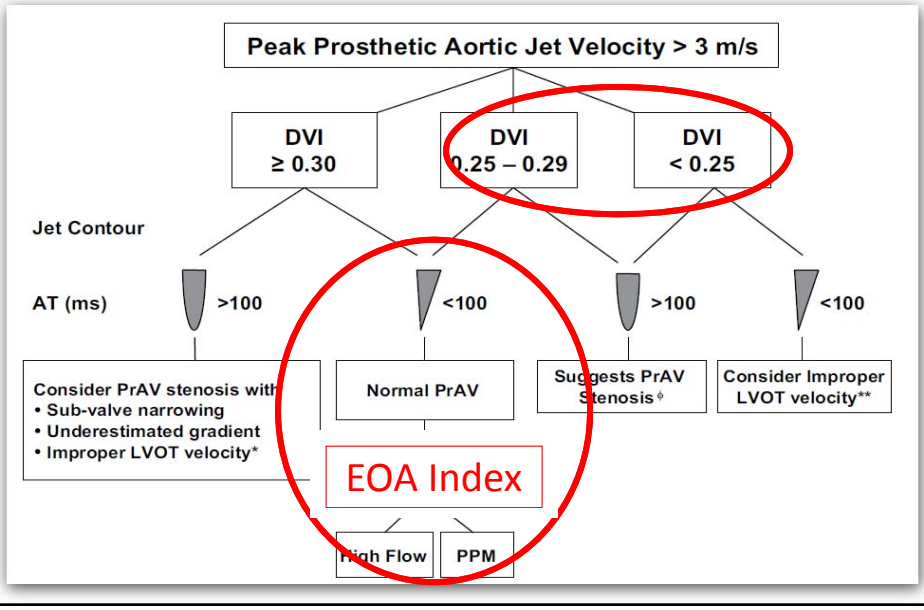
Doppler Parameters of Prosthetic Aortic Valve Function

	Normal	Suggests Stenosis
Peak Velocity	< 3 m/s	3.4 > 4 m/s
Mean Gradient	< 20 mmhg	30 > 35 mmhg
Doppler Velocity Index	>= 0.3	0.25 < 0.25
Effective Orifice area	> 1.2 cm2	< 0.8 cm2
Contour of Jet	Triangular Early Peaking	Rounded Symmetrical contour
Acceleration Time	< 80 ms	90 ms > 100 ms

An approach to prosthetic AV stenosis

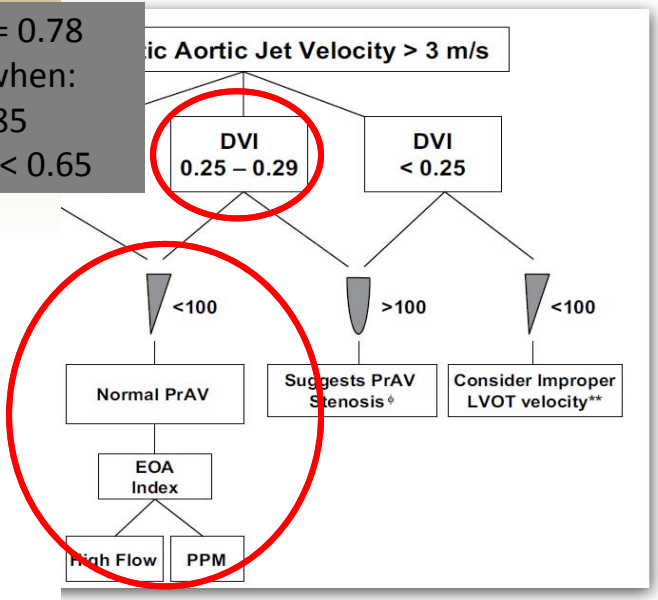


An approach to prosthetic AV stenosis



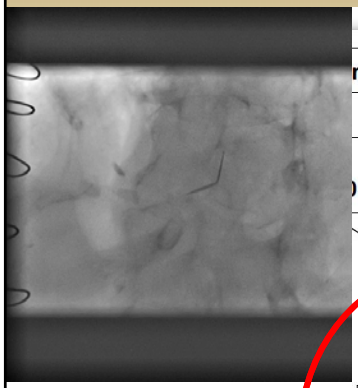
An approach to prosthetic AV stenosis

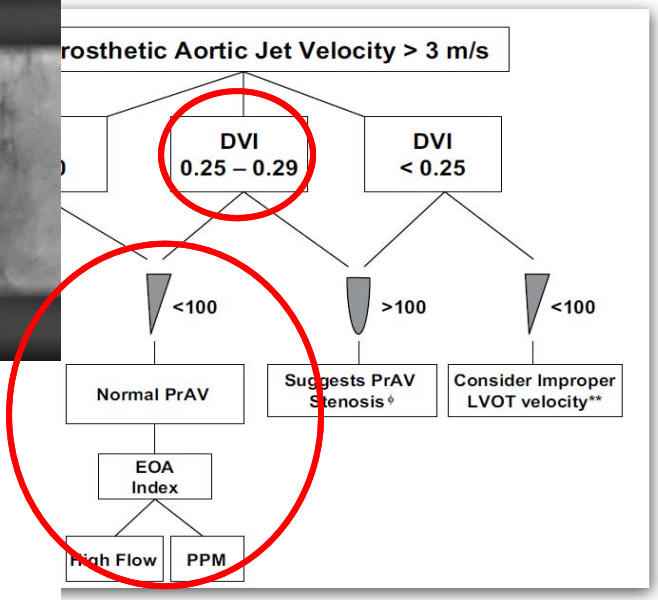
Indexed EOA = 0.78
PPM occurs when:
iEOA < 0.85
Severe if iEOA < 0.65



OU WB

An approach to prosthetic AV stenosis



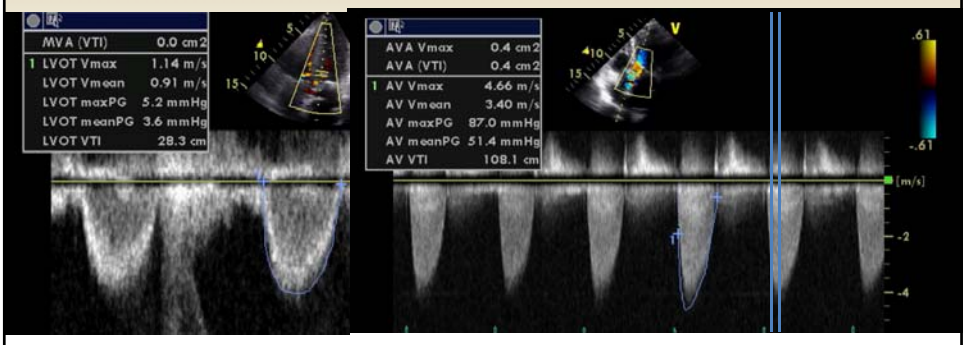


OU WB

What is your diagnosis?

- A) Prosthesis – Patient Mismatch
- B) Normal Prosthetic Valve Function
- C) High Flow State
- D) Prosthetic Valve Stenosis
- E) Improper LVOT Velocity (Prosthetic valve stenosis)

Patient Prosthesis Mismatch



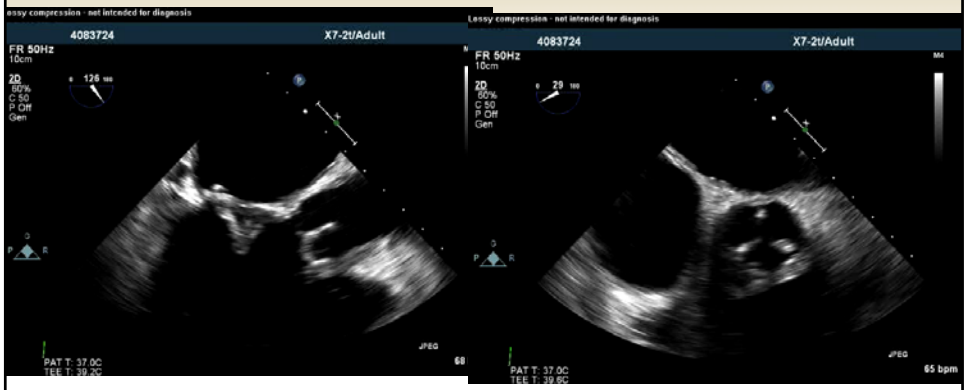
- AVA velocity:4.6
- DVI: 1.14/4.6 = 0.25, AVA= 0.4 cm^2
- Acceleration Time: 60 msec

B

Doppler Parameters of Prosthetic Aortic Valve Function

	Normal		Suggests Stenosis
Peak Velocity	< 3 m/s	4.6	> 4 m/s
Mean Gradient	< 20 mmhg	51	> 35 mmhg
Doppler Velocity Index	>= 0.3	0.25	< 0.25
Effective Orifice area	> 1.2 cm2	0.4	< 0.8 cm2
Contour of Jet	Triangular Early Peaking	TRI	Rounded Symmetrical contour
Acceleration Time	< 80 ms	60 ms	> 100 ms

Patient Prosthesis Mismatch



OU WB

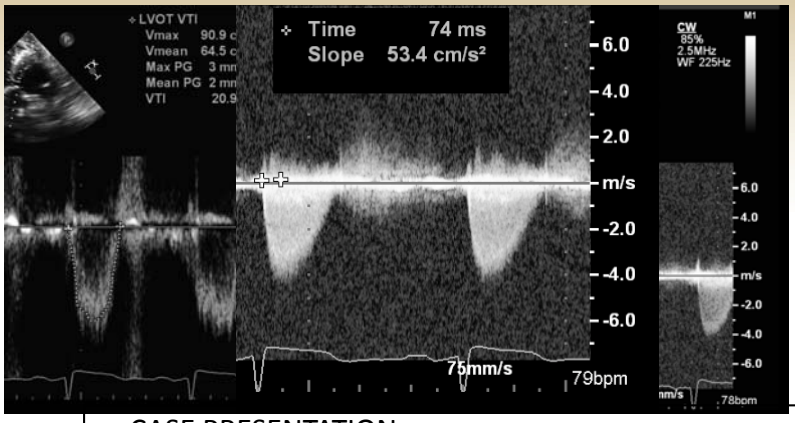
Patient Prosthesis Mismatch

- $\Delta P = Q^2/(K \times EOA^2)$
- Q = Flow, K = Constant
- For gradients to remain low, EOA has to accommodate and be proportionate to flow
- At rest, Q is determined by BSA, bigger people have bigger flow
- In patients with large BSA and increased flow, a "too small of a valve" with a small EOA will produce a high gradient:
- Small valves + Big people = High gradients

Patient Prosthesis Mismatch

- Moe common in SAVR versus TAVR
  - PARTNER 28% vs 20%
  - In smaller annulus even more pornounced
    - 36% Vs 19%

ECHOCARDIOGRAM



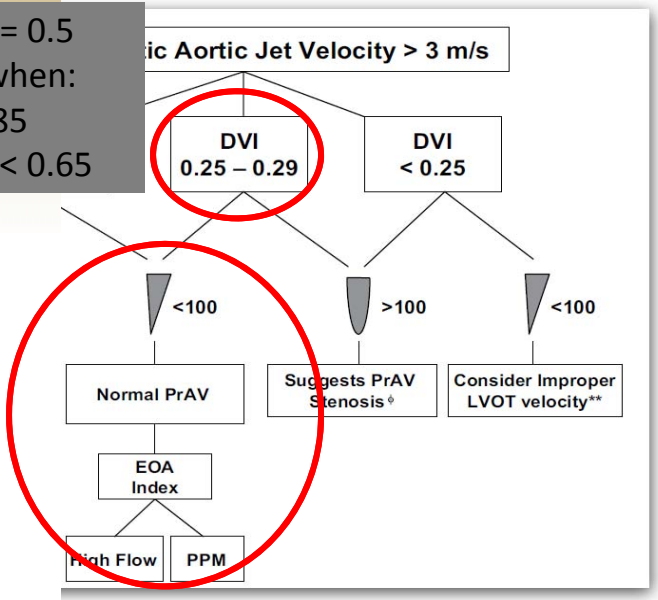
- CASE PRESENTATION
- 69 Y/O F Hx AVR (BIOPROSTHETIC BIOCOR 23 MM 2006)
- SOB, FATIGUE, NEVER FELT MUCH BETTER AFTER SAVR
- BSA 2.2, 6 2’

Doppler Parameters of Prosthetic Aortic Valve Function

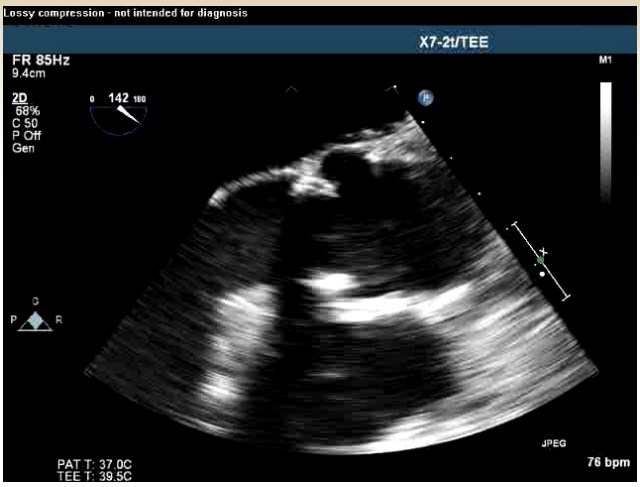
	Normal		Suggests Stenosis
Peak Velocity	< 3 m/s	4.1	> 4 m/s
Mean Gradient	< 20 mmhg	36	> 35 mmhg
Doppler Velocity Index	>= 0.3	0.25	< 0.25
Effective Orifice area	> 1.2 cm2	1	< 0.8 cm2
Contour of Jet	Triangular Early Peaking	TRI	Rounded Symmetrical contour
Acceleration Time	< 80 ms	74 ms	> 100 ms

An approach to prosthetic AV stenosis

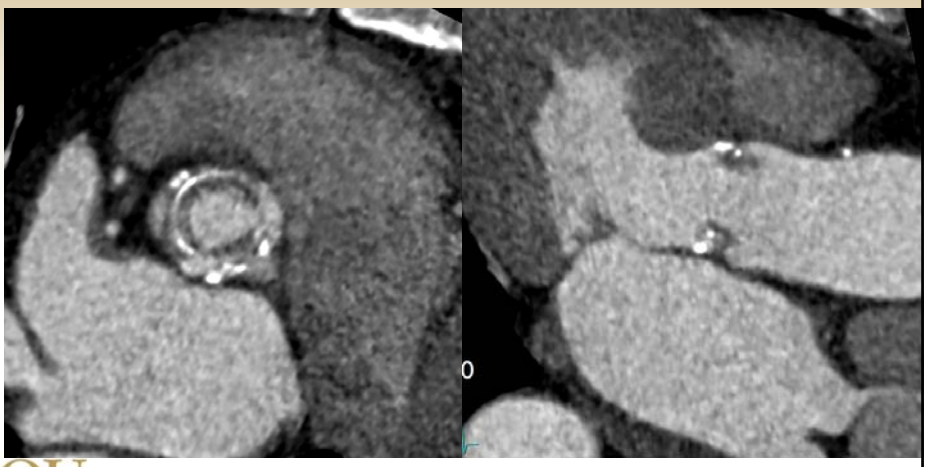
Indexed EOA = 0.5
PPM occurs when:
iEOA < 0.85
Severe if iEOA < 0.65



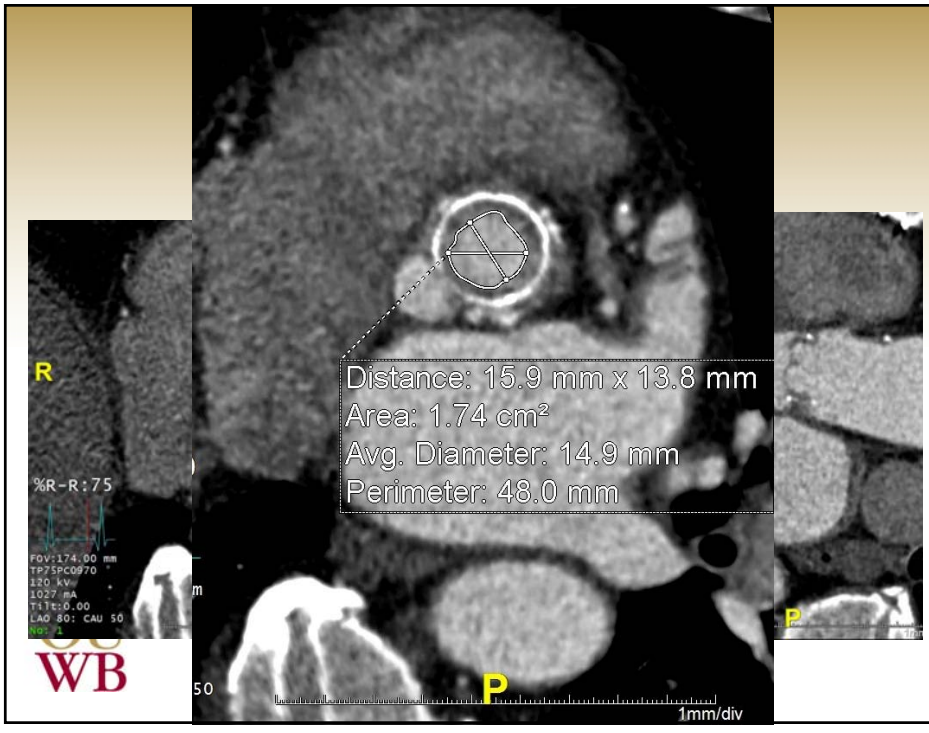
TEE



CTA SYSTOLE

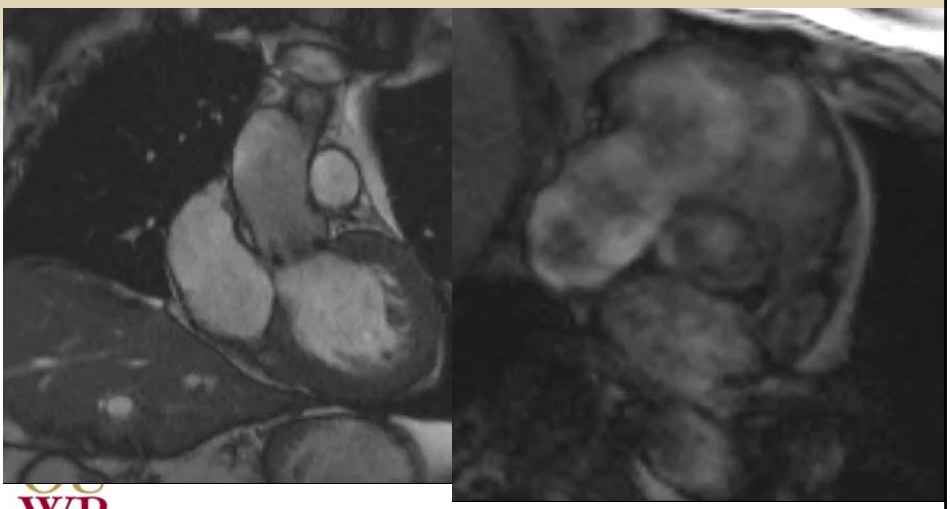


OU WB



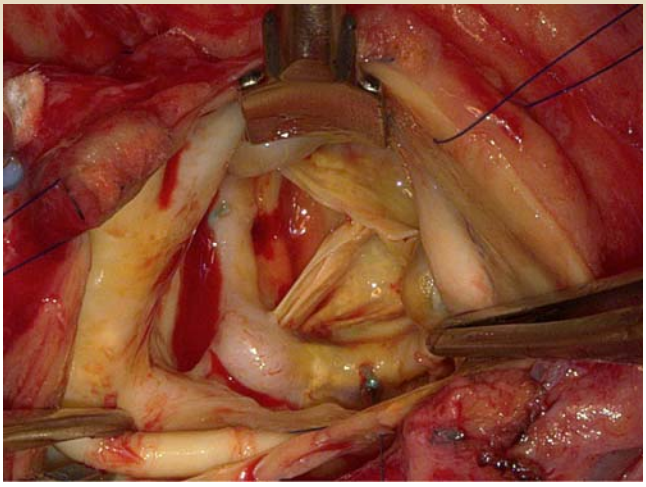
OU WB

MRI



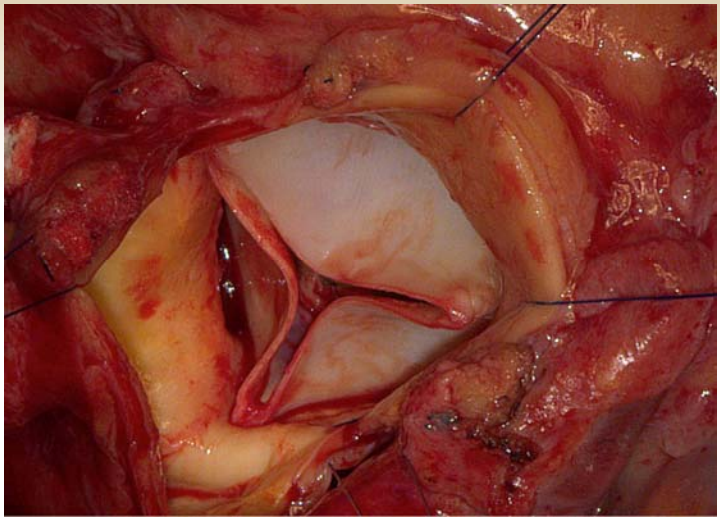
OU WB

SURGERY PRE



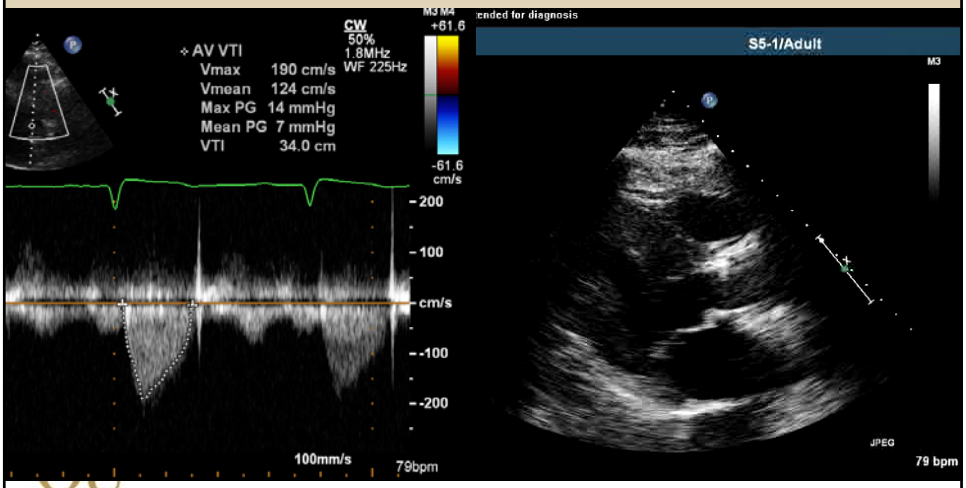
OU WB

SURGERY POST



OU WB

ECHO POST



OU WB

Echocardiographic Evaluation of Prosthetic Valve Regurgitation

Types of Regurgitation

- Regurgitation may be
  - Physiological
  - Pathological
- Physiological regurgitation
  - Closing volume (blood displacement by occluder motion)
  - At the hinges of occluder

Types of Regurgitation

- Pathological
  - Central
    - Mostly with bioprosthetic
    - Technical or infection related
  - Paravalvular
    - Either type, usually the site with mechanical
    - Mild is common after surgery (5-20%) and likely insignificant in the absence of infection
    - Usually after calcium debridement, redo, older patients
    - Hemolytic anemia
    - TAVR

OU WB

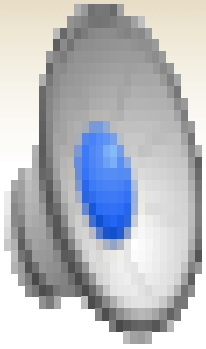
Central Aortic Regurgitation

OU WB

Central Aortic Regurgitation

OU WB

Central Aortic Regurgitation

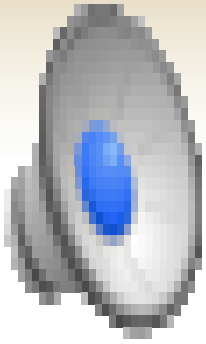


OU WB

Paravalvular Aortic Regurgitation

OU WB

Paravalvular Aortic Regurgitation



OU WB

Assessment of Prosthetic Aortic Valve Regurgitation: TTE

- Challenging due to
  - Shadowing
  - Eccentric Jet
  - Difficult to quantify paravalvular leak
- Width of vena contracta may be difficult to measure
- Off axis views may be required

OU WB

Assessment of Prosthetic Aortic Valve Regurgitation

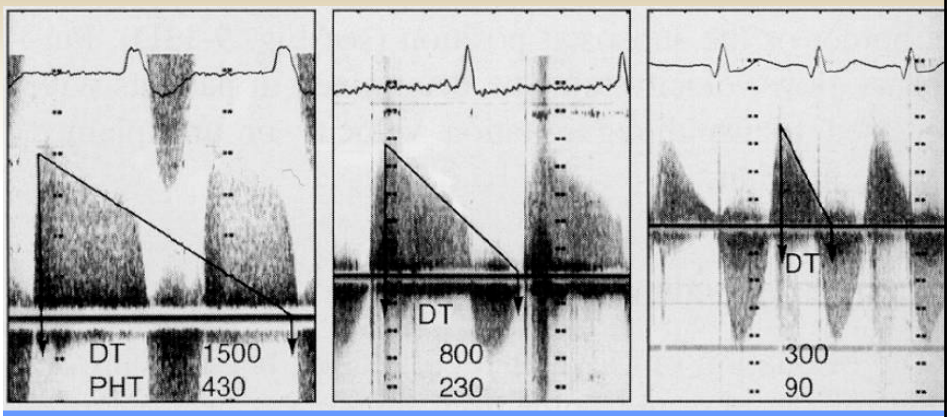
- Jet diameter/LVO diameter <25% in PS views
- Pressure Half Time < 200 ms
- Holodiastolic flow reversal in Descending aorta
- Neck in the short axis view
  - < 10% of sewing ring is mild
  - 10-20% moderate
  - > 20% severe
  - > 40% rocking motion

OU WB

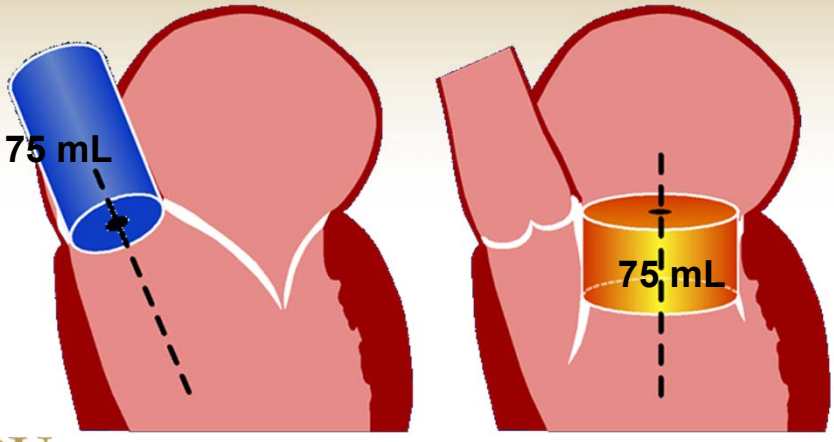
Assessment of Prosthetic Aortic Valve Regurgitation

Parameter	Mild	Moderate	Severe
Valve structure and motion			
Mechanical or bioprosthetic	Usually normal	Abnormal†	Abnormal†
Structural parameters			
LV size	Normal‡	Normal or mildly dilated‡	Dilated‡
Doppler parameters (qualitative or semiquantitative)			
Jet width in central jets (% LVO diameter): color*	Narrow (≤25%)	Intermediate (26%-64%)	Large (≥65%)
Jet density: CW Doppler	Incomplete or faint	Dense	Dense
Jet deceleration rate (PHT, ms): CW Doppler§	Slow (>500)	Variable (200-500)	Steep (<200)
LVO flow vs pulmonary flow: PW Doppler	Slightly increased	Intermediate	Greatly increased
Diastolic flow reversal in the descending aorta: PW Doppler	Absent or brief early diastolic	Intermediate	Prominent, holodiastolic
Doppler parameters (quantitative)			
Regurgitant volume (mL/beat)	<30	30-59	>60
Regurgitant fraction (%)	<30	30-50	>50

PROSTHETIC VALVE REGURGITATION



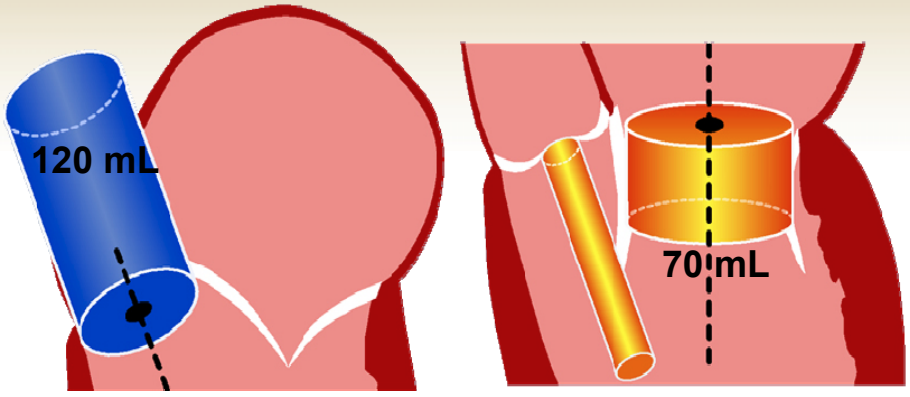
Assessment of Prosthetic Aortic Valve Regurgitation



NORMAL

OU WB

Assessment of Prosthetic Aortic Valve Regurgitation



AORTIC REGURGITATION

R Volume = 120-70 = 50 mL

R Fraction = 50/120 = 42%

OU WB

Assessment of Prosthetic Aortic Valve Regurgitation: TEE

- Identifies:
  - Location,
  - Mechanism,
  - AR width to LVOT width,
  - Posterior jets may be identified
- LVOT obscured by accompanied MV prosthesis
- 3D: value? Especially for transcatheter repair, challenging for AV versus MV

OU WB

TAVR ASSESSMENT

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Assessment of Prosthetic Valve Function After TAVR

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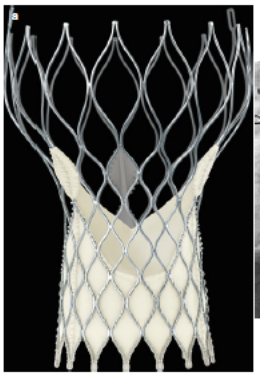
Assessment of Paravalvular Regurgitation Following TAVR

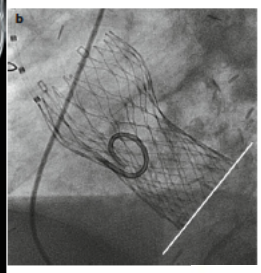
A Proposal of Unifying Grading Scheme

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

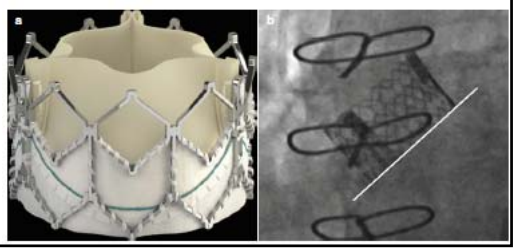
Trans-Catheter Valves

CORE VALVE SELF EXPANDING





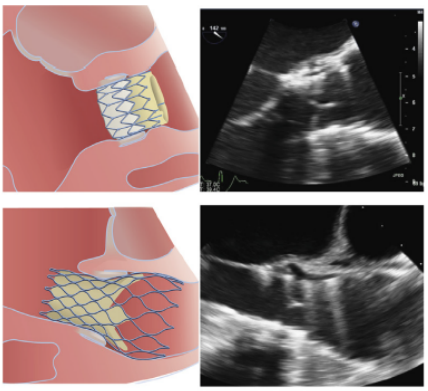
Sapien Balloon Expandable



OU WB

Trans-Catheter Valves

TAVR Follow-up:
What Are We Looking For?



VISUAL APPEARANCE
- Stent position
- Cusp mobility, thickness
- Color Doppler

→ Normal
→ TAV malposition

HEMODYNAMICS
- Mean gradient, peak velocity
- EOA, EOAi
- Regurgitation (circumferential extent, ERO, RV, PHT)

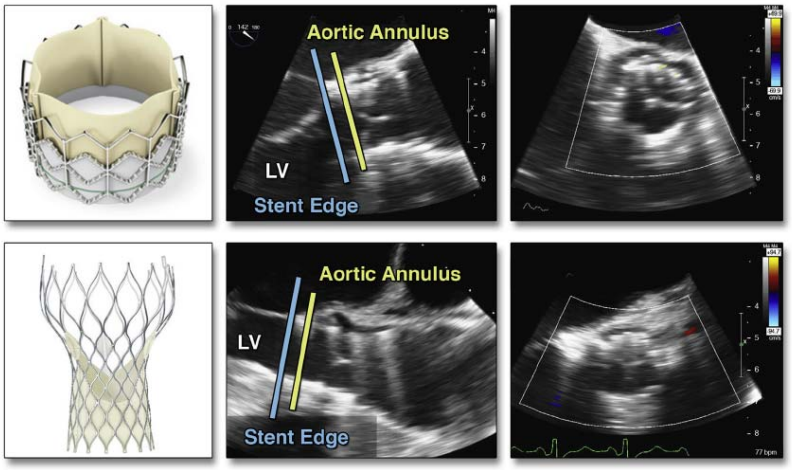
→ TAV thrombosis
→ TAV obstruction
→ TAV PPM
→ TAV regurgitation

OTHER STRUCTURES
- Mitral valve, aorta, coronaries

→ Mitral valve impingement
→ Aortic hematoma/dissection
→ Coronary obstruction

CARDIAC FUNCTION
- LV (size, SV, cardiac index)
- RV (size, function)

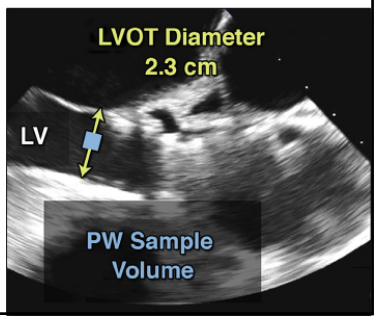
Trans-Catheter Valves



WB

Technical Points

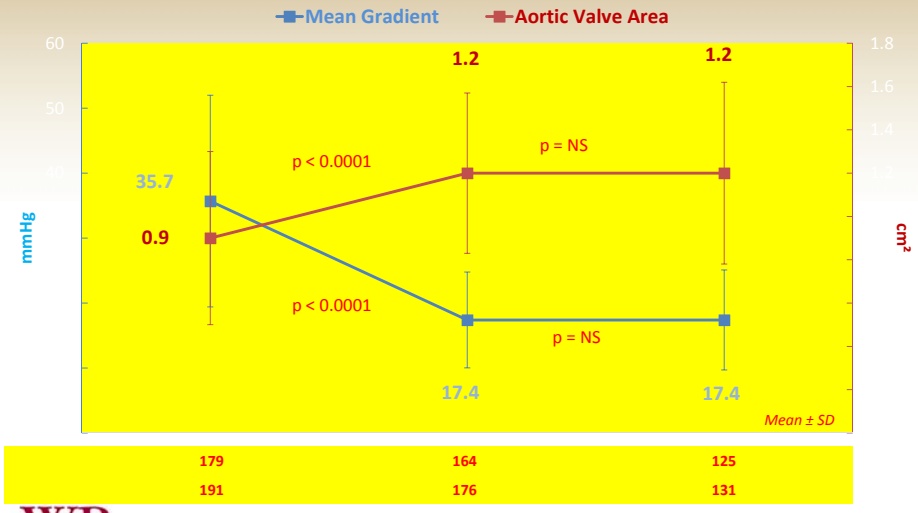
- PW at inferior border of stent
- LVOT diameter
  - Use baseline numbers prior to TAVR
  - BE TAVR: inferior border of stent
  - SE TAVR: inferior border of stent/ 5 mm below leaflets



OU WB

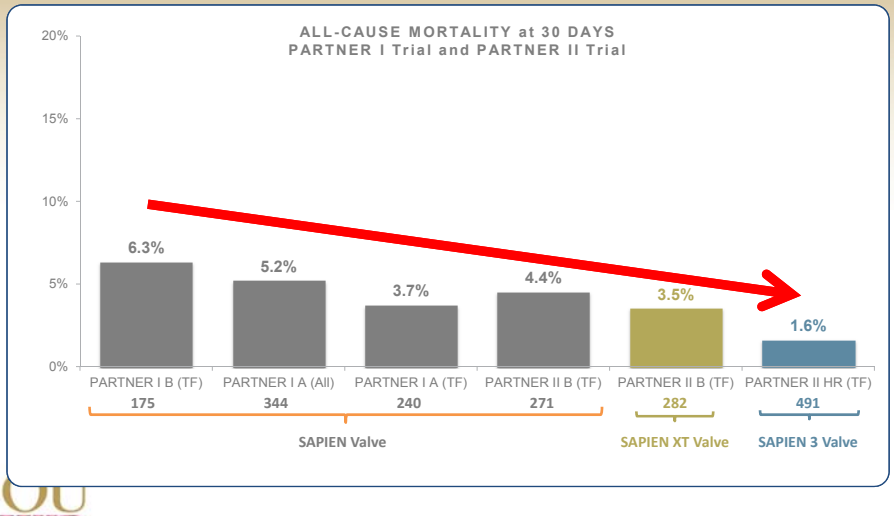
Echocardiographic Outcomes

Mean Gradient and Aortic Valve Area



WB

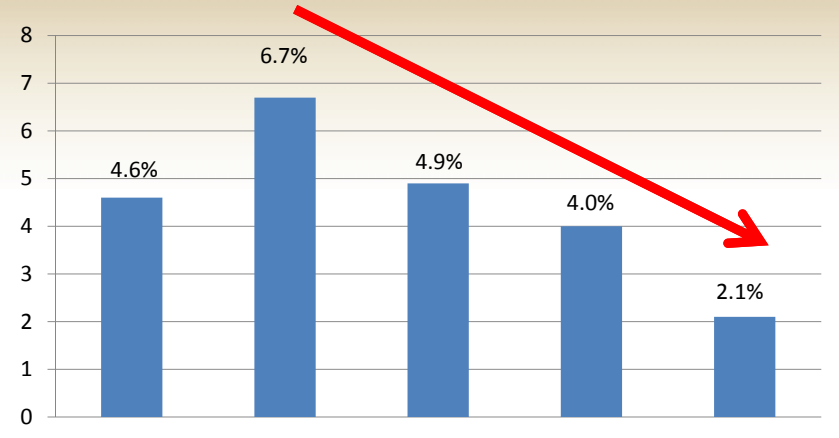
All-Cause Mortality Has Decreased Overall



OU WB

104

All Stroke at 30 Days



PARAVALVULAR REGURGITATION

Assessment of Paravalvular Regurgitation Following TAVR

A Proposal of Unifying Grading Scheme

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

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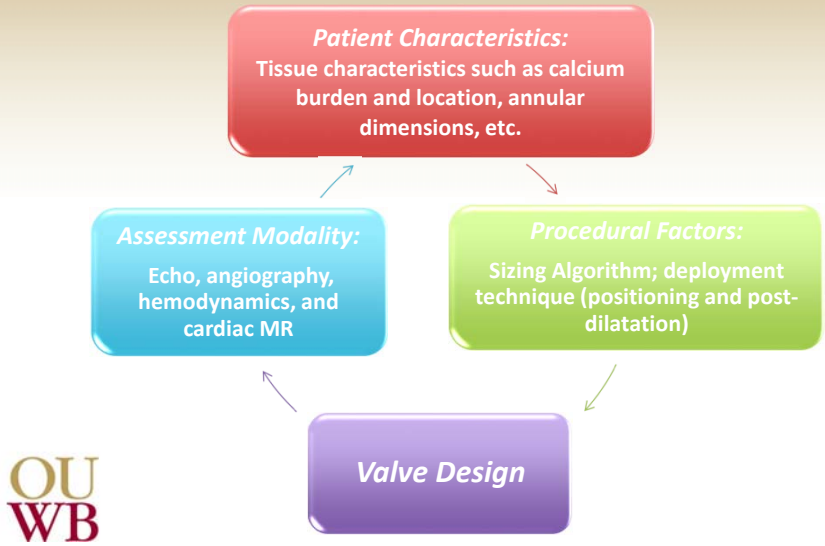
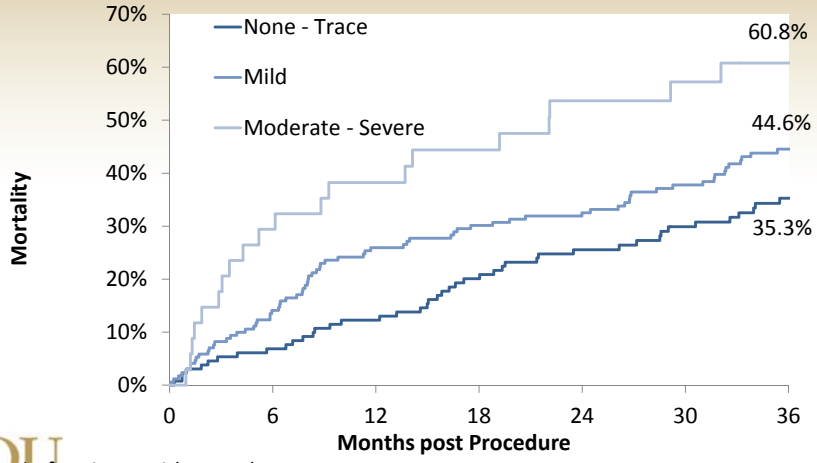
Determinants of PVR after TAVR



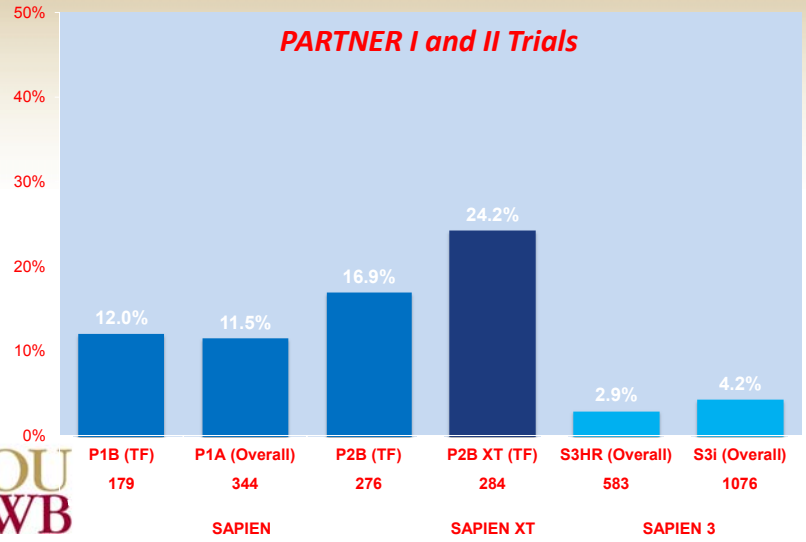
Impact of Aortic Regurgitation on Mortality: PARTNER Trial



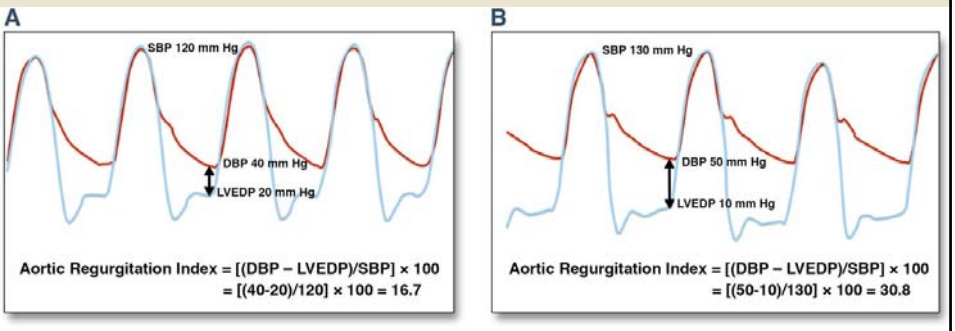
12-15% of patients with ≥ moderate AR

Moderate/Severe PVL at 30 Days

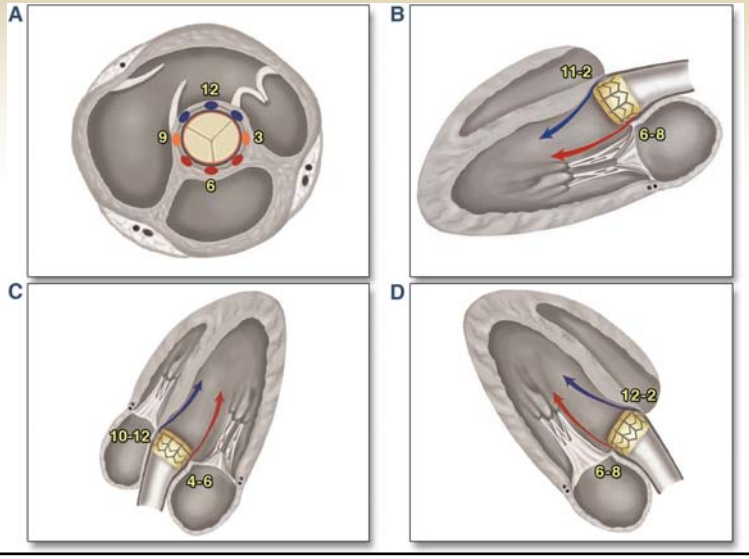
Edwards SAPIEN Valves



INVASIVE ASSESSMENT

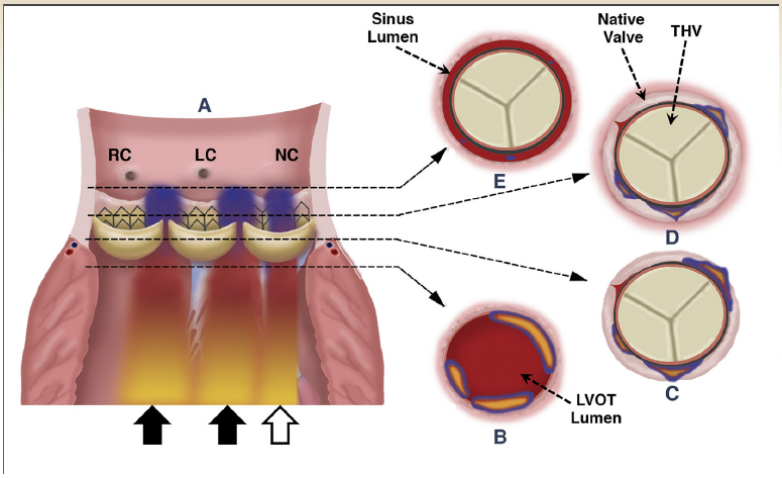


ECHOCARDIOGRAPHIC ASSESSMENT



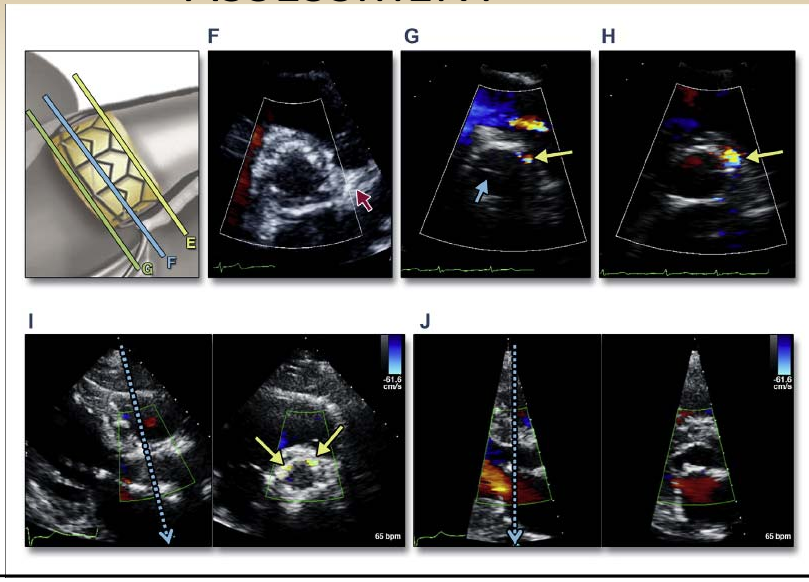
OU WB

ECHOCARDIOGRAPHIC ASSESSMENT



OU WB

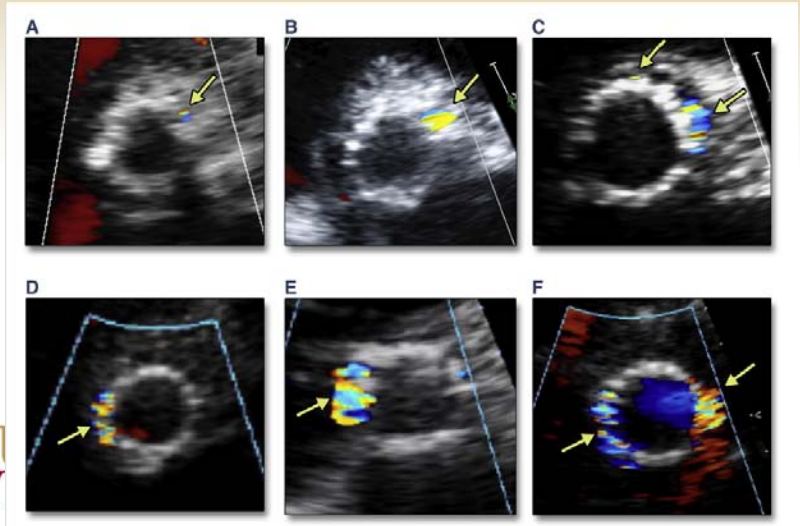
ECHOCARDIOGRAPHIC ASSESSMENT



TAVR PVR ASSESSMENT

3-Class Grading Scheme 4-Class Grading Scheme Unifying 5-Class Grading Scheme	Trace 1 Trace	Mild 1 Mild	Mild 2 Mild-to-Moderate	Moderate 2 Moderate	Moderate 3 Moderate-to-Severe	Severe 4 Severe
Cineangiography	Grade 1	Grade 1	Grade 1	Grade 2	Grade 3	Grade 4
Invasive hemodynamics						
Aortic regurgitation index*	>25	>25	>25	10-25	10-25	<10
Doppler echocardiography						
Structural parameters						
● Valve stent	Usually normal	Usually normal	Normal/abnormal†	Normal/abnormal†	Usually abnormal†	Usually abnormal†
○ LV size‖	Normal	Normal	Normal	Normal/mildly dilated	Mildly/moderately dilated	Moderately/severely dilated
Doppler parameters (qualitative or semiquantitative)						
● Jet features§						
Extensive/wide jet origin	Absent	Absent	Absent	Present	Present	Present
Multiple jets	Possible	Possible	Often present	Often present	Usually present	Usually present
Jet path visible along the stent	Absent	Absent	Possible	Often present	Usually present	Present
Proximal flow convergence visible	Absent	Absent	Absent	Possible	Often present	Often present
○ Vena contracta width (mm): color Doppler‖	<2	<2	2-4	4-5	5-6	>6
○ Vena contracta area (mm^2): 2D/3D color Doppler¶	<5	5-10	10-20	20-30	30-40	>40
● Jet width at its origin (%LVOT diameter): color Doppler‖	Narrow (<5)	Narrow (5-15)	Intermediate (15-30)	Intermediate (30-45)	Large (45-60)	Large (>60)
○ Jet density: CW Doppler	Incomplete or faint	Incomplete or faint	Variable	Dense	Dense	Dense
○ Jet deceleration rate (PHT, ms): CW Doppler*‡	Slow (>500)	Slow (>500)	Slow (>500)	Variable (200-500)	Variable (200-500)	Steep (<200)
○ Diastolic flow reversal in the descending aorta: PW Doppler	Absent	Absent or brief early diastolic	Intermediate	Intermediate	Holodiastolic (end-diast. vel. >20 cm/s)	Holodiastolic (end-diast. vel. >25 cm/s)
● Circumferential extent of PVR (%): color Doppler‖	<10	<10	10-20	20-30	>30	>30
Doppler parameters (quantitative)						
○ Regurgitant volume (ml/beat)#	<15	<15	15-30	30-45	45-60	>60
○ Regurgitant fraction (%)	<15	<15	15-30	30-40	40-50	>50
○ Effective regurgitant orifice area (mm^2)**	<5	<5	5-10	10-20	20-30	>30
Cardiac magnetic resonance imaging						
Regurgitant fraction (%)††	<10 <15	<10 <15	10-20 15-25	20-30 15-25	20-30 25-50	>30 >50

ECHOCARDIOGRAPHIC ASSESSMENT



OTHER TAVR ISSUES

- Infective endocarditis 1.1%
  - 62% 60 days-1 year
  - RF: DM, CKD, infections, Performance in cathlab
  - ABX, Surgical survival (38-75%
- Thrombosis 0.8%
  - RF Cancer, incomplete expansion, oveerhanging leaflets
  - Anticoagulation
- Structural failure 13 cases
  - 24 months (up to 5 years
  - Valve in valve

Echocardiographic Evaluation of Prosthetic Valve Endocarditis

OU WB

Endocarditis

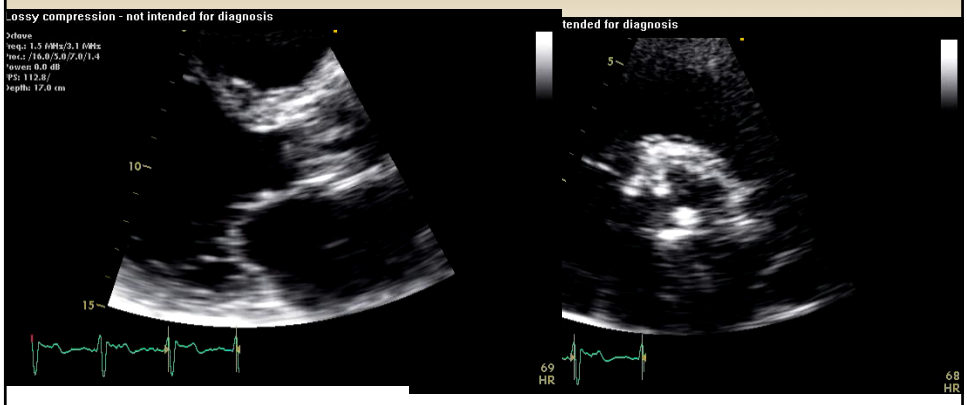
- Incidence < 1% and has declined with perioperative antibiotics
- Form in valve ring and extend to and spread to stent, occluder, or leaflet
- Irregular and independently mobile
- Can not adequately differentiate between vegetations, thrombus, pledgets, sutures, etc

OU WB

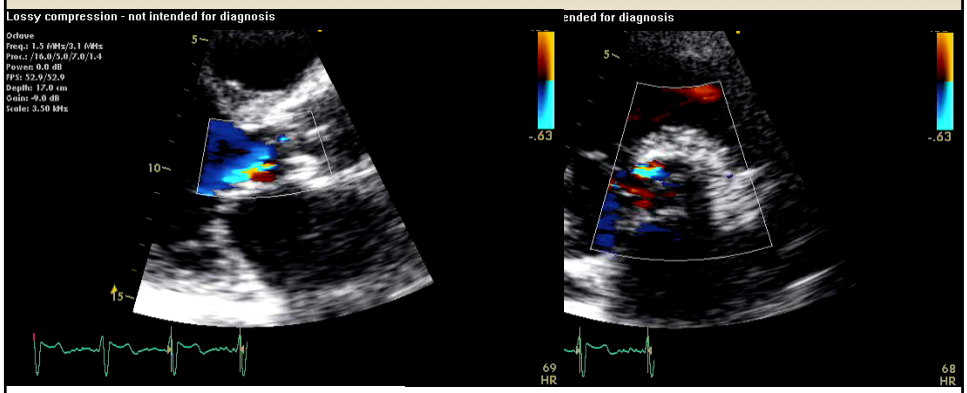
Endocarditis

- TEE has better sensitivity and specificity for
  - Vegetations
  - Abscess in the posterior but not anterior location
- Combined TEE and TTE have a NPV of 95%
- If clinical suspicion high and studies negative, repeat studies in 7-10 days

Parasternal Long



Color



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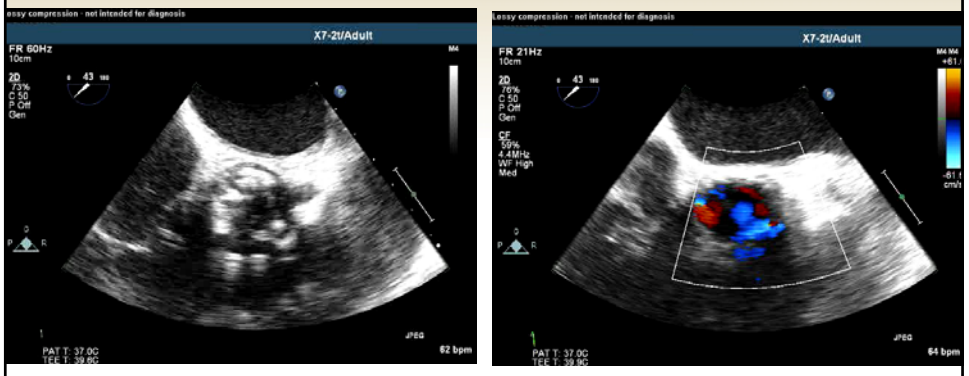
TEE Short



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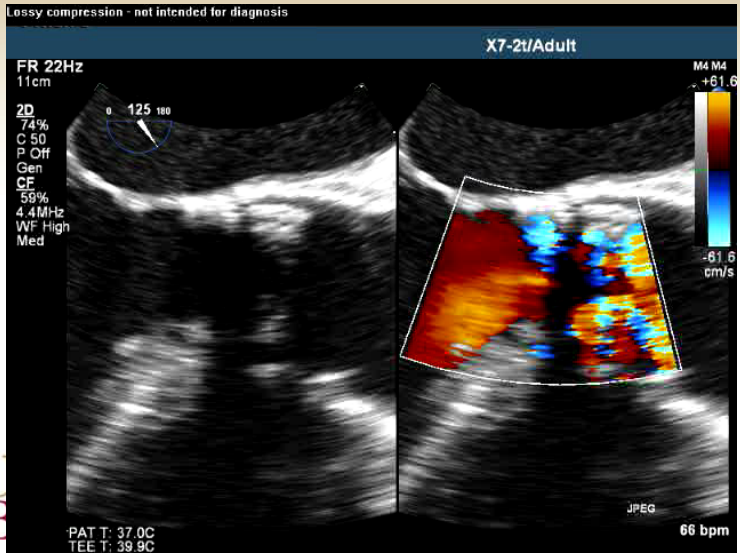
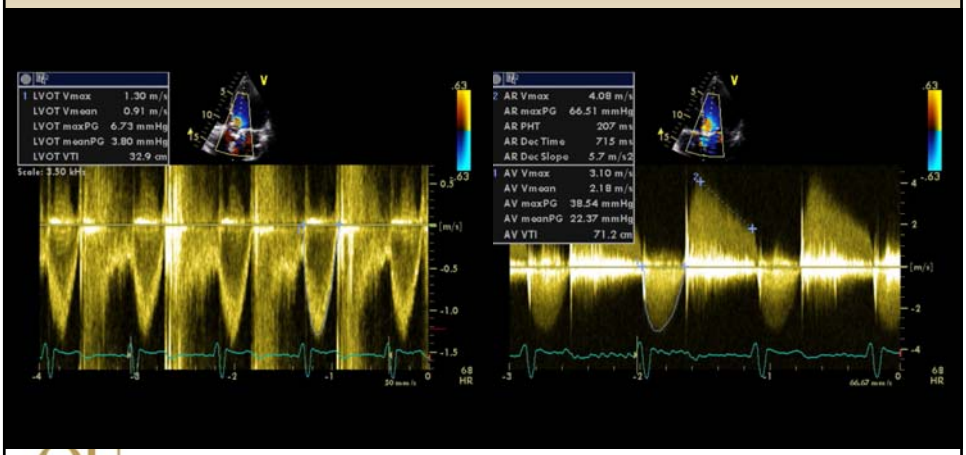
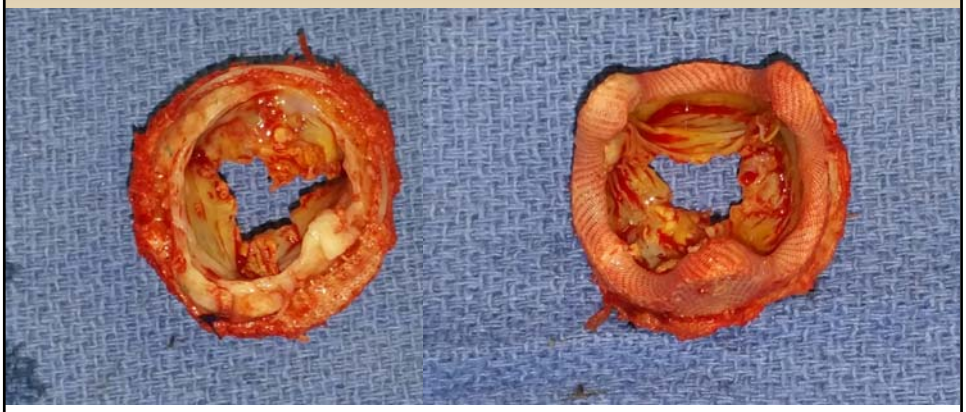
TEE Long



Doppler



Pathology



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Echocardiographic Evaluation of Prosthetic Valve Thrombosis/Pannus

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Thrombus versus Pannus

Thrombus

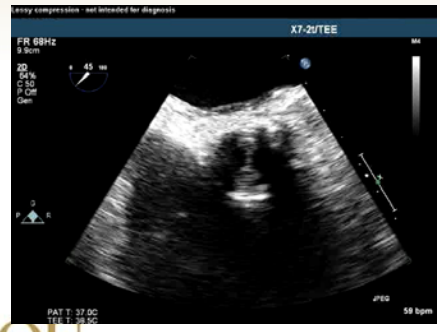
- Larger
- Soft density similar to myocardium
- More likely to encounter abnormal valve motion
- Short duration of symptom
- Poor anticoagulation
- Size < 0.85 cm2 less likely to embolize
- More with mechanical

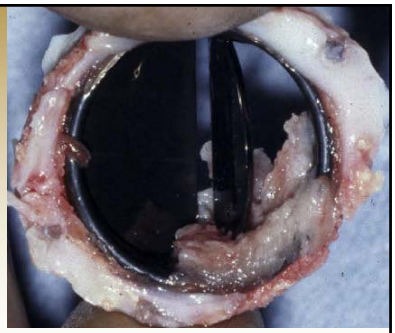
Pannus

- Small
- Dense, 30% may not be visualized
- Longer duration
- More common in aortic

Pannus

TEE





2014 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease

A Report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines

11.6 Prosthetic Valve Thrombosis

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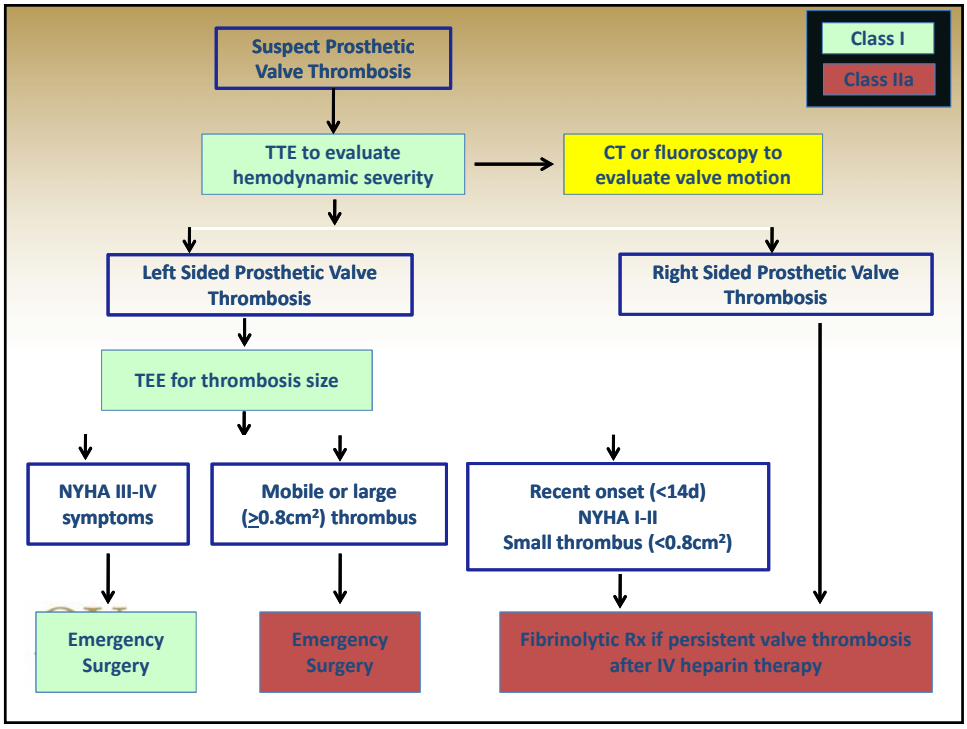

Pre Questions (1)

- Regarding Aortic Prosthetic Valves
  - A. A routine echocardiogram is required very two years after AVR
  - B. An elevated gradient with a decreased EOA is always suggestive of valvular stenosis
  - C. Transthoracic echocardiogram alone is always sufficient to diagnose valvular stenosis
  - D. It is more challenging to quantify para-valvular versus valvular aortic regurgitation.

Answer (1)

- D. It is more challenging to quantify para-valvular versus valvular aortic regurgitation.

Pre Questions (2)

- Patients with Prosthesis-Patient Mismatch
  - A. Have abnormal prosthetic valve function
  - B. Progressively worsen with time
  - C. Have a small valve compared to the demands of their body and cardiac output
  - D. Have a benign condition

Answer (2)

C. Have a small valve compared to the demands of their body and cardiac output

Conclusions

- Elevated gradients across prosthetic aortic valves may be due to other factors besides stenosis
- Regurgitation may be physiological or pathological and may be valvular or paravalvular
- Endocarditis, pannus, and thrombosis may be difficult to distinguish based solely on echocardiographic findings
- TAVR has its unique problems