SNS COLLEGE OF ALLIED HEALTH SCIENCES
SNS Kalvi Nagar, Coimbatore - 35
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DEPARTMENT OF CARDIAC TECHNOLOGY -II YEAR

UNIT IV : PROSTHETIC VALVE ASSESSMENT

PROSTHETIC VALVE ASSESSMENT

Prosthetic valve

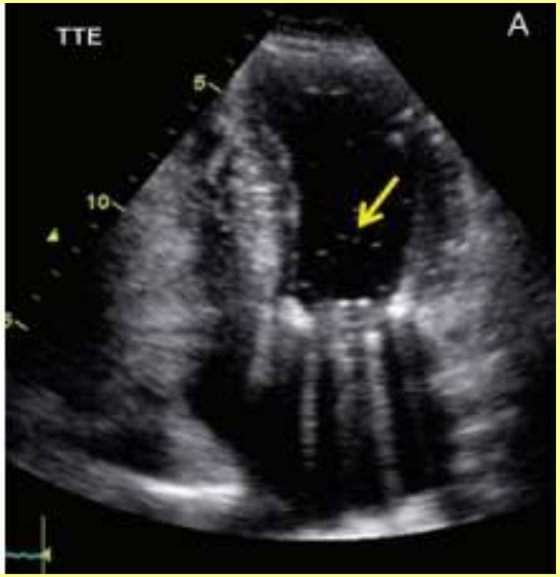
- Severe valvular disease to mild valvular disease
- **Normal** vs abnormal
- Background knowledge
  - **Fingerprint ECHO** – immediate post op ECHO + first follow up ECHO
- Time consuming
- Anthropometry – BP, Height, weight, BSA
- Old ECHO clips and Reports

New Normal

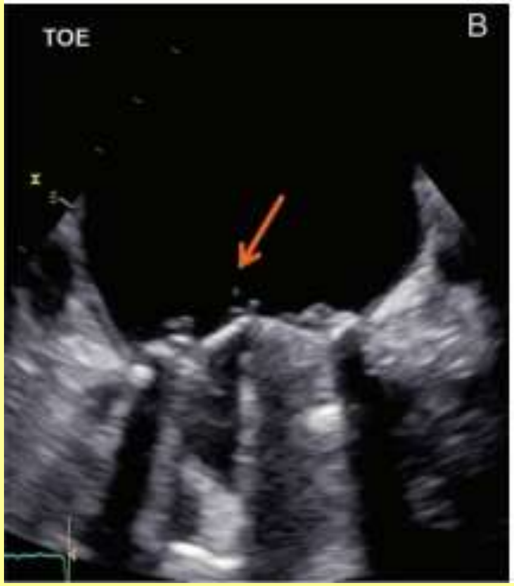
- Mild increase in gradients
- Mild regurgitation
- Artifacts in 2D/Color/Doppler
- High normal chamber size

2D Artefacts

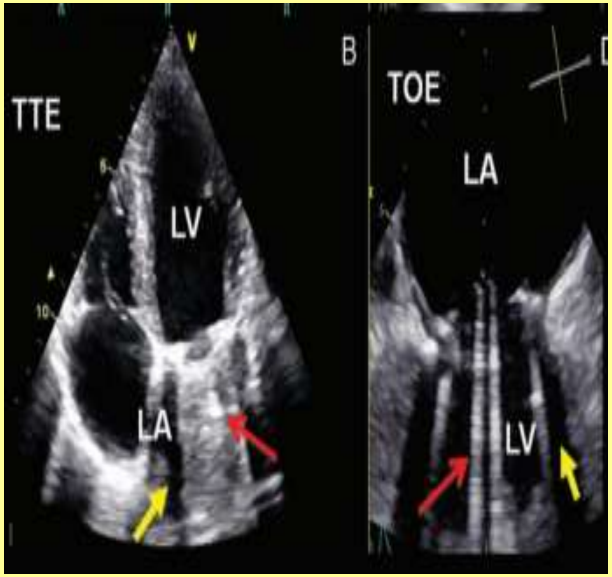
- CAVITATIONS/MICROBUBBLES



- Filamentous strands



- ACOUSTIC SHADOWING/
- REVERBATIONS



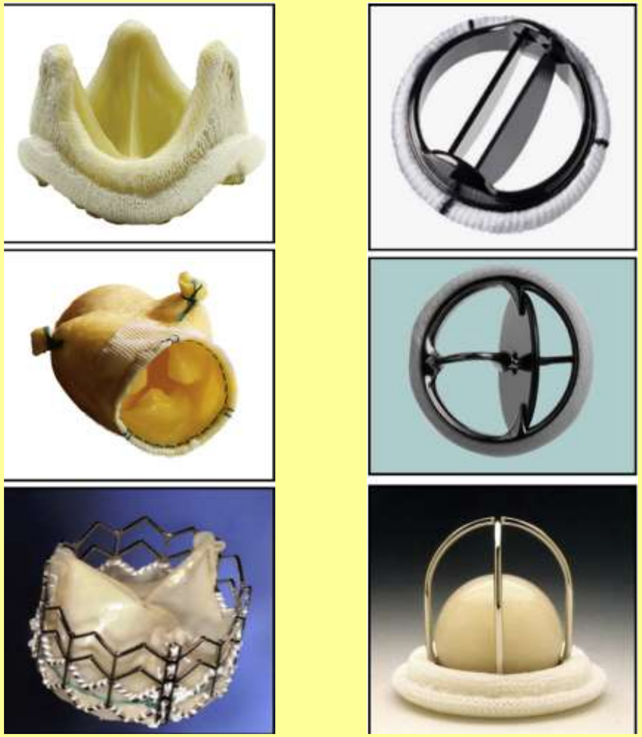
Doppler/Color Artefacts

- Doppler
  - Double envelope
  - Clicks
  - Multiple velocity jets
- Color
  - Physiologic jets (new normal)
    - Closing volume
    - Leakage volume
    - Washing effect
    - 1-3 jets
    - Low momentum with narrow neck

Types of Prosthetic Valves

Table 1 **Types of prosthetic heart valves**

- Biological
  - Stented
    - Porcine bioprosthesis
    - Pericardial bioprosthesis
  - Stentless
    - Porcine bioprosthesis
    - Pericardial bioprosthesis
    - Aortic homograft
    - Pulmonary autograft (Ross procedure)
  - Sutureless
  - Transcatheter
- Mechanical
  - Bileaflet
  - Single tilting disk
  - Caged ball



Design and Models

Table 2 Designs and models of biological replacement heart valve

Stented porcine replacement valve
- Hancock standard and Hancock II
- Medtronic Mosaic[a]
- Carpentier-Edwards standard and supra-annular
- St Jude Medical Biocor, Bioimplant, Epic
- AorTech Aspire
- Labcor
- Carbomedics Synergy

Stentless valve Porcine
- St Jude Medical Toronto[a]
- Medtronic Freestyle
- Cryolife-O'Brien[a]
- Cryolife-Ross Stentless porcine pulmonary
- Edwards Prima Plus
- AorTech Aspire
- St Jude Biocor
- Labcor
- St Jude Quattro stentless mitral
- Shelhigh Skeletorized Super-Stentless aortic porcine and pulmonic
- Medtronic-Venpro Contegra pulmonary valve conduit

Stented pericardial replacement valve
- Carpentier-Edwards Perimount
- Carpentier Edwards Magna
- Mitroflow Synergy
- St Jude Biocor pericardia
- St Jude Trifecta
- Labcor pericardial
- Sorin Pericarbon MORE[a]

Stentless pericardial
- Sorin Pericarbon
- 3F-SAVR
- Freedom Solo

Sutureless
- Perceval S (Sorin)
- Edwards Intuity (Edwards Lifesciences)
- 3F Enable (ATS Medical)
- Trilogy (Arbor Surgical Technologies)

Table 3 Designs and models of mechanical replacement heart valve

Bileaflet mechanical replacement valves
- St Jude Medical: standard, HP, Masters, and Regent
- Carbomedics: standard, reduced cuff, Optiform, Orbis, and supra-annular (Top Hat) Carboseal includes a woven aortic graft
- Edwards Tekna
- Sorin Bicarbon
- Edwards Mira
- ATS
- On-X
- Medtronic Advantage
- Jyros

Tilting disk replacement valves
- Bjork-Shiley monostrut[a]
- Sorin Monoleaflet Allcarbon
- Medtronic-Hall
- Omnicarbon
- Ultracor

Caged ball
- Starr-Edwards
- Smeloff-Cutter

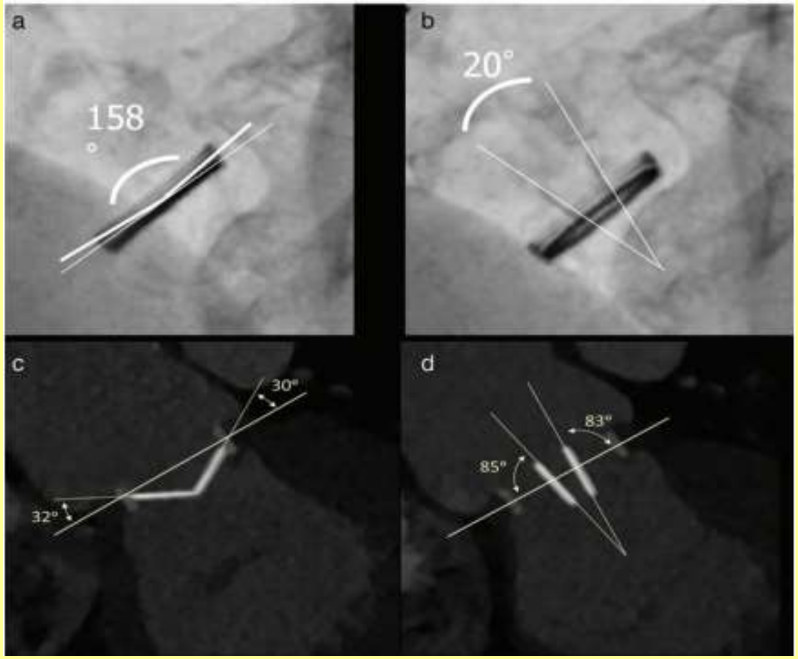
[a]Indicates withdrawn from market.

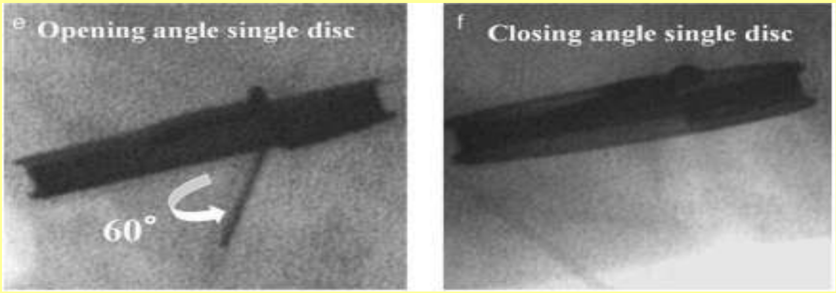
Various Modalities

Table 5 Imaging modalities: advantages and limitations

	Technical considerations	Advantages	Limitations
2D TTE	• Multiple views • Careful probe angulation (alignment) for accurate leaflet motion display	• First-line imaging • Ease of use • Assessment of LV function and size and pulmonary pressure	• Limited by acoustic window and body habitus • Acoustic shadowing by prosthetic material • Angle dependent on accuracy of Doppler data
2D TOE	• Multiple views • Careful probe angulation (alignment) for accurate leaflet motion display	• Higher resolution than TTE • Proximity of the oesophagus with the heart • Better visualization of the atrial side of mitral PHV and posterior part of aortic PHV • Better visualization of peri-annular complications	• Acoustic shadowing by prosthetic material • Angle dependent on accuracy of Doppler data
3D TOE	• Multiple cropping planes • Narrow angle mode/Oblique views • Full-volume dataset • Zoom mode	• Ease of use • Excellent spatial imaging • Enable enface viewing (surgical view) • Add on to 2D echo imaging	• Poor visualization of anterior cardiac structure • Poor temporal resolution • Tissue dropout • Lack of tissue characterization • Artefacts due to an oblique (rather than horizontal) orientation of PHVs in mitral position
Cinefluoroscopy	• Postero-anterior (0°) and lateral (90°) projections • '*in profile*' projection (beam parallel to both the valve ring plane and the tilting axis of discs) • '*en face*' projection (beam parallel to the valve outflow tract)	• Ease of use • Evaluation of PHV functioning • Detection of calcium on the leaflets	• No haemodynamic assessment • No clues about the aetiology of limited disc motion

Opening and Closing angles



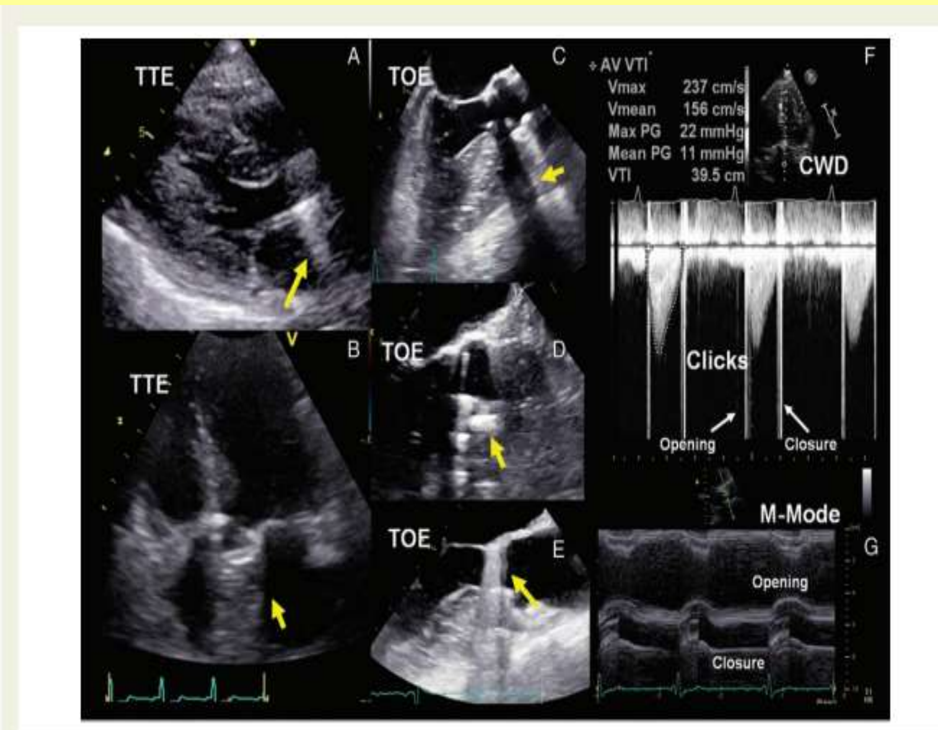


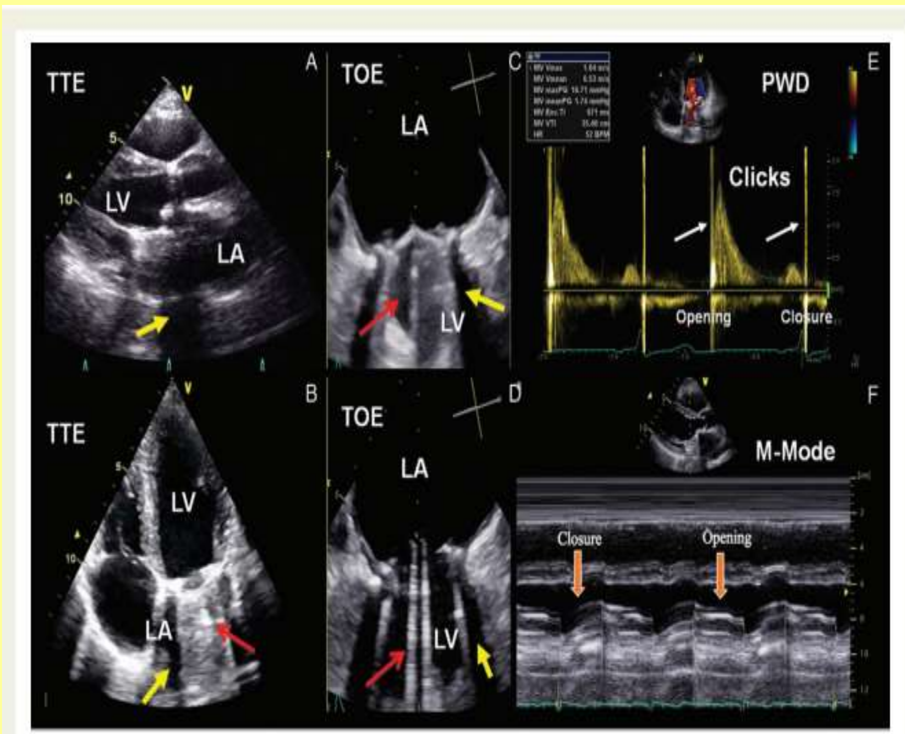
Reference Angles

Table 6 **Mechanical valves: opacification and opening angles**

	Prosthesis materials		Open (Degrees)	Closed (Degrees)
	Housing	Occluder		
Caged-ball valves				
Starr-Edwards	Three (aortic) or four-strut (mitral) cobalt-chrome alloy cage	Silicone rubber	N/A	N/A
Tilting disc valves				
Björk–Shiley	Cobalt-chrome alloy	Silicon alloyed pyrolytic carbon on graphite substrate with radio-opaque tantalum marker	60 (<1981) 70 (>1981)	0
Medtronic-Hall	Titanium alloy	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	75 (aortic) 70 (mitral)	0
Omniscience	Titanium alloy	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	80	12
Omnicarbon	Pyrolytic carbon over graphite substrate	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	80	12
Sorin Allcarbon	Cobalt-chromium alloy coated with a thin layer of pyrolytic carbon	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	60	0
Bileaflet valves				
ATS Medical	Pyrolytic carbon over graphite substrate with metallic band	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	85	25
Carbomedics	Solid pyrolytic carbon with titanium stiffening ring metallic band	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	78–80	15
Edwards Tekna (previously Duromedics)	Solid pyrolytic carbon with titanium stiffening ring	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	73–77	15
St Jude Medical	Pyrolytic carbon over graphite substrate with metallic band	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	85	30 (19–25 mm) 25 (27–31 mm)
On-X	Pyrolytic carbon with graphite substrate with titanium alloy bands	Pure pyrolytic carbon on tungsten-loaded graphite substrate	85–90	40
Bicarbon	Cobalt-chromium alloy coated with a thin layer of pyrolytic carbon	Silicon alloyed pyrolytic carbon on tungsten-loaded graphite substrate	80	20

Aortic and Mitral Mechanical





Parameters checklist

- Clinical
  - Date/type/size of the valve replacement
  - Height/weight/BSA/BMI
  - BP & HR
- 2D
  - Motion of cusps/leaflets/occlude
  - Structures attached to the valve
  - Sewing ring integrity
- Doppler
  - Doppler scale
  - Peak velocity and gradient
  - Mean gradient
  - DVI doppler velocity index
  - PHT pressure half time
  - AT,AT/ET ratio
  - Measured EOA/Reference EOA/indexed EOA
  - Regurgitation – no/location/relation to the valve apparatus
- Others
  - Chambers, valves, PAH
  - Comparison to the old and fingerprint reports

Orifice areas

Theoretical GOA

- Manufactures list

Planimetered GOA

- Measured Valve apparatus

EOA

- Vena contracta Functional area

DVI & EOA

$$\Delta P = 4(V_2^2)$$

$$EOA = CSA \times VTI_{LVOT}/VTI_{PrV}$$
$$= 0.785 \times (D_{LVOT})^2 \times VTI_{LVOT}/VTI_{PrV}$$

$$EOA = \frac{\text{Stroke volume}}{VTI_{PrV}}$$

$$DVI = \frac{\text{peak } V_{LVOT}}{\text{peak } V_{PrV}} \text{ or } \frac{VTI_{LVOT}}{VTI_{PrV}}$$

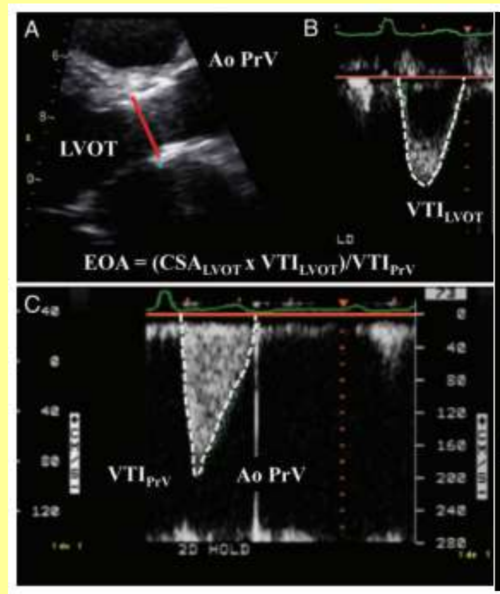
Aortic

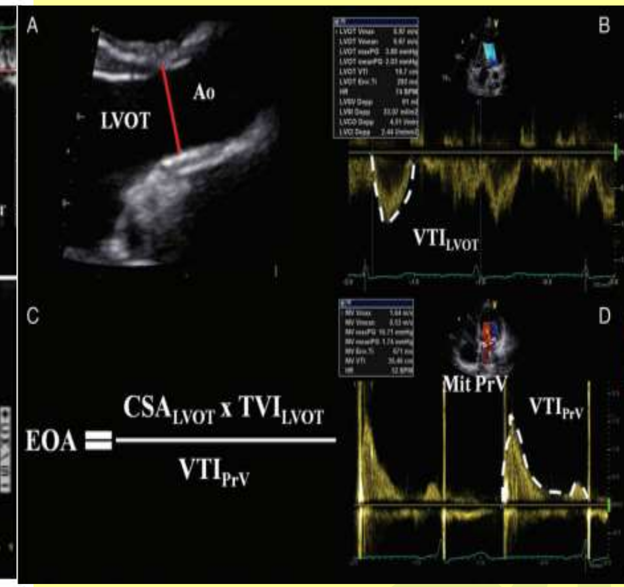
>0.30 Aortic Valve

$$DVI = \frac{VTI_{PrV}}{VTI_{LVOT}}$$

Mitral

< 2.2 for Mechanical Aortic Valve





Mitral

Reference EOA of Aortic & Valvar prosthesis

Table 7 Normal reference values of effective orifice areas for the prosthetic aortic valves

Prosthetic valve size (mm)	19	21	23	25	27	29
Stented bioprosthetic valves						
Mosaic	1.1 ± 0.2	1.2 ± 0.3	1.4 ± 0.3	1.7 ± 0.4	1.8 ± 0.4	2.0 ± 0.4
Hancock II	–	1.2 ± 0.2	1.3 ± 0.2	1.5 ± 0.2	1.6 ± 0.2	1.6 ± 0.2
Carpentier-Edwards Perimount	1.1 ± 0.3	1.3 ± 0.4	1.5 ± 0.4	1.8 ± 0.4	2.1 ± 0.4	2.2 ± 0.4
Carpentier-Edwards Magna	1.3 ± 0.3	1.5 ± 0.3	1.8 ± 0.4	2.1 ± 0.5	–	–
Biocor (Epic)	1.0 ± 0.3	1.3 ± 0.5	1.4 ± 0.5	1.9 ± 0.7	–	–
Mitroflow	1.1 ± 0.2	1.2 ± 0.3	1.4 ± 0.3	1.6 ± 0.3	1.8 ± 0.3	–
Trifecta	1.4	1.6	1.8	2.0	2.2	2.4
Stentless bioprosthetic valves						
Medtronic Freestyle	1.2 ± 0.2	1.4 ± 0.2	1.5 ± 0.3	2.0 ± 0.4	2.3 ± 0.5	–
St Jude Medical Toronto SPV	–	1.3 ± 0.3	1.5 ± 0.5	1.7 ± 0.8	2.1 ± 0.7	2.7 ± 1.0
Prima Edwards	–	1.3 ± 0.3	1.6 ± 0.3	1.9 ± 0.4	–	–
Mechanical valves						
Medtronic-Hall	1.2 ± 0.2	1.3 ± 0.2	–	–	–	–
St Jude Medical Standard	1.0 ± 0.2	1.4 ± 0.2	1.5 ± 0.5	2.1 ± 0.4	2.7 ± 0.6	3.2 ± 0.3
St Jude Medical Regent	1.6 ± 0.4	2.0 ± 0.7	2.2 ± 0.9	2.5 ± 0.9	3.6 ± 1.3	4.4 ± 0.6
MCRI On-X	1.5 ± 0.2	1.7 ± 0.4	2.0 ± 0.6	2.4 ± 0.8	3.2 ± 0.6	3.2 ± 0.6
Carbomedics Standard and Top Hat	1.0 ± 0.4	1.5 ± 0.3	1.7 ± 0.3	2.0 ± 0.4	2.5 ± 0.4	2.6 ± 0.4
ATS Medical[a]	1.1 ± 0.3	1.6 ± 0.4	1.8 ± 0.5	1.9 ± 0.3	2.3 ± 0.8	–

Table 8 Normal reference values of effective orifice areas for the prosthetic mitral valves

Prosthetic valve size (mm)	25	27	29	31	33
Stented bioprosthetic valves					
Medtronic Mosaic	1.5 ± 0.4	1.7 ± 0.5	1.9 ± 0.5	1.9 ± 0.5	–
Hancock II	1.5 ± 0.4	1.8 ± 0.5	1.9 ± 0.5	2.6 ± 0.5	2.6 ± 0.7
Carpentier-Edwards Perimount	1.6 ± 0.4	1.8 ± 0.4	2.1 ± 0.5	–	–
Mechanical valves					
St Jude Medical Standard	1.5 ± 0.3	1.7 ± 0.4	1.8 ± 0.4	2.0 ± 0.5	2.0 ± 0.5
MCRI On-X[a]	2.2 ± 0.9	2.2 ± 0.9	2.2 ± 0.9	2.2 ± 0.9	2.2 ± 0.9

Problems in the prosthetic valve

- Structural (valve damage)
  - Fracture
  - Wear
  - Poppet escape
  - Leaflet tear
- Non structural (normal valve)
  - **Thrombus stuck valve**
  - Para valvar leak
  - Pannus
  - **Patient prosthesis Mismatch PPM**
- Endocarditis

Thrombus vs Pannus

Thrombus

Acute organized blood clot attaches to the valve causing stenosis and sometimes regurgitation

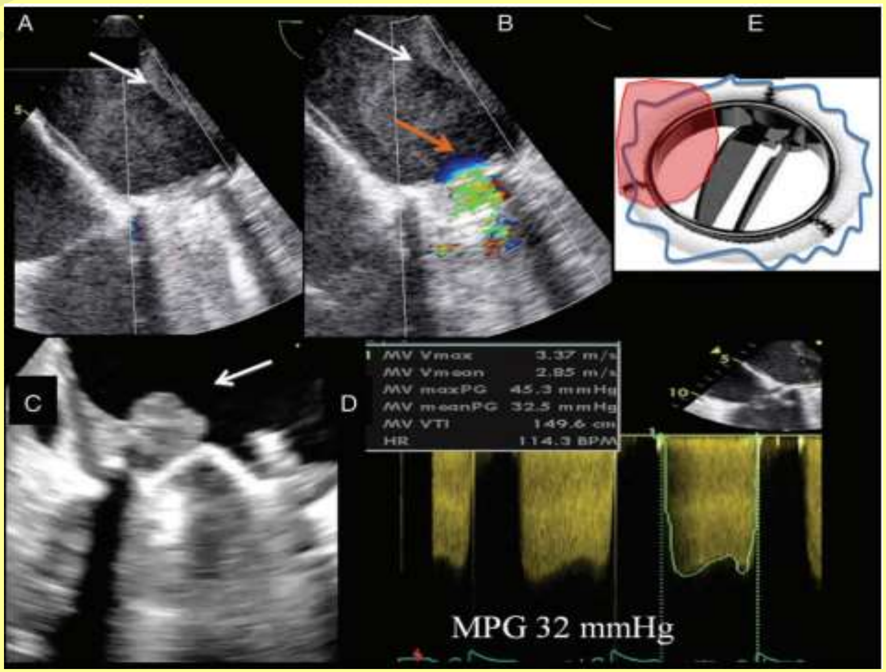
Pannus

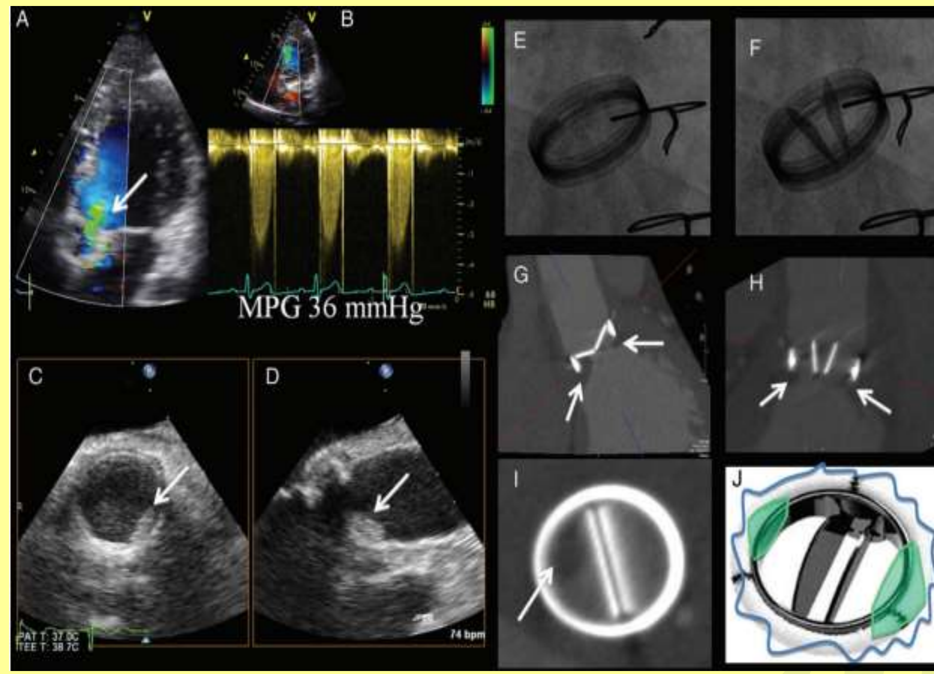
Chronic tissue overgrowth along the valve apparatus that causes stenosis

Table 10 Differential diagnosis: pannus vs. thrombosis

	Pannus	Thrombosis
Chronology	Minimum 12 months, commonly >5 years from surgery date	Occurs at any time (if late usually associated with pannus)
Relation to anticoagulation (low INR)	Poor relationship	Strong relationship
Location	MV > AV	TV >> MV = AV
Morphology	• Small mass • Mostly involve suture line (Ring) • Centripetal growth • Confine to the disk plane • Growth beneath disc	• Larger mass than pannus • Independent motion common • Thin outer ring maybe visible • Project into LA for MV position • Mobile elements
Echo density (video-intensity ratio)	More >0.7 (100% specific)	Less (<0.4)
Cardiac CT: attenuation value	>200 HU	<200 HU
Impact on gradient	AV > MV	MV > AV
Impact on valve orifice	AV > MV	MV > AV
Impact on disc motion	Yes/no	Yes

Thrombus vs Pannus





Pathologic Regurgitation

- Central/valvar vs Para valvar
- Regular regurgitation severity
- Valvar
  - Biological – structural deterioration
  - Close to commissure
  - Progress usually
  - Vegetations
  - Thrombus
  - Pannus
  - Disappearance of normal Jet
- Para valvar
  - Surgical techniques
    - Size/position/tissue quality
  - Localisation
  - 5-20%

Valve Dehiscence

- Excessive motion of sewing ring
- More than 15 degree
- Mitral some motion allowed
  - Retention of posterior leaflet
- May require resurgery

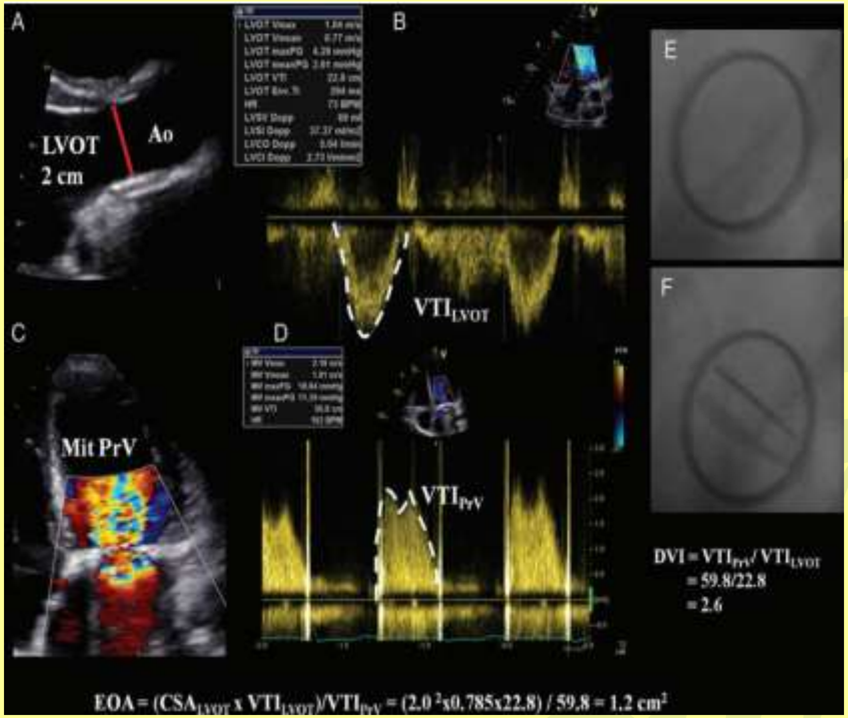
Patient Prosthesis Mismatch PPM

- Normal valve in relation to the patients body size
- Early after surgery
- High gradients
- May result in suboptimal improvement after surgery
- Needs thorough comparison of every serial ECHO reports

PPM

Table 12 Imaging criteria or the identification and quantitation of prosthesis-patient mismatch

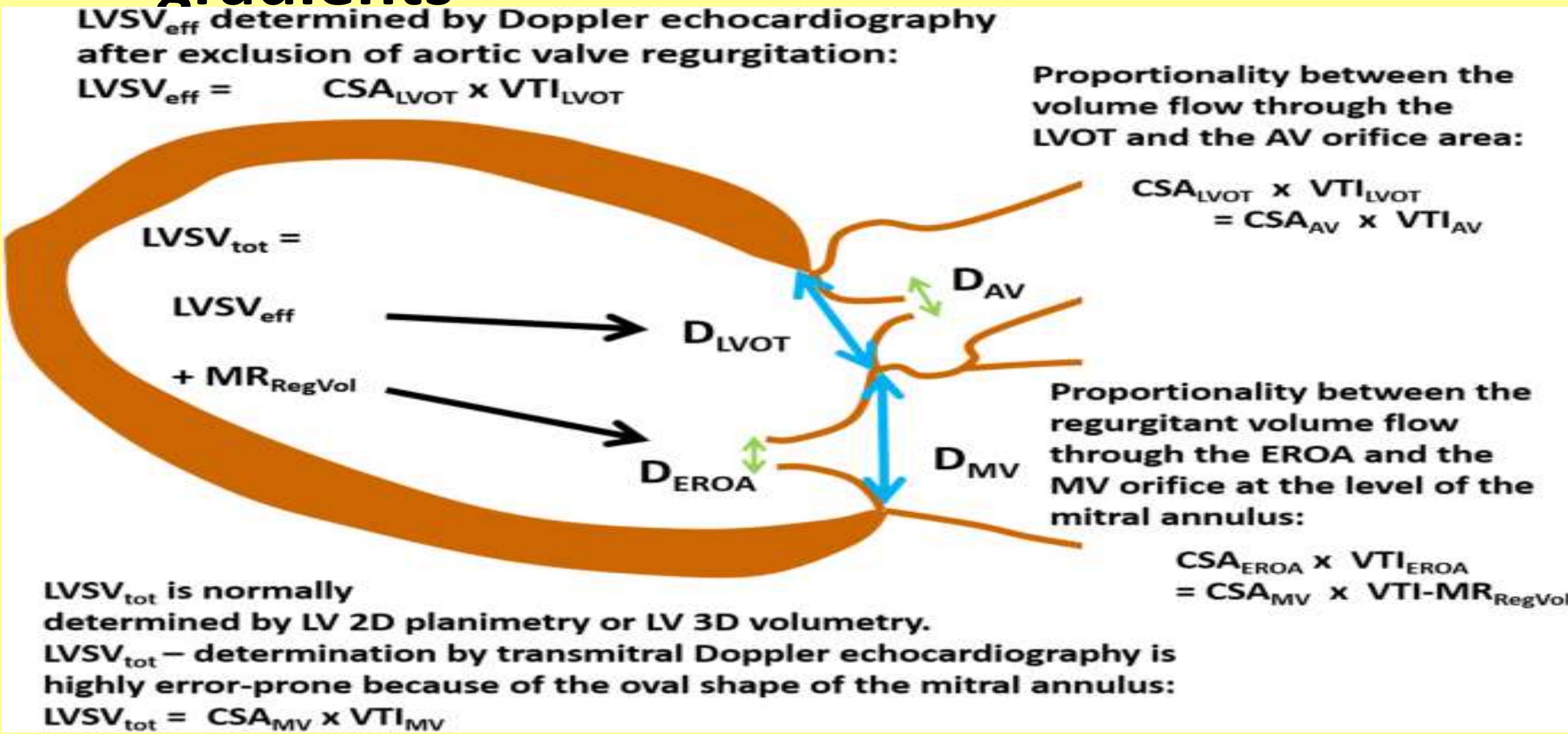
	Mild or not clinically significant	Moderate	Severe
Aortic prosthetic valves			
Indexed EOA (projected or measured)			
BMI <30 kg/m^2	>0.85	0.85–0.66	≤ 0.65
BMI ≥ 30 kg/m^2	>0.70	0.70–0.56	≤ 0.55
Measured EOA vs. normal reference value[a]	Reference $\pm$ 1SD	Reference $\pm$ 1SD	Reference $\pm$ 1SD
Difference (reference EOA − measured EOA) (cm^2)[a]	<0.25	<0.25	<0.25
Valve structure and motion	Usually normal	Usually normal	Usually normal
Mitral prosthetic valves			
Indexed EOA (projected or measured)			
BMI <30 kg/m^2	>1.2	1.2–0.91	≤ 0.90
BMI ≥ 30 kg/m^2	>1.0	1.0–0.76	≤ 0.75
Measured EOA vs. normal reference value[a]	Reference $\pm$ 1SD	Reference $\pm$ 1SD	Reference $\pm$ 1SD
Difference (reference EOA − measured EOA) (cm^2)[a]	<0.25	<0.25	<0.25
Valve structure and motion	Usually normal	Usually normal	Usually normal



- Normal valves
- High gradients
- Less EOA and iEOA
- High DVI

Approach to Increased Trans Aortic Valve gradients

Approach to Increased Trans Mitral Valve gradients



THANK YOU...