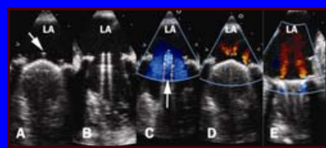
TEE Assessment of Prosthetic Valves



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Massachusetts General Hospital
Harvard Medical School

Lecture Outline

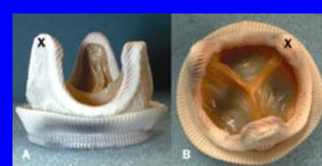
- Prosthetic Valve Construction
- Echo characteristics of PVs
- Intraoperative Assessment of PVs
- 10 General Principles

Prosthetic Valve Classification

- Bioprosthetic
  - Stented
  - Stentless
  - Transcatheter
- Mechanical
  - Bileaflet
  - Monoleaflet
  - Ball-cage
- Composite
- Homograft

Stented Bioprosthetic Valves: Porcine

Porcine



Carpentier Edwards
Med Hancock
Med Mosaic
SJM Biocor

Stented Bioprosthetic Valve: Porcine

1. Valve tissue
   - Porcine Ao Valve(s)
2. Frame (Stent)
   - *Elgiloy Struts* (3) serve as commissure supports*
3. Sewing ring
   - Suture ring (e.g., soft silicone rubber) for stitches
   - Cloth covering (PTFE or Dacron) to promote endothelial encapsulation

Stented Bioprosthetic Valves

Porcine: Carpentier-Edwards, Hancock, Mosaic, Biocor

Pericardial: Carpentier-Edwards, Sorin Mitroflow, Ionescu-Shiley

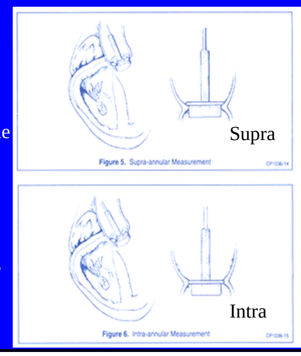
C-E PERIMOUNT Magna and Magna Ease

- Supra-annular design
- "Enables up to 23% greater EOA"
- State of the art tissue treatment eliminates up to 98% of calcium binding sites

Clinical note

Supra-annular Insertion

- Supra-annular
  - Sizer should be parallel to the plane of the annulus and the lip of the sizer sits in a supraannular position
- Intra-annular
  - Entire sizer and lip should fit in the annulus



CE Mitral vs Aortic Pericardial Valve

Aortic valve scalloped to conform to aortic root
If oversize can cause regurgitation (esp. with RSR)

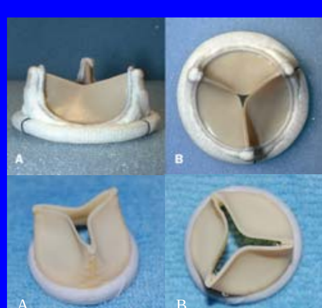
Stented Bioprosthetic Valve: Sorin Mitroflow Valve

- Mounting of pericardium outside the stent allows for unimpeded leaflet opening
- Supra-annular or intra-annular placement
- Only approved in US for AV position

C-E vs Sorin Pericardial Valve

Carpentier-Edwards

Sorin Mitroflow



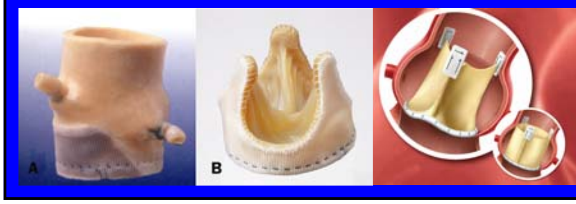
Key differences are location of commissural supports and central aperture

Stentless Bioprosthetic Valves

- Allow valve 1-2 sizes larger
- Increased EOA
- Decreased Gradient
- Theoretically less stress on leaflets
- However more complicated surgery

Stentless Bioprosthetic Valves

- Medtronic Freestyle—porcine (A)
- St Jude Toronto SPV—porcine (B)
- ATS 3f—equine pericardial



Medtronic Freestyle Valve

- Porcine Aortic Root
- No Stent
- Dacron ring
- 4 insertion options

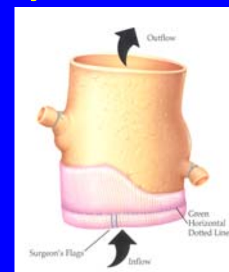
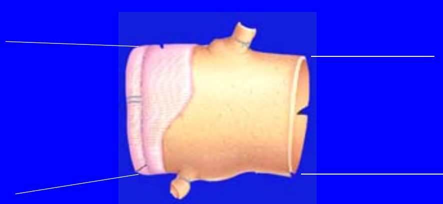


Figure 16: Freestyle Aortic Root Bioprosthesis

Freestyle Full Root Insertion



1. Annular suture line
2. STJ suture line
3. Coronary reimplantation

Freestyle Insertion--Subcoronary

Insertion steps

1. Excise R & L sinuses
2. Inflow suture line
3. Seat the bioprosthesis
4. Outflow suture line

**Note stitch issues

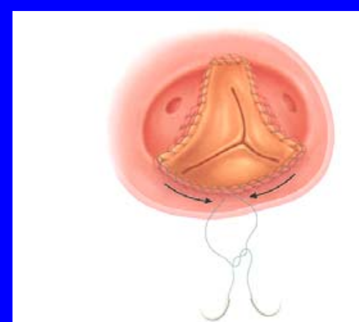
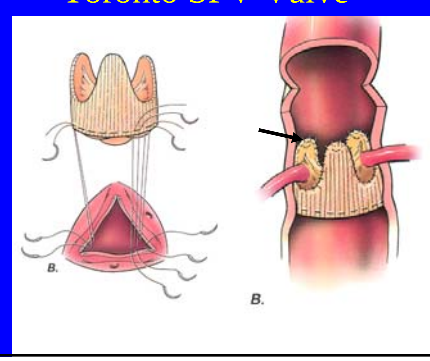


Figure 15: Completed Outflow Suture Line

St Jude Toronto SPV Valve

- Porcine valve
- Stentless subcoronary design
- One insertion option
- ST Junction size determines valve size
- Vulnerable to root dilation

Toronto SPV Valve



Medtronic ATS 3f—Pericardial Stentless Valve

- Three equine pericardial leaflets shaped in the form of a tube
- Less complex implant technique
  - Annular suture line
  - 3 commissural stitches

Medtronic ATS 3f Enable Valve

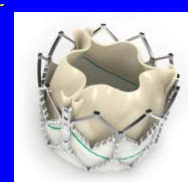
- First sutureless valve
- Bioprosthesis within a self-expanding nitinol frame
- Should decrease surgical time and XC period
- In European clinical trials

Transcatheter Bioprosthetic Aortic Valves

- Edwards SAPIEN valve
- Medtronic CoreValve (not FDA approved)

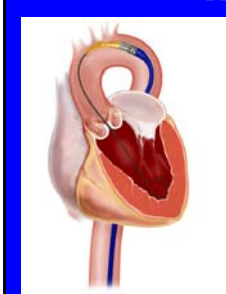
Edwards Transcatheter/Apical Aortic Valve

Edwards SAPIEN THV
- Bovine Pericardial Tissue
- 23 and 26mm Valves
- ThermaFix Process
- Leaflet Matching Technology



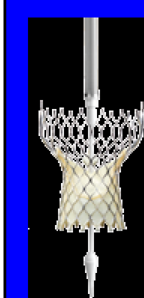
Edwards SAPIEN XT THV
- New Frame Design
  - Lower Crimp Profile Geometry
- New Leaflet Design
  - Scallop-shaped Design
- New Valve Design
  - Increased Leaflet Coaptation

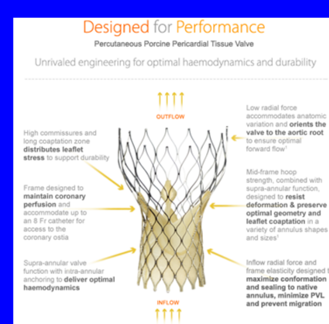
Edwards Transcatheter Sapien Aortic Valve



1. PAV
2. Catheter inserted across AV
3. Slide valve into position
4. Rapid V-pacing
5. Inflate balloon to open valve

Medtronic Core Valve



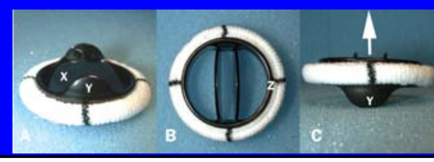


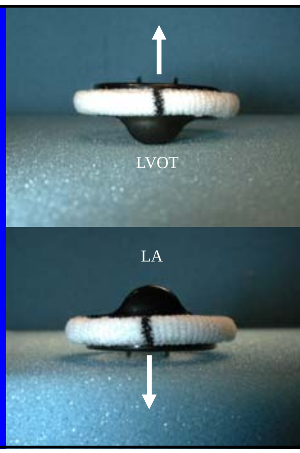
Mechanical Valves

Bileaflet	Single leaflet	Ball-cage
St Jude	Medtronic-Hall	Starr-Edward
Carbomedics (Sorin)	Bjork-Shiley	
ATS (Medtronic)	Omniscience	

St Jude Valve

- 2 semicircular leaflets attached to a midline hinge
- Hinge above sewing ring (pivot guard)
- Leaflets move from 30 to 85 degrees (55 degree travel arc)
- Typically rotatable
- AVs and MVs



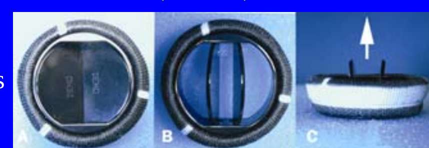


Aortic Position

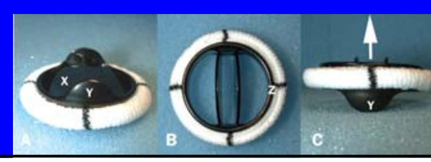
Mitral Position

Carbomedics (Sorin) Valve

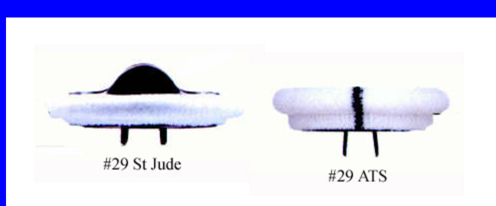
Carbomedics



St Jude



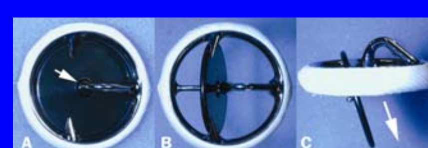
ATS (Medtronic) Valve



- Recently obtained by Medtonic

Single Tilting Disc Valves

Medtronic-Hall

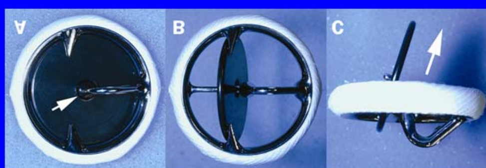


Bjork Shiley

Key differences are leaflet retention mechanism and the central aperture

Medtronic Hall Valve

- Opening arc is restricted (55-70 degrees)
- Creates a major and minor orifice
- Closure occurs by backpressure on valve disc



Medtronic Hall in motion

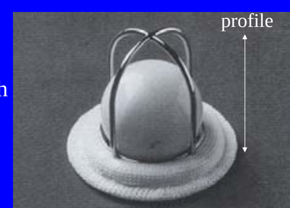
Bjork-Shiley Valve

- Discs held in place by two metal struts (inflow and outflow)
- Standard design very durable
- Convexo-Concavo valve subject to extensive recall in 1986*

*619/80,000 valves fractured and 2/3 patients died

Starr Edwards Valve

- Stellite alloy double cage
- Silicone rubber poppet
- Teflon/polypropylene cloth sewing ring

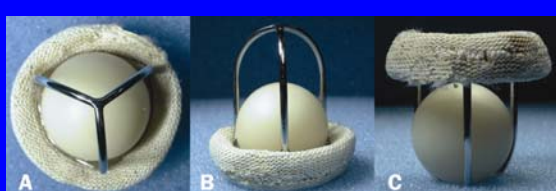


- High profile
- High gradient
- High risk thrombosis

Profile=height from base to top of struts

Weyman, Principles and Practice of Echocardiography

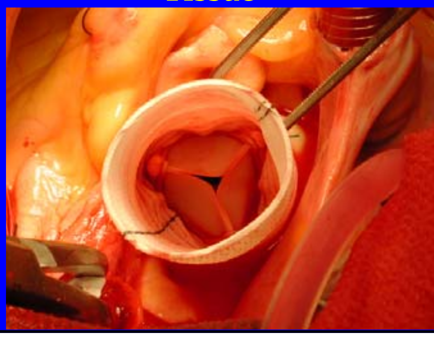
Starr Edwards



Composite Root Valves: Mechanical

St Jude Medical

Composite Root Valves: Tissue



Homograft

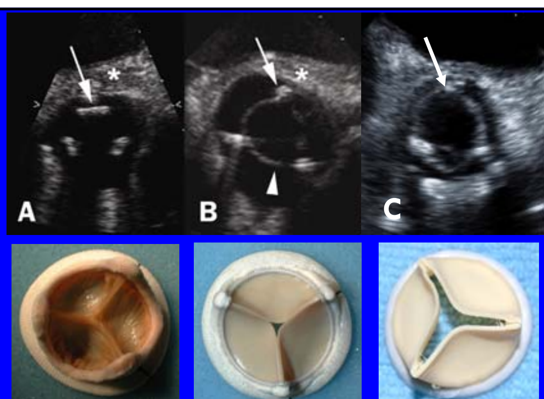
- Human cadaveric aortic and pulmonary valves
- Cryopreserved
- No Stent or Dacron ring
- Good for aortic root abscess Tx

Echo Assessment of Prosthetic Valves

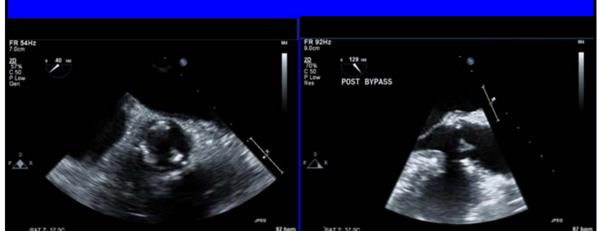
- 2-D
- Color Doppler
- Hemodynamics
- Look for Collateral Damage

Step 1: 2-D Exam

- What type of valve is it?
- Is the valve well-seated?
- Are the leaflets moving appropriately?
- Are there any extraneous masses present?

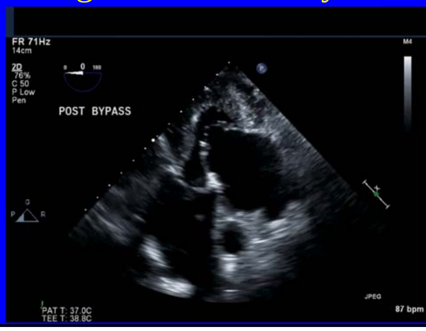


Assessment of Valve Seating and Leaflet Motion

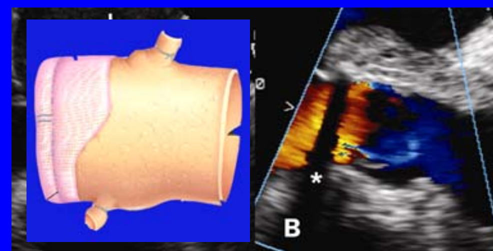


What type of valve is this?

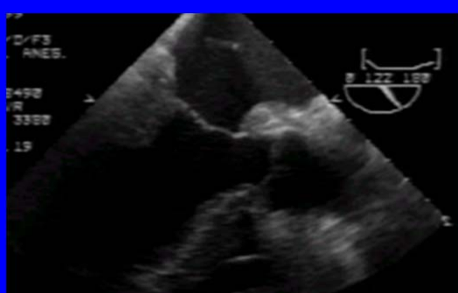
Assessment of Leaflet Motion—Transgastric views very useful



Stentless vs Stented Valves



Stentless Valves vs Homograft



Homograft has no shadow

Stentless Valve vs Homograft

A Homograft does not create an acoustic shadow

Transcatheter SAPIEN Aortic Valve

St Jude Valve Mitral Position

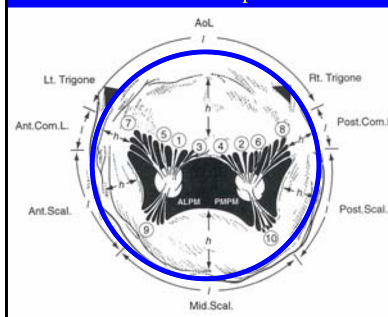
Leaflet motion easy to assess in the esophageal views
The appearance changes with the imaging plane

Clinical note

Orientation of the St Jude Valve

- Anatomic?
- Anti-anatomic?

Orientation of a Bileaflet valve in the mitral position

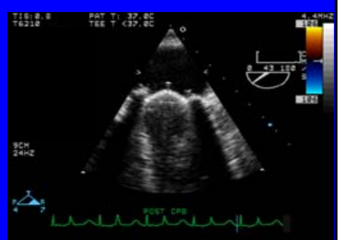


Anatomic

Anti-anatomic

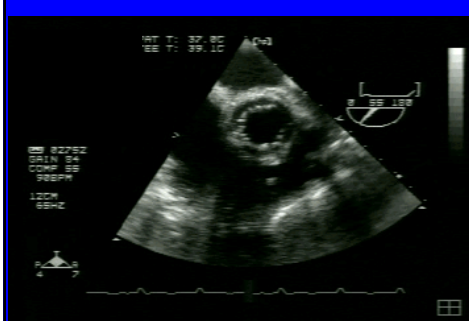
Orientation of the St Jude Valve

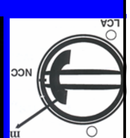
- Anatomic?
- Anti-anatomic?



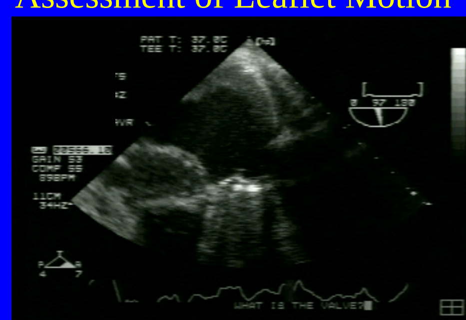
St Jude Valve Aortic Position Long Axis View

St Jude Aortic Position Post



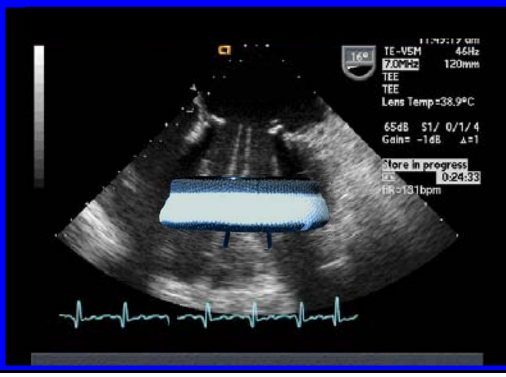


Assessment of Leaflet Motion

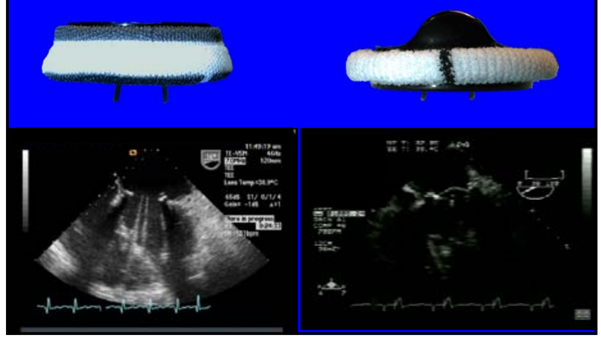


Aortic valve mechanical valve leaflet motion easy to assess in TGx views

Carbomedics in the Mitral Position



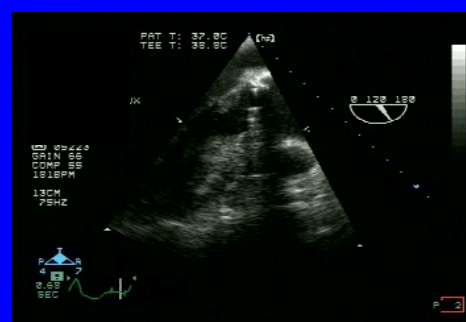
Carbomedics vs St Jude



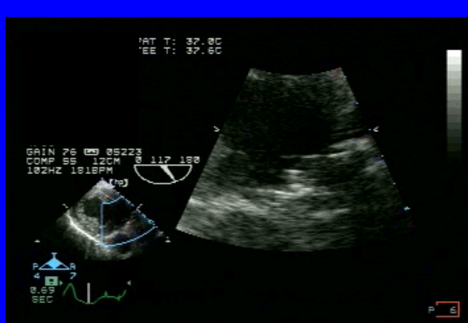
Medtronic Hall in Mitral Position

Orientation: Major Axis directed toward lateral wall

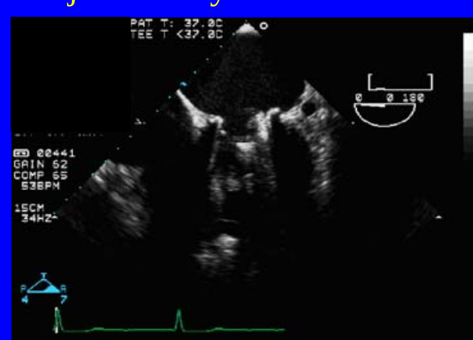
Medtronic Hall in Aortic Position



Medtronic Hall in Aortic Position



Bjork Shiley Mitral Valve

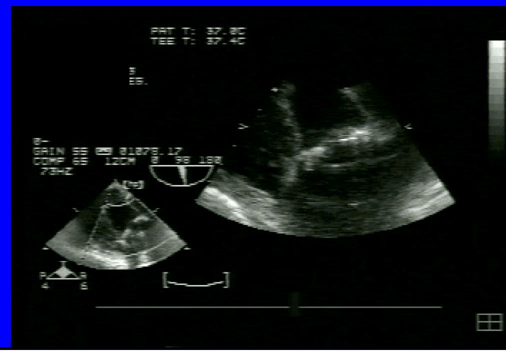


Atypical Orientation

Starr-Edwards Valve in Mitral Position

Note: Acoustic reverberation
Shadowing

Starr Edwards in Aortic Position



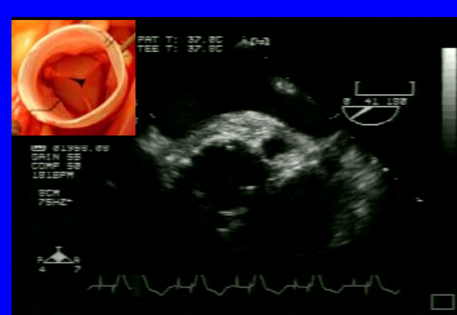
St Jude Composite Root

Medtronic-Hall Composite Graft

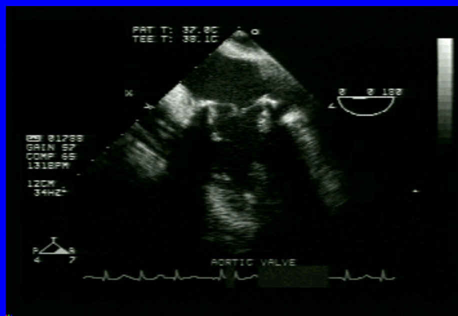
Review
Step 1: 2-D Exam

- What type of valve is it?
- Is the valve well-seated?
- Are the leaflets moving appropriately?
- Are there any extraneous masses present?

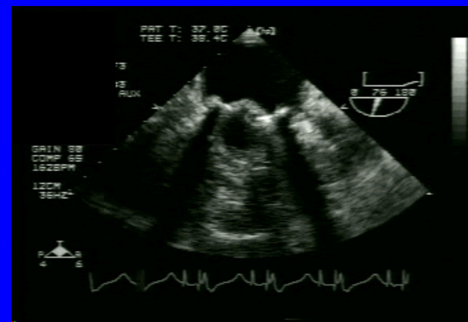
What kind of valve is this?



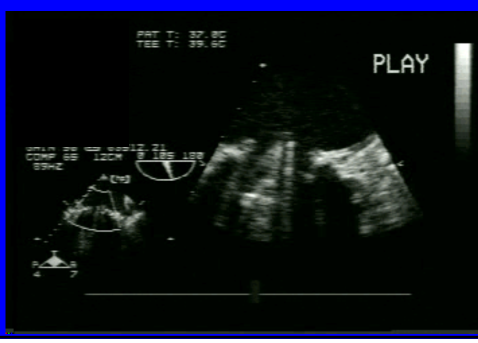
Is this valve well seated?



Are these leaflets moving normally?



Are there any extraneous masses?



Step 2: Color Doppler

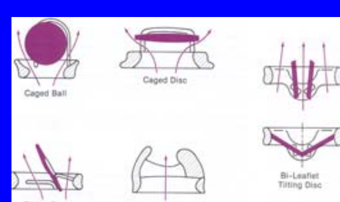
- Does the antegrade flow look normal?
- Are the normal washing jets present?
- Is there any intravalvular pathologic regurgitation?
- Is there a paraprosthetic leak?

Color Doppler Exam Essentials

1. Wide enough sector to see outside sewing ring
2. Omniplane 0-180 degrees
3. If confused: Freeze—slow motion replay

Is the Antegrade Flow Profile Normal?

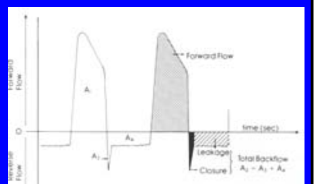
- Limited turbulence
- Symmetric flow with most valves



Are the Normal Washing Jets Present?

Regurgitant Jets

1. Closure backflow
   – Short duration
2. Leakage backflow*
   – After valve closes
   – Low velocity and uniform color
   – Low signal strength with CWD

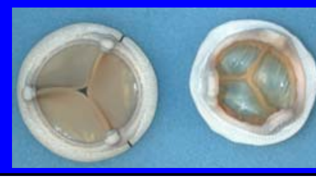


* A.K.A. Washing jets

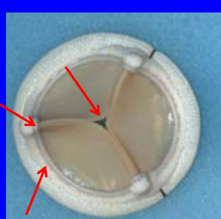
Weyman, Principles of Echo p1213

Bioprosthetic Regurgitation

- Should be minimal
- Occasionally occurs between leaflet edges
- More with C-E Perimount/Magna valves than porcine aortic valve or Mitroflow valve



C-E Pericardial Valves



- Trivial / trace to mild central regurgitation arising from free space
- One or more trivial jets along coaptation edge of the leaflets originating at the stent posts
- One or more trivial jets at the base of the valve through the cloth

Courtesy Edwards Lifescience

Mild Central MR

- Trace to mild central or commissural jets are commonly seen with mitral PERIMOUNT valves and are clinically insignificant

Courtesy Edwards Lifescience

Trivial Jets at Stent Posts

Courtesy Edwards Lifescience

Other Flow Patterns: Leakage through Cloth

- Occasionally seen on *both* porcine and pericardial valves
- Originates from base of stent post
- May see more than one symmetrical jet depending on view
- Unlike signature flow patterns, these jets have been observed to resolve intraoperatively following protamine

Courtesy Edwards Lifescience

Leakage through Cloth

- Pre-protamine
- Two symmetric commissural jets are noted
- Jets are low velocity, mild
- Number and direction of jets will vary depending on view

Courtesy Edwards Lifescience

C-E Pericardial Valves

- Commissural leaks and cloth leakage jets typically improve after time and protamine

Leakage through Cloth

- Post-protamine
- Four jets visible, magnitude greatly reduced from pre-protamine view

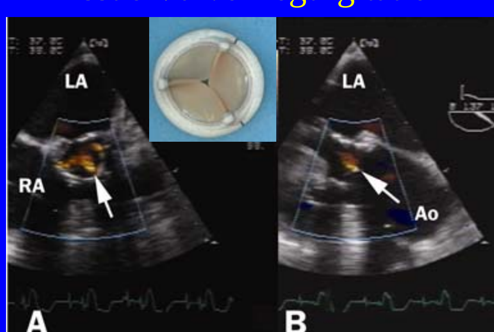
Courtesy Edwards Lifescience

Leakage through Cloth

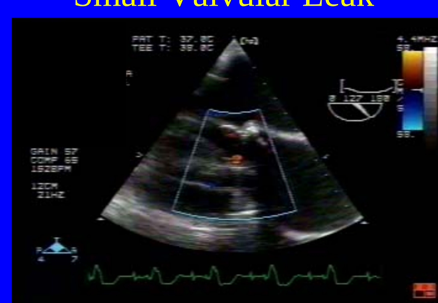
- Post-protamine, 2 min later
- Commissural jets not apparent
- Only tiny central jet apparent

Courtesy Edwards Lifescience

Tissue Valve Regurgitation



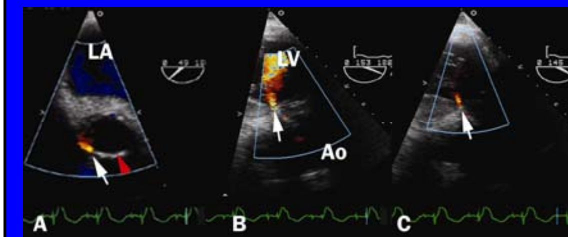
Aortic Pericardial Valve Small Valvular Leak



What would expect in the SAx view?

Aortic Pericardial Valve Valvular Leak

Tissue Valve Regurgitation



ME AV Sax | TGx LAx before protamine | TGx LAx after protamine

Paravalvular leaks

- Small, low velocity paravalvular leaks typically resolve after protamine.

Morehead, et al., Ann Thorac Surg 2000; 69:135-9

Abnormal Flow Patterns Associated with the C-E Pericardial valves

- Large, high velocity paravalvular leaks
- Eccentric jets (may be result of oversizing)
- Moderate or greater MR (may be result of suture looping, oversizing, or interference by subvalvular apparatus)

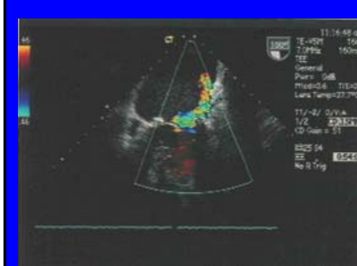
Courtesy Edwards Lifescience

Abnormal Flow: Moderate MR

- Moderate (2+ or greater) MR is not normal flow for PERIMOUNT valves

Courtesy Edwards Lifescience

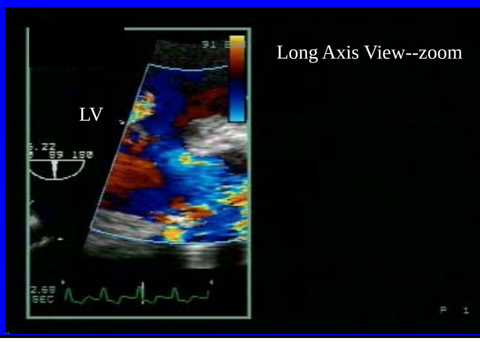
Abnormal Flow: Oversizing

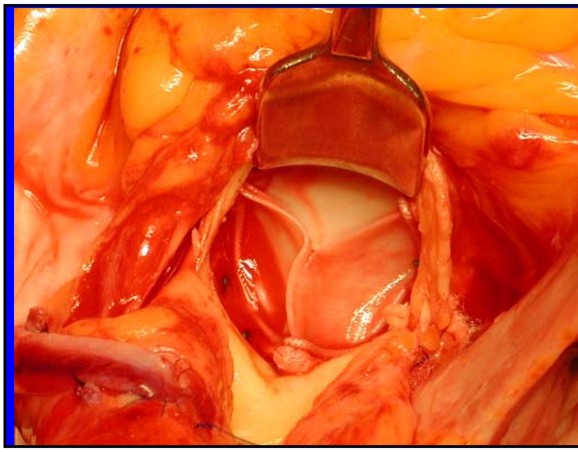


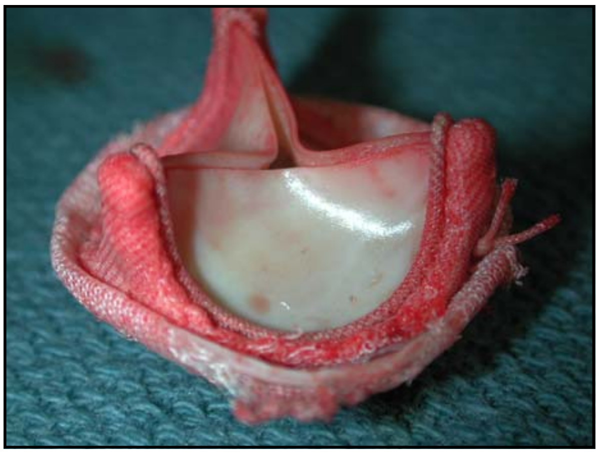
- Eccentric jets noted on echo
  - Severity of eccentric jets often underestimated
- This valve was explanted, found to be severely distorted at implant

Courtesy Edwards Lifescience

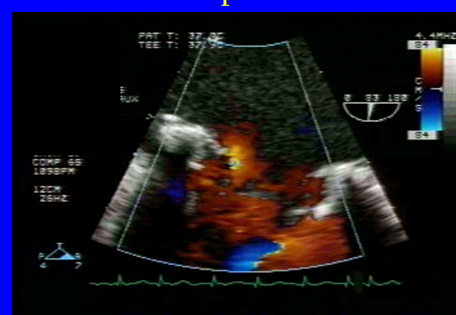
Abnormal C-E Perimount Regurgitation







Suture Looped over Post



C-E PERIMOUNT vs Sorin Mitroflow Valve

Sorin Mitroflow

Abnormal Regurgitation in a Sorin Mitroflow valve

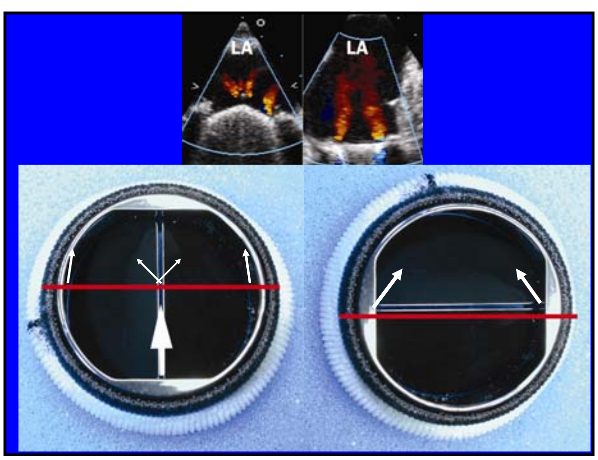
Transcatheter SAPIEN Valve

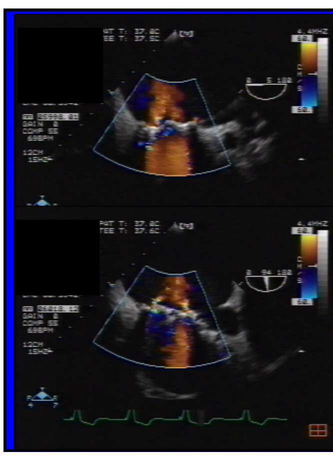
- May see paravalvular leaks
- Less likely to see intravalvular leaks once catheter removed

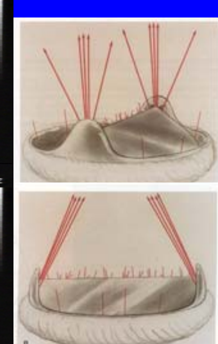
Mechanical Valve Regurgitation Sites

Two Key Principles Regarding Washing Jets for Mechanical Valves

- Dependent on the valve type
- Dependent on the imaging plane







Weyman, Principles of Echo

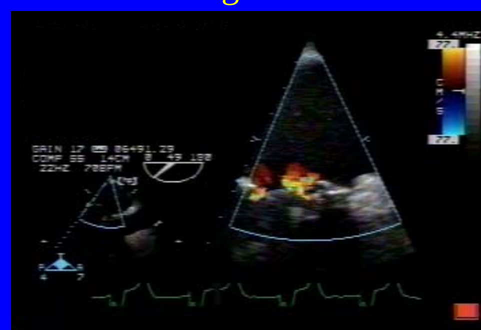
Classic St Jude Color Jets

St Jude Valve in Aortic Position

Post MVR Color Doppler II

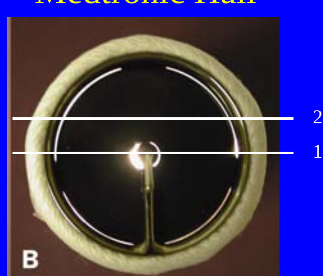
Notice more dominant central jets in this St Jude valve
Key: No paravalvular leak

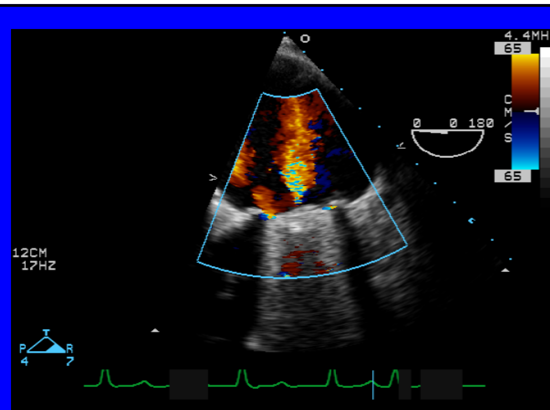
St Jude Washing Jets while on CPB



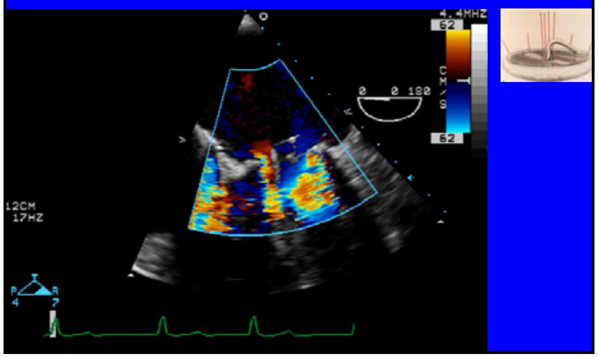
Washing jets may be exaggerated while on bypass

Prosthetic Valve Regurgitation Medtronic Hall

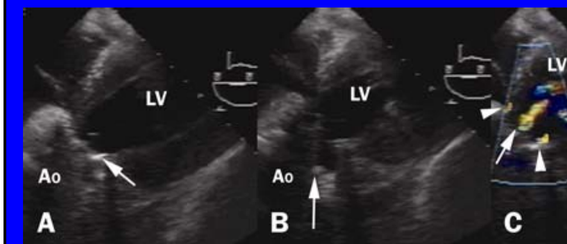




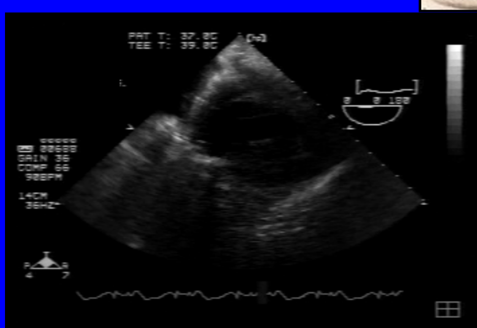
Medtronic Hall color Jets



Medtronic Hall in Aortic Position

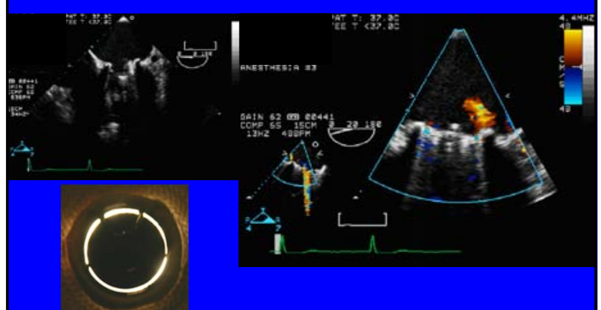


Medtronic Hall

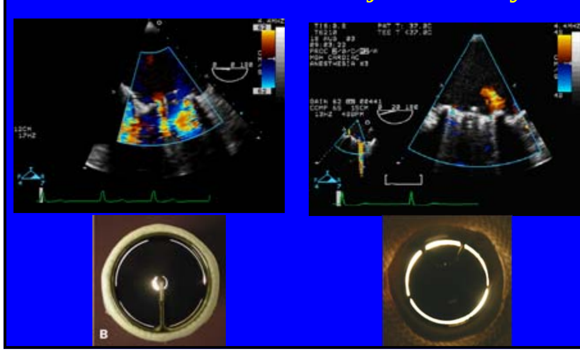


Deep Transgastric View

Bjork Shiley Mitral Valve

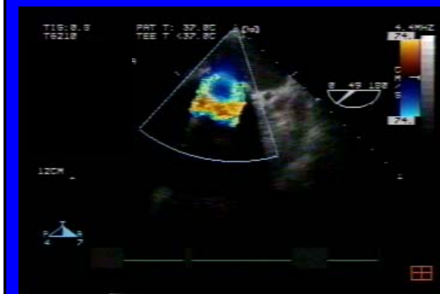


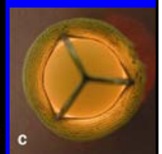
Medtronic Hall vs Bjork Shiley



St Jude vs Bjork Shiley

Starr Edwards Valve





There may be a transient closing jet, but no washing jet associated with a Starr-Edwards valve.

Summary of Mechanical Valve Washing Jets

• St Jude	1 leaflet: 2 lateral jets
	2 leaflets: small central and lateral jets
• Medtronic Hall	1 large central jet, 2 lateral
• Bjork Shiley	2 lateral jets
• Starr Edwards	2 curved closing jet
	no washing jets

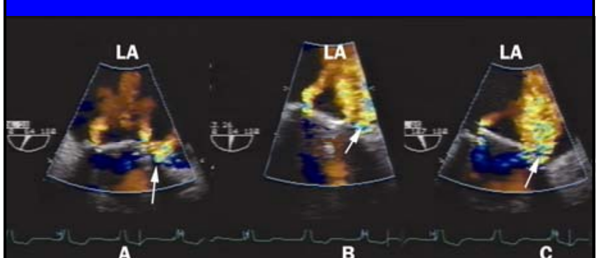
Normal vs Pathologic Regurgitation

- Normal (expected) Regurgitation
  - Short duration
  - Low velocity and uniform color
  - Low signal strength with CWD
- Pathologic Regurgitation
  - Deeply penetrating jets
  - High velocity
  - Non-homogenous jets
  - PISA in the proximal chamber
  - Anything outside the sewing ring

Intraprosthetic vs Paraprosthetic?

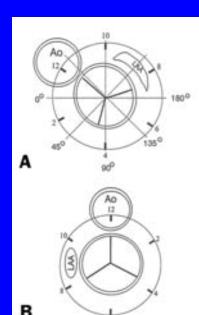
- Use multiple views
- Use color suppress
- Use zoom and slow motion replay
- 3-D

Mapping a Paraprosthetic Leak

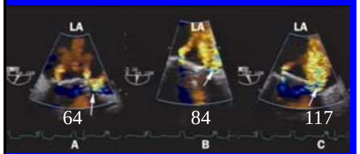


64 degrees 84 degrees 107 degrees

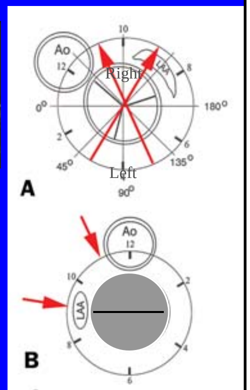
Mitral Valve Mapping



Mapping the Paravalvular leak:
Isselbacher, Foster, Picard, et al.
Ann Thorac Surg 1998;65: 1025
Also see my handout



1. Start at 0 degrees and center the valve
2. “Omniplane” until see PV leak
3. Check Omniplane angle
4. If jet on left (bottom)
5. If jet on right (top)
6. Rotate to surgeon’s view



Ann Thorac Surg 1998;65: 1025

Review
Step 2: Color Doppler

- Does the antegrade flow look normal?
- Are the normal washing jets present?
- Is there any intravalvular pathologic regurgitation?
- Is there a paraprosthetic leak?

Step 3: Hemodynamics

- Valve Specific Assessment
  - Velocity
  - Gradients
  - Area calculation

Hemodynamics: Aortic Valve

- Peak Velocity
- Peak and Mean Gradient
- Doppler Velocity Index (DVI)
- Effective Orifice Area (EOA) and Index (EOAI)

ASE PV Guidelines Document
Assessment of Prosthetic AV stenosis

Table 5 Doppler parameters of prosthetic aortic valve function in mechanical and stented biologic valves*

Parameter	Normal	Possible stenosis	Suggests significant stenosis
Peak velocity (m/s)†	<3	3-4	>4
Mean gradient (mm Hg)†	<20	20-35	>35
DVI	≥0.30	0.29-0.25	<0.25
EOA (cm^2)	>1.2	1.2-0.8	<0.8
Contour of the jet velocity through the PrAV	Triangular, early peaking	Triangular to intermediate	Rounded, symmetrical contour
AT (ms)	<80	80-100	>100

PrAV, Prosthetic aortic valve.
*In conditions of normal or near normal stroke volume (50-70 mL) through the aortic valve.
†These parameters are more affected by flow, including concomitant AR.

JASE 2009; 22(9):990

Post Aortic St Jude Valve
Transgastric View with CWD

Peak AV Velocity

Table 5 Doppler parameters of prosthetic aortic valve function in mechanical and stented biologic valves*

Parameter	Normal	Possible stenosis	Suggests significant stenosis
Peak velocity (m/s)†	<3	3-4	>4
Mean gradient (mm Hg)†	<20	20-35	>35
DVI	≥0.30	0.29-0.25	<0.25
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Contour of the jet velocity through the PrAV	Triangular, early peaking	Triangular to intermediate	Rounded, symmetrical contour
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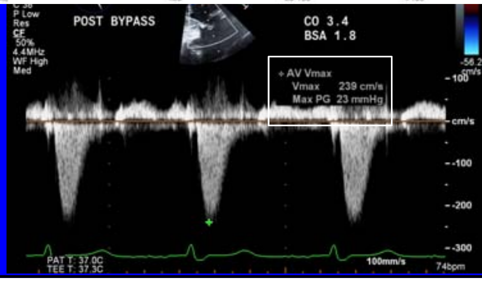

Gradients

Table 5 Doppler parameters of prosthetic aortic valve function in mechanical and stented biologic valves*

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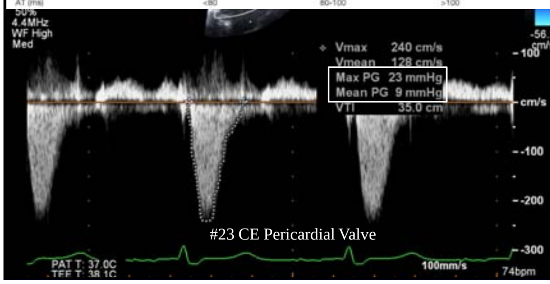
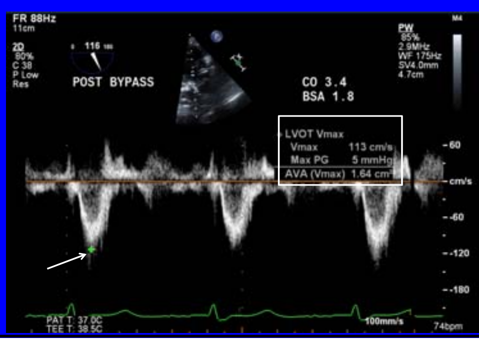
Contour of the jet velocity through the PrAV	Triangular, early peaking	Triangular to intermediate	Rounded, symmetrical contour
AT (ms)	<80	80-100	>100



Peak LVOT velocity



Doppler Velocity Index

- DVI = $\frac{\text{LVOT velocity}}{\text{AV velocity}}$

  = $\frac{1.1 \text{ m/s}}{2.4 \text{ m/s}}$

  = .46

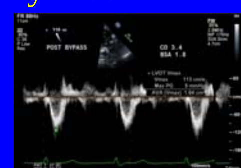


Table 5 Doppler parameters of prosthetic aortic valve function in mechanical and stented biologic valves*

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AT (ms)	<80	80-100	>100

Effective Orifice Area

- EOA = $.785 D^2 \times \frac{VTI_{LVOT}}{VTI_{AV}}$

  = $.785(2.1^2) \times 1.1 / 2.4$

  = 1.58 cm^2

Table 5 Doppler parameters of prosthetic aortic valve function in mechanical and stented biologic valves*

Parameter	Normal	Possible stenosis	Suggests significant stenosis
Peak velocity (m/s)†	<3	3-4	>4
Mean gradient (mm Hg)†	<20	20-35	>35
DVI	≥0.30	0.29-0.25	<0.25
EOA (cm²)	>1.2	1.2-0.8	<0.8
Contour of the jet velocity through the PrAV	Triangular, early peaking	Triangular to intermediate	Rounded, symmetrical contour
AT (ms)	<80	80-100	>100

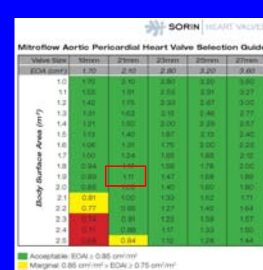
May substitute the velocity for VTI

Effective Orifice Area Index

- EOA/BSA = $1.58 \text{ cm}^2 / 1.8 \text{ m}^2$

  = $.88 \text{ cm}^2/\text{m}^2$

Acceptable EOAI	> .85
Marginal EOAI	.75 - .85
Unacceptable EOAI	< .75



ASE PV Guidelines Document
Assessment of Prosthetic AV stenosis

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Peak velocity (m/s)†	<3	3-4	>4
Mean gradient (mm Hg)†	<20	20-35	>35
DVI	≥0.30	0.29-0.25	<0.25
EOA (cm^2)	>1.2	1.2-0.8	<0.8
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PrAV, Prosthetic aortic valve.
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†These parameters are more affected by flow, including concomitant AR.

JASE 2009; 22(9):990

ASE PV Guidelines Document
Appendix A

Appendix A. Normal Doppler Echocardiographic Values for Prosthetic Aortic Valves*

Valve	Size	Peak gradient (mm Hg)	Mean gradient (mmHg)	Effective orifice area (cm^2)
ATS *Bileaflet*	19	47.0± 12.6	25.3± 8.0	1.1± 0.3
	21	23.7± 6.8	15.9± 5.0	1.4± 0.5
	23		14.4± 4.9	1.7± 0.5
	25		11.3± 3.7	2.1± 0.7
	27		8.4± 3.7	2.5± 0.1
	29		8.0± 3.0	3.1± 0.8
ATS AP *Bileaflet*	18		21.0± 1.8	1.2± 0.3
	20	21.4± 4.2	11.1± 3.5	1.3± 0.3
	22	18.7± 8.3	10.5± 4.5	1.7± 0.4
	24	15.1± 5.6	7.5± 3.1	2.0± 0.6
	26		6.0± 2.0	2.1± 0.4
Baxter Perimount *Stented bovine pericardial*	19	32.5± 8.5	19.5± 5.5	1.3± 0.2
	21	24.9± 7.7	13.8± 4.0	1.3± 0.3
	23	19.9± 7.4	11.5± 3.9	1.6± 0.3
	25	16.5± 7.8	10.7± 3.8	1.6± 0.4
	27	12.8± 5.4	4.8± 2.2	2.0± 0.4
Biocor *Stented porcine*	23	30.0± 10.7	20± 6.6	1.3± 0.3
	25	23.0± 7.9	16± 5.1	1.7± 0.4
	27	22.0± 6.5	15.0± 3.7	2.2± 0.4
Extended Biocor *Stentless*	19-21	17.5± 6.5	9.6± 3.6	1.4± 0.4
	23	14.7± 7.3	7.7± 3.8	1.7± 0.4
	25	14.0± 4.3	7.4± 2.5	1.8± 0.4
Bioflo *Stented bovine pericardial*	19	37.2± 8.8	26.4± 5.5	0.7± 0.1
	21	28.7± 6.2	18.7± 5.5	1.1± 0.1
	21	38.9± 11.9	21.8± 3.4	1.1± 0.3

JASE 2009; 22(9):1010

Hemodynamics: Mitral Valve

- Peak Velocity
- Peak and Mean Gradient
- Pressure Half-Time (PHT)
- Effective Orifice Area (EOA)

ASE PV Guidelines Document
Assessment of Prosthetic Mitral Valves

Table 8 Doppler parameters of prosthetic mitral valve function

	Normal*	Possible stenosis‡	Suggests significant stenosis*‡
Peak velocity (m/s)†§	<1.9	1.9-2.5	≥2.5
Mean gradient (mm Hg)†§	≤5	6-10	>10
VTI_{PrMV}/VTI_{LVO}†§	<2.2	2.2-2.5	>2.5
EOA (cm^2)	≥2.0	1-2	<1
PHT (ms)	<130	130-200	>200

PHT, Pressure half-time; *PrMV*, prosthetic mitral valve.
*Best specificity for normality or abnormality is seen if the majority of the parameters listed are normal or abnormal, respectively.
†Slightly higher cutoff values than shown may be seen in some bioprosthetic valves.
‡Values of the parameters should prompt a closer evaluation of valve function and/or other considerations such as increased flow, increased heart rate, or PPM.
§These parameters are also abnormal in the presence of significant prosthetic MR.

JASE 2009; 22(9):996

Mitral Valve Gradients

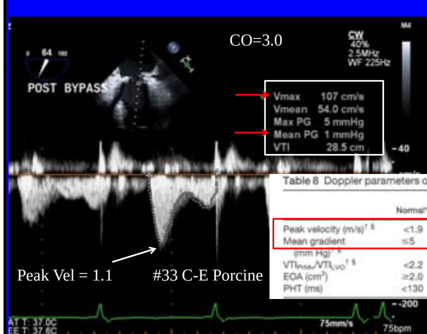


Table 8 Doppler parameters of prosthetic mitral valve function

	Normal*	Possible stenosis‡	Suggests significant stenosis*‡
Peak velocity (m/s)†§	<1.9	1.9-2.5	≥2.5
Mean gradient (mm Hg)†§	≤5	6-10	>10
VTI_{PrMV}/VTI_{LVO}†§	<2.2	2.2-2.5	>2.5
EOA (cm^2)	≥2.0	1-2	<1
PHT (ms)	<130	130-200	>200

Mitral Valve PHT

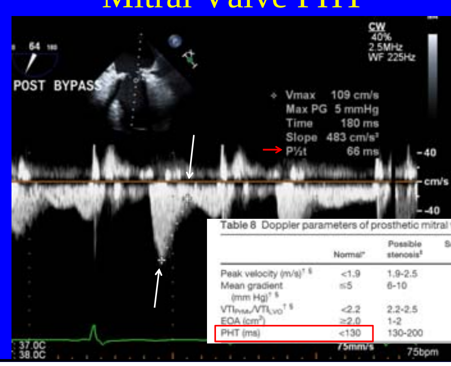


Table 8 Doppler parameters of prosthetic mitral valve function

	Normal*	Possible stenosis‡	Suggests significant stenosis*‡
Peak velocity (m/s)†§	<1.9	1.9-2.5	≥2.5
Mean gradient (mm Hg)†§	≤5	6-10	>10
VTI_{PrMV}/VTI_{LVO}†§	<2.2	2.2-2.5	>2.5
EOA (cm^2)	≥2.0	1-2	<1
PHT (ms)	<130	130-200	>200

Expected values for C-E MV

Valve	Size	Peak gradient (mm Hg)	Mean gradient (mm Hg)	Peak velocity (m/s)	Pressure half-time (ms)
Carpentier- Edwards *Stented bioprosthesis*	29		4.7 ± 2	1.76 ± 0.27	92 ±14
	31		4.4 ± 2	1.54 ± 0.15	92 ± 19
	33		6 ±3		93 ± 12
Carpentier- Edwards pericardial *Stented Bioprosthesis*	27		3.6	1.6	100
	29		5.25 ± 2.36	1.67 ± 0.3	110 ± 15
	31		4.05 ± 0.83	1.53 ± 0.1	90 ± 11
	33		1.0	0.8	80

JASE Sept 2009 p 1010

Hemodynamics: Tricuspid Valve

- Peak Velocity
- Mean Gradient
- Pressure Half-Time (PHT)

ASE PV Guidelines Document: Assessment of Prosthetic TV stenosis

Table 15 Doppler parameters of prosthetic tricuspid valve function

	Consider valve stenosis*
Peak velocity†	>1.7 m/s
Mean gradient†	≥6 mm Hg
Pressure half-time	≥230 ms
EOA and VTI_{PrTV}/VTI_{LVO}	No data yet available for tricuspid prostheses

PrTV, Prosthetic tricuspid valve.
*Because of respiratory variation, average ≥5 cycles.
†May be increased also with valvular regurgitation.

JASE 2009; 22(9):1001

Review
Step 3: Hemodynamics

- Valve Specific Assessment
  - Velocity
  - Gradients
  - Area calculation
- Use ASE PV Guidelines Document

Echo Assessment of Prosthetic Valves

- 2-D
- Color Doppler
- Hemodynamics
- ***Look for Collateral Damage***

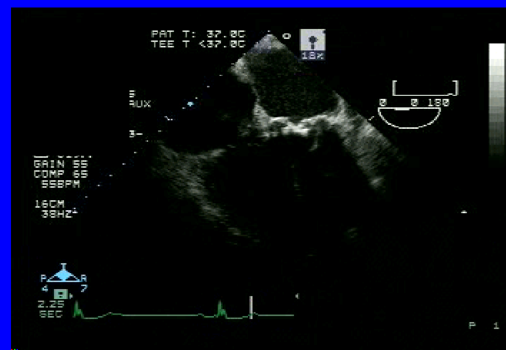
Step 4: Rule Out Collateral Damage

- Non-operative valve damage
  - Suture through AML during AVR
  - Suture through the AV during MVR
- Coronary obstruction
  - Valve too large in aortic position
  - Misplaced suture
- LV or RV dysfunction
- VSD
- LVOT obstruction
  - High profile tissue valve in mitral position
- LV rupture

Case #11

- 74 yo woman s/p bioprosthetic valve 13 years ago
- Presented with CHF

Case #11



What do you see?

Case #11

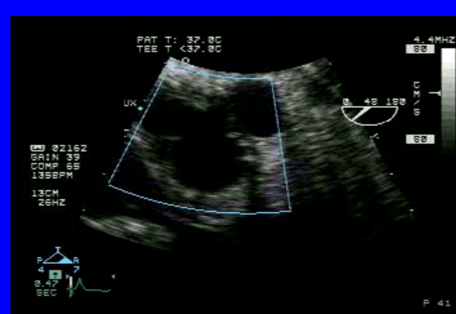
What is the diagnosis?

Case #11

Case #11

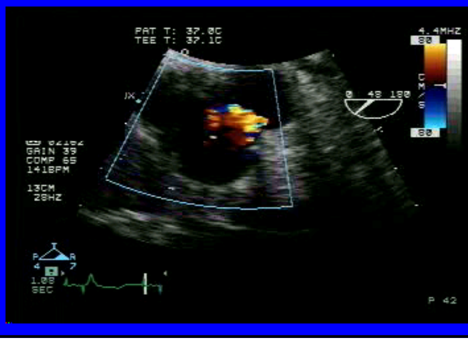
- #27 mm Medtronic Mosaic valve inserted into mitral position
- PFO closed
- While warming, after cardiac rhythm returned, noted a lot of ejection
- What is the differential?

Case #11

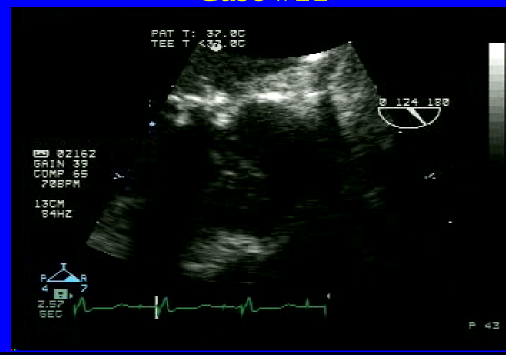


Post op—Notice anything wrong?

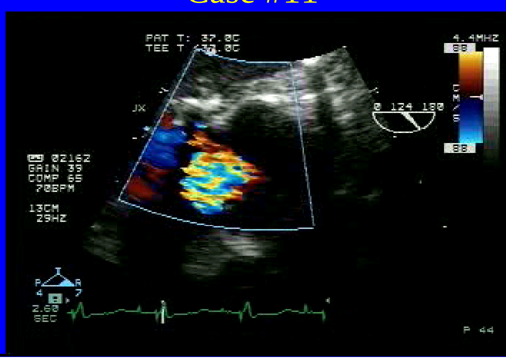
Case #11



Case #11



Case #11



Clinical Prosthetic Valve Exam Post-Bypass

1. Sewing ring well-seated
2. Leaflet(s) demonstrate normal excursion
3. Normal valvular leak present
4. No *significant* pathologic valvular or paravalvular leak (0-180 degrees)
5. Hemodynamics (grad, velocities, EOA, etc)
6. R/O collateral damage

10 General Principles

- Know the prosthetic valves used in your hospital (2D and washing jet pattern)
- Record baseline (pre-bypass) loops of all cardiac structures
- Listen to/watch the surgeons during bypass period
- Begin post-op assessment BEFORE separation from bypass

10 General Principles

- Use ME LAx view during de-airing
- Become an expert at obtaining TGx views
- Use zoom and slow motion replay
- Get a second opinion if any question
- Have a copy of the HDs reference in OR
- Use the same exam sequence every time

Summary

What should you do if you really want to become an expert in Prosthetic Valve Assessment?

1. Read a comprehensive chapter on Prosthetic Valves
2. Get samples of the different valve types and study their construction and mechanism
3. Read the ASE Guidelines for Prosthetic Valve Assessment JASE 2009