2019 JCR

Interventions for Mitral and Structural Heart Disease

Interventional Echocardiography

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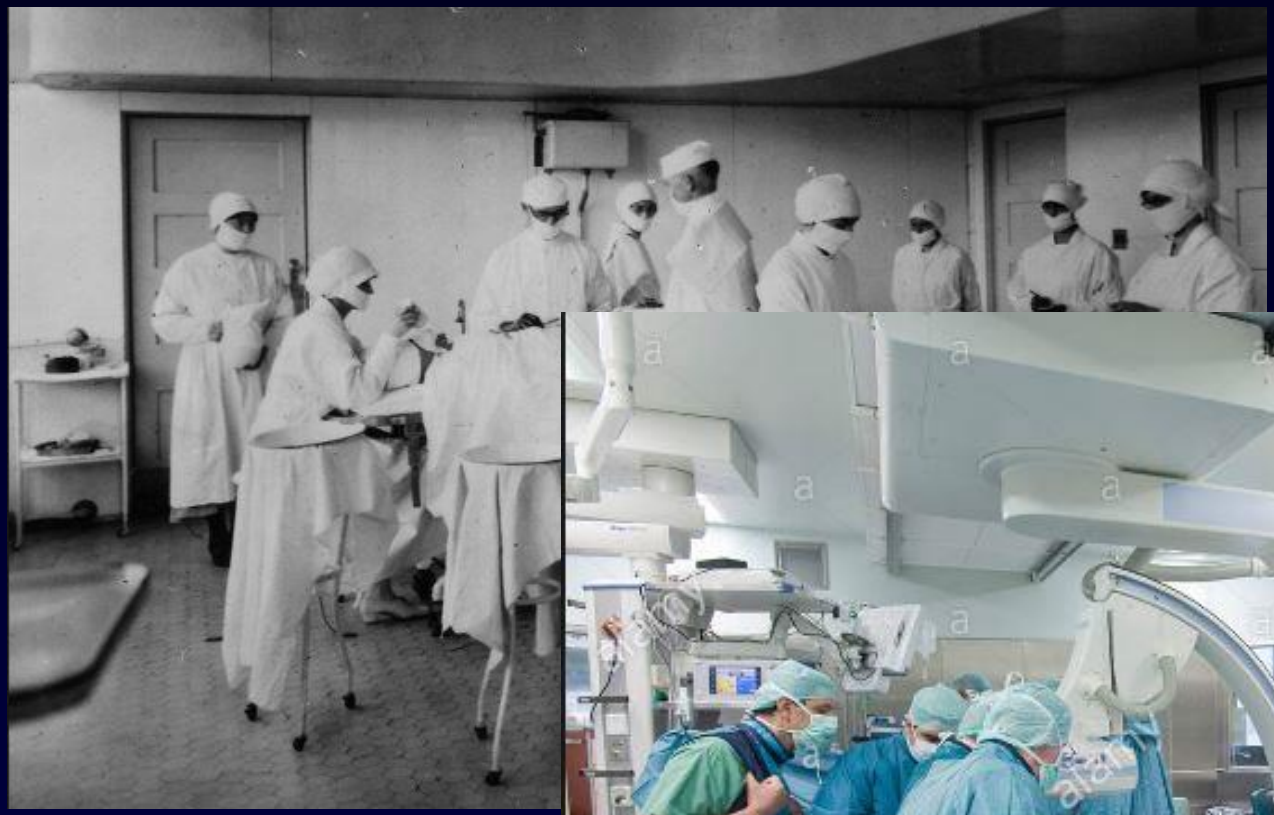
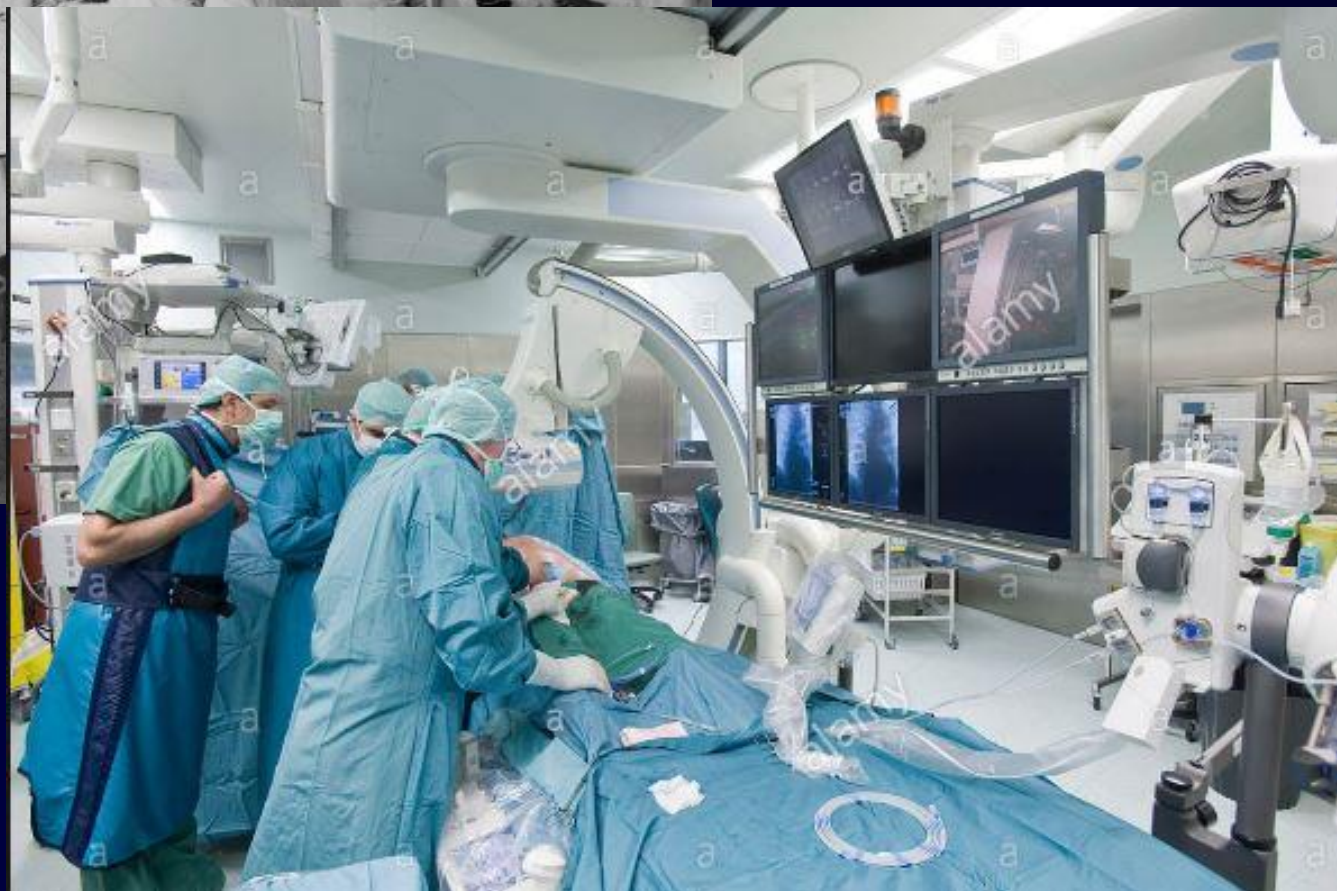
Structural Heart Intervention

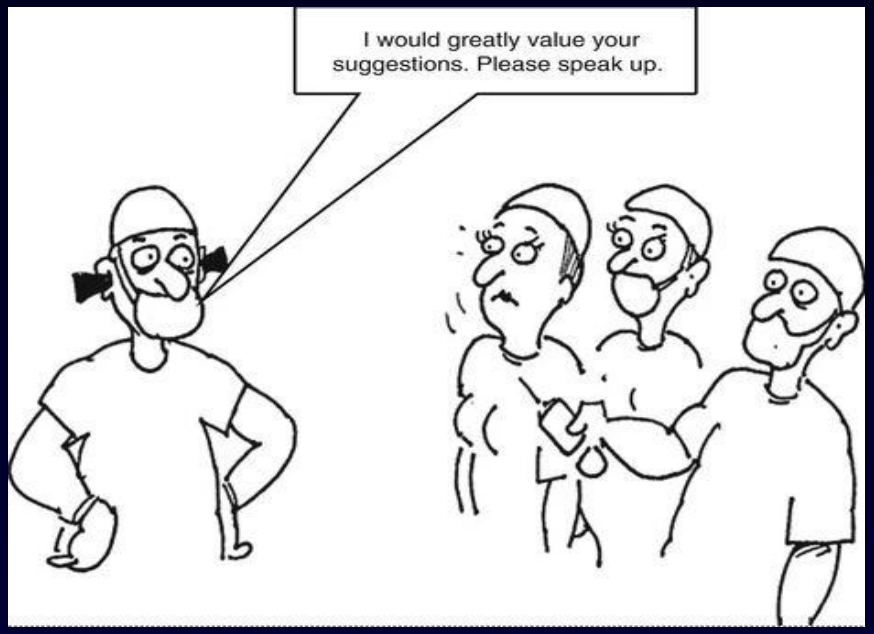


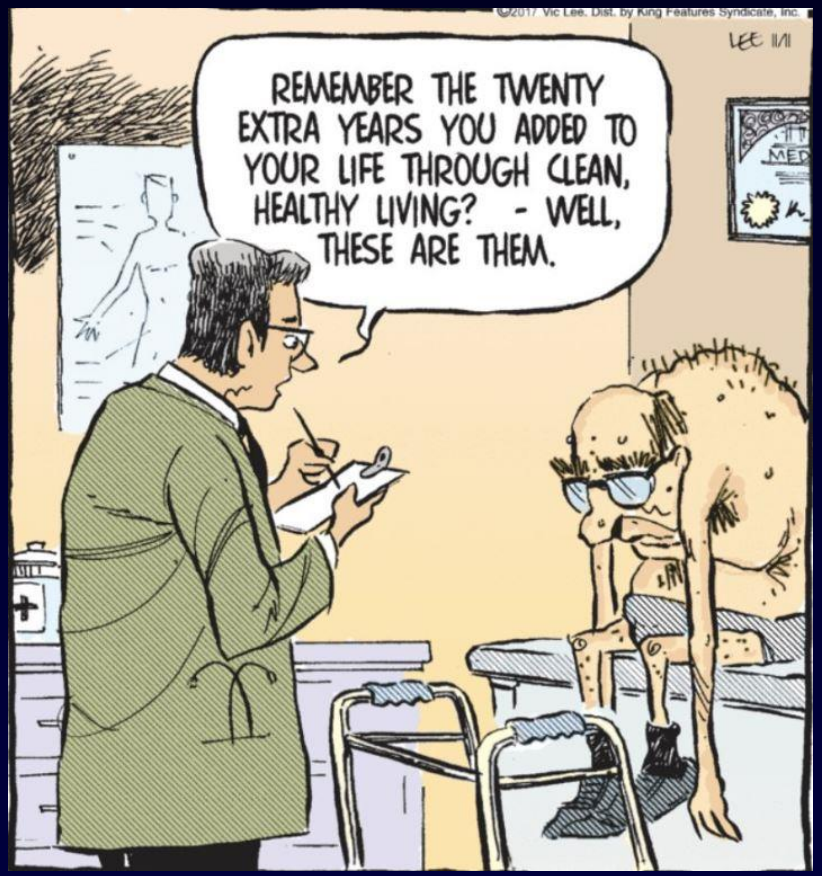


Structural Heart Interventions

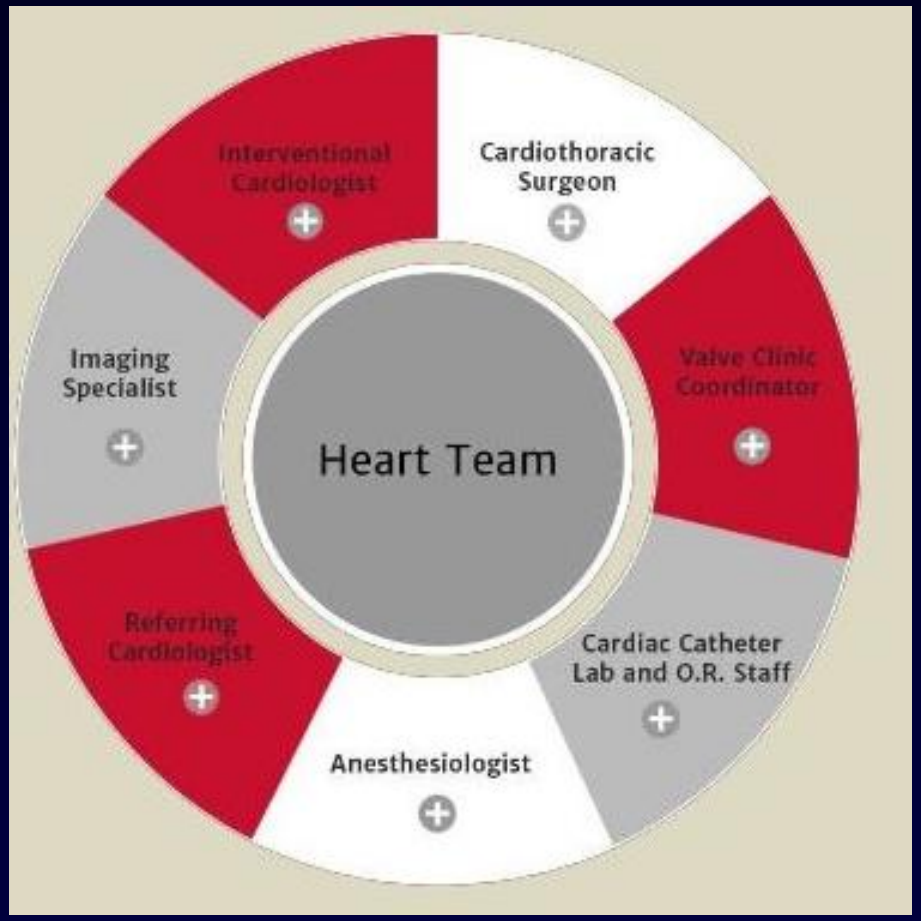
- ASD, PFO, VSD, PDA closures
- LA appendage closure
- Paravalvular leak closure
- CoA stenting
- Valves
  - PMV, Mitral clip
  - TAVR, TMVR
  - TV, PV replacement

Decision of Treatment of SHD





Heart Team for SHD Intervention



Case F/75

- **Chief complaint**

  Exertional dyspnea

- **Present illness**

  Diagnosed moderate AS 4 years ago

  Aggravated DOE for 1 year

- **Comorbidities**

  HTN, Minimal CAD

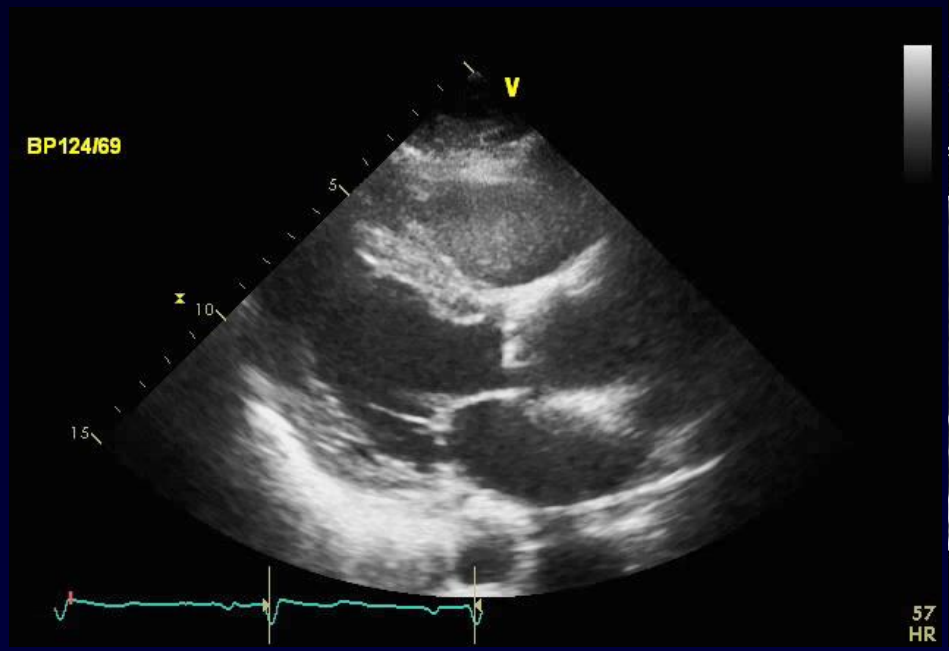
- **Lab**

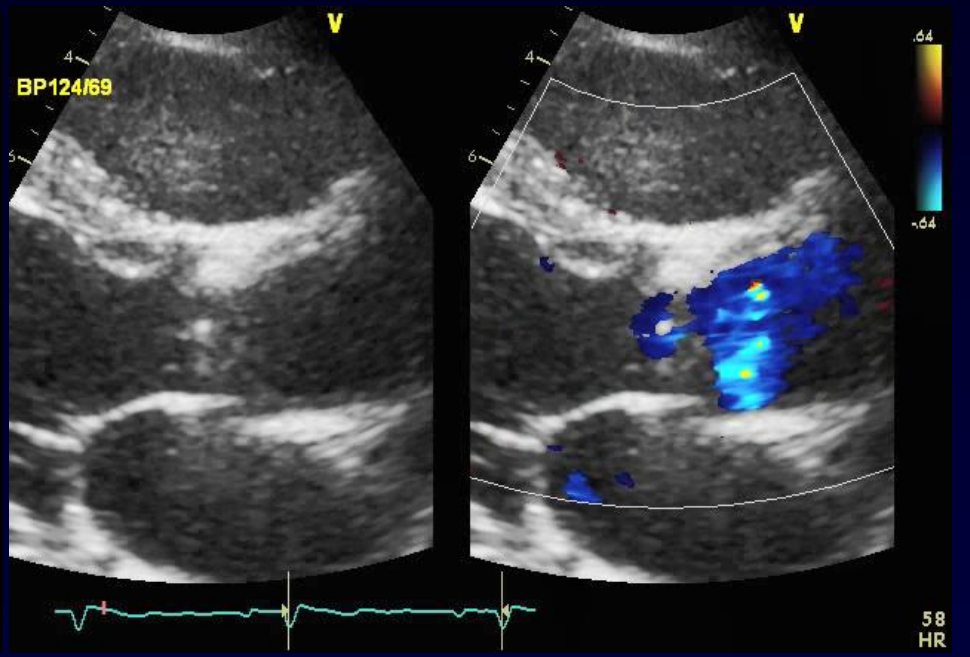
  BUN/Cr 21.3/0.92 (eGFR 59)

  NT-proBNP 53

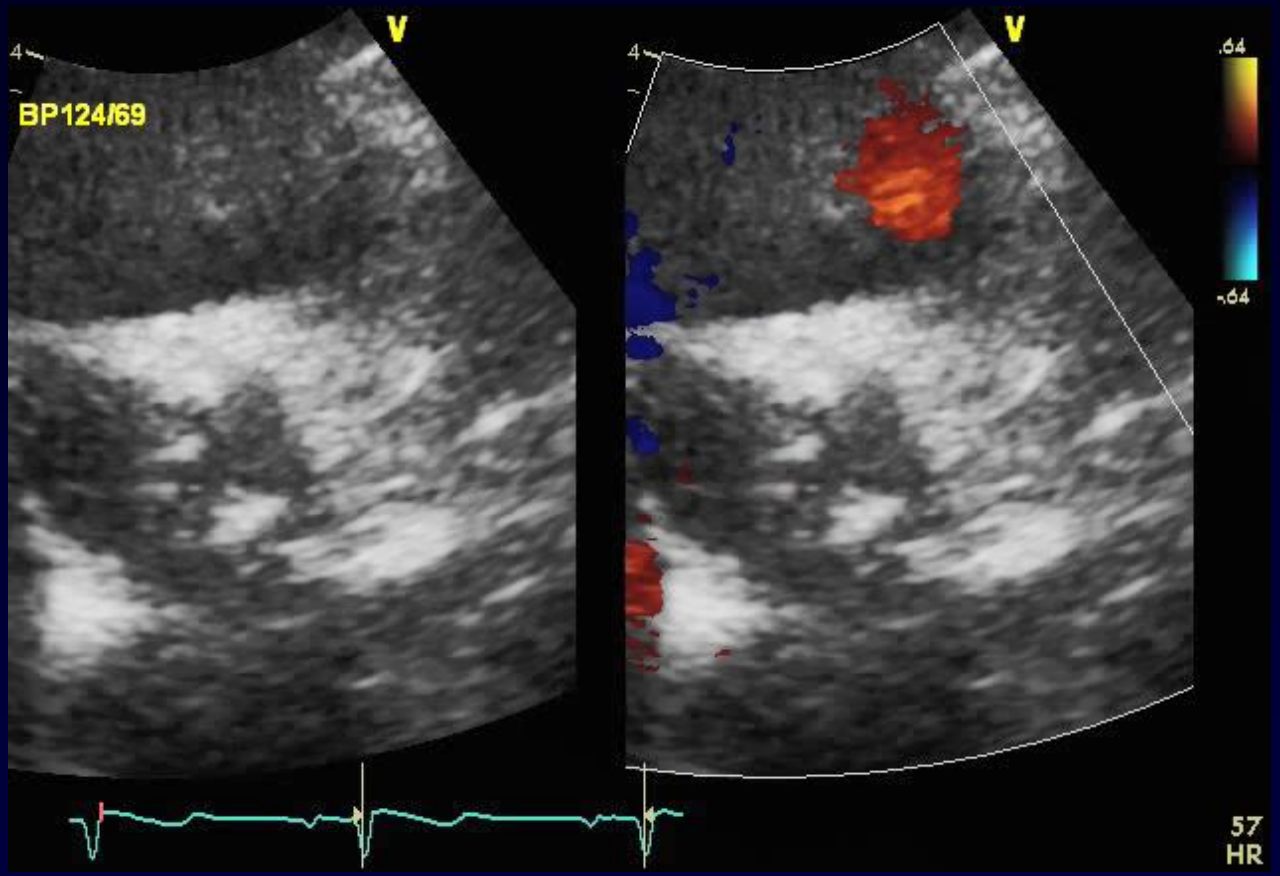
- **Euroscore II: 1.88%, STS score: 2.42%**

TTE

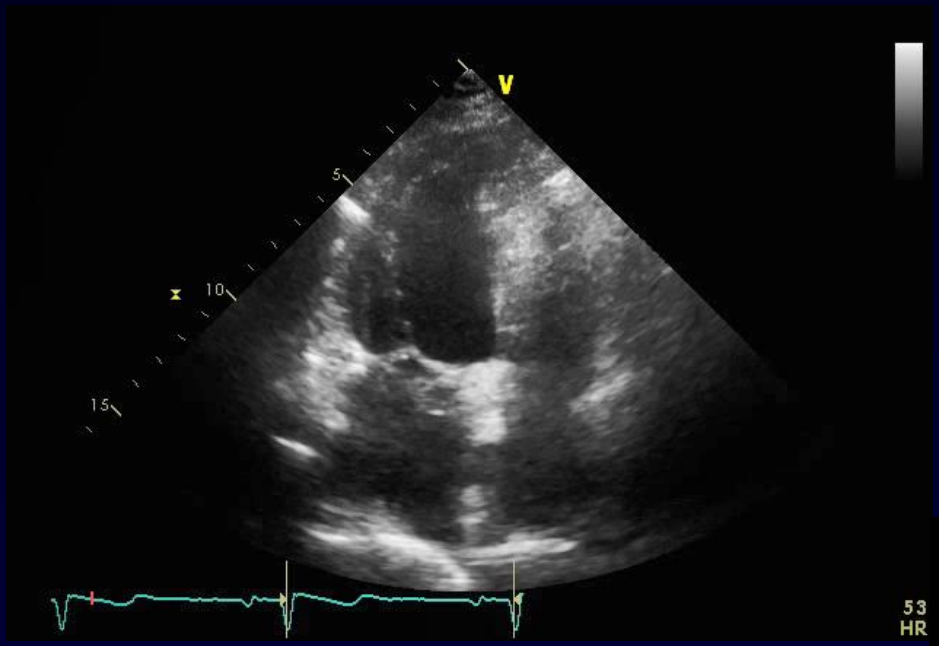


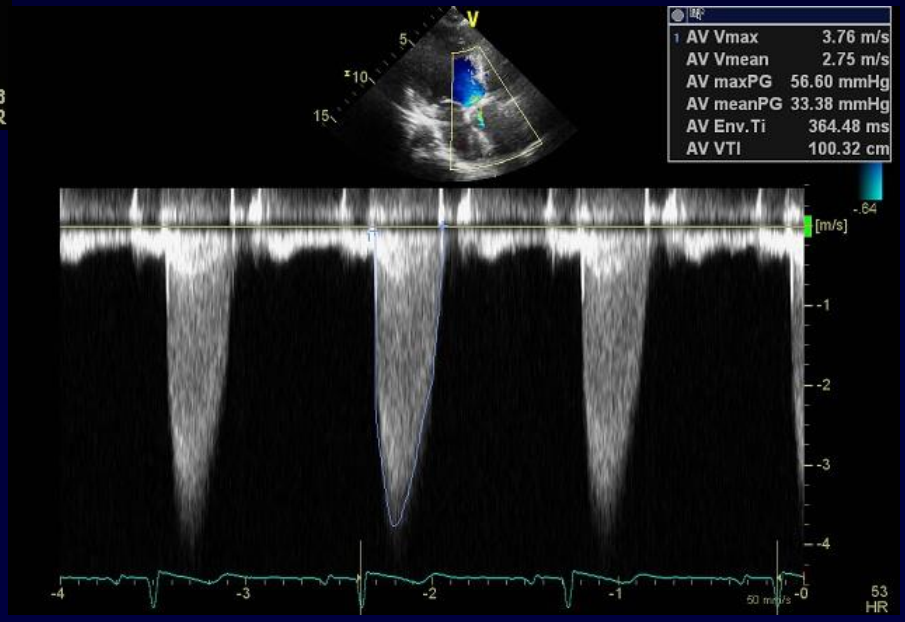


TTE

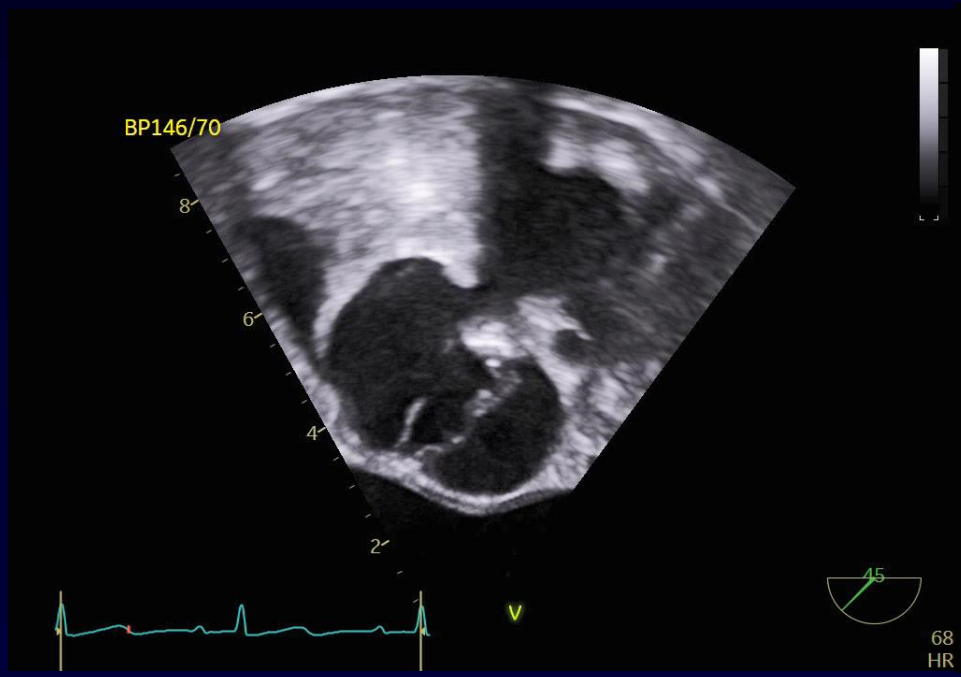


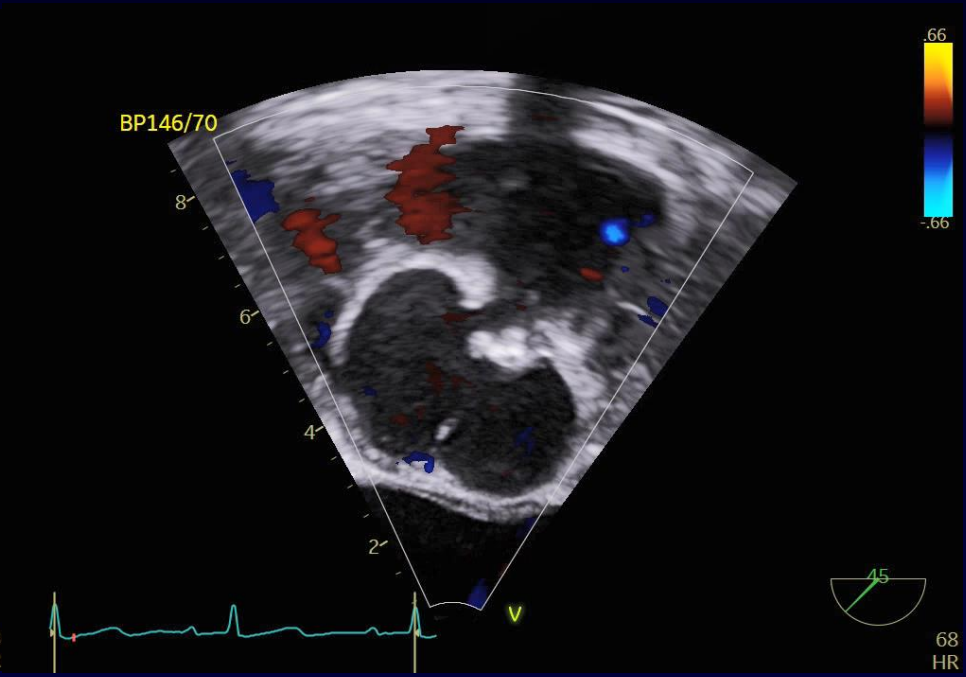
TTE


V
5
10
15
53
HR


V
5
10
15
AV Vmax 3.76 m/s
AV Vmean 2.75 m/s
AV maxPG 56.60 mmHg
AV meanPG 33.38 mmHg
AV Env.Ti 364.48 ms
AV VTI 100.32 cm
[m/s]
-1
-2
-3
-4
-4
-3
-2
-1
-0
53
HR

TEE





Severe AS (AVA: 0.94cm2 by 2D) with trial AR

Multidisciplinary team

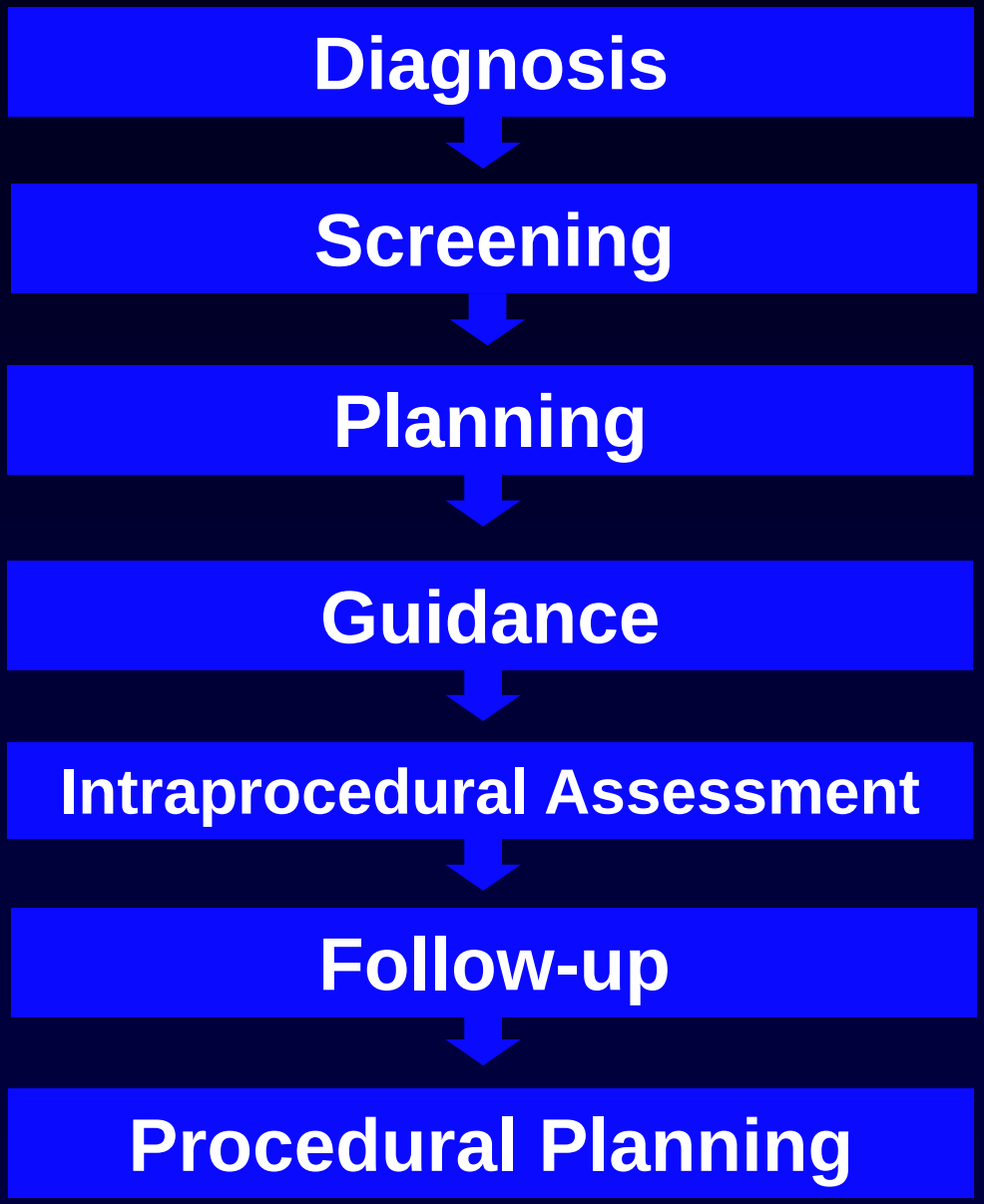
TAVI Meeting

1. Low risk and Bicuspid AV (true type)
2. Patient did not get any information about surgical AVR → The surgery team will interview you again to provide accurate information about the surgery.
3. If she refuses the operation, TAVI team explains once again the AV morphology and explains the risks such as PVL and PM insertion after TAVI.
   → If agree re-schedule.

Benefit of Heart Team Approach

- Reconfirm correct diagnosis
- Making treatment plan
- Best choice of treatment option
- Feedback of prior therapy
- Patient first..!!!!

Which is the Role of Cardiac Imaging?



Tools in Interventional Imaging

- **Echo**
  - TTE, TEE
  - Contrast, 3D Echo
  - ICE
- **CT**
- **Angiography**
- **CMR**

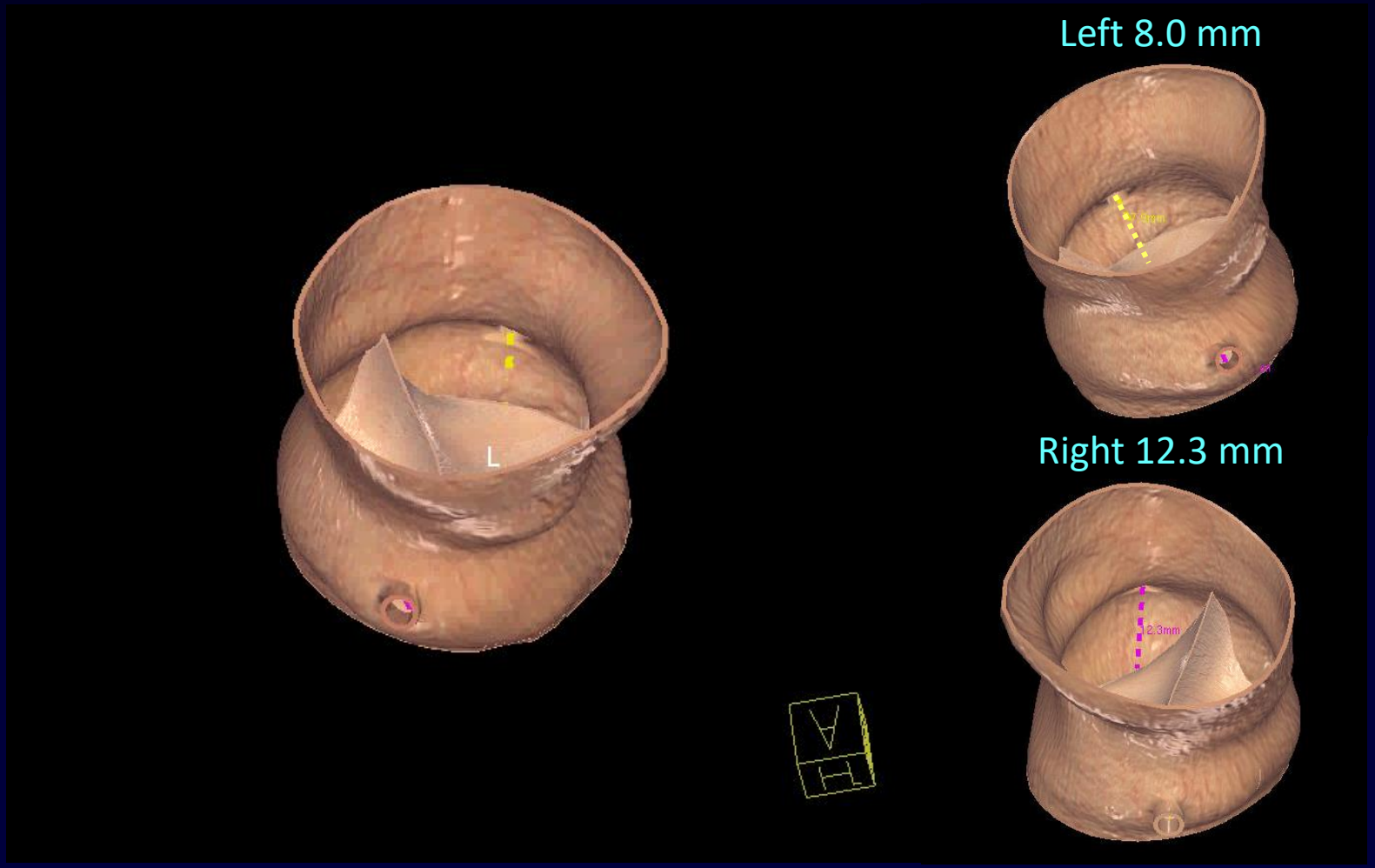
Echo Guidance

- Echocardiographic guidance has evolved from relatively intensive to limited role.
- There may be significant inter-institutional variability
- Still very important when new devices are introduced.

Limitation of 2D echo

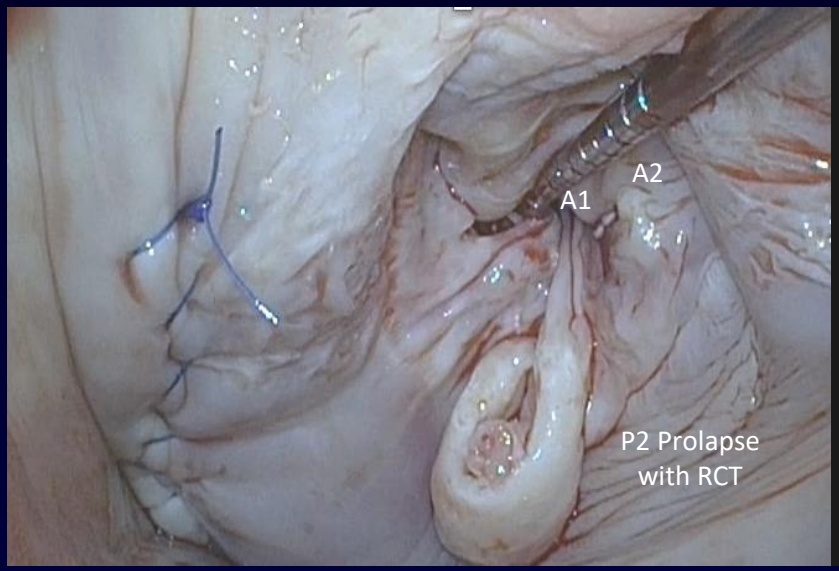
- Heart has a complex geometry
- Thin slices & tomographic images
- Mental reconstruction of 3D

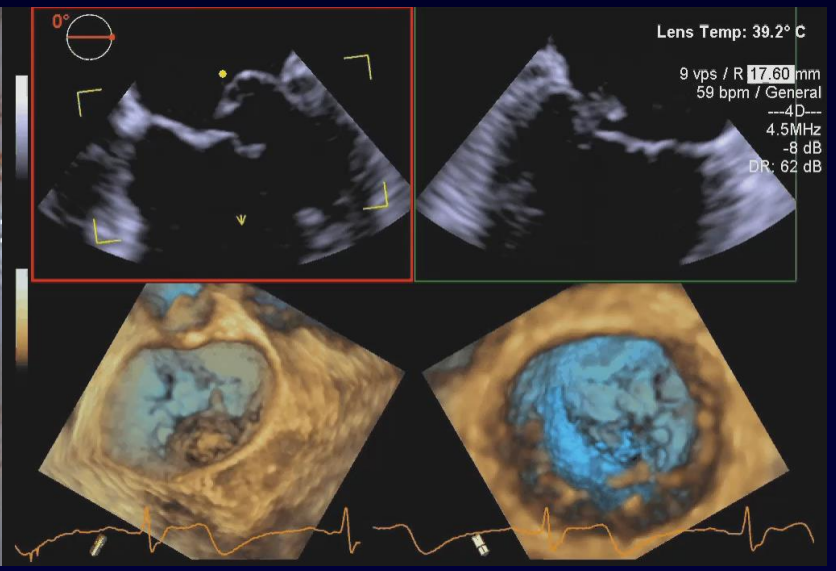
3D Echo: Automatic Quantification



Calleja A, Paaladinesh Thavendiranathan et al., Circ Cardiovasc Imaging 2013:6;99-108

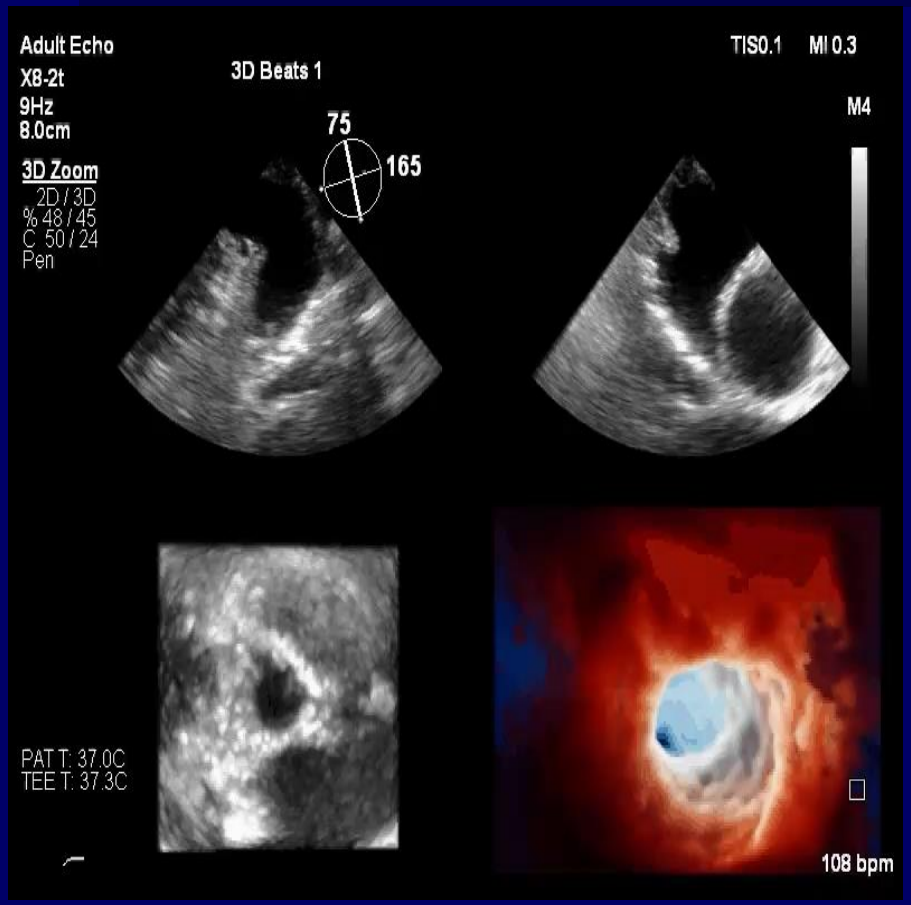
Primary MR - Leaflet Abnormalities
P2 Prolapse

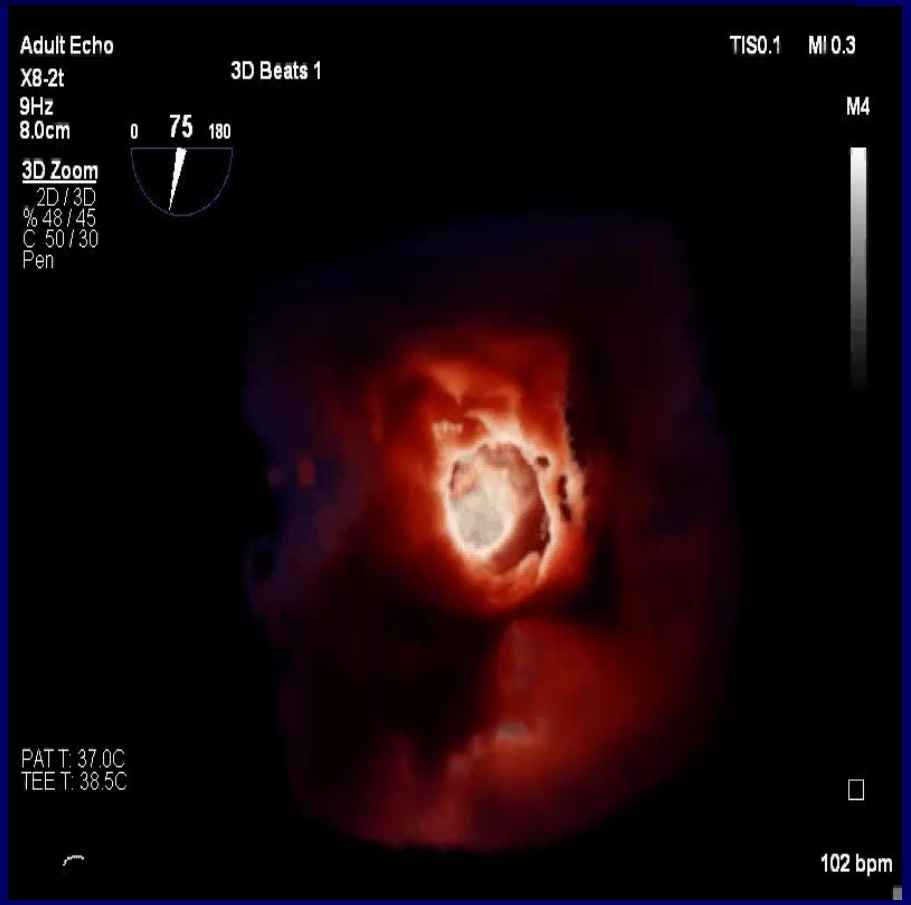




Surgical Anatomy **3D Echo Anatomy**

Photorealistic 3D imaging





Technical Advantages of TEE/TTE/ICE

Parameter	TEE	TTE	ICE
Sedation required	Yes	None	None
Imaging characteristics	High frequency/High resolution, superior 3D imaging	Lower frequency/lower resolution, difficult 3D imaging	TEE > ICE > TTE
Imaging windows	Esophagus/stomach → heart, interference with angiography, hiatal hernia, Esophageal Dz.	Chest wall→ Heart COPD, obesity, rib shadow, interference with sterility	Intravascular/Invasive
Aortic regurgitation	Optimal 2D and 3D	Device shadowing affects posterior paravalvular leakage	TEE > ICE > TTE
Cardiogenic shock/complications	Continuous monitoring Coronary occlusion, aortic complications	Discontinous monitoring Poor for aortic complications, poor for coronary occlusion	Continuous monitoring
Limitation	Requiring G.A	Poor Image quality Inability to monitoring	Expensive Invasive Need experience

Interventional Echo

MAX

Added Value

MIN

Mitral clip, TV repair
TMVR, PVL occlusion

TAVR, LAA occlusion

ASD occlusion

PMV, PPV, PDA occlusion

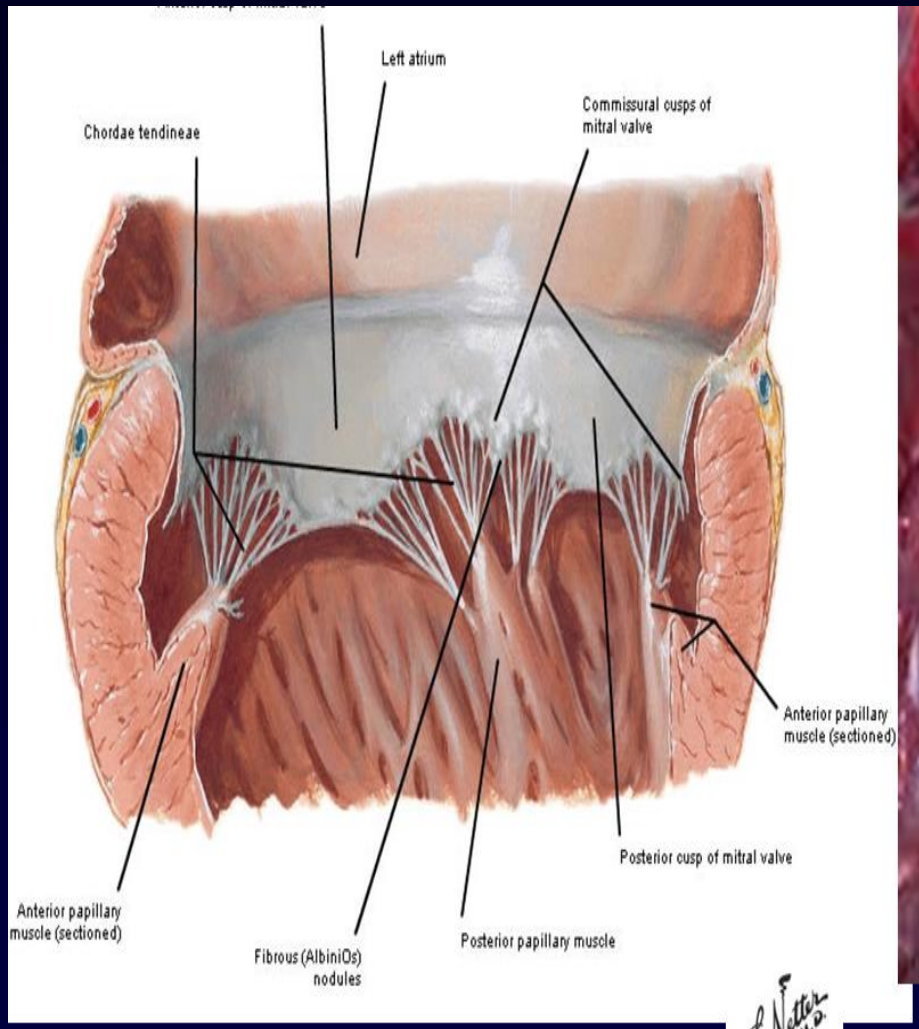
Echo Team Value

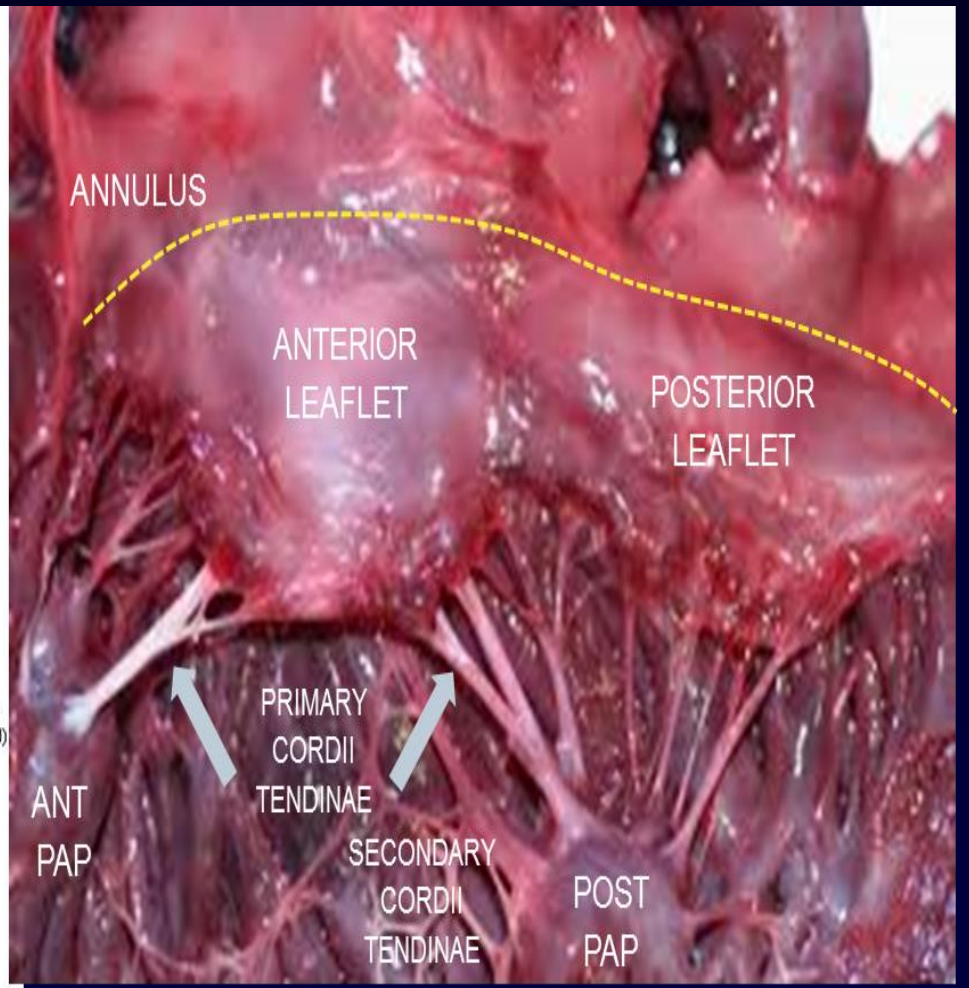
- **Patient Selection**
  - Etiology
  - Disease severity
  - Valve anatomy
- **Procedural Guidance**
  - Transeptal, Device implantation
  - Monitoring for complication
  - Final result assessment
- **Follow-Up**
  - Immediate & long term
  - Re-intervention

Mitral Valve

- Most complex structure of human heart
  - Multifaceted anatomy
  - Annulus, two leaflets, chordae, two papillary muscles
  - Structure of ventricle, not atrium !
  - Aortomitral angle, risk of SAM
  - Attached to AoV via aortomitral continuity
- The only valve that has a distinguishable anatomic annulus
- The level of free edge is normally lower than the annulus.

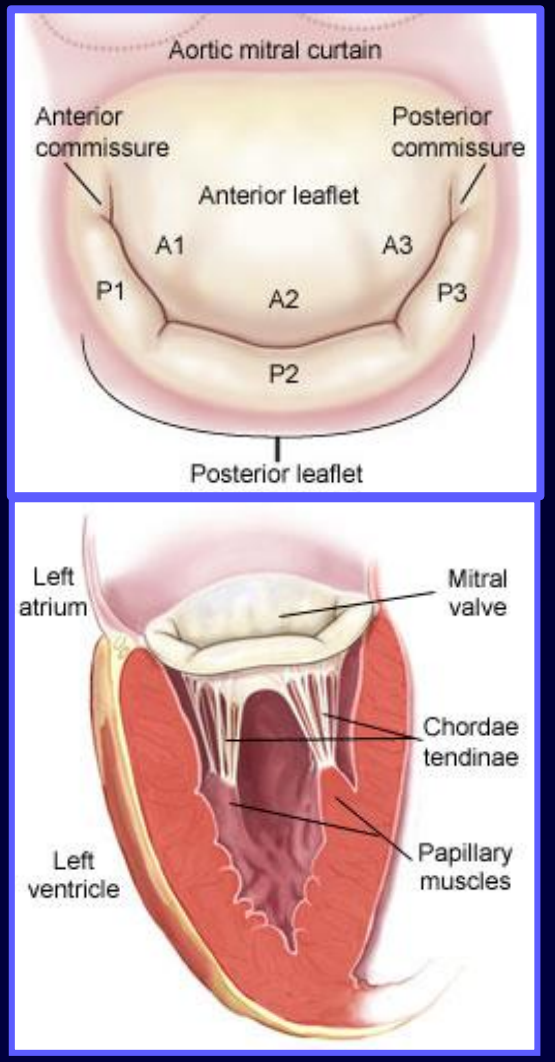
Mitral Valve Anatomy





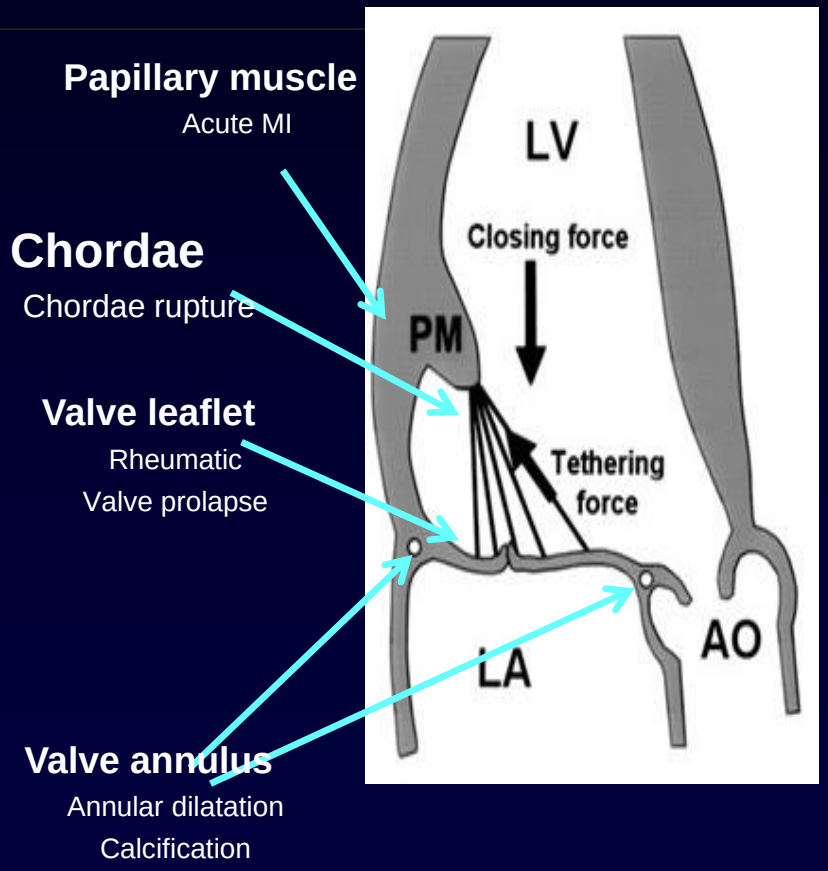
Element of MV Apparatus

- Annulus
- Leaflets
- Subvalvular appratus
  - Chordae tendinae
  - Papillary muscles



Mechanism of MR

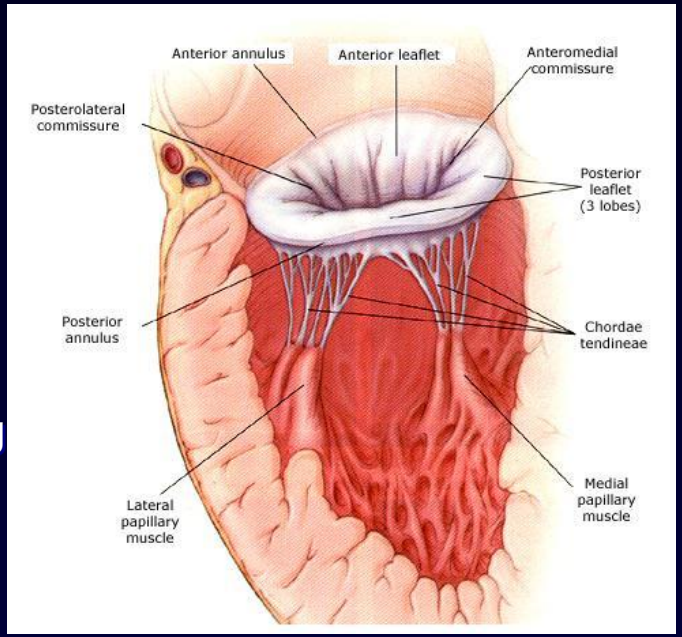
- **Leaflet Abnormalities**
  - Prolapse
  - Indentations/Clefts
  - Calcification
  - Perforation
  - Tethering
- **Chordal Abnormalities**
  - Elongation/Rupture
  - Shortening
- **Annular Dilatation**



Transcatheter Mitral Valve Devices Mechanism of Action

Annulus

- **Indirect annuloplasty**
  - Coronary sinus approach
  - Asymmetrical approach
- **Direct annuloplasty**
- Mechanical cinching
- Energy mediated cinching
- Hybrid



Leaflets

- **Edge-to-Edge**
- Leaflet ablation
- Space occupier

Left Ventricle

- LV (and MA) remodeling

MV replacement

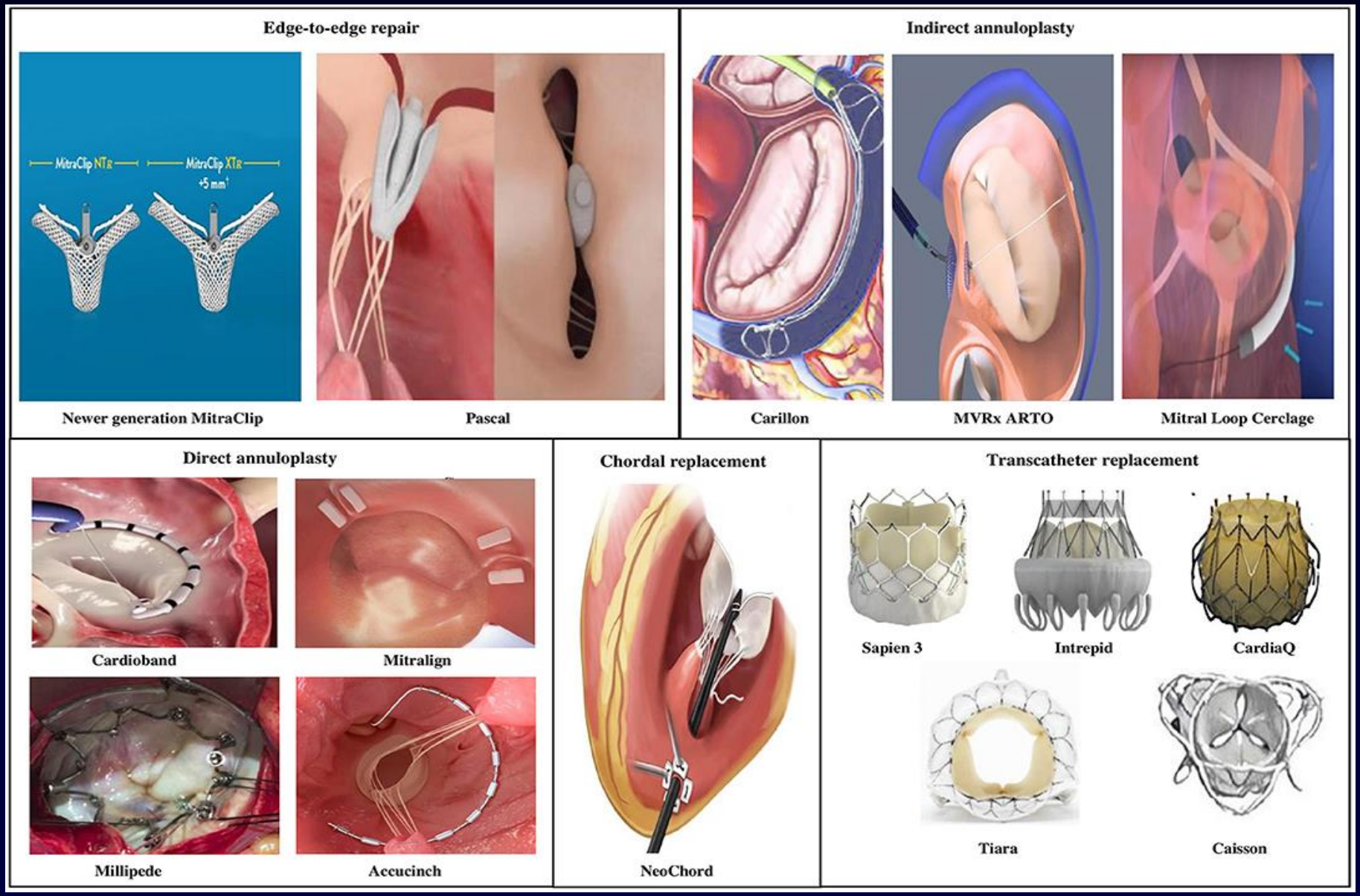
- Right mini-thoracotomy
- Transapical
- Transseptal

Chordal implants

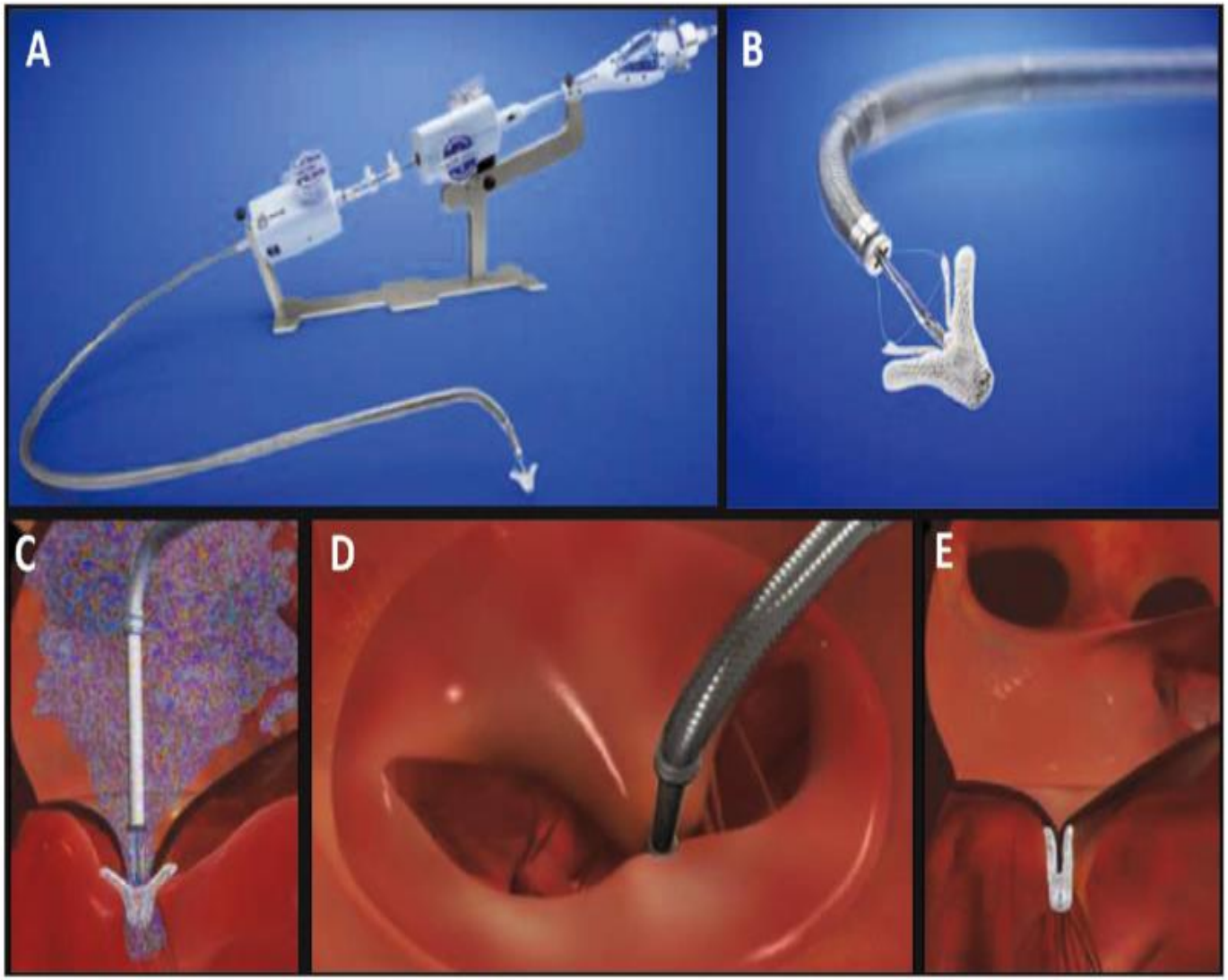
- Transapical
- Transapical-Transseptal

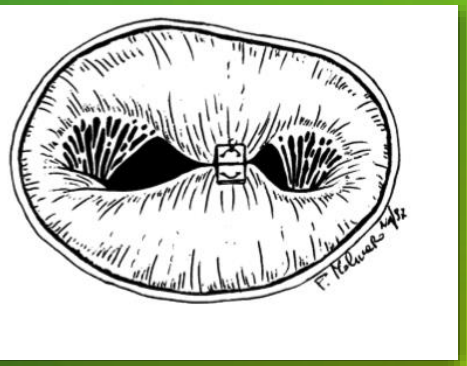
Otto *N Engl J Med* 2001:345:740-746

Five transcatheter approaches



MitraClip





1998

ELSEVIER

European Journal of Cardio-thoracic Surgery 13 (1998) 240–246

EUROPEAN JOURNAL OF CARDIO-THORACIC SURGERY

The edge-to-edge technique: a simplified method to correct mitral insufficiency[1]

F. Maisano [a,*], L. Torracca [a], M. Oppizzi [a], P.L. Stefano [a], G. D'Addario [a], G. La Canna [b], M. Zogno [b], O. Alfieri [a]

[a] *Division of Cardiac Surgery, IRCCS S. Raffaele Hospital, Via Olgettina 60, 20132, Milano, Italy*
[b] *Cardiac Surgery Department, Civic Hospital, Brescia, Italy*

Received 14 October 1997; received in revised form 2 January 1998; accepted 14 January 1998

2003, 1st MitraClip patient

2003 — EVEREST I 2003-2006: Feasibility Study, *55 Patients Enrolled*; FIRST IMPLANT

2004

2005 — EVEREST II 2005-2008: Randomized Controlled Trial, *279 Patients Enrolled*

2006

2007 — EVEREST II HIGH RISK STUDY 2007-2008: Single-Arm Study, *78 Patients Enrolled*

2008 — CE MARK

2009 — EVEREST II REALISM 2009-2014: Continued Access, *965 Patients Enrolled*; ACCESS EUROPE 2009-2012: Single-Arm Study, *567 Commercial Patients Enrolled*

2010

2011

2012

2013 — STS/ACC TVT REGISTRY 2013-Present: Commercial Registry, *1998 Patients Enrolled*; COAPT 2013-2017: Randomized Controlled Trial, *614 Patients Enrolled*; FDA

2014 — HEALTH CANADA

2015

2016 — MITRACLIP® NTR LAUNCH

2017 — COAPT CAS 2017-Present: Single-Arm, Continued Access *Currently Enrolling*

2018 — MITRACLIP® XTR LAUNCH

MITRACLIP™ IS THE ONLY TMVr OPTION WITH OVER 15 YEARS OF CLINICAL EXPERIENCE

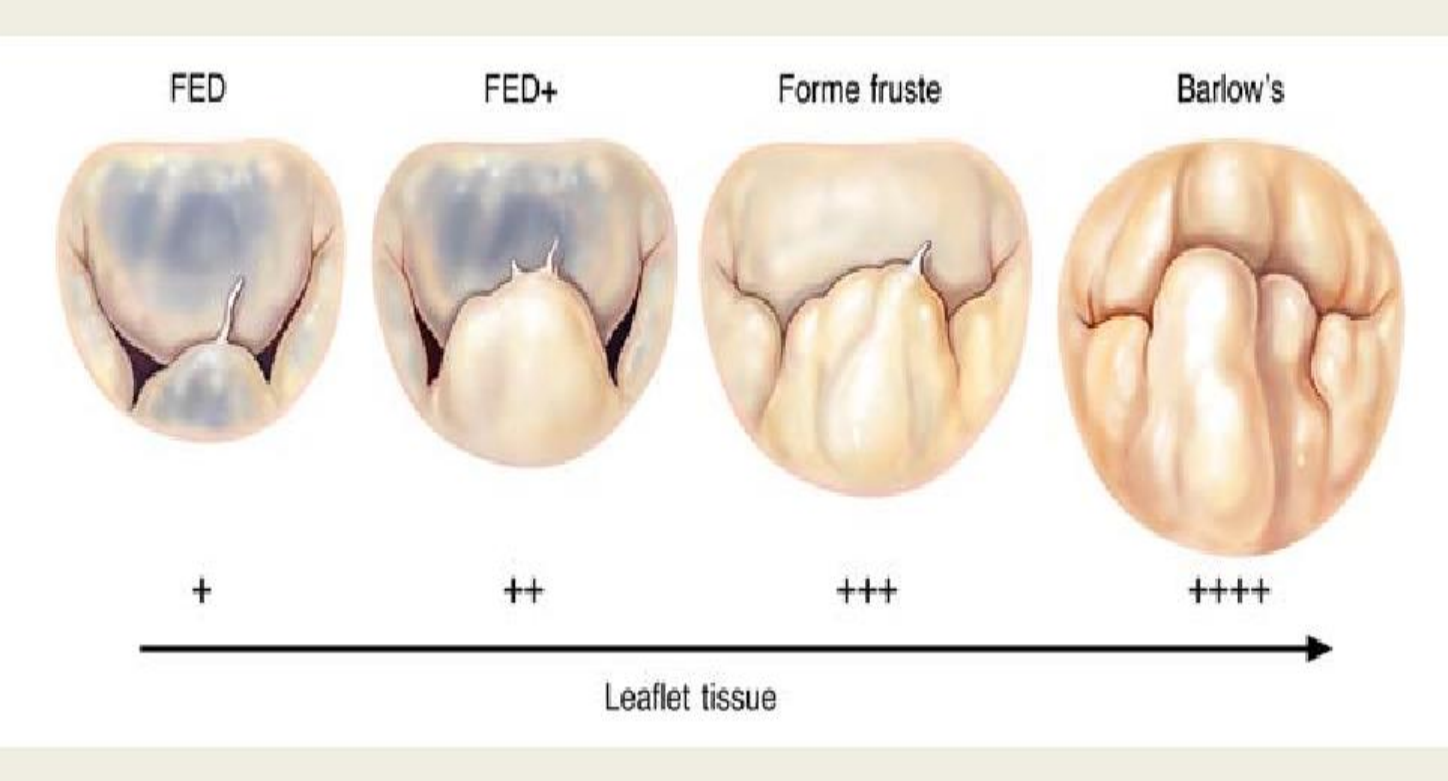
Echo in MV Intervention

- **Patient Selection**
  - Etiology
  - MR severity
  - Valve Anatomy
- **Procedural Guidance**
  - Transseptal
  - Alignment, positioning and grasping
- **Follow Up**
  - MR post
  - Stability

Echocardiographic predictors of feasibility

Likely

Unlikely



Abdallah El Sabbagh et al. JIMG 2018;11:628-643

EVEREST criteria (favorable morphology)

- Planimetered MV area ≥4.0 cm^2
- Minimal leaflet calcification in the grasping area
- Coaptation length of >2 mm
- Coaptation depth of <11 mm
- A flail gap of <10 mm and a flail width of <15 mm in degenerative disease
- Preferred in A2-P2 area

Feldman T et al. J Am Coll Cardiol. 2005;46:2134–40.

Unfavorable echo characteristics for mitral valve repair

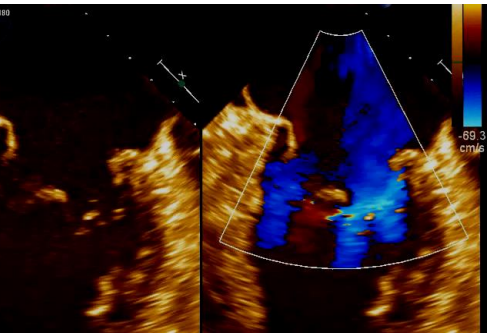
Mitral valve deformation	- Coaptation distance ≥1 cm - Tenting area > 2.5–3 cm^2 - Complex jets originating centrally and posteromedially - Posterolateral angle >45˚ (high posterior leaflet tethering)
Local LV remodeling	- Interpapillary muscle distance >20 mm - Posterior papillary-fibrosa distance >40 mm - Lateral wall motion abnormality
Global LV remodeling	- EDD >65 mm, ESD >51 mm (ESV >140 mL) (low likelihood of reverse LV remodeling after repair and poor long-term outcome) - Systolic sphericity index > 0.7

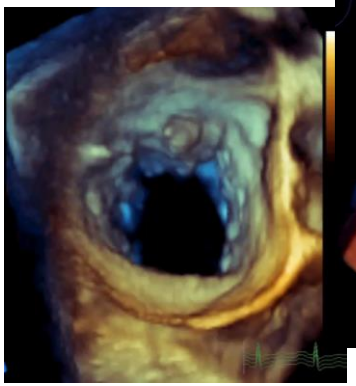
Eur Heart J-CVI. 2013;14:1611-1644

Pre-procedural assessment

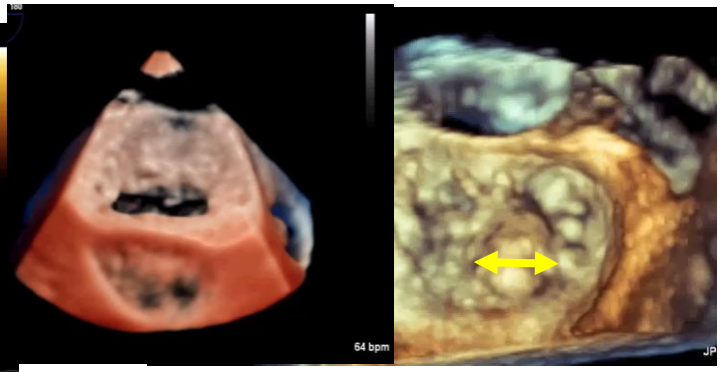
Characterization of valve morphology

Location of pathology

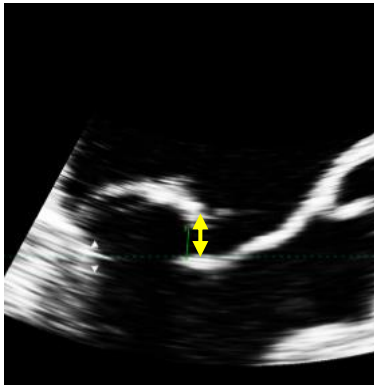




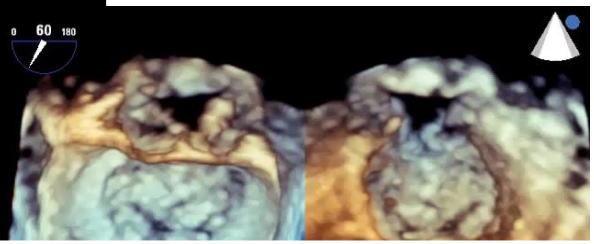
Flail width



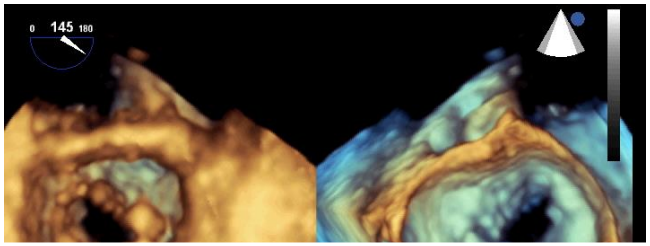
Flail gap

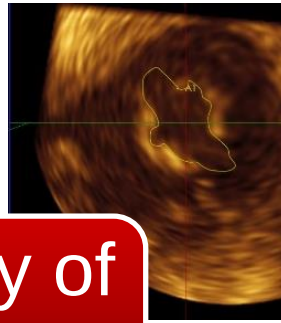


Deep identations/Clefts



Severe Calcification / Small MVA





A profound understanding of the 3D anatomy of the MV sets the stage für the entire procedure

A = 3.7 cm

Percutaneous MV Repair

Diagnosis and Work-Up

- TTE: Initial diagnosis and valve characterization
- TEE: Define structure, including 3D
- CT: Angle independent analysis and planning

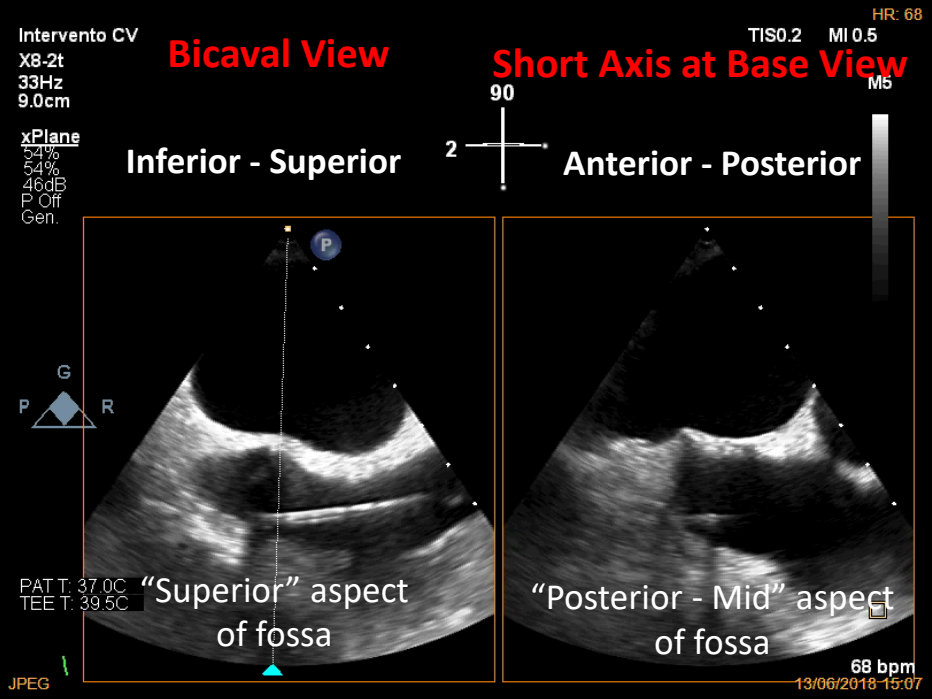
Intra Procedure

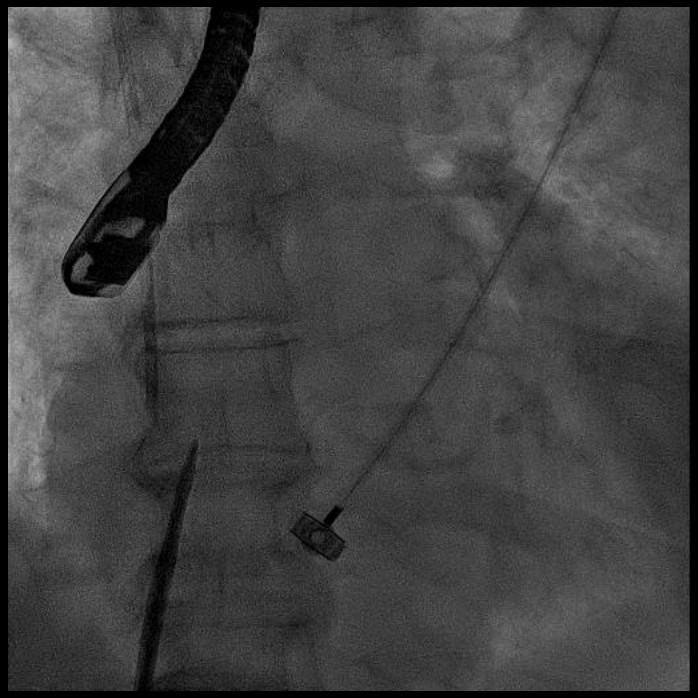
- TEE: Trans-septal puncture, 3D and multiplane
- Fluoroscopy: catheter motion
- Echo-navigation technique
- ICE

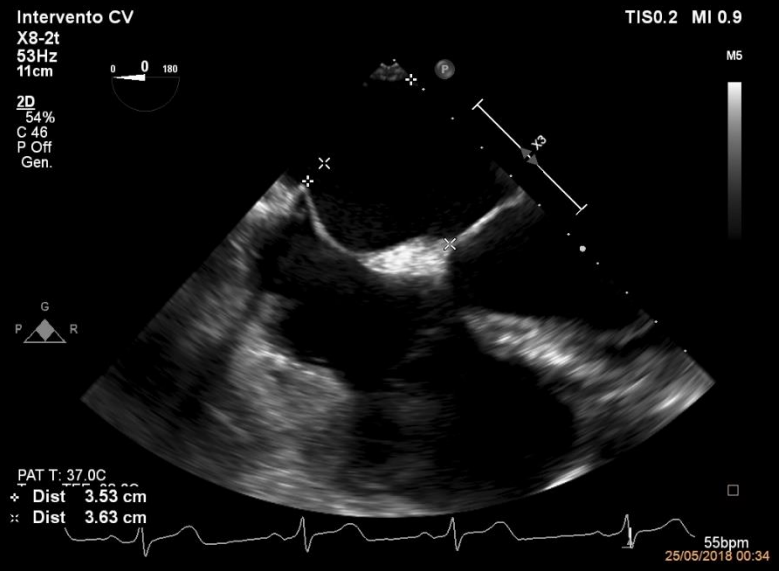
7 Procedural main steps

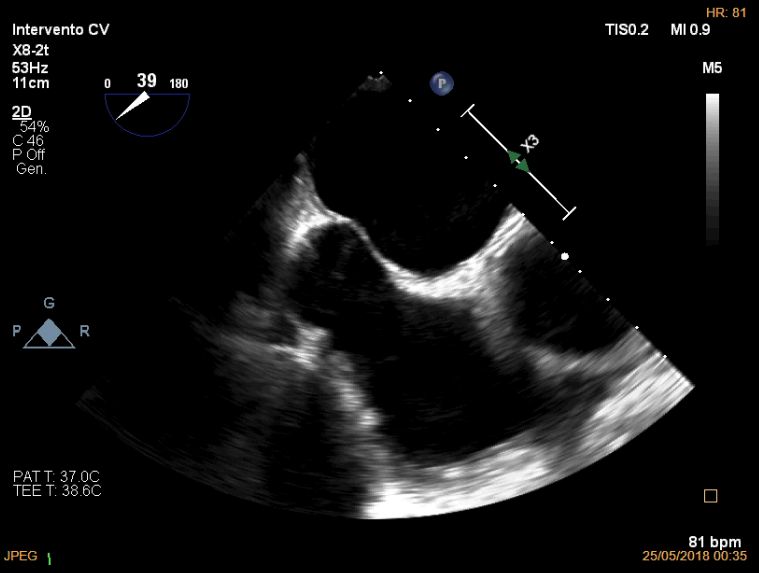
1. Transseptal puncture
2. Introduction of the Steerable Guide Catheter
3. Insertion of Clip Delivery System (CDS) in the LA
4. Clip positioning in LA
5. Advancement of open Clip into the LV
6. Grasping of leaflets
7. Assessment of final result and leaflet insertion

1. Transseptal Puncture

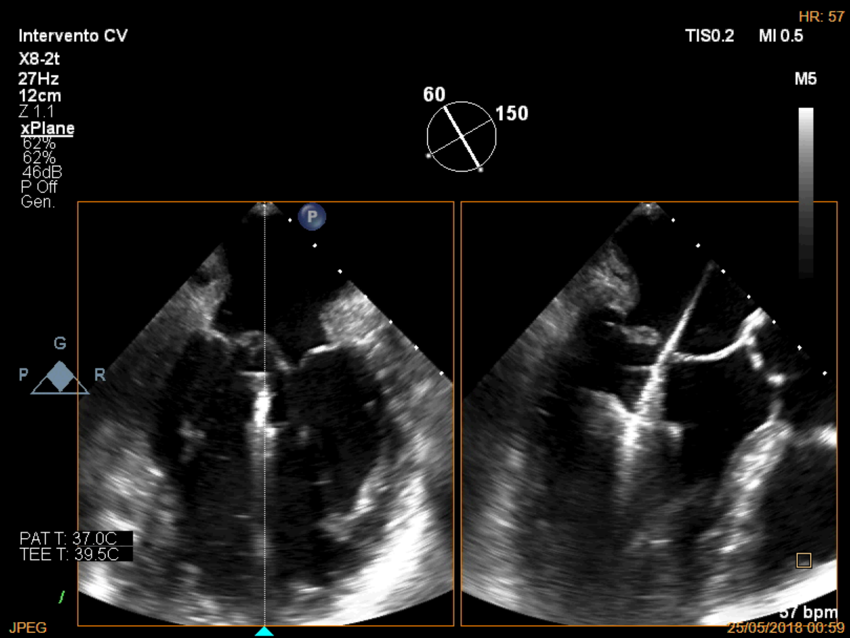


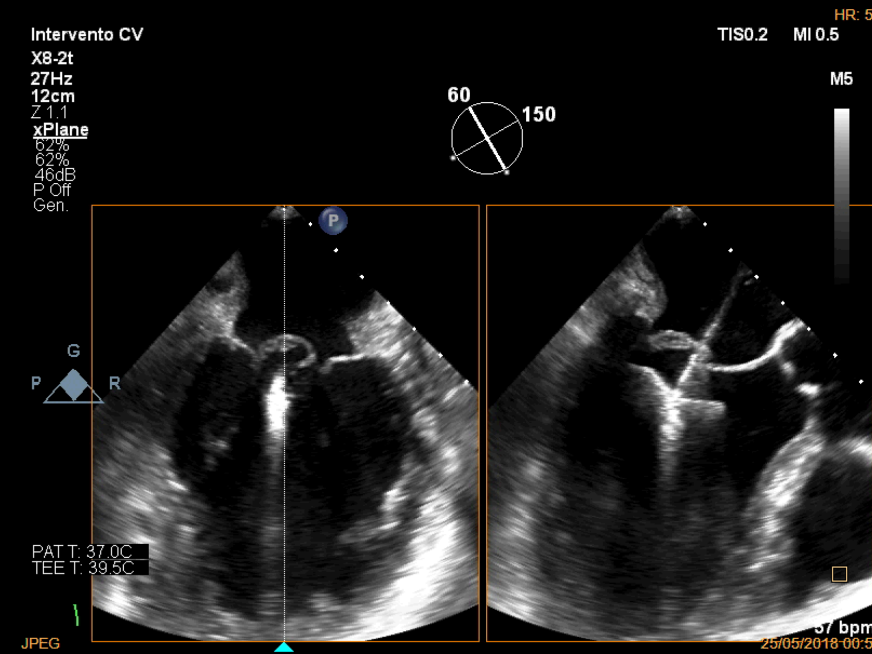


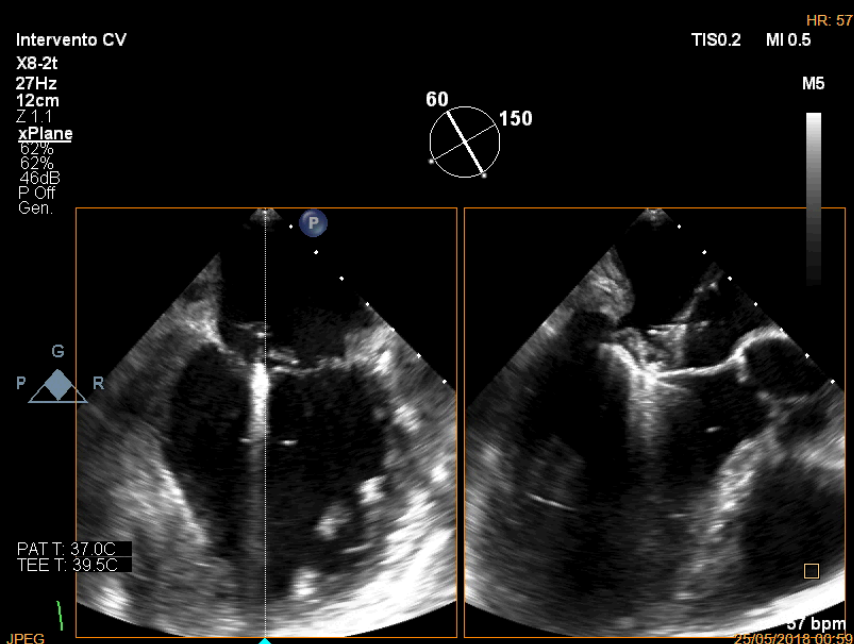


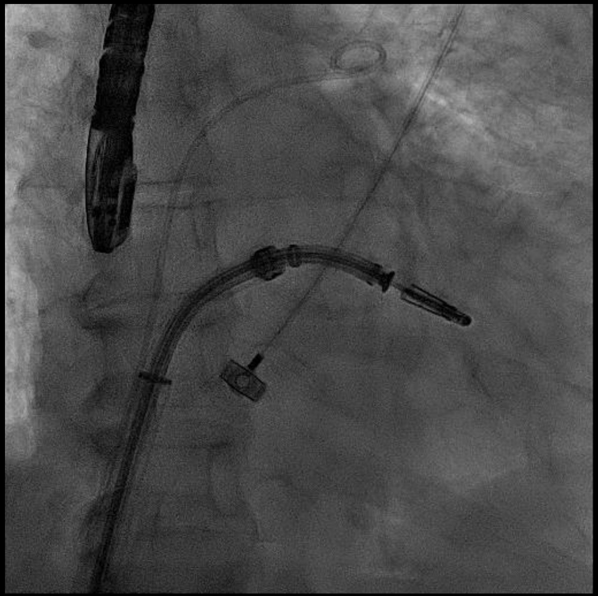


6. Advancement into LV - Grasping



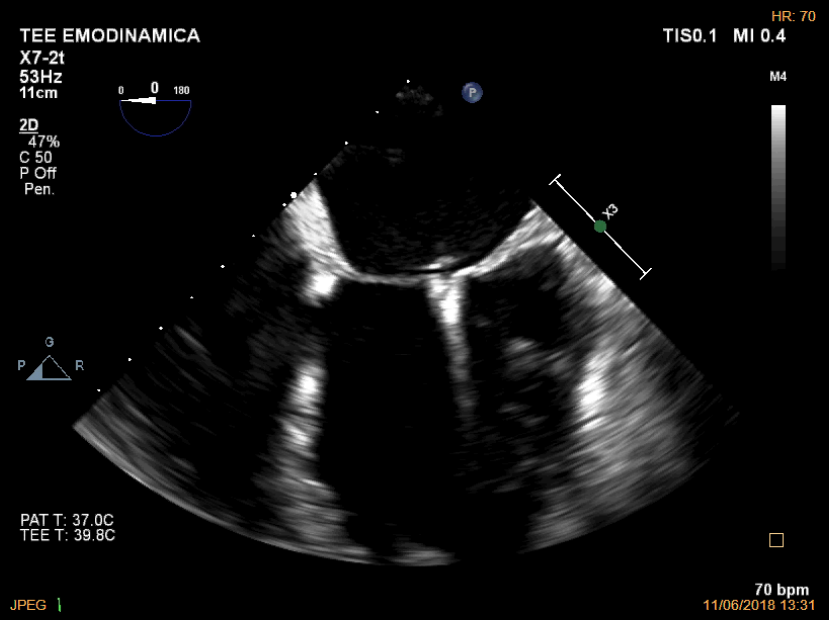




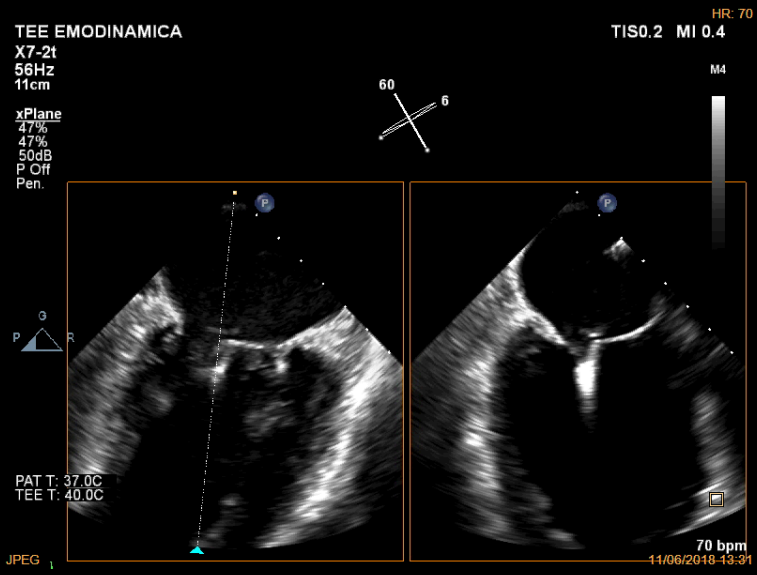


7. Assessment of Leaflets Insertion

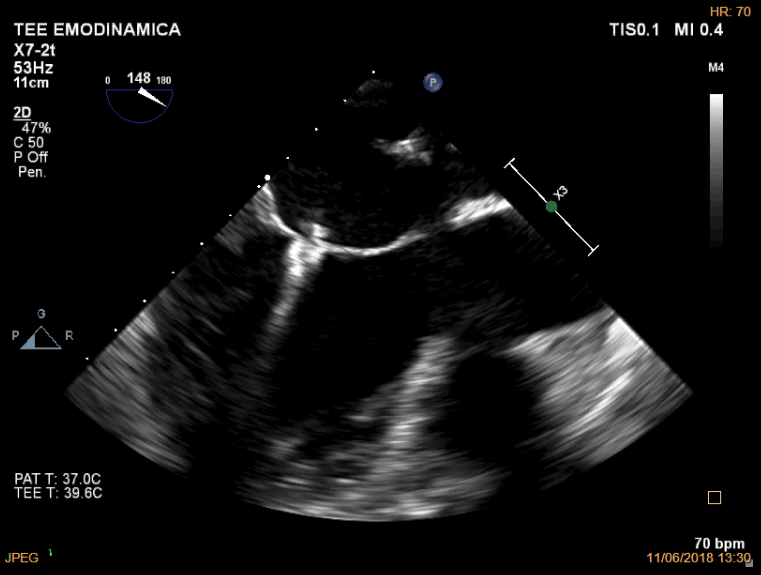
Four chamber view



Biplane view

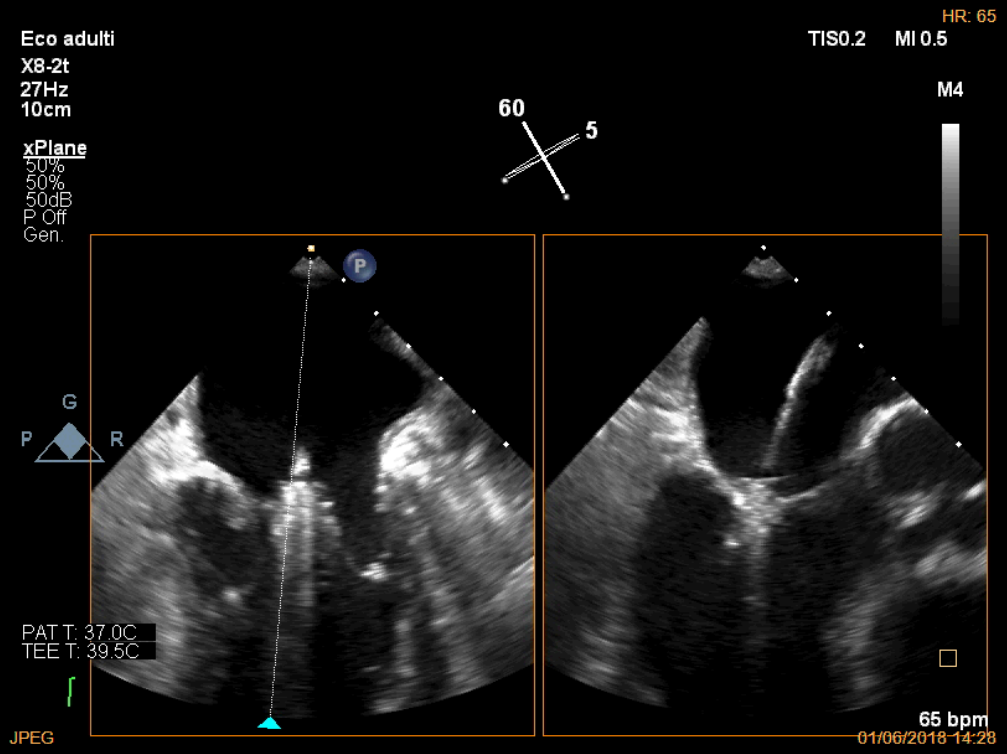


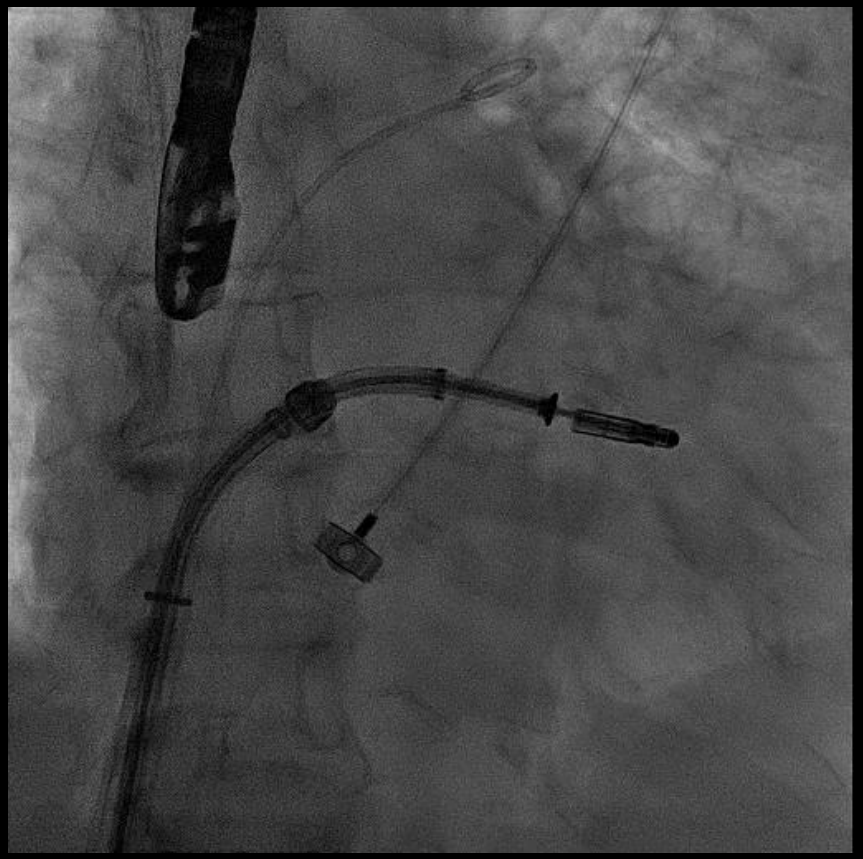
Long axis view



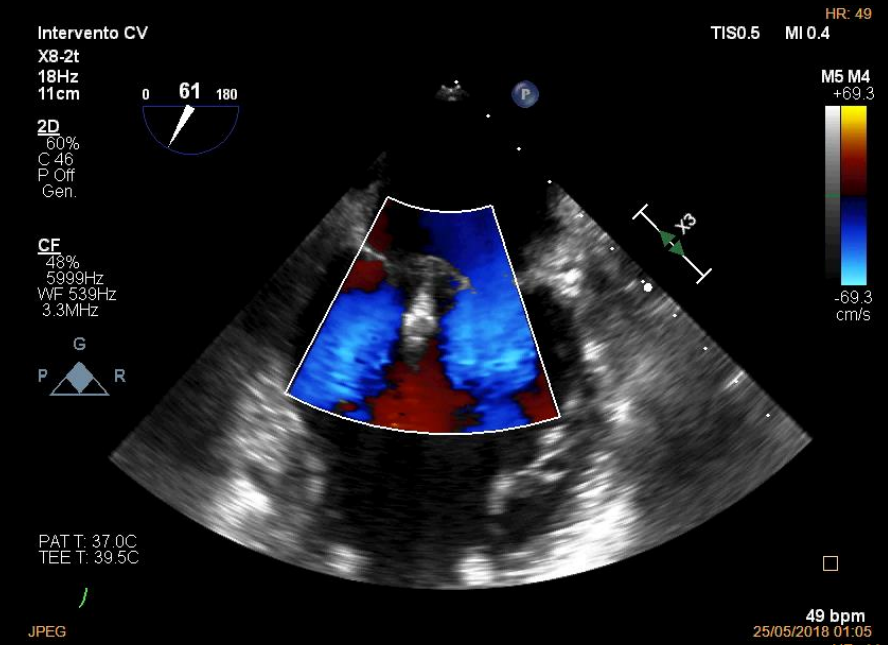
Double Orifice

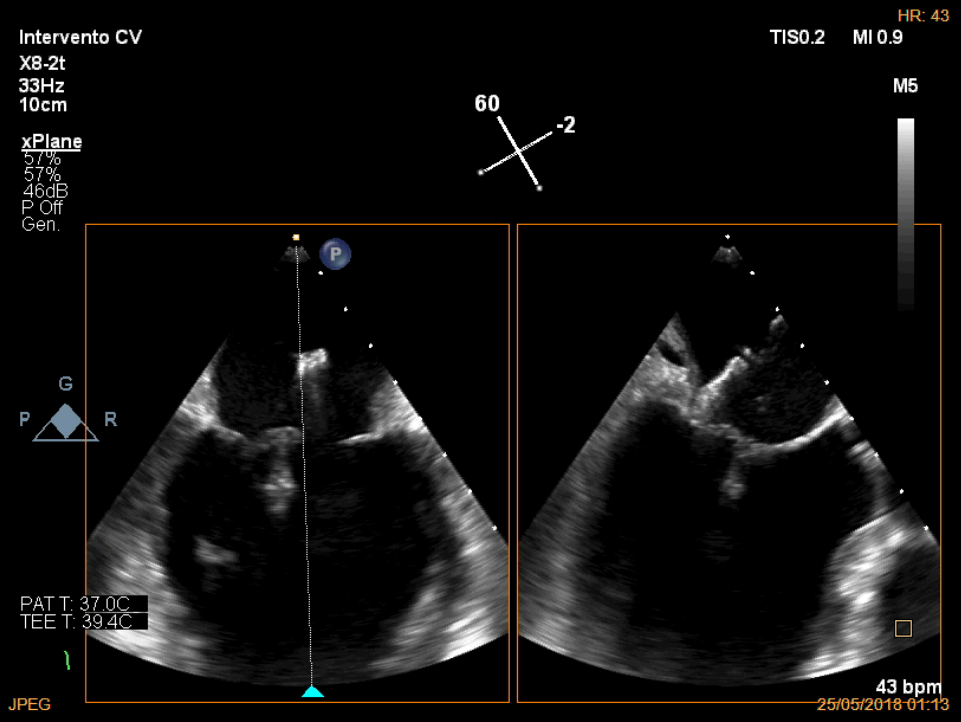
9. Clip Deployment

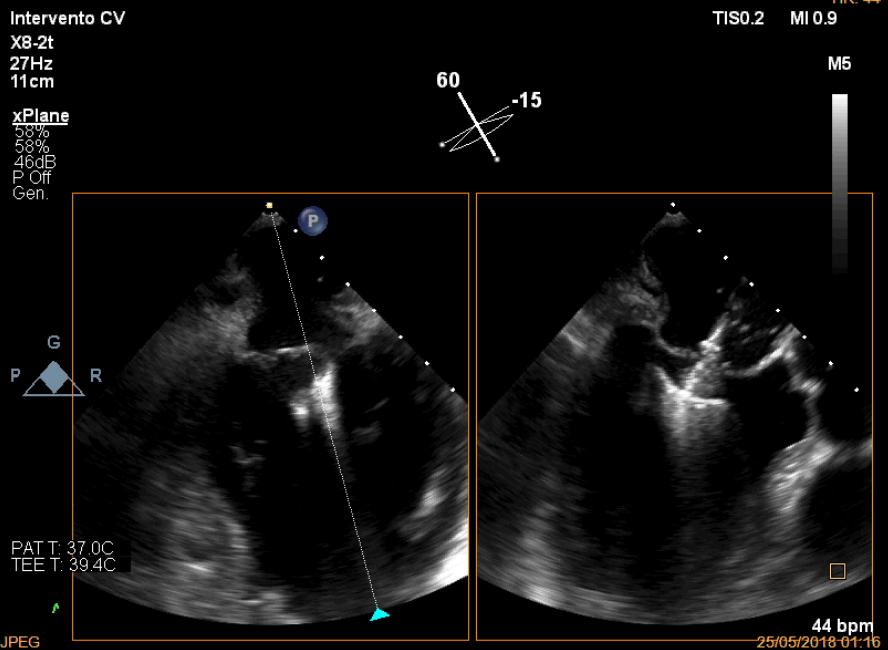




10. Final Result Assessment – Second Clip







Guidelines for the Evaluation of Valvular Regurgitation After Percutaneous Valve Repair or Replacement

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Angiography and Interventions, Japanese Society of Echocardiography, and Society for Cardiovascular Magnetic Resonance

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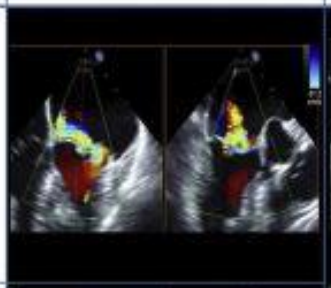
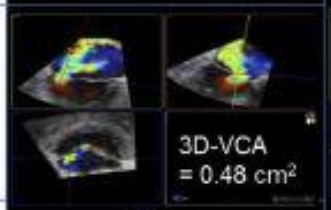
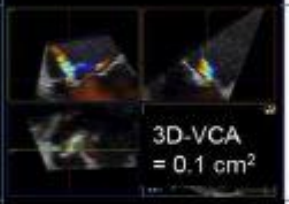
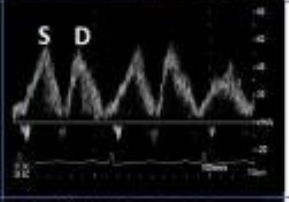
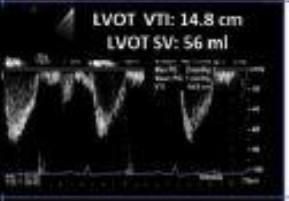
Keywords: Doppler echocardiography, Valve disease, Transaortic valve replacement, Magnetic resonance imaging, Aortic regurgitation, Mitral regurgitation

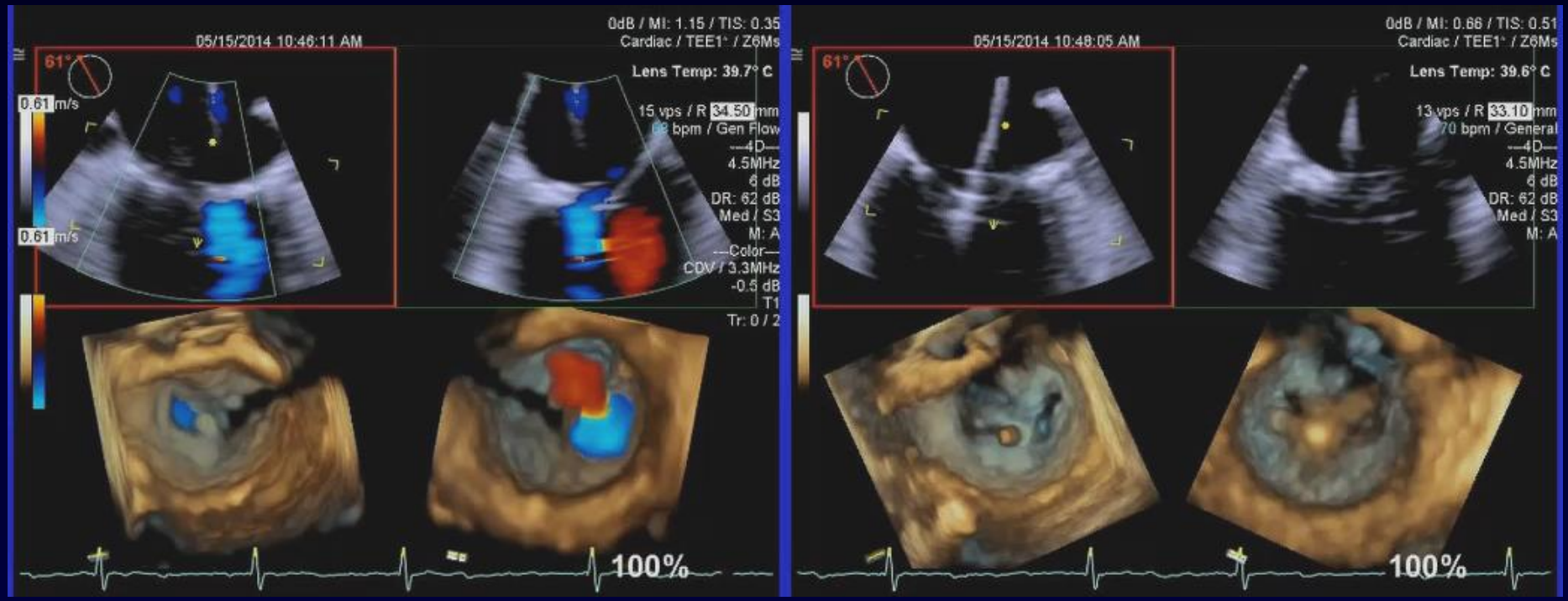
Findings of ≤ Mild Residual MR	Baseline	After Edge-to-edge Repair	Specific Features
Significant reduction in color Doppler jet features			• Small vena contracta width (< 0.3 cm) of individual MR jets • Small flow convergence radius (≤ 0.3 cm) • Central MR jet with limited penetration into LA
Significant reduction in VCA by 3D color Doppler			• More tedious to perform • VCA < 0.2 cm²
Improvement or normalization of pulmonary vein flow			• Change from S-wave reversal or blunting to antegrade flow • Marked reduction in D-wave velocity
Improvement of forward stroke volume (Deep trans-gastric LVOT VTI); often with decrease in LVEF			• Marked increase in PWD VTI in LVOT and derived systemic stroke volume • "paradoxical" decrease in LVEF by 5-10%
New onset spontaneous contrast within LA or LA appendage			• Associated with low flow conditions including atrial fibrillation, and/or severe LV systolic dysfunction • Mean diastolic MV gradient may not be markedly elevated (e.g. < 7mmHg)

gure 11 Illustrative echocardiographic parameters of reduction of MR severity to mild after edge-to-edge mitral valve repair.

Table 5 Hemodynamics and TEE parameters useful in determining residual MR severity during MV interventions in the catheterization laboratory

Parameter	Assessing severity of residual MR
Invasive hemodynamics	Decrease in regurgitant *v* wave, LA pressure, and pulmonary pressures are specific signs of reduction in MR severity; Consider effects of general anesthesia on MR severity
General echocardiographic findings	
Spontaneous echo contrast in LA	Appearance of spontaneous contrast after MV intervention suggests significant reduction in MR severity
LVEF	Decline in LVEF after MV intervention suggests significant MR reduction in the absence of other causes (ischemia, pacemaker-related, etc.)
Color Doppler	
Color Doppler jet (size, number, location, eccentricity)	- Easy to obtain with a comprehensive, systematic approach - Difficult to assess multiple and eccentric jets - Jet area affected by eccentricity, technical and hemodynamic factors (especially driving velocity)
Flow convergence	- Large flow convergence denotes significant residual MR whereas a small or no flow convergence suggests mild MR - Difficult to use in presence of multiple jets or very eccentric jets, or may be masked by the device
Vena contracta width	- VCW ≥0.7 cm specific for severe MR - Difficult to use in presence of multiple small jets or very eccentric jets for which orifice shape is not well delineated
Vena contracta area (3D planimetry)	- Allows better delineation of eccentric orifice shape and possibly the addition of VCA of multiple jets - Prone to blooming artifacts
Spectral Doppler	
Pulmonary vein flow pattern	- Systolic flow reversal in >1 vein specific for severe MR - Increase in forward systolic velocity after MV intervention helps confirm MR reduction
MR jet profile by CWD (contour, density, peak velocity)	- Dense, triangular pattern suggests severe MR - May be hard to line up CWD properly in flail leaflet or very eccentric jet after intervention
Mitral inflow pattern	- In sinus rhythm, mitral A-wave-dominant flow excludes severe MR - Decrease in mitral E velocity and VTI suggests reduction in MR severity
Pulsed Doppler of LVOT (deep transgastric view)	Increase in LVOT velocity and VTI after procedure suggests MR reduction
Quantitative parameters	In general, more difficult to perform; some procedure-specific limitations in quantitation
EROA by PISA	- Not recommended after edge-to-edge repair because assumption of hemispheric proximal flow convergence is violated by the device. - PISA often underestimates MR severity in the presence of multiple jets or markedly eccentric jets. - Not feasible in PVR of mechanical prosthetic MV or possibly TMVR (flow masking in LV by TEE)
Regurgitant volume	- Difficult to perform volumetric RVol with pulsed Doppler by TEE

Post-Procedure
Real-Time Volume Color Flow Doppler TEE

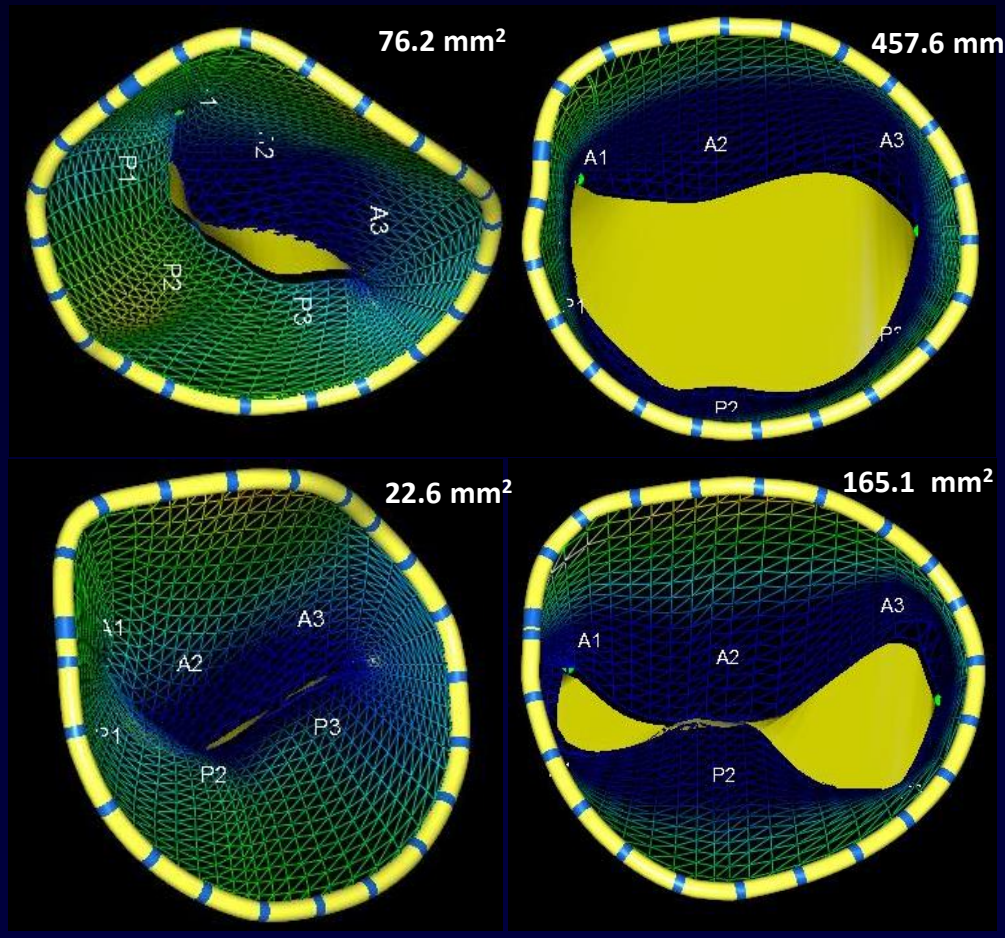


Quantification of Severity of MR

Anatomic EROA - MitraClip

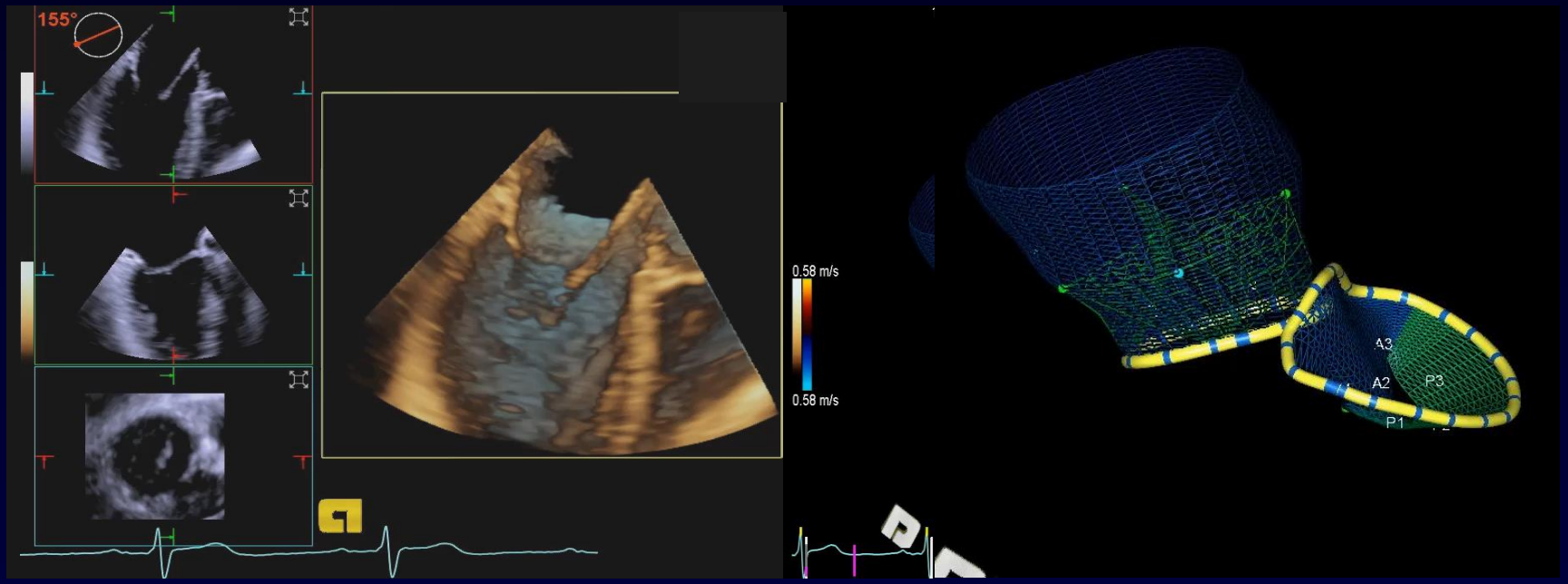
Pre

Post

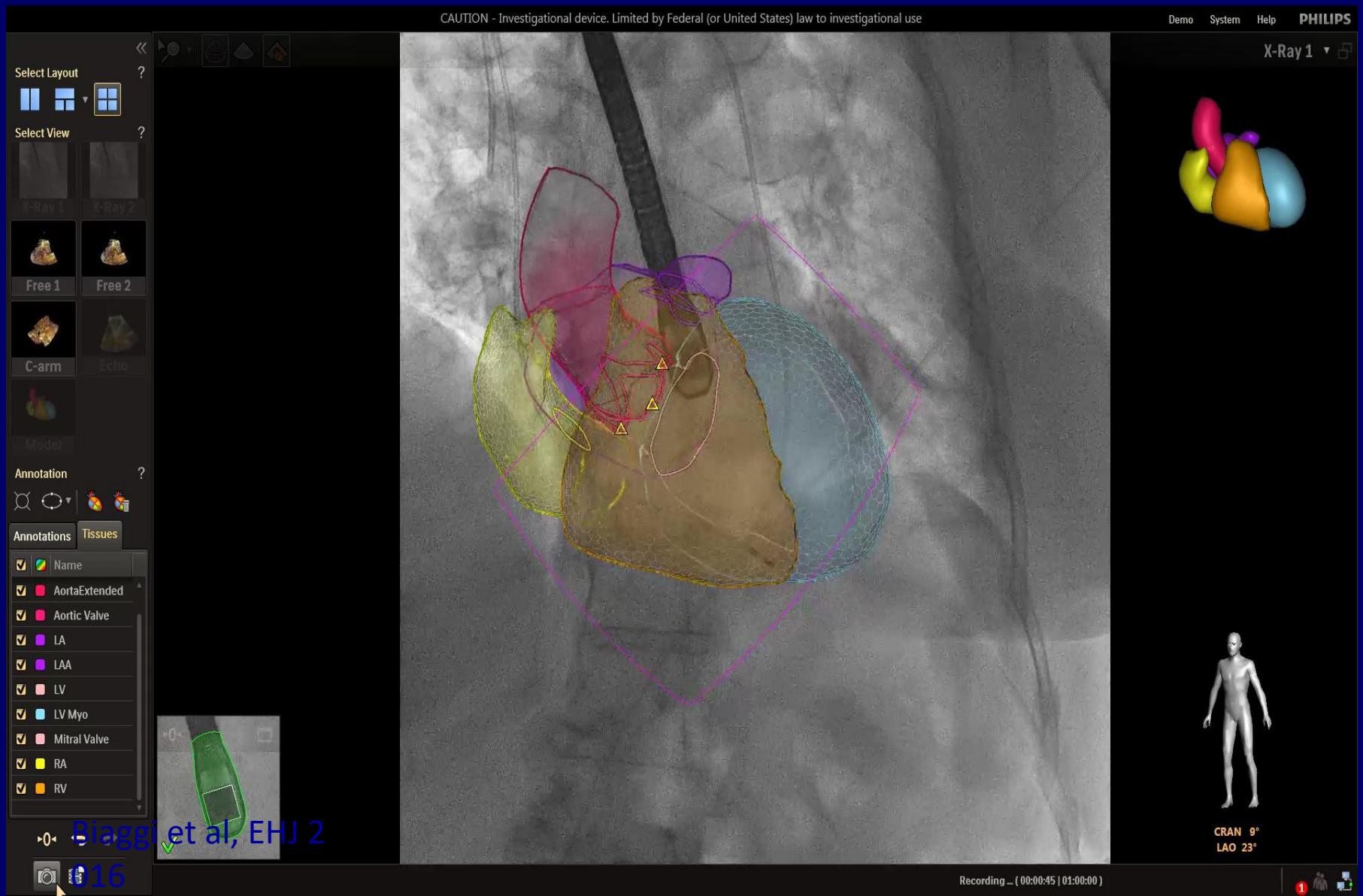


Aorto-Mitral Continuity

Imaging/Automated Modeling



Fusion Imaging



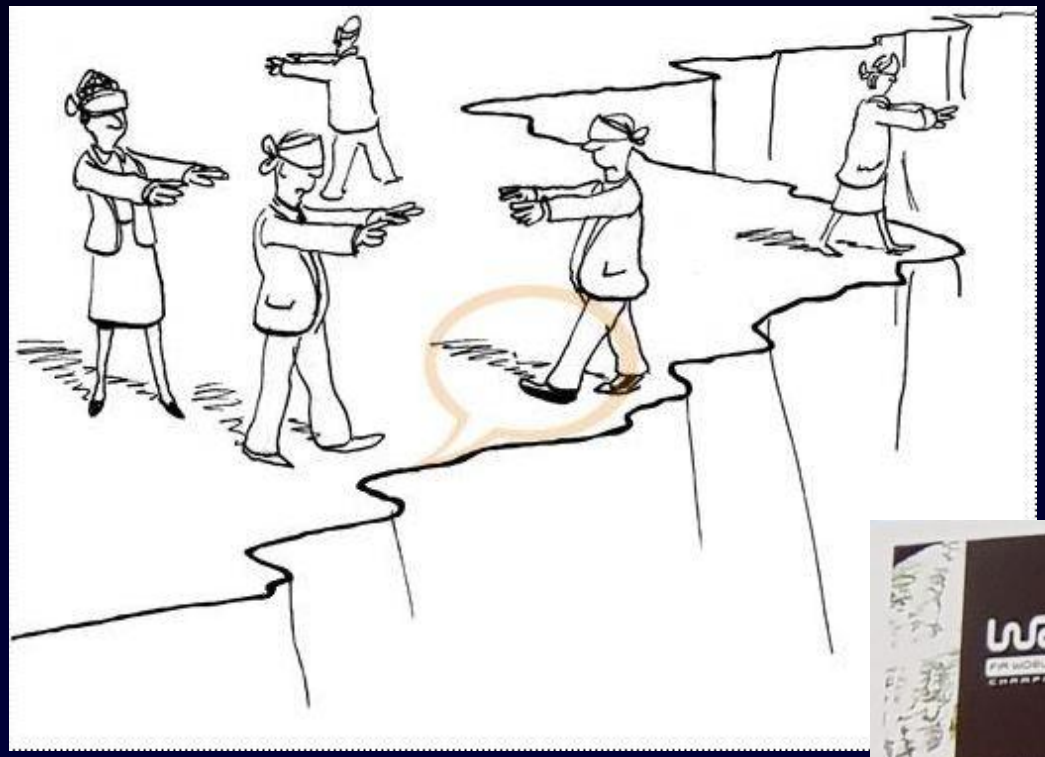
Biaggi et al, EHJ 2016

Take Home Message

- Cardiac imaging has an essential role in the planning and provision of valve intervention
- The imaging specialist must possess procedural knowledge, and precision in quantification, and communication in order to be part of a team that delivers good outcomes

SHD Intervention = Art, Science

Role of Echo in SHD



Thank you for your attention

Take Home Messages

- Each device has unique characteristics that require device specific imaging protocols for successful and safe deployment, as well as for evaluating residual MR severity.
- Color Doppler is a convenient first-line method for detecting the presence of residual MR, determining the number, location, and direction of MR jets, and for estimating MR severity

Take Home Messages

- Integration of echo/Doppler measures with invasive hemodynamics can help determine residual MR severity.
- In addition to assessment of residual MR severity, trans-mitral pressure gradient, mitral valve area, and potential LVOT obstruction should be evaluated.

Take Home Messages

- Echo is important for proper MV & TV intervention, preventing complications, and lethal outcomes.
- The imaging specialist must possess procedural knowledge, and precision in quantification, and communication with interventional cardiologist and cardiac surgeons.
- An experienced team can diagnose complications promptly and manage properly

Transcatheter Options to Treat MR

Timeline