Imaging of the mitral valve for screening: Echo vs TEE vs Stress Echo

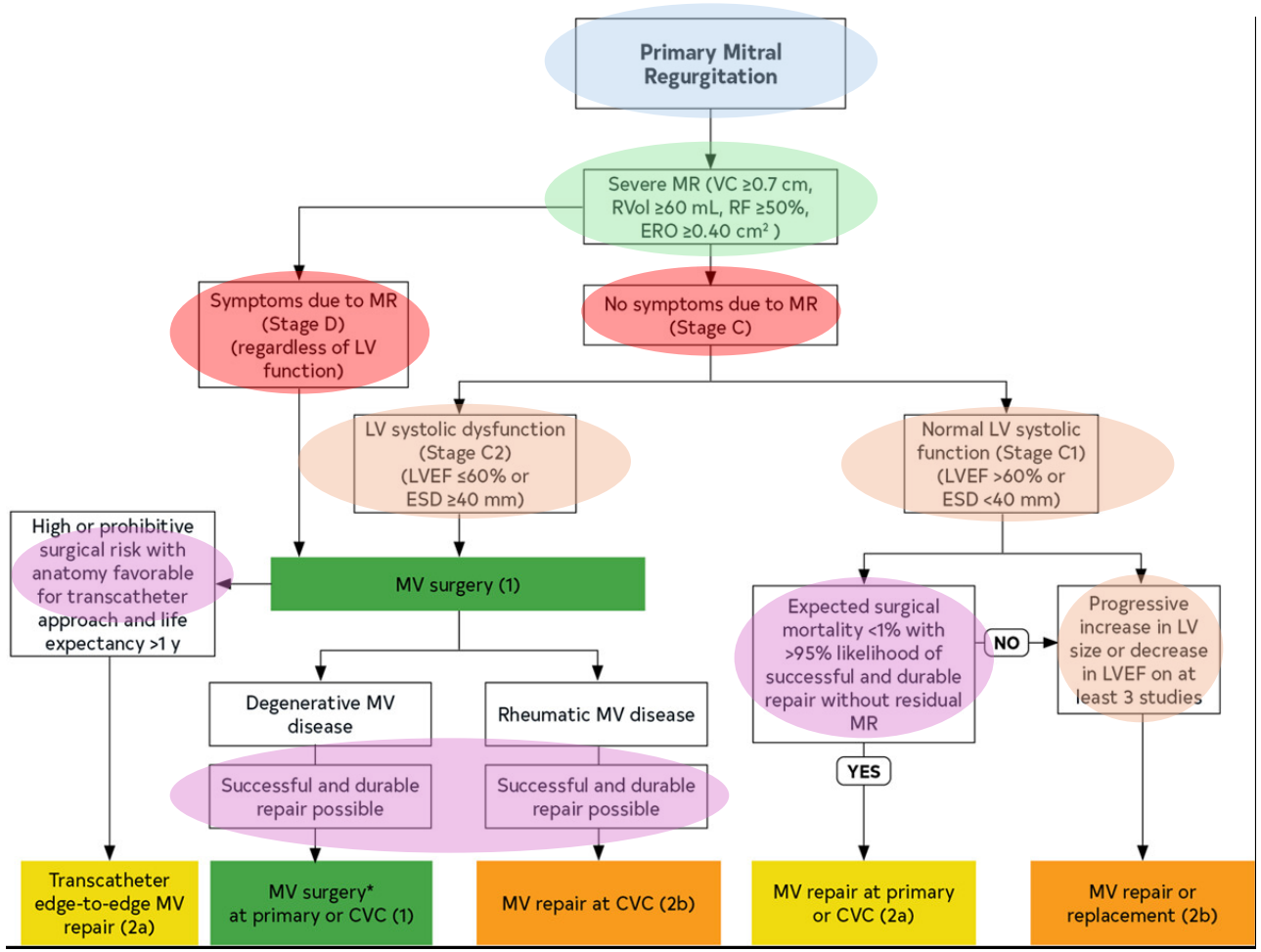
Rhonda Miyasaka, MD

Section of Cardiovascular Imaging

Cleveland Clinic

Management of Mitral Regurgitation

2020 ACC/AHA valve guidelines



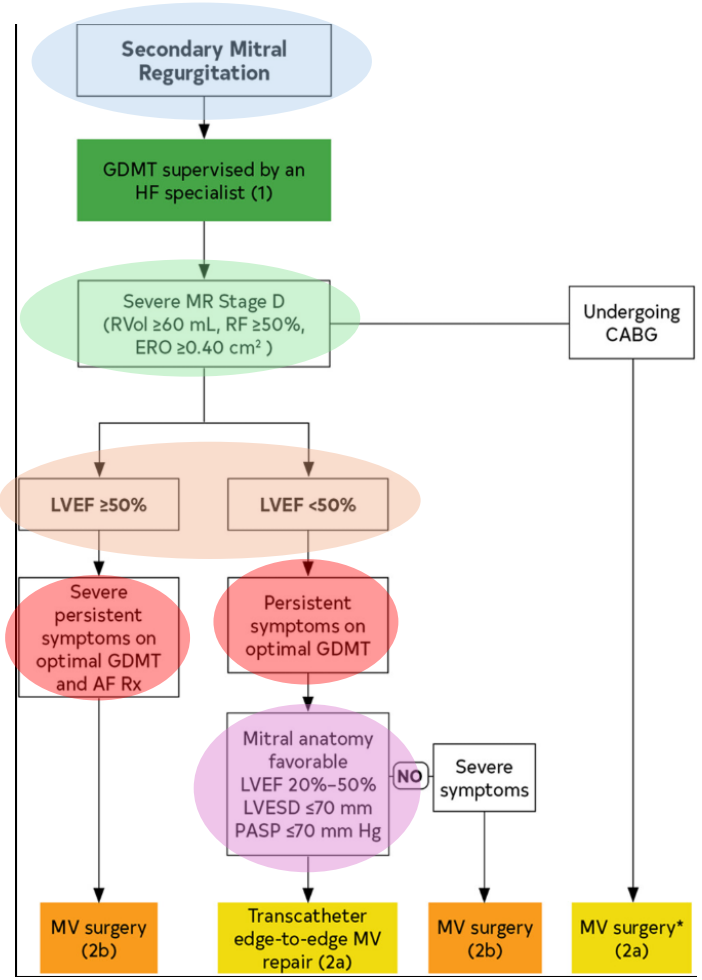
MR mechanism

MR severity

LV size/function

MV anatomy for surgical or transcatheter repair

Symptoms



TTE

TEE

Stress Echo

Evaluation of MR: TTE is your workhorse

- MR severity
- MR mechanism
- LV size and function
- Estimation of PA pressure

Recommendations for Diagnostic Testing: Initial Diagnosis of Chronic MR

Referenced studies that support the recommendations are summarized in Online Data Supplement 25.

COR	LOE	Recommendations
1	B-NR	1. In patients with known or suspected primary MR, TTE is indicated for baseline evaluation of LV size and function, RV function, LA size, pulmonary artery pressure, and the mechanism and severity of primary MR (Stages A to D).[1-5]

Diagnosis

Recommendation for Diagnostic Testing: Changing Signs or Symptoms in Patients With Primary MR

Referenced studies that support the recommendation are summarized in Online Data Supplement 26.

COR	LOE	Recommendation
1	B-NR	1. In patients with primary MR (Stages B to D) and new-onset or changing symptoms, TTE is indicated to evaluate the mitral valve apparatus and LV function.[1,2]

Change in Sx

Recommendations for Diagnostic Testing: Routine Follow-Up for Chronic Primary MR

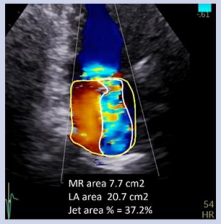
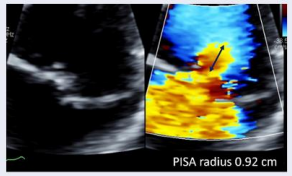
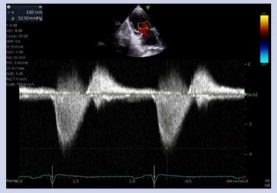
Referenced studies that support the recommendations are summarized in Online Data Supplement 27.

COR	LOE	Recommendations
1	B-NR	1. For asymptomatic patients with severe primary MR (Stages B and C1), TTE is indicated every 6 to 12 months for surveillance of LV function (estimated by LVEF, LVEDD, and LVESD) and assessment of pulmonary artery pressure.[1-11]

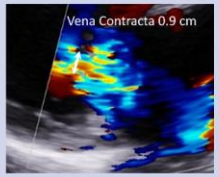
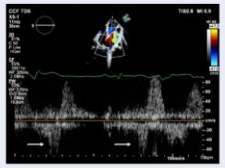
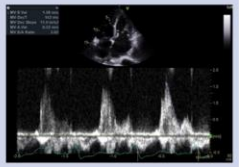
Routine follow up

MR severity

Qualitative

Method	Description	Example	Definition of Severe
Jet area	Apical view. Measure largest jet area compared to left atrial area		>50% LA
Flow convergence	Shift the Nyquist baseline in the direction of the regurgitant jet to see hemispheric flow convergence. Measure PISA radius from vena contracta to point of color aliasing.		Large, holosystolic
CW jet	Align CW with MR jet		Dense, holosystolic, triangular

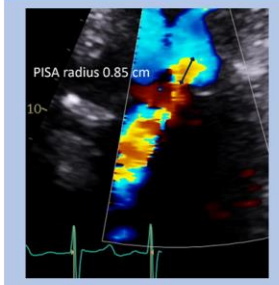
Semi quantitative

Method	Description	Example	Definition of Severe
Vena contracta width	The narrowest segment of the color jet, typically at the level of the regurgitant orifice.		> 0.7 cm
Pulmonary vein flow	PW 1 cm into pulmonary vein		Systolic flow reversal
Mitral inflow	PW at the leaflet tips in the apical four chamber view		E velocity >1.2 m/s E wave dominant

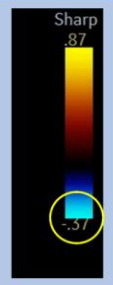
MR severity

Quantitative

Variables needed

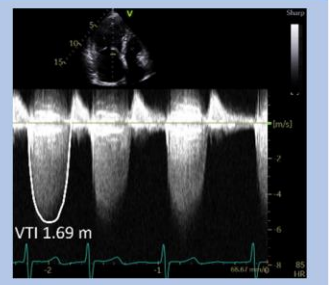


PISA radius (r)



Aliasing velocity (Va)

Peak velocity MR jet (PKV_{reg})



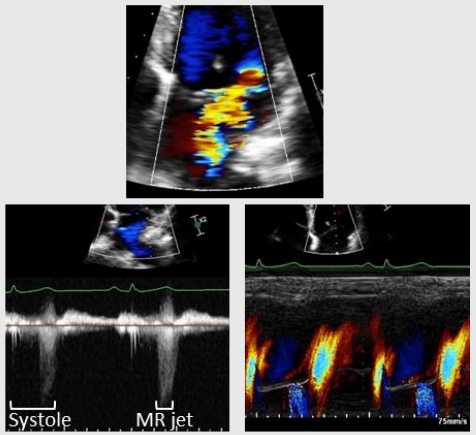
MR VTI (VTI_{reg})

Parameter	Equation	Sample calculation
Regurgitant flow (Rflow, mL/sec)	$2\pi r^2$ x Va	$2\pi(0.85)^2$ x 0.37 = 1.67 mL/sec
EROA (cm^2)	Rflow/ PKV_{reg}	1.67/5.92= 0.28 cm^2
Regurgitation volume (Reg vol, mL)	EROA x VTI_{reg}	0.28 x 1.69 = 0.48 mL

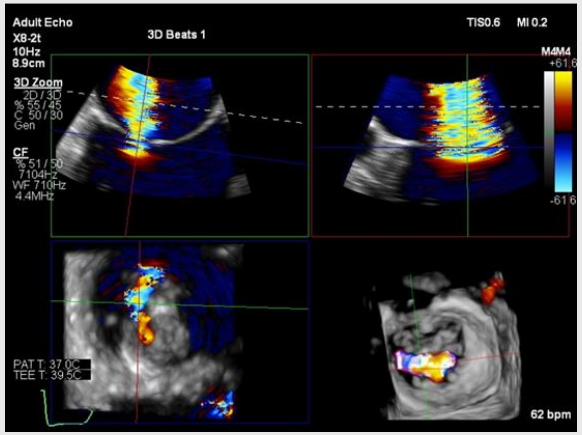
Cutoffs for severe:
EROA > 0.40 cm2
Rvol >60 mL

Inaccuracies of PISA method

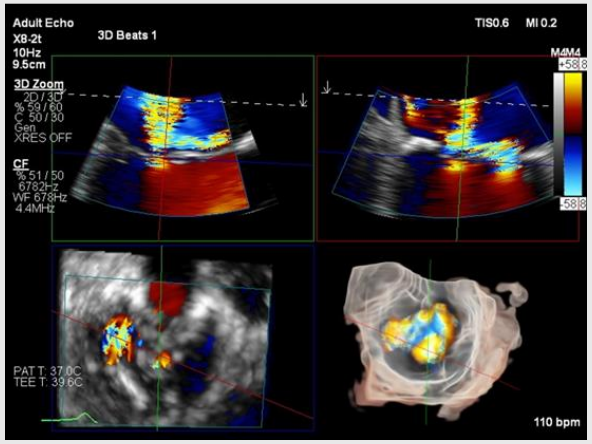
A: Non holosystolic MR



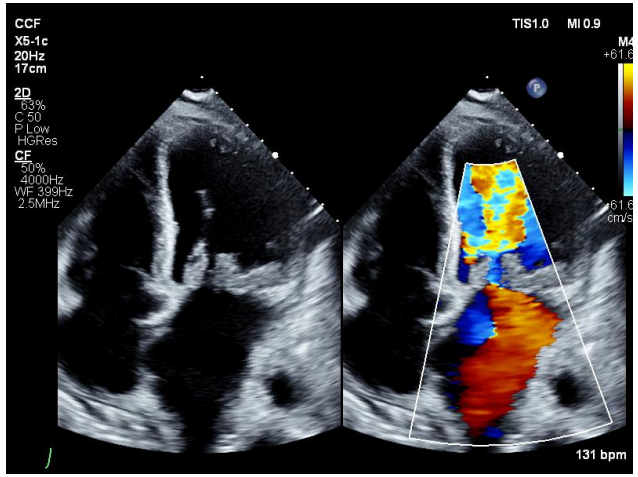
B: Non circular MR orifice

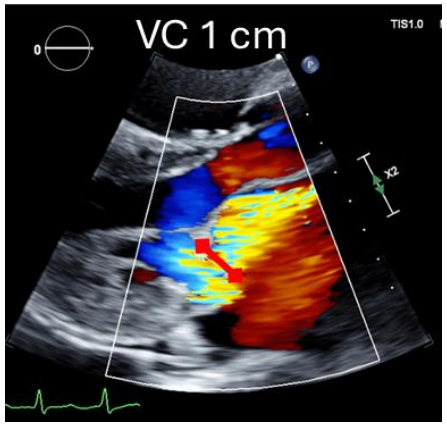


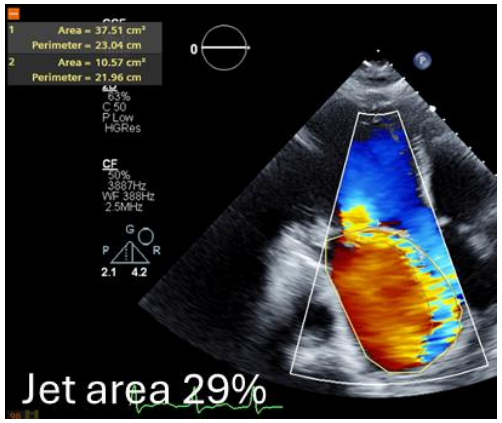
C: Multiple jets

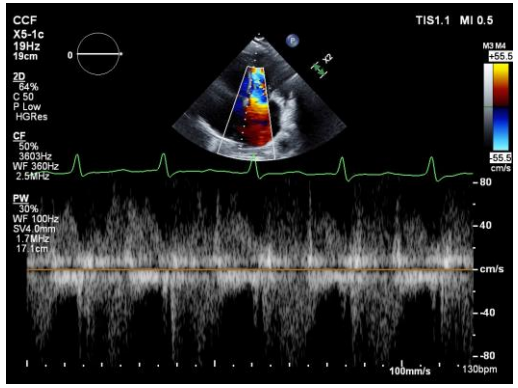


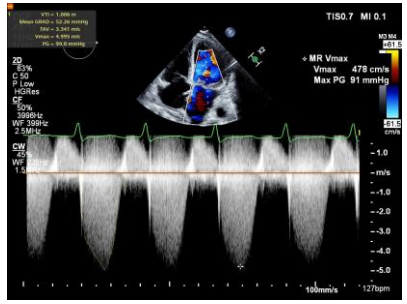
Case: 55 yo referred for evaluation of MR











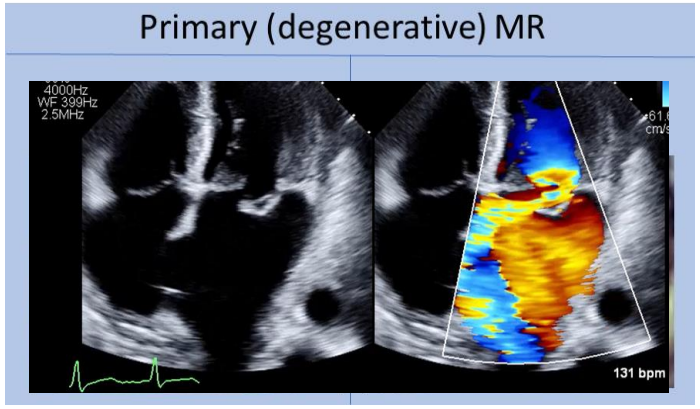
Qualitative:
- Flail
- Large PISA
- Triangular dense CW

Semi Qualitative:
- VC 1 cm (> 0.7)
- PV reversal

Quantitative
- EROA 2.8 cm2
- RV 280 mL/beat

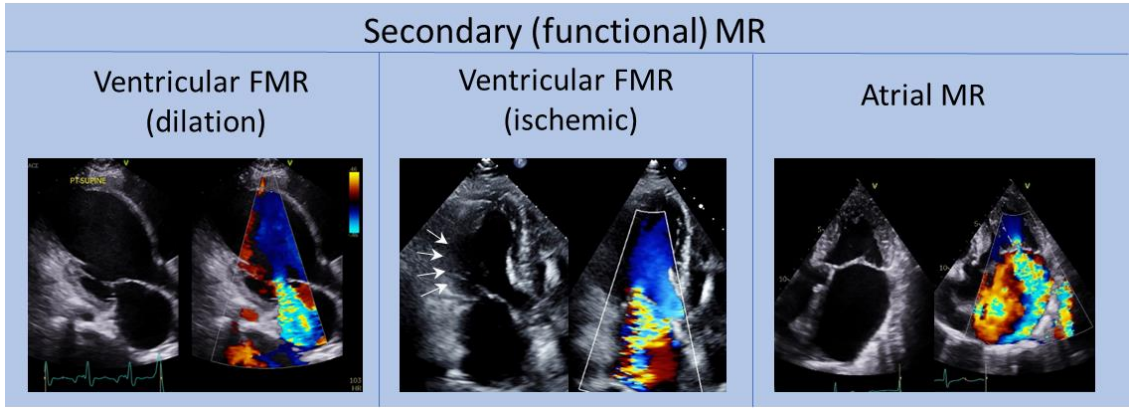
MR mechanism

Degenerative Mitral Regurgitation (DMR, Primary MR)



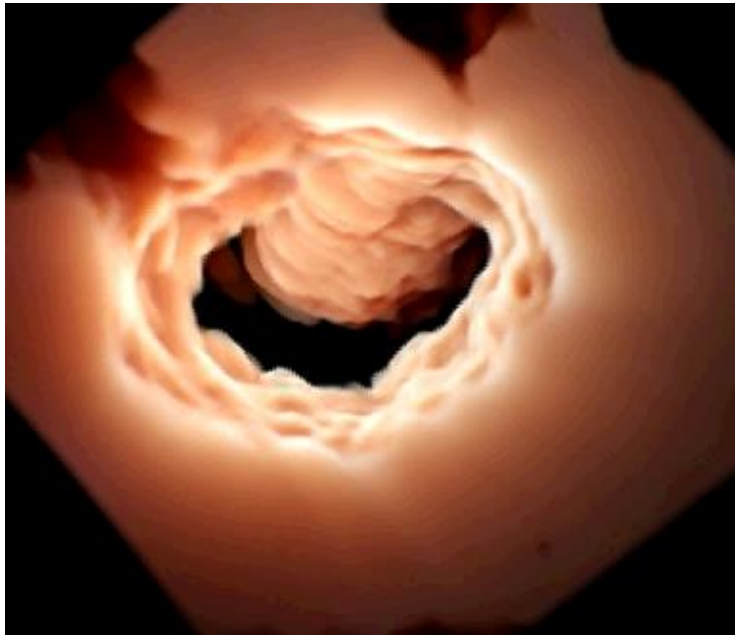
- Prolapse
- Flail
- Papillary muscle rupture
- Perforation
- Calcific changes
- Endocarditis
- Rheumatic

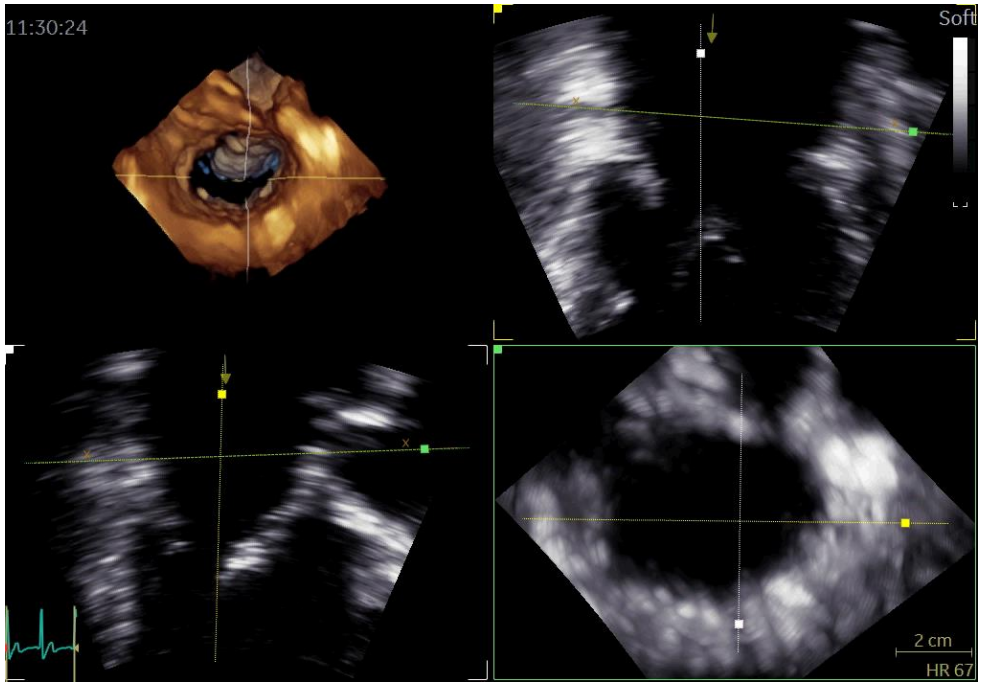
Functional Mitral Regurgitation (FMR, Secondary MR)

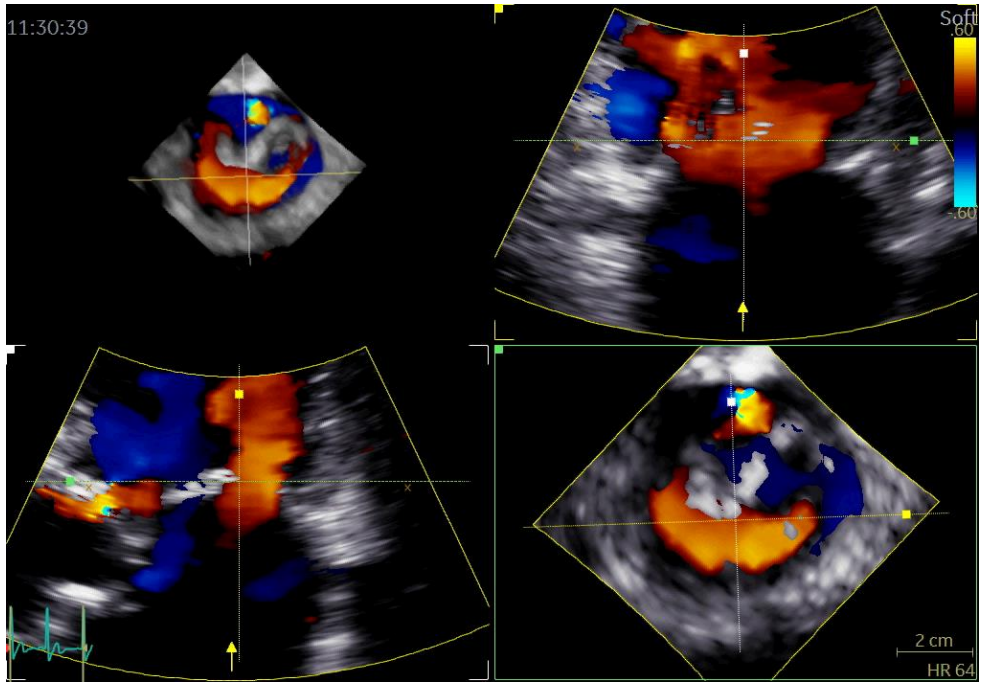


- Normal mitral leaflets but other forces cause dysfunction
- Several subtypes of FMR, and etiology may be mixed

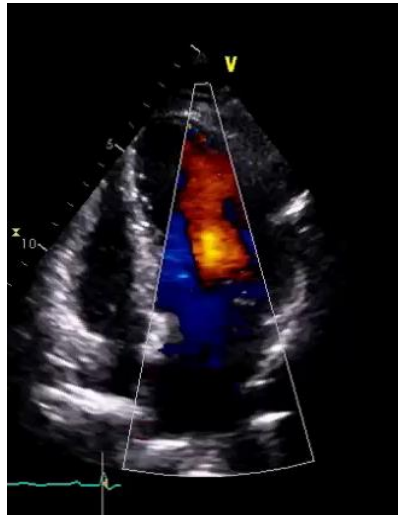
3D TTE:
Anterior leaflet prolapse and flail



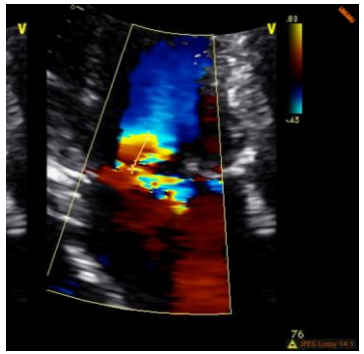




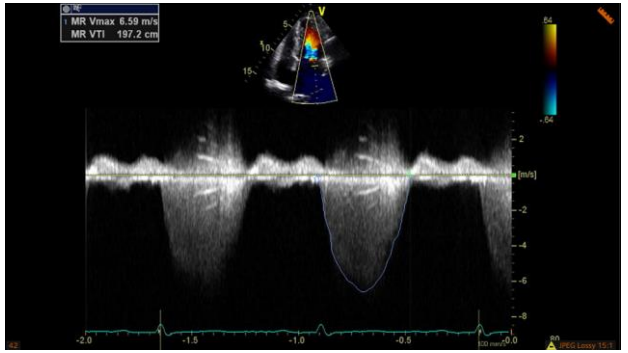
Case: *65 yo patient presents with newly diagnosed, severe primary mitral regurgitation. Overall she feels well but she's noticed some dyspnea with her favorite activity – Jazzercise.*



- Normal LV size and function, EF 65%
- Severe MR 2/2 posterior prolapse



ERO 0.46 cm2
RV 90 mL/beat



1	B-NR	1. In symptomatic patients with severe primary MR (Stage D), mitral valve intervention is recommended irrespective of LV systolic function.[269,302]

Should Patients With Severe Degenerative Mitral Regurgitation Delay Surgery Until Symptoms Develop?

A. Marc Gillinov, MD, Tomislav Mihaljevic, MD, Eugene H. Blackstone, MD, Kristopher George, MD, Lars G. Svensson, MD, Edward R. Nowicki, MD, MS, Joseph F. Sabik III, MD, Penny L. Houghtaling, MS, and Brian Griffin, MD

Departments of Thoracic and Cardiovascular Surgery and Cardiovascular Medicine, Heart and Vascular Institute, and Department of Quantitative Health Sciences, Research Institute, Cleveland Clinic, Cleveland, Ohio

Methods. From January 1985 to January 2008, 4,586 patients had primary isolated mitral valve surgery for degenerative mitral regurgitation; 4,253 (93%) underwent repair. Preoperatively, 30% were in New York Heart Association (NYHA) class I (asymptomatic), 56% in class II, 13% in class III, and 2% in class IV. Multivariable analysis and propensity matching were used to assess association of symptoms (NYHA class) with cardiac structure and function and postoperative outcomes.

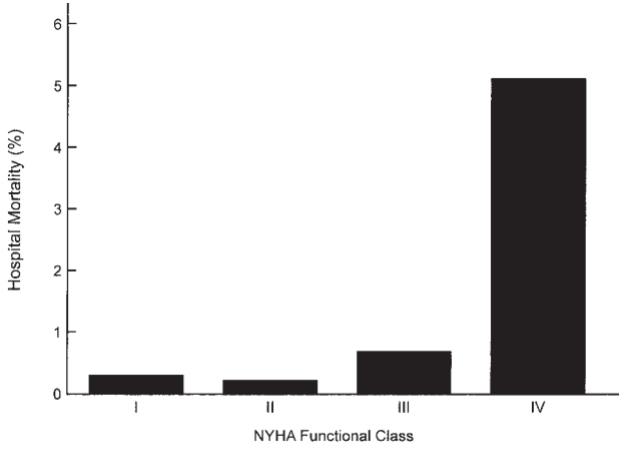


Fig 2. Hospital mortality according to preoperative New York Heart Association (NYHA) functional class.

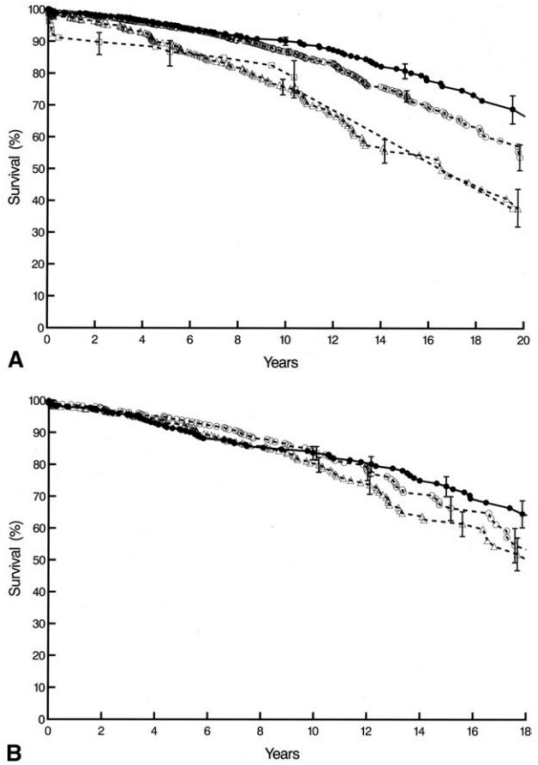


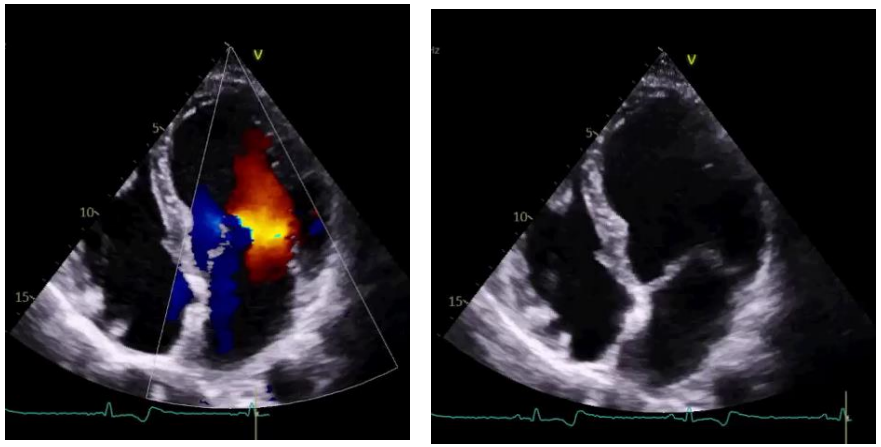
Fig 3. Survival according to New York Heart Association (NYHA) functional class. (A) Unadjusted survival. (Solid circles = class I; open circles = class II; triangles = class III; squares = class IV.) (B) Survival in propensity-matched groups. (Solid circles = class I; open circles = class II; triangles = class III/IV.)

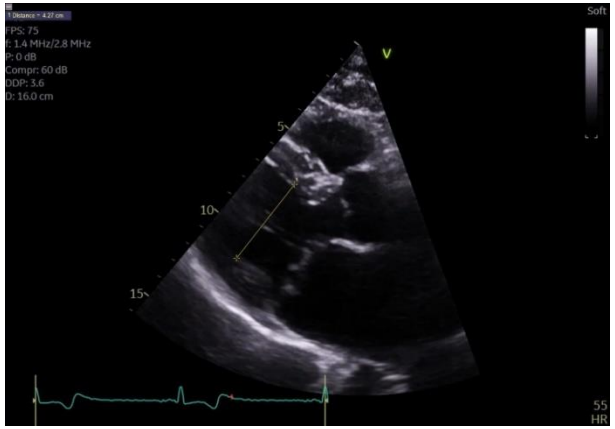
Increasing NYHA functional class was associated with:

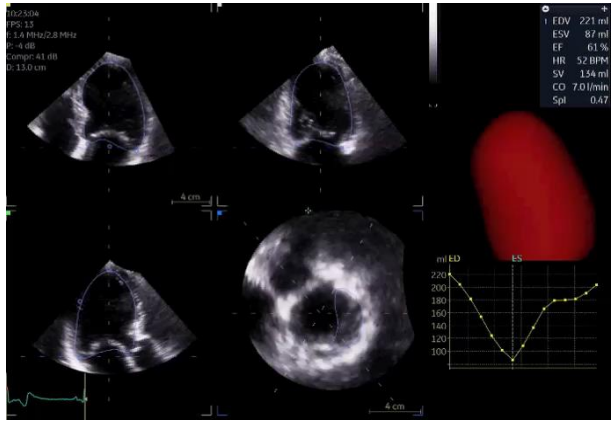
- Reduction in LV function
- Left atrial enlargement
- Atrial fibrillation
- Tricuspid regurgitation

Case:

68 yo incidentally diagnosed with severe MR after a murmur was heard on exam. Asymptomatic.







1	B-NR	2. In asymptomatic patients with severe primary MR and LV systolic dysfunction (LVEF ≤60%, LVESD ≥40 mm) (Stage C2), mitral valve surgery is recommended.[261,262,272,273,275,303–305]
2b	C-LD	5. In asymptomatic patients with severe primary MR and normal LV systolic function (LVEF >60% and LVESD <40 mm) (Stage C1) but with a progressive increase in LV size or decrease in EF on ≥3 serial imaging studies, mitral valve surgery may be considered irrespective of the probability of a successful and durable repair.[310]

Normal EF. But LV is dilated (LVESD > 40).

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CME

Survival Implication of Left Ventricular End-Systolic Diameter in Mitral Regurgitation Due to Flail Leaflets

A Long-Term Follow-Up Multicenter Study

Christophe Tribouilloy, MD, PHD,* Francesco Grigioni, MD, PHD,† Jean François Avierinos, MD,‡ Andrea Barbieri, MD,§ Dan Rusinaru, MD,* Catherine Szymanski, MD,* Marinella Ferlito, MD,† Laurence Tafanelli, MD,‡ Francesca Bursi, MD,§ Faouzi Trojette, MD,* Angelo Branzi, MD,† Gilbert Habib, MD,‡ Maria G. Modena, MD,§ Maurice Enriquez-Sarano, MD,‖
on behalf of the MIDA Investigators

Amiens and Marseille, France; Bologna and Modena, Italy; and Rochester, Minnesota

Lower survival with LVESD > 40 mm

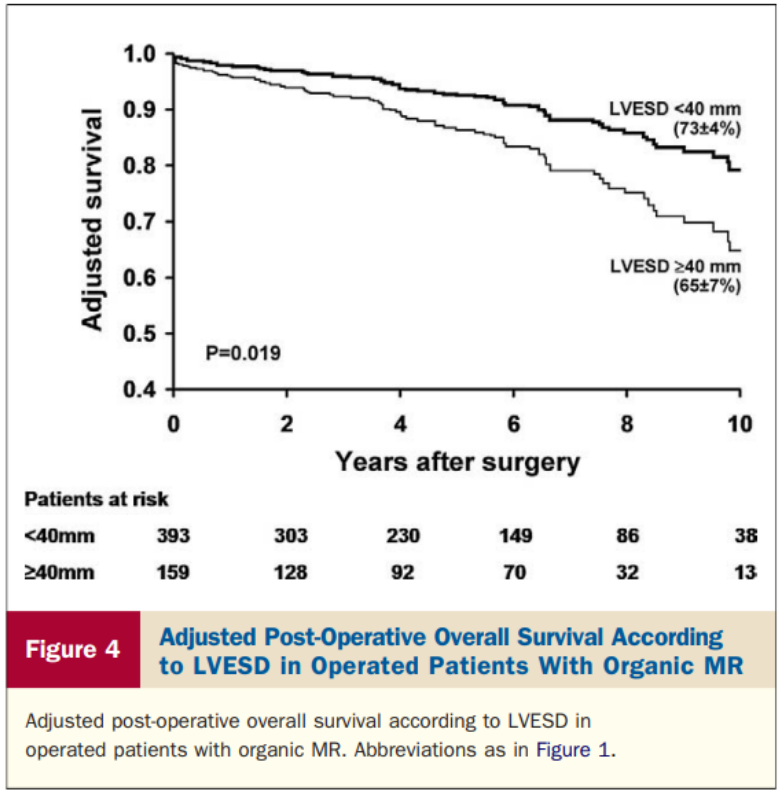


Figure 4 **Adjusted Post-Operative Overall Survival According to LVESD in Operated Patients With Organic MR**

Adjusted post-operative overall survival according to LVESD in operated patients with organic MR. Abbreviations as in Figure 1.

Echocardiographic Prediction of Survival After Surgical Correction of Organic Mitral Regurgitation

(*Circulation*. 1994;90:830-837.)

Maurice Enriquez-Sarano, MD; A. Jamil Tajik, MD; Hartzell V. Schaff, MD; Thomas A. Orszulak, MD; Kent R. Bailey, PhD; Robert L. Frye, MD

Methods and Results The survival of 409 patients operated on between 1980 and 1989 for pure, isolated, organic mitral regurgitation and with a preoperative echocardiogram (within 6 months of operation) was analyzed. The overall survival was 75% at 5 years (90% of expected), 58% at 10 years (88% of

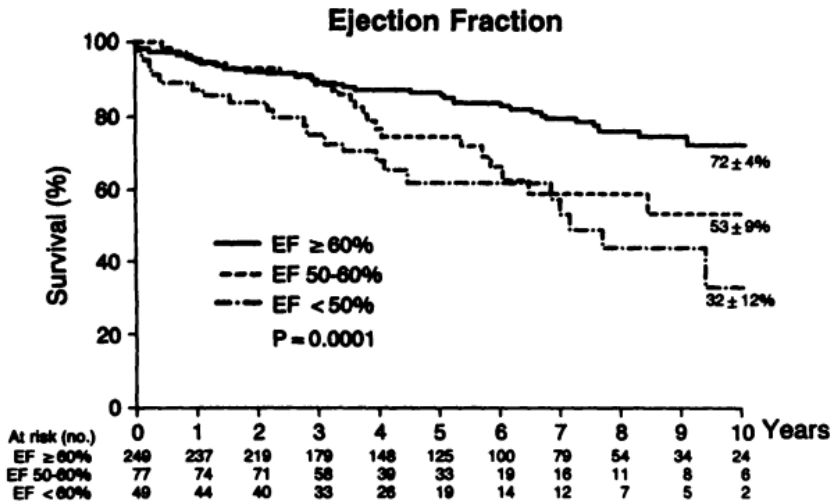
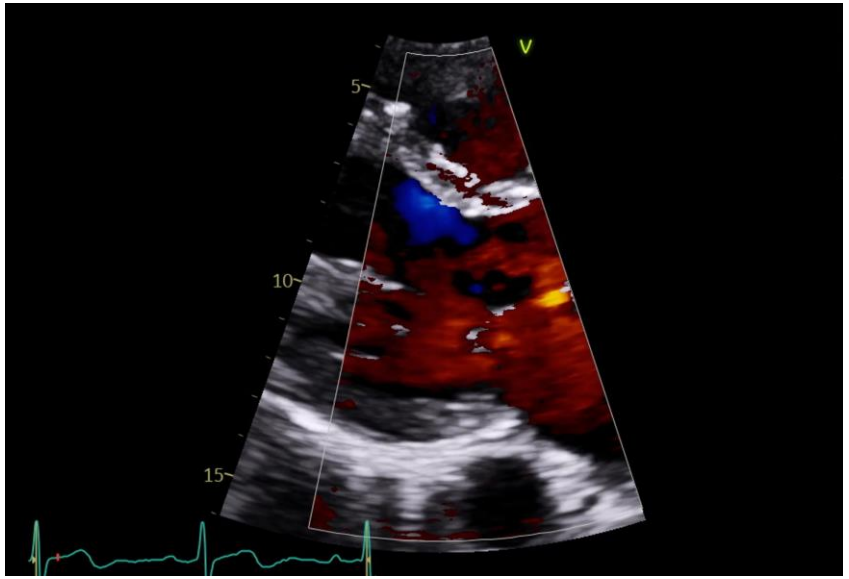
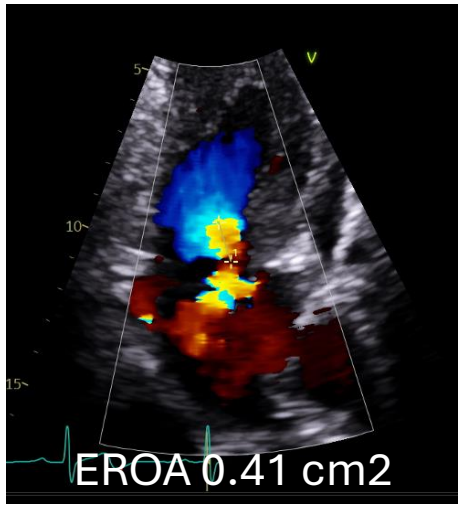


FIG 2. Graph of late survival of operative survivors according to preoperative echocardiographic ejection fraction (EF). Number at risk for each interval is indicated at bottom.

Case:

58 yo with mitral valve prolapse followed for years. Last echo showed severe MR. Asymptomatic, good exercise tolerance. Biplane EF 65%.





P2 prolapse

2a	B-NR	4. In asymptomatic patients with severe primary MR and normal LV systolic function (LVEF ≥60% and LVESD ≤40 mm) (Stage C1), mitral valve repair is reasonable when the likelihood of a successful and durable repair without residual MR is >95% with an expected mortality rate of <1%, when it can be performed at a Primary or Comprehensive Valve Center.[273,308,310]

Original Investigation

Association Between Early Surgical Intervention vs Watchful Waiting and Outcomes for Mitral Regurgitation Due to Flail Mitral Valve Leaflets

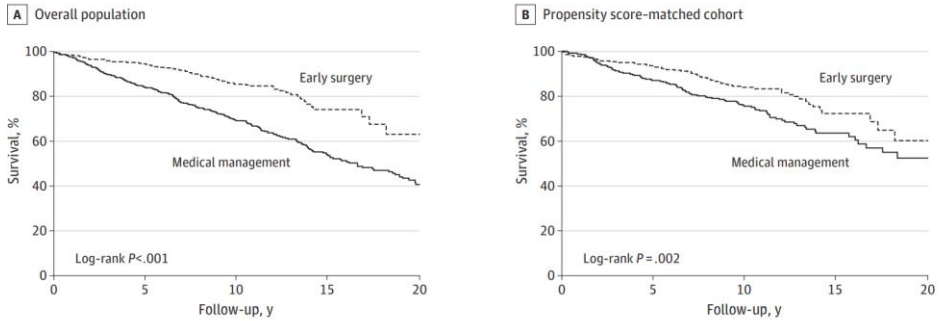
Rakesh M. Suri, MD, DPhil; Jean-Louis Vanoverschelde, MD; Francesco Grigioni, MD, PhD; Hartzell V. Schaff, MD; Christophe Tribouilloy, MD; Jean-Francois Avierinos, MD; Andrea Barbieri, MD; Agnes Pasquet, MD; Marianne Huebner, PhD; Dan Rusinaru, MD; Antonio Russo, MD; Hector I. Michelena, MD; Maurice Enriquez-Sarano, MD

JAMA. 2013;310(6):609-616. doi:10.1001/jama.2013.8643

DESIGN, SETTING, AND PARTICIPANTS The Mitral Regurgitation International Database (MIDA) registry includes 2097 consecutive patients with flail mitral valve regurgitation (1980-2004) receiving routine cardiac care from 6 tertiary centers (France, Italy, Belgium, and the United States). Mean follow-up was 10.3 years and was 98% complete. Of 1021 patients with mitral regurgitation without the American College of Cardiology (ACC) and the American Heart Association (AHA) guideline class I triggers, 575 patients were initially medically managed and 446 underwent mitral valve surgery within 3 months following detection.

Early surgery better survival

Figure 1. Survival After Diagnosis of Mitral Regurgitation Due to Flail Mitral Leaflet According to Initial Treatment Strategy



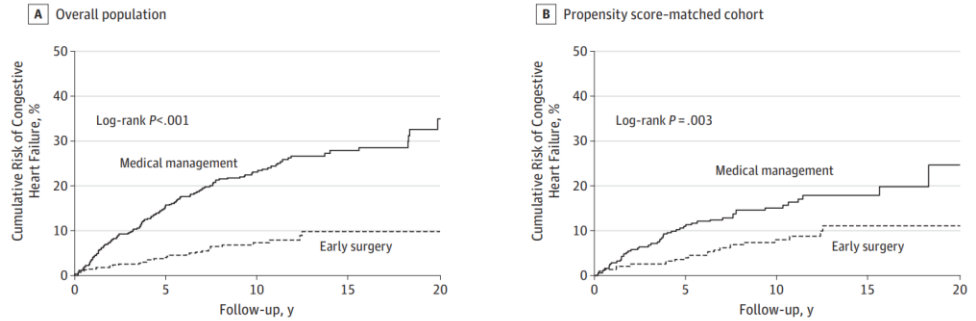
No. at risk

Medical management	575	477	296	126	42	324	276	157	53	8
Early surgery	446	412	203	41	10	324	295	160	35	10

Long-term survival following early surgery vs initial medical management overall population (A) and in the propensity score–matched cohort (B).

Early surgery less CHF

Figure 2. Heart Failure Incidence After Diagnosis of Mitral Regurgitation Due to Flail Mitral Leaflet According to Initial Treatment Strategy



No. at risk

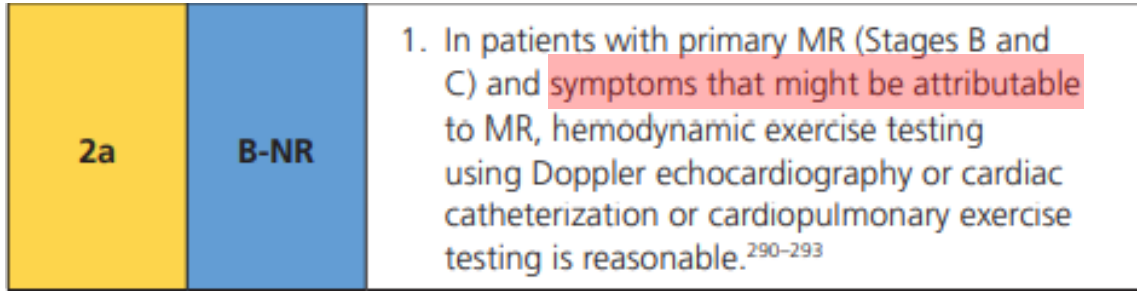
Medical management	575	419	249	100	27	324	253	142	48	3
Early surgery	446	399	189	37	9	324	289	149	31	9

Long-term heart failure risk following early surgery vs initial medical management overall (A) and in the propensity score–matched cohort (B).

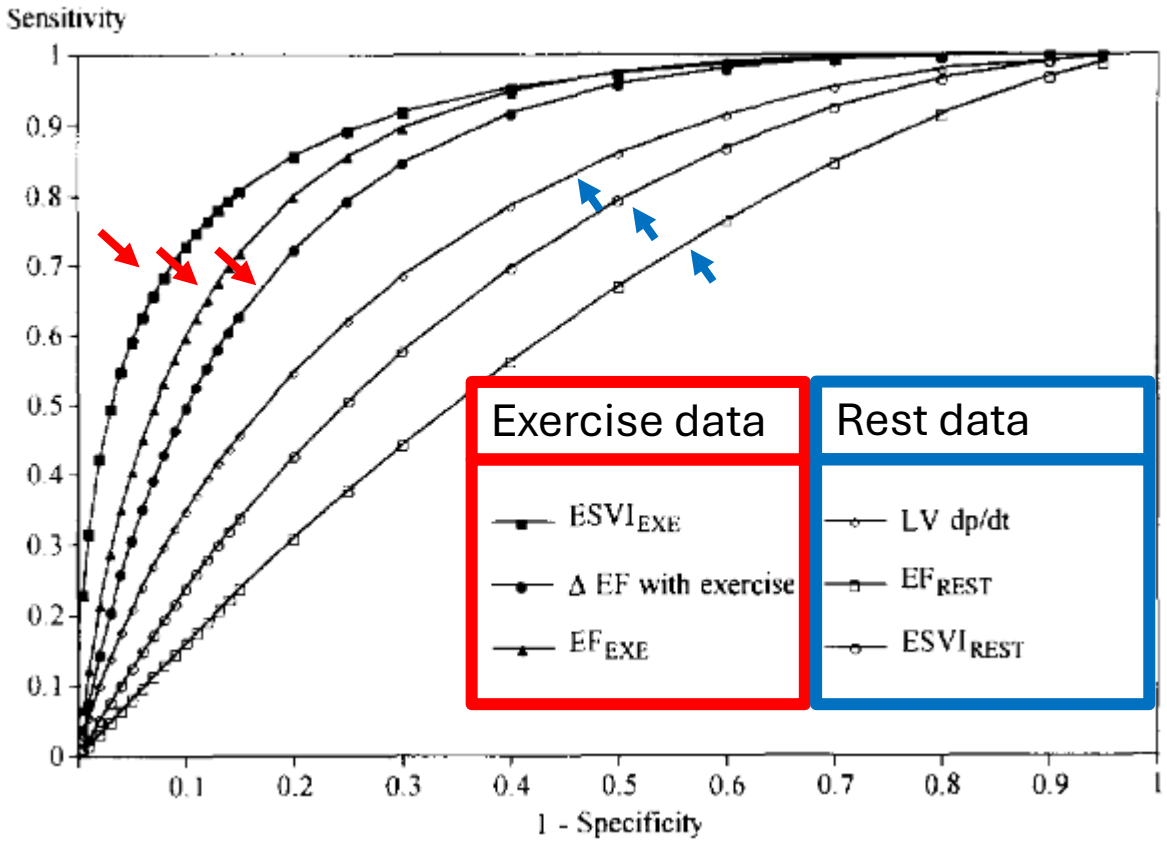
Thus far, all of the cases have been determined by TTE and clinical findings, when do we need further testing like exercise echo?

Exercise Echo

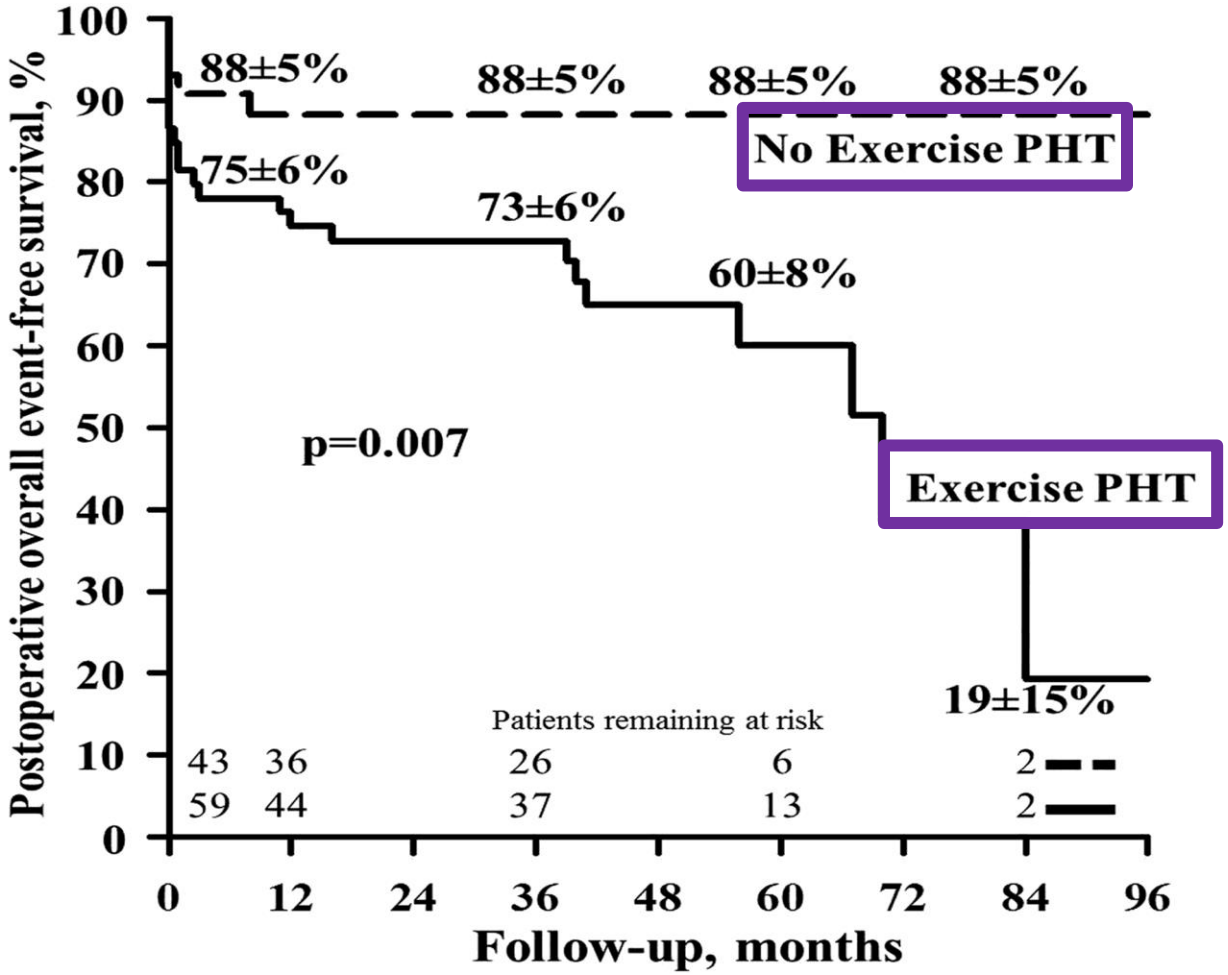
- Clarify symptoms/functional status
- Evaluate for change in MR severity
- Evaluate for development of pulmonary hypertension
- Evaluate for contractile reserve



2a	B-NR	1. In patients with primary MR (Stages B and C) and symptoms that might be attributable to MR, hemodynamic exercise testing using Doppler echocardiography or cardiac catheterization or cardiopulmonary exercise testing is reasonable.[290–293]



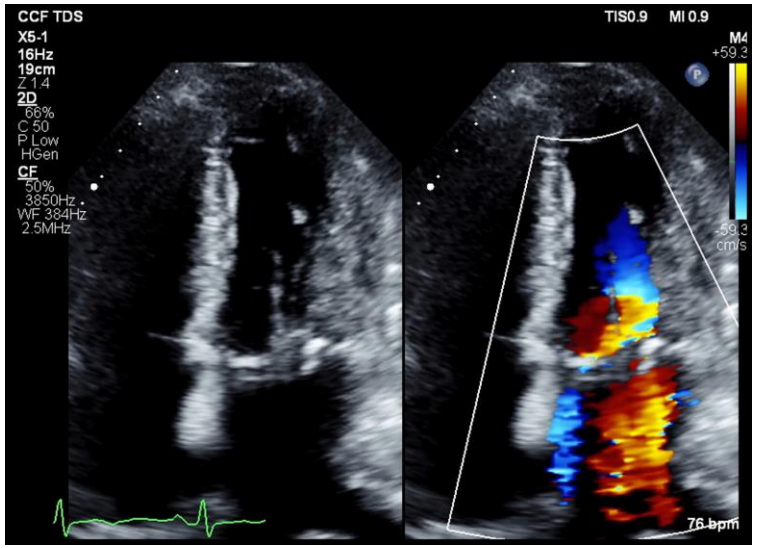
Leung DY, Griffin BP et al. Left ventricular function after valve repair for chronic mitral regurgitation: predictive value of preoperative assessment of contractile reserve by exercise echocardiography. J Am Coll Cardiol 1996;28:1198-205.

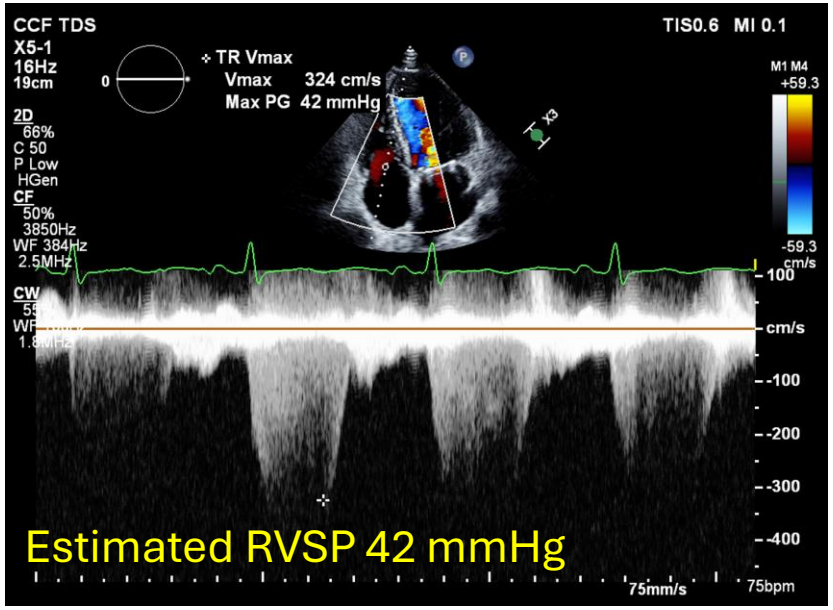


Magne J et al. Impact of exercise pulmonary hypertension on postoperative outcome in primary mitral regurgitation. Heart 2015;101:391-6.

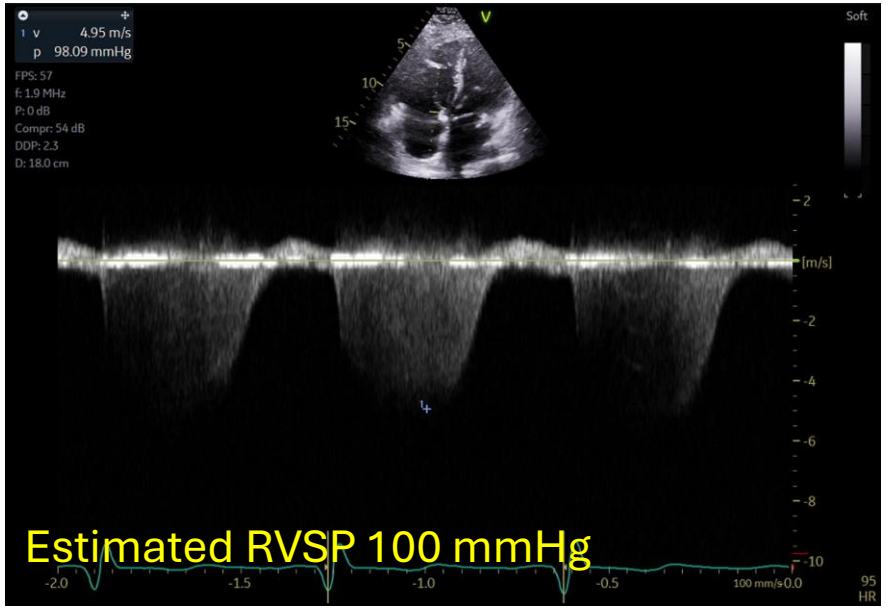
Courtesy of Serge Harb, MD

Case: 61-year-old gentleman with asymptomatic severe primary mitral regurgitation after a failed MV repair





4 METs



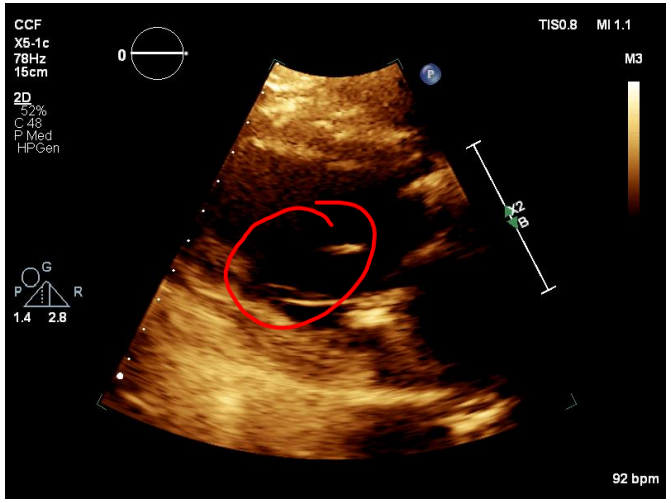
Courtesy of Serge Harb, MD

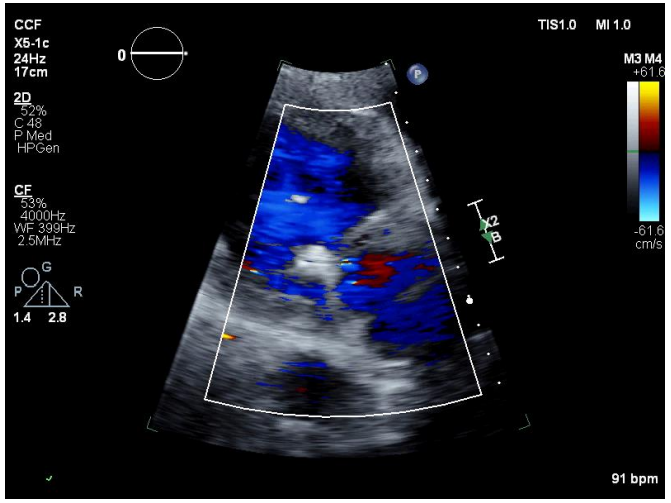
When do we need TEE?

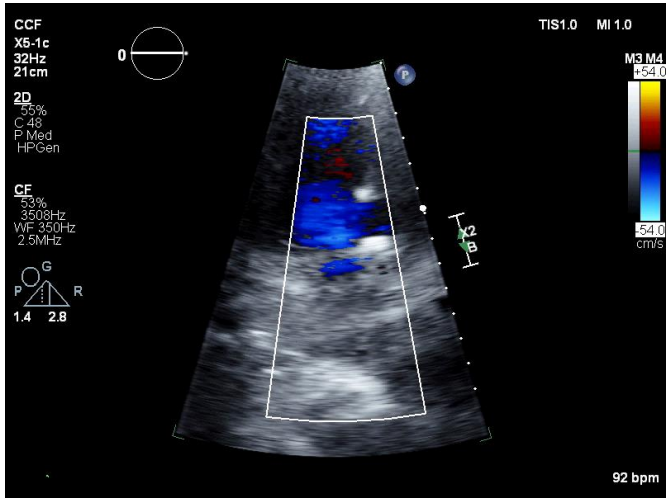
1	C-EO	2. In patients with primary MR, when TTE provides insufficient or discordant information, TEE is indicated for evaluation of the severity of MR, mechanism of MR, and status of LV function (Stages B to D).
1	B-NR	3. In patients with chronic secondary MR with severe symptoms (Stage D) that are unresponsive to GDMT who are being considered for transcatheter mitral valve interventions, TEE is indicated to determine suitability for the procedure.[3–8]

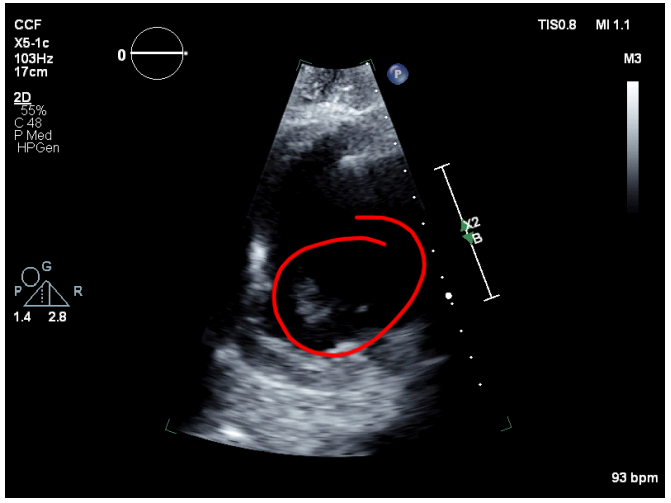
- To clarify MR severity
- To clarify MR mechanism
- To determine intervention

Case: 61 yo transferred to the cardiac ICU with respiratory failure after a late presenting STEMI

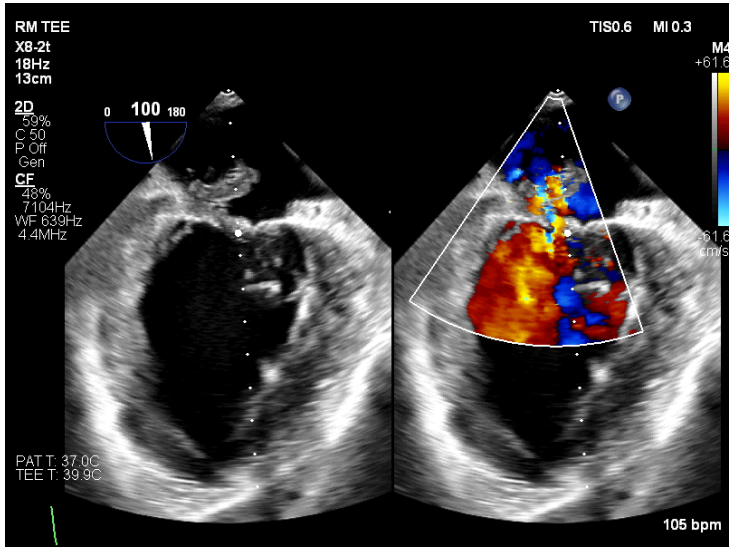


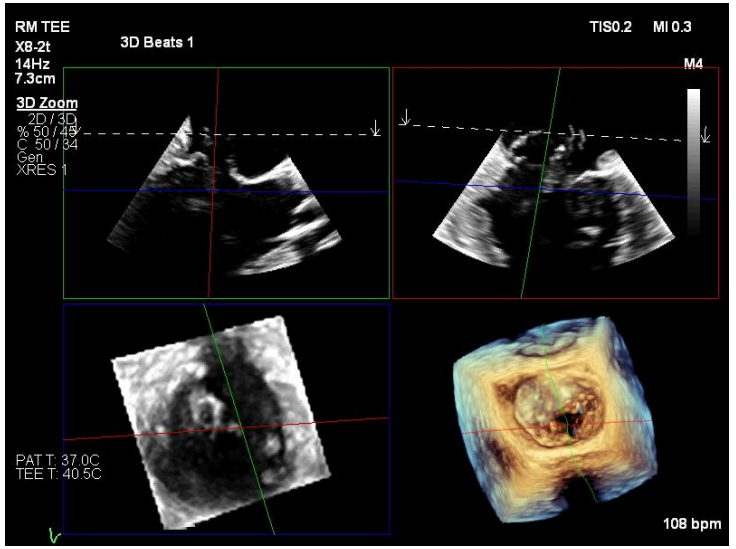


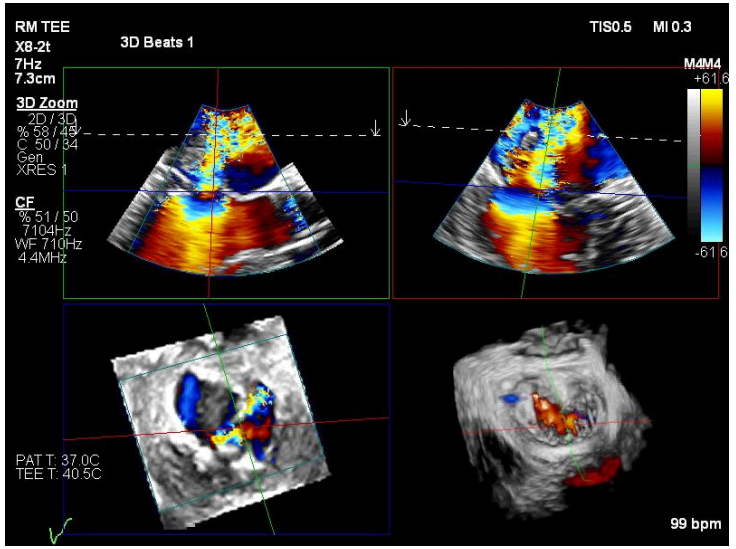




TEE: Severe MR 2/2 ruptured pap muscle

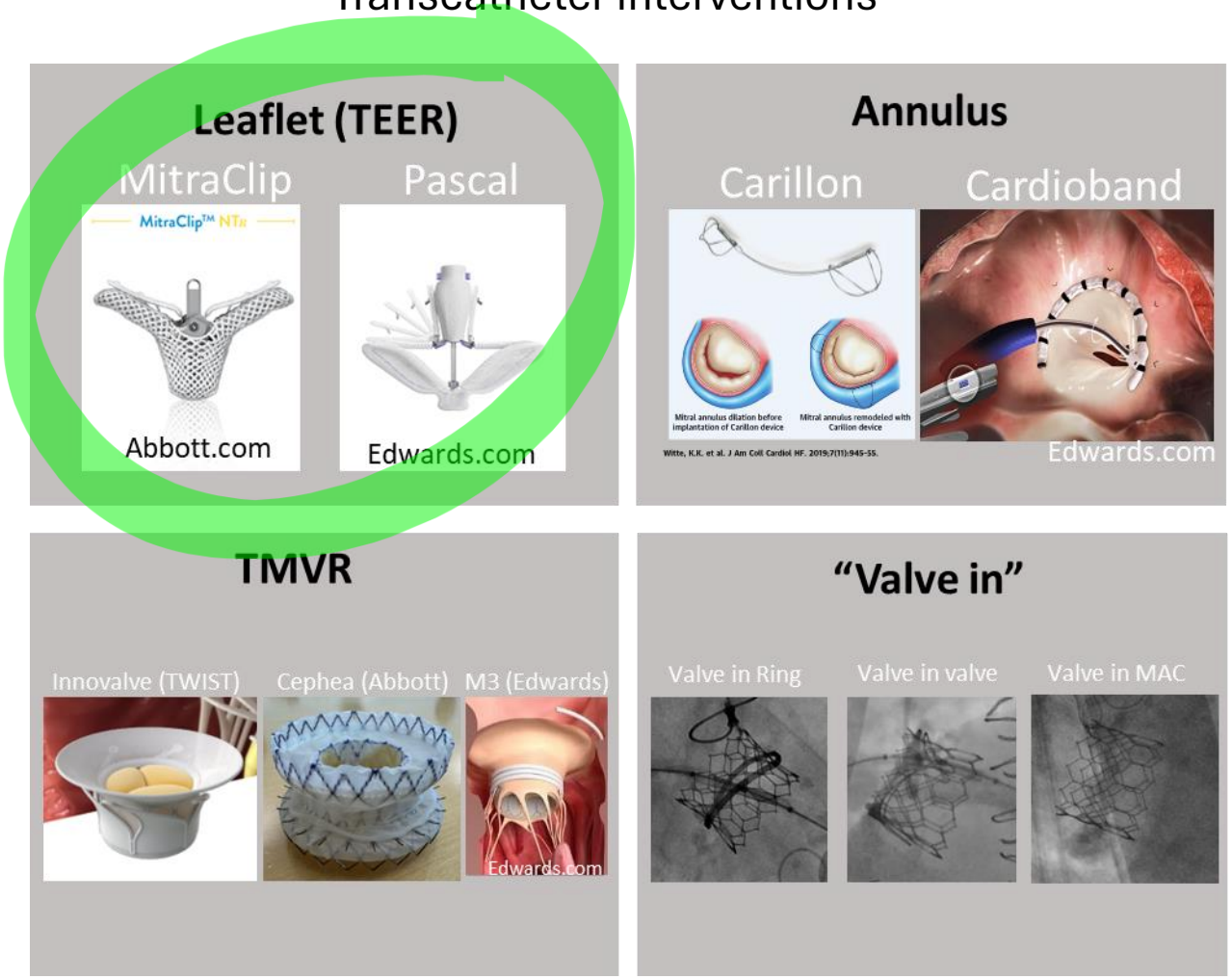






TEE to clarify procedural candidacy

Transcatheter interventions



Surgical interventions

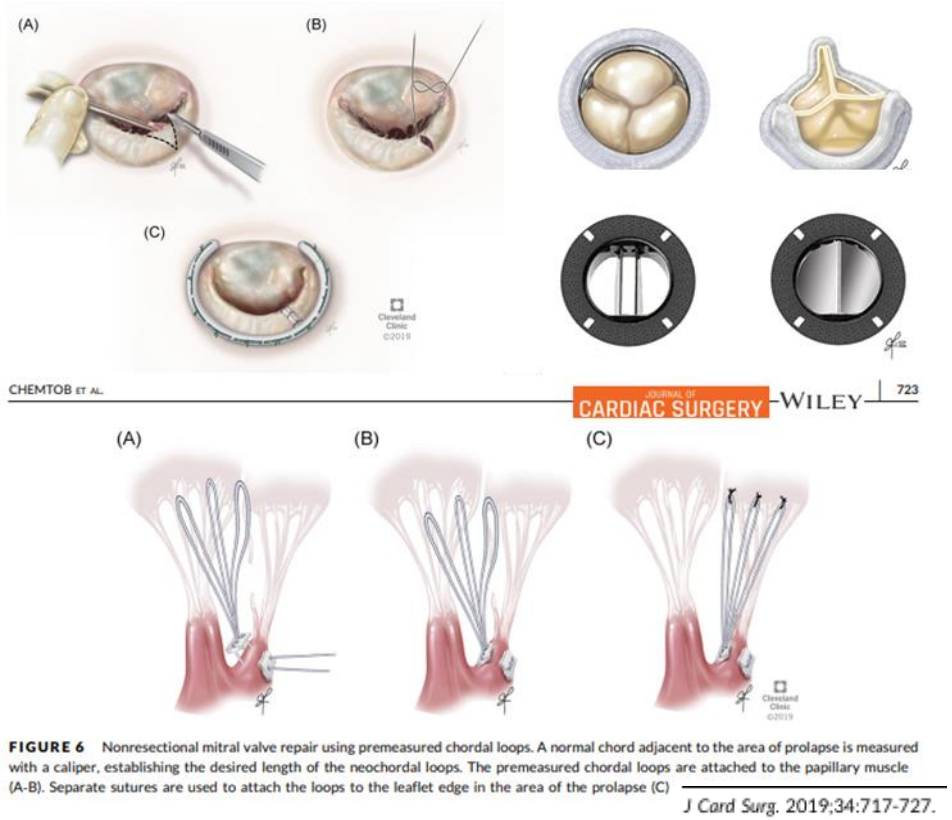
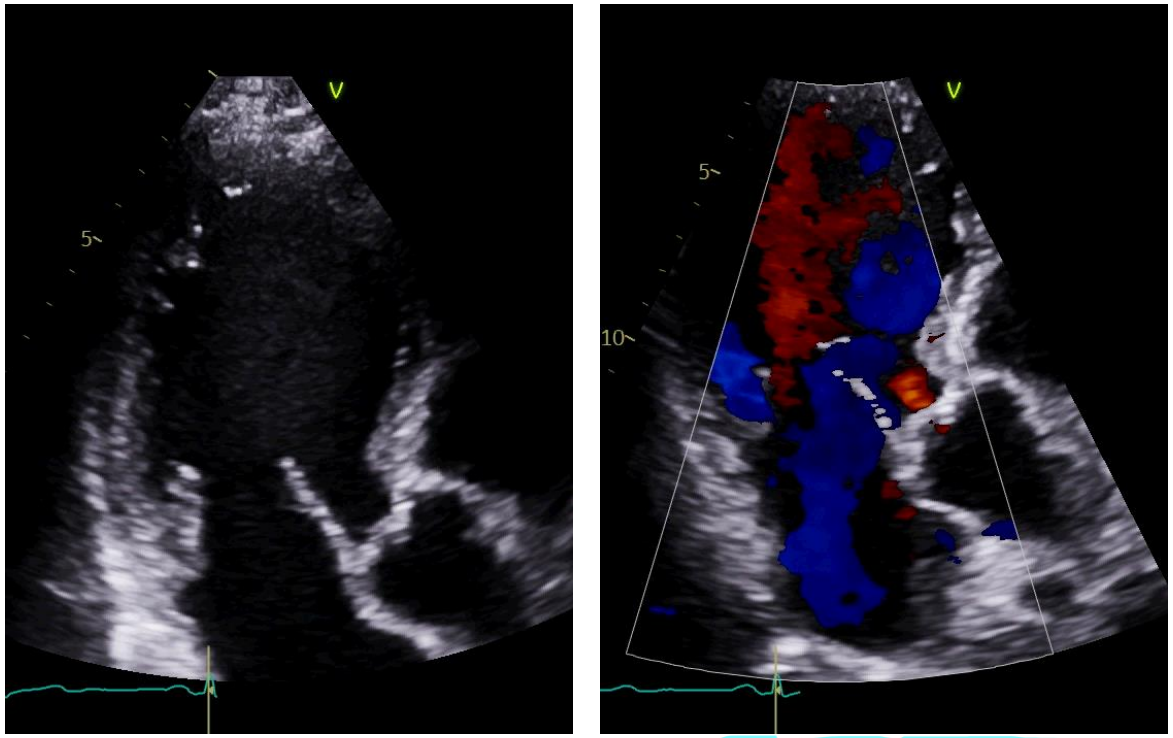


FIGURE 6 Nonresectional mitral valve repair using premeasured chordal loops. A normal chord adjacent to the area of prolapse is measured with a caliper, establishing the desired length of the neochordal loops. The premeasured chordal loops are attached to the papillary muscle (A-B). Separate sutures are used to attach the loops to the leaflet edge in the area of the prolapse (C)

J Card Surg. 2019;34:717-727.

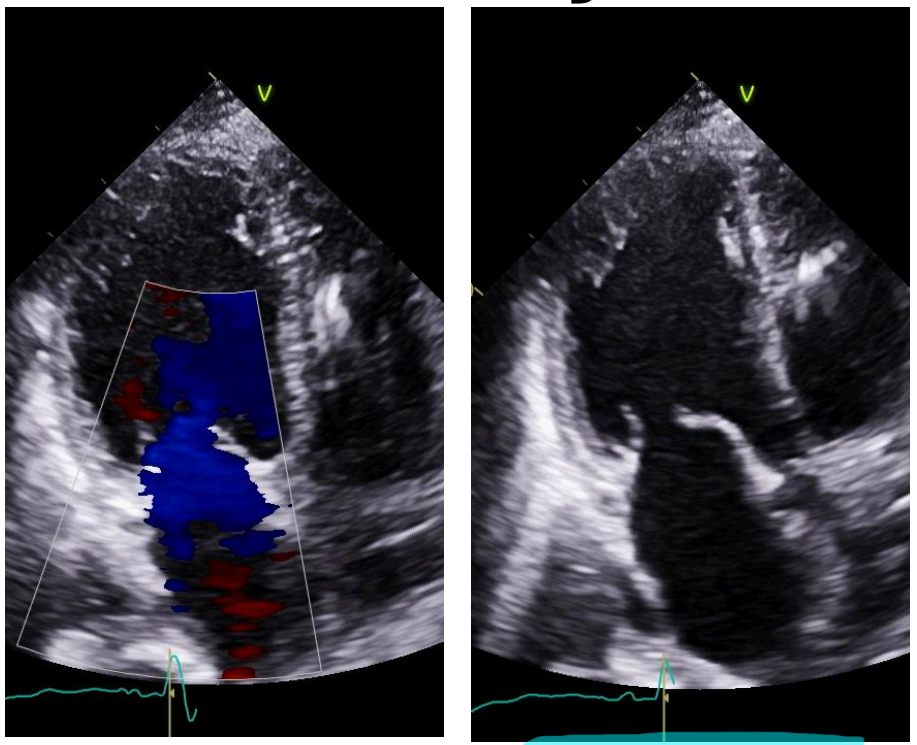
When do we consider mitral TEER?

Primary MR



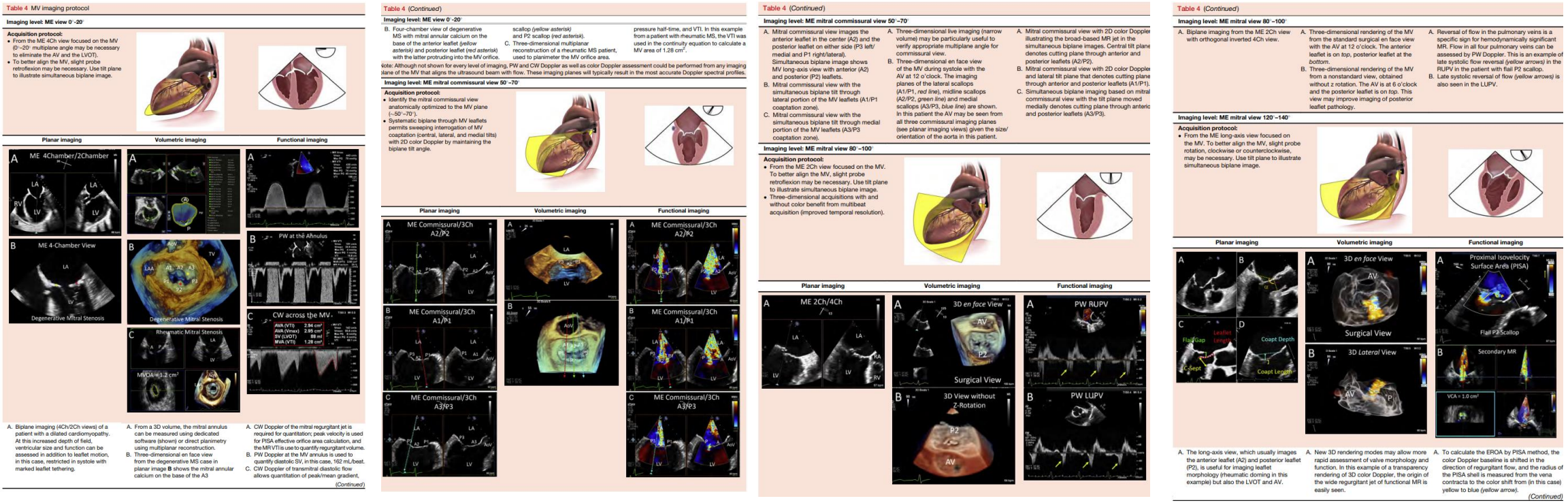
2a	B-NR	6. In severely symptomatic patients (NYHA class III or IV) with primary severe MR and high or prohibitive surgical risk, transcatheter edge-to-edge repair (TEER) is reasonable if mitral valve anatomy is favorable for the repair procedure and patient life expectancy is at least 1 year.[311,312]

Secondary MR



2a	B-R	1. In patients with chronic severe secondary MR related to LV systolic dysfunction (LVEF <50%) who have persistent severe symptoms (NYHA class II, III, or IV) while on optimal GDMT for HF (Stage D), TEER is reasonable in patients with appropriate anatomy as defined on TEE and with LVEF between 20% and 50%, LVESD ≤70 mm, and pulmonary artery systolic pressure ≤70 mm Hg.[318,338-344]

How do we determine favorable anatomy? ASE guidelines



- Very comprehensive. Details every possible view of the mitral valve.

The key to structural imaging is understanding what questions are being asked and… *answer them*.

Key Questions for M-TEER

Can we adequately **reduce the MR**?

- **Where is the MR?**
  - Central vs medial or lateral
  - Focal origin vs broad or multiple jets
- **Are the leaflets graspable?**

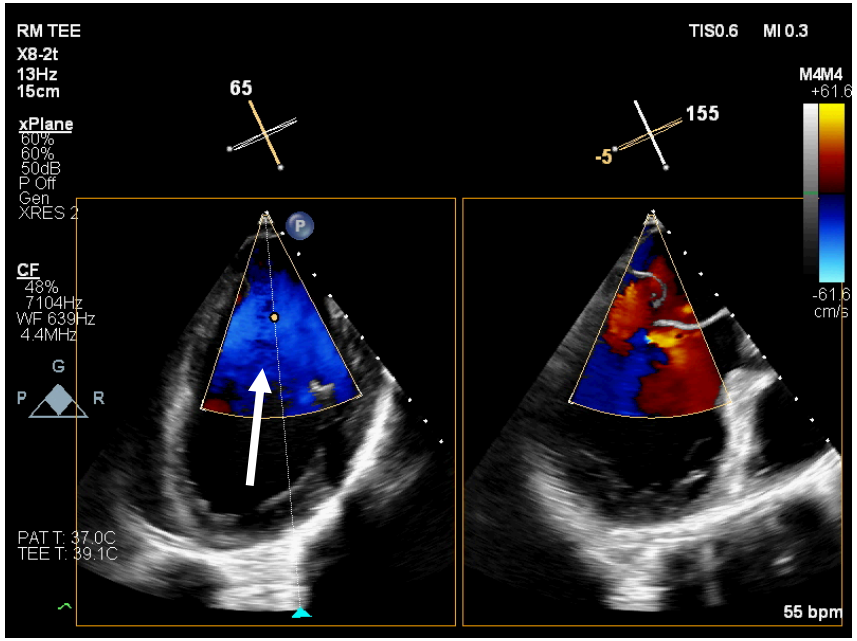
Will we cause **mitral stenosis**?

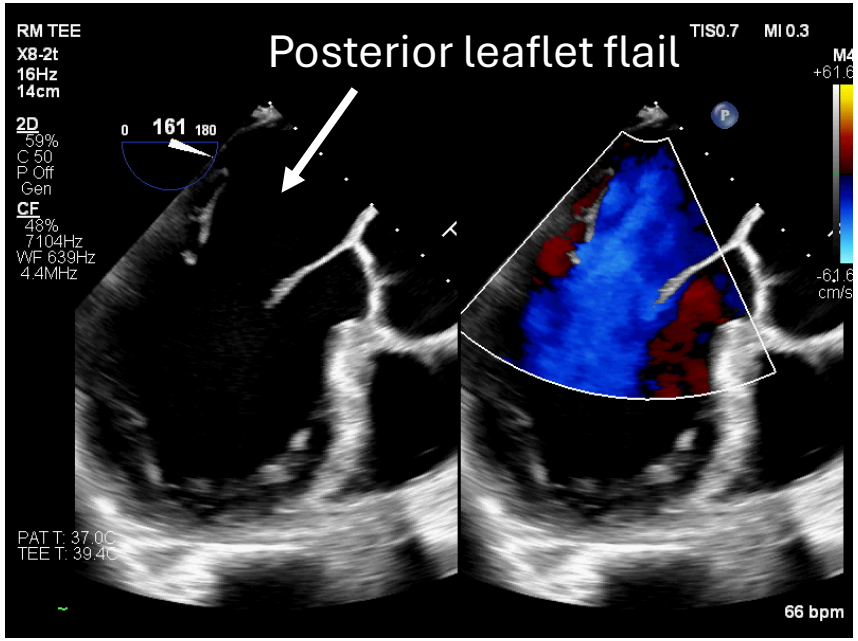
- Ideal mean gradient (<5 mmHg)
- Ideal MVA >4 cm2
- Rheumatic, radiation or calcific disease higher risk

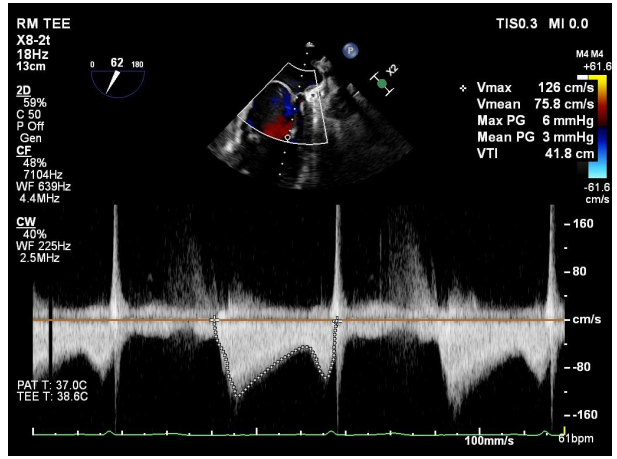
Other **procedural challenges**?

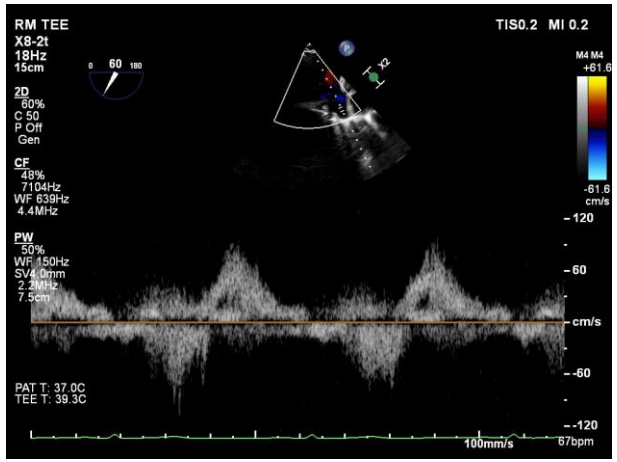
- Complex anatomy?
- Transseptal puncture?
- Imaging challenges?

Case: 91 yo with dyspnea on exertion, can no longer golf without stopping to catch his breath





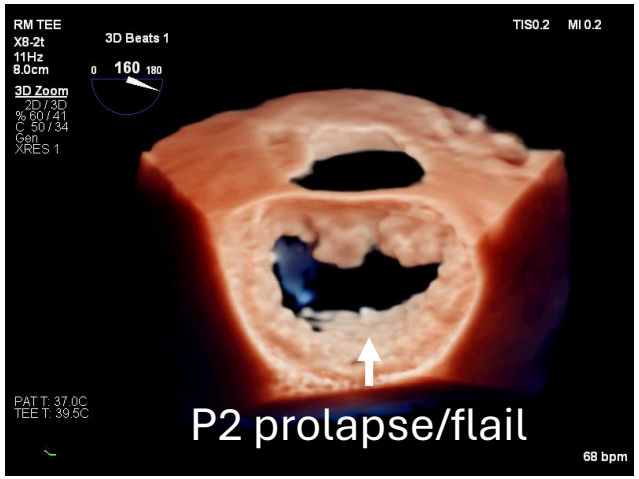




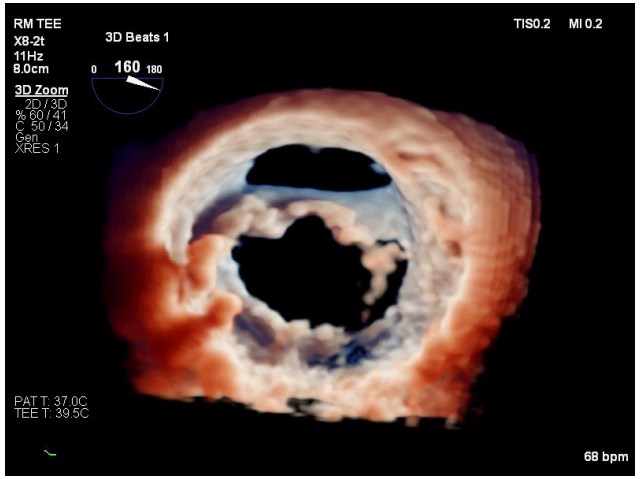
P2 prolapse and flail

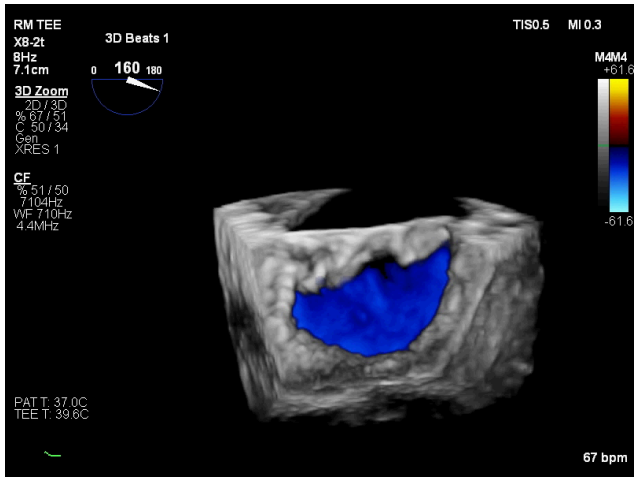
3D imaging

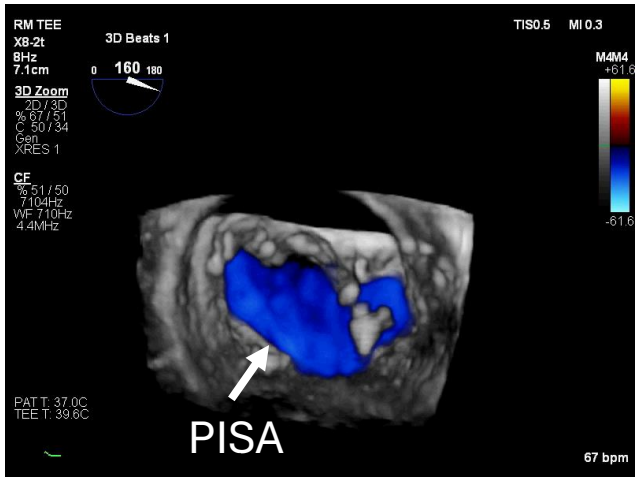
Atrial view



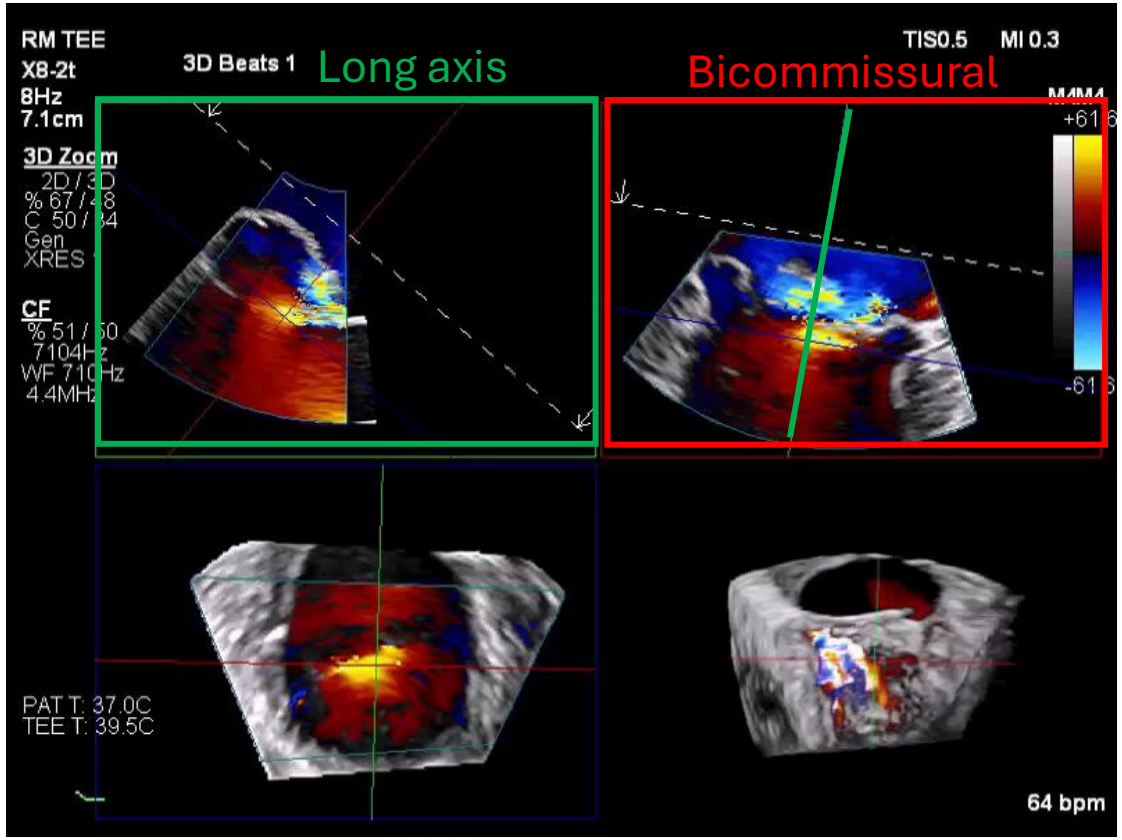
Ventricular view

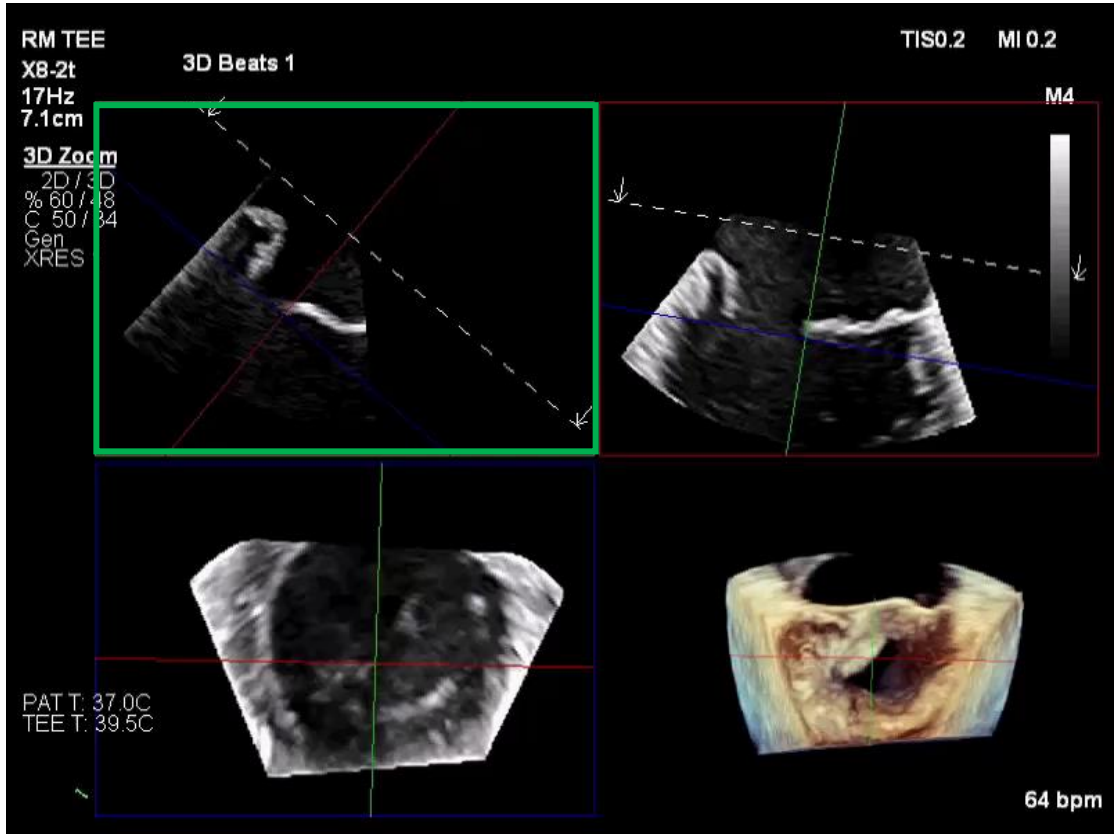




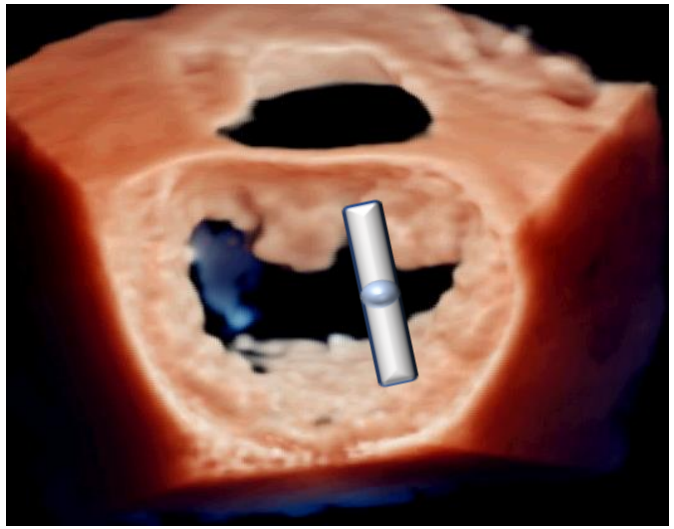


3D MPR

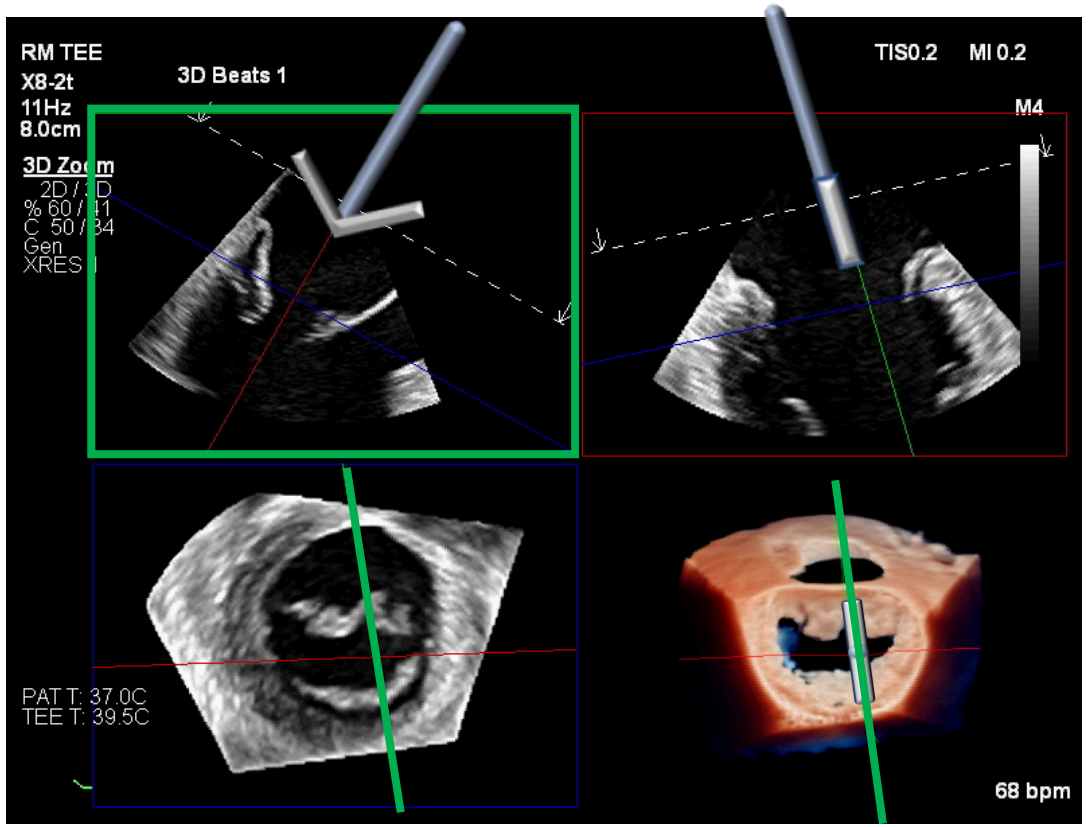

RM TEE
X8-2t
8Hz
7.1cm
3D Beats 1
Long axis
Bicommissural
TIS0.5
MI 0.3
3D Zoom
Gen
XRES
CF
PAT T: 37.0C
TEE T: 39.5C
64 bpm


RM TEE
X8-2t
17Hz
7.1cm
3D Beats 1
TIS0.2
MI 0.2
M4
3D Zoom
Gen
XRES
PAT T: 37.0C
TEE T: 39.5C
64 bpm

Are the leaflets graspable at P2?



What would our grasping view look like if we placed the clip like this?

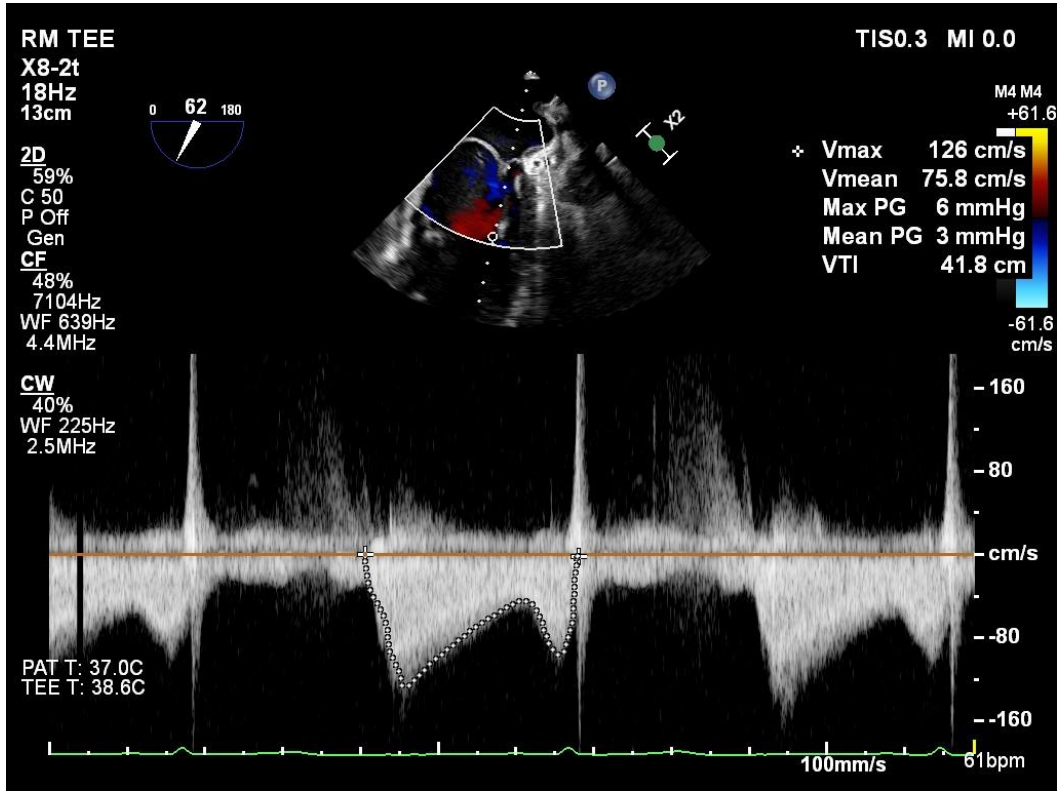


We can then analyze this specific plane for “graspability”

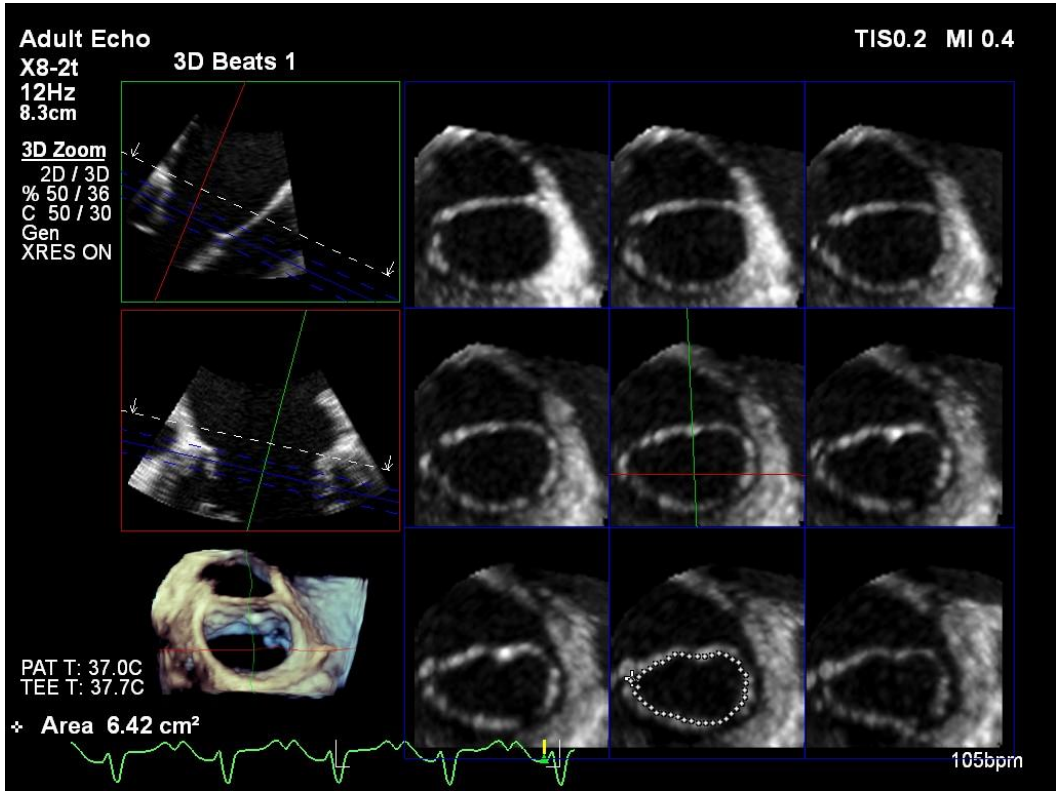
- Leaflet length
- Chords
- Coaptation gap

Will we cause mitral stenosis?

Goal MG < 5 mmHg



Goal MVA > 4 cm2



Should we offer TEER?

Can we adequately reduce the MR?

- ✓Focal MR origin
- ✓Central pathology
- ✓Adequate leaflet length

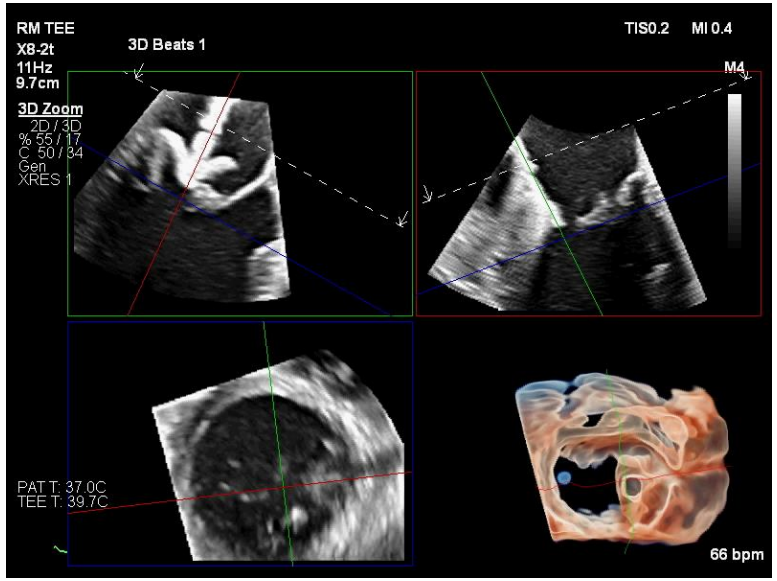
Risk of Mitral Stenosis?

- ✓MG < 5 mmHg
- ✓MVA > 4 cm2

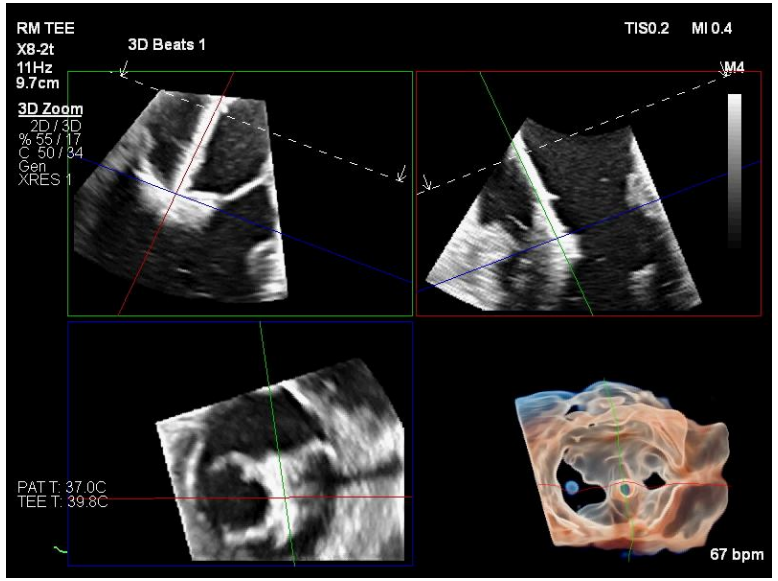
Proceed with Mitral TEER A2-P2

- ✓MitraClip XTW chosen

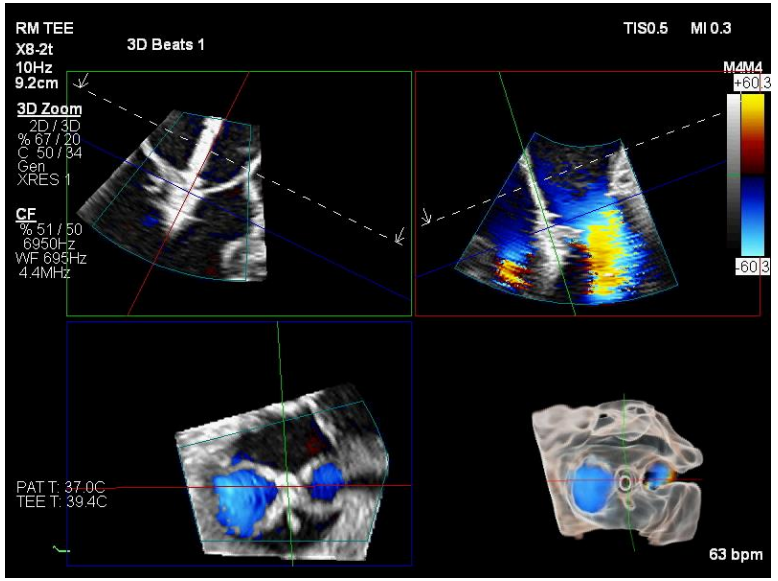
Align device in the LA



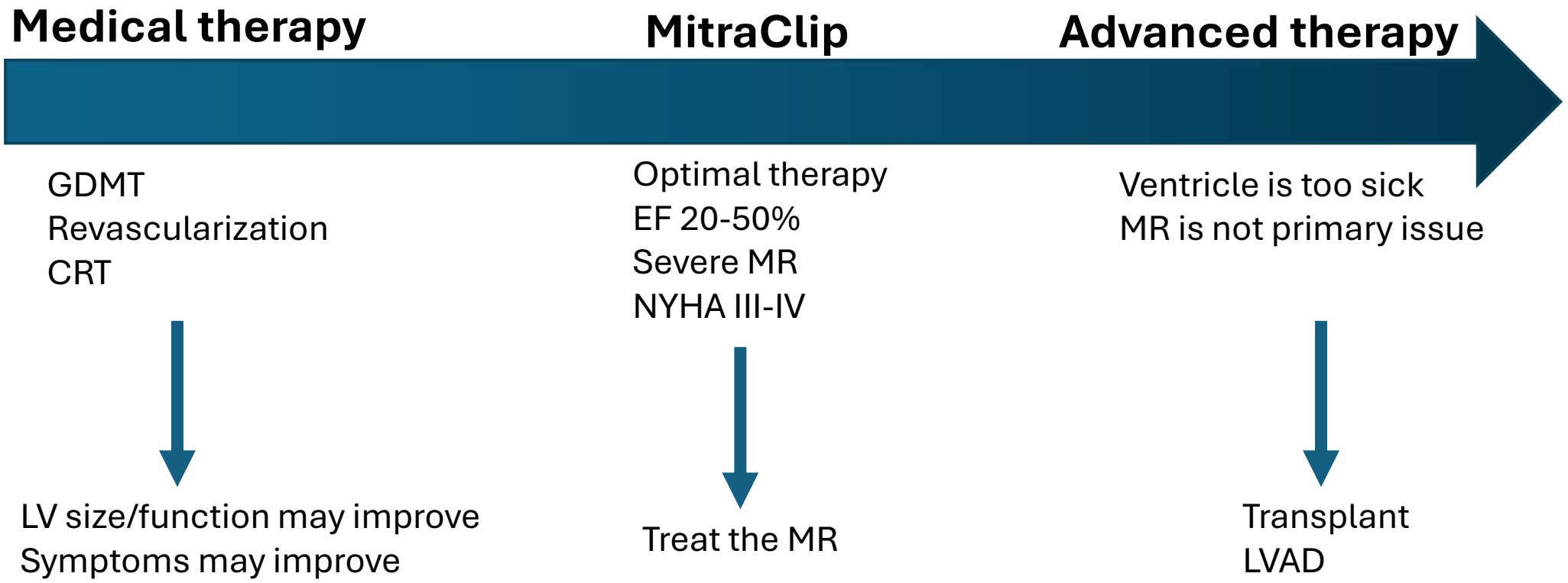
Cross the valve
Leaflet insertion



Close the clip
Reduction in MR

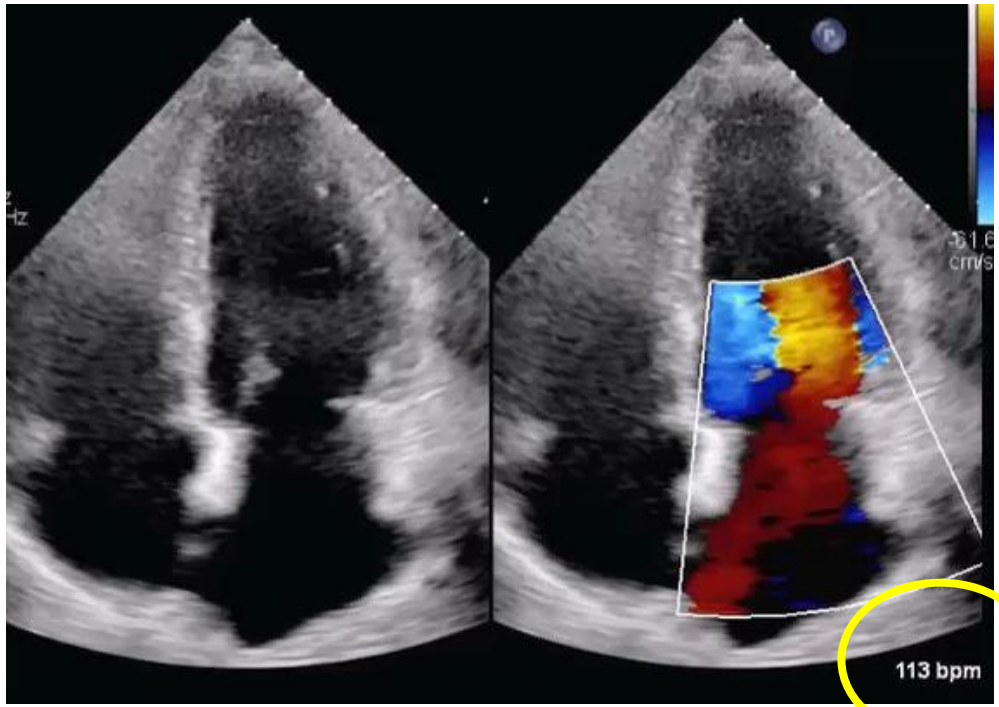


FMR : patient selection is key



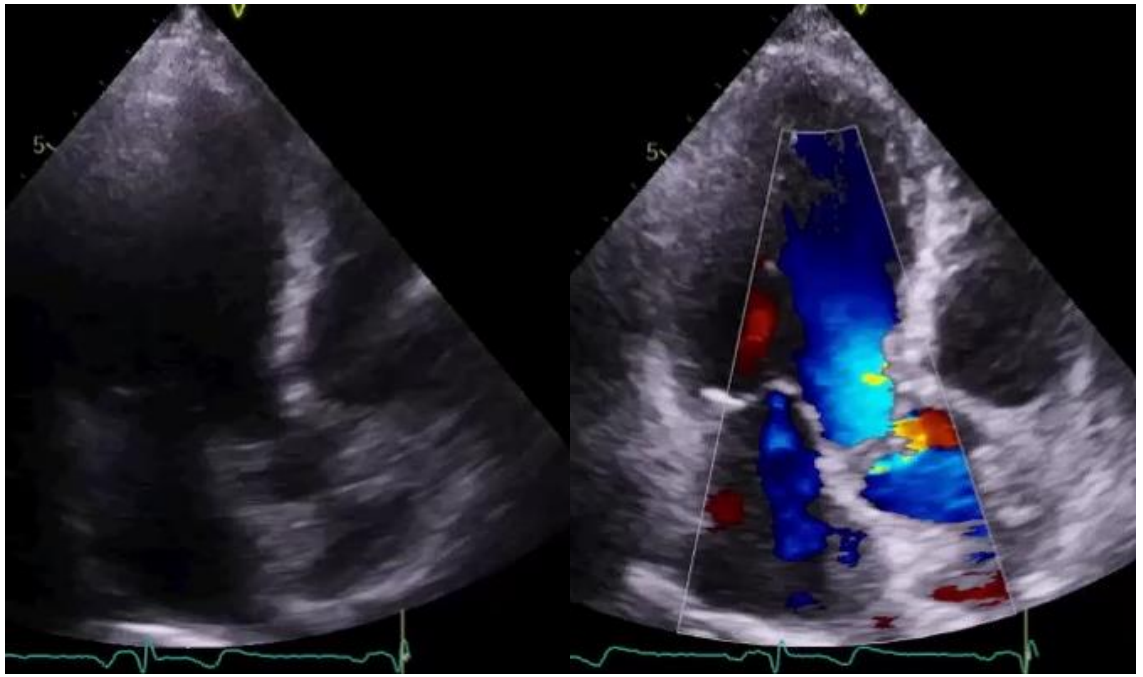
FMR related to atrial fibrillation

78 yo admitted to outside hospital with CHF, found to be in afib with RVR. TTE with severe MR. Referred to for mitral valve intervention..

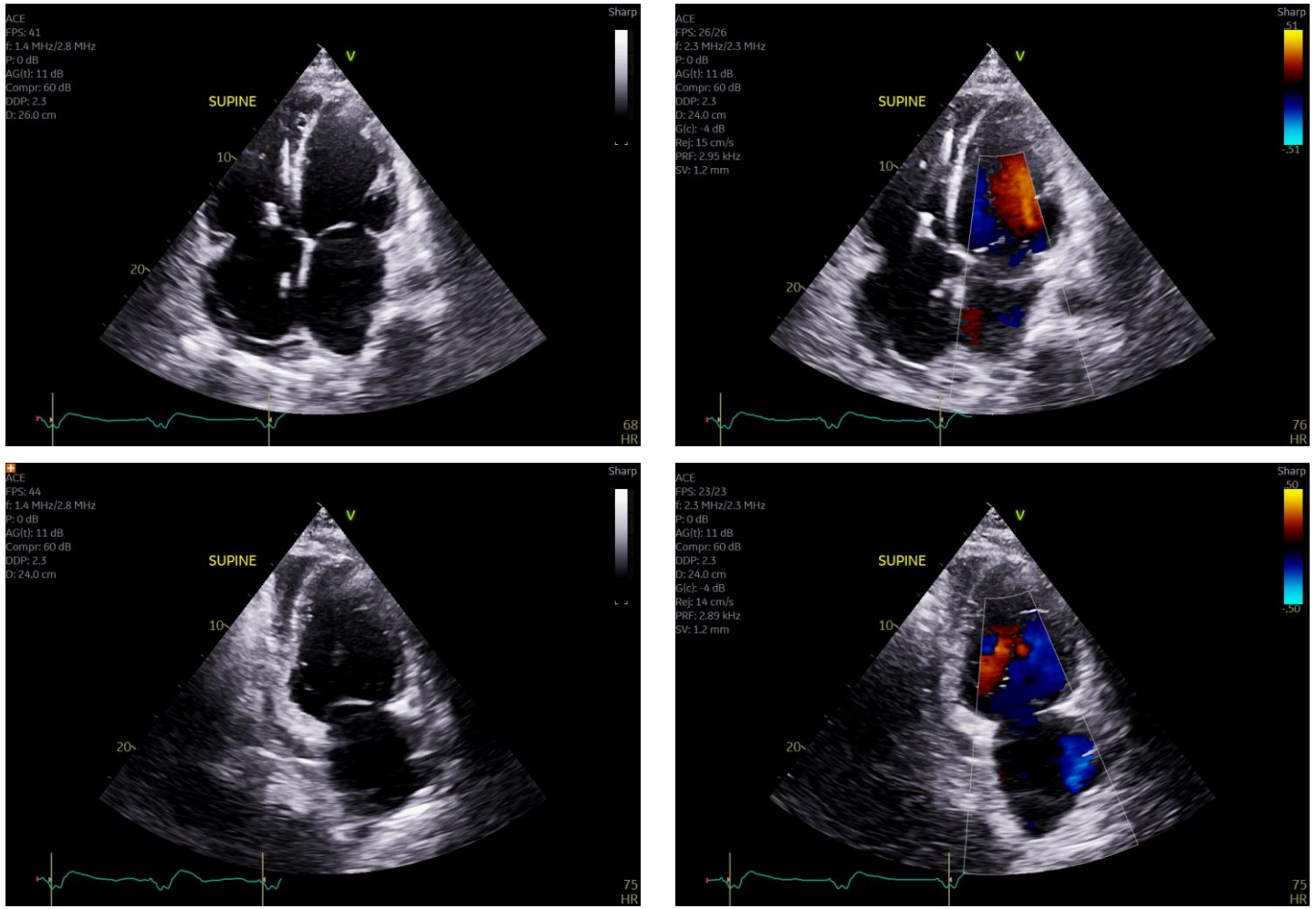


Afib with RVR

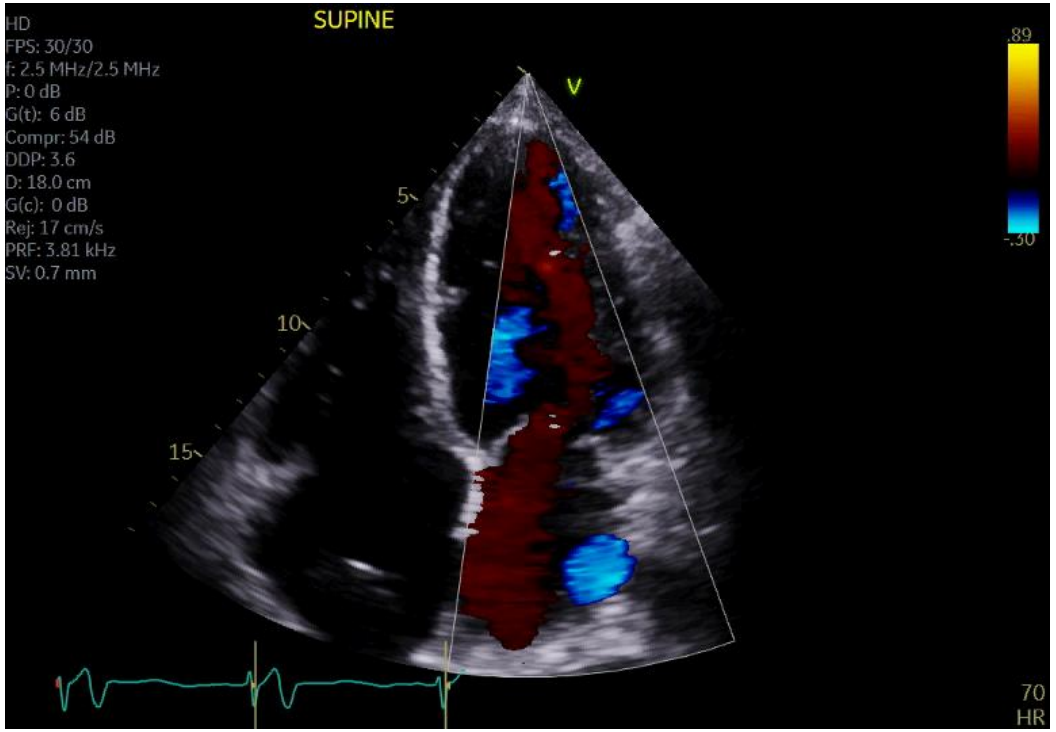
DCCV, diuresis → trivial MR

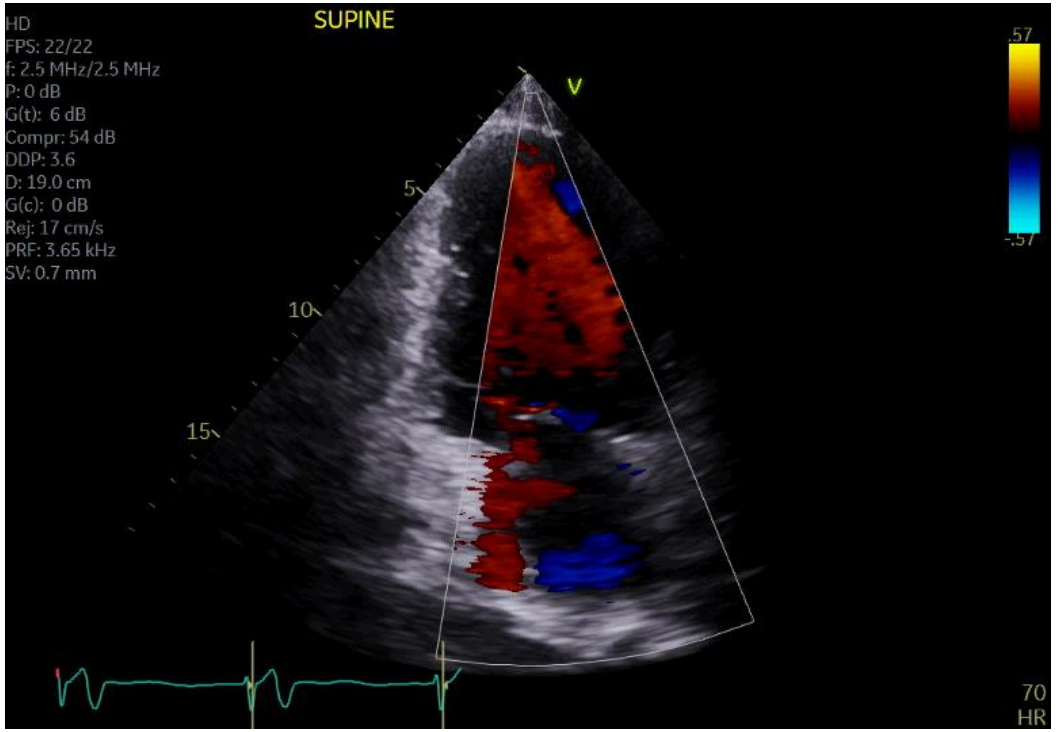


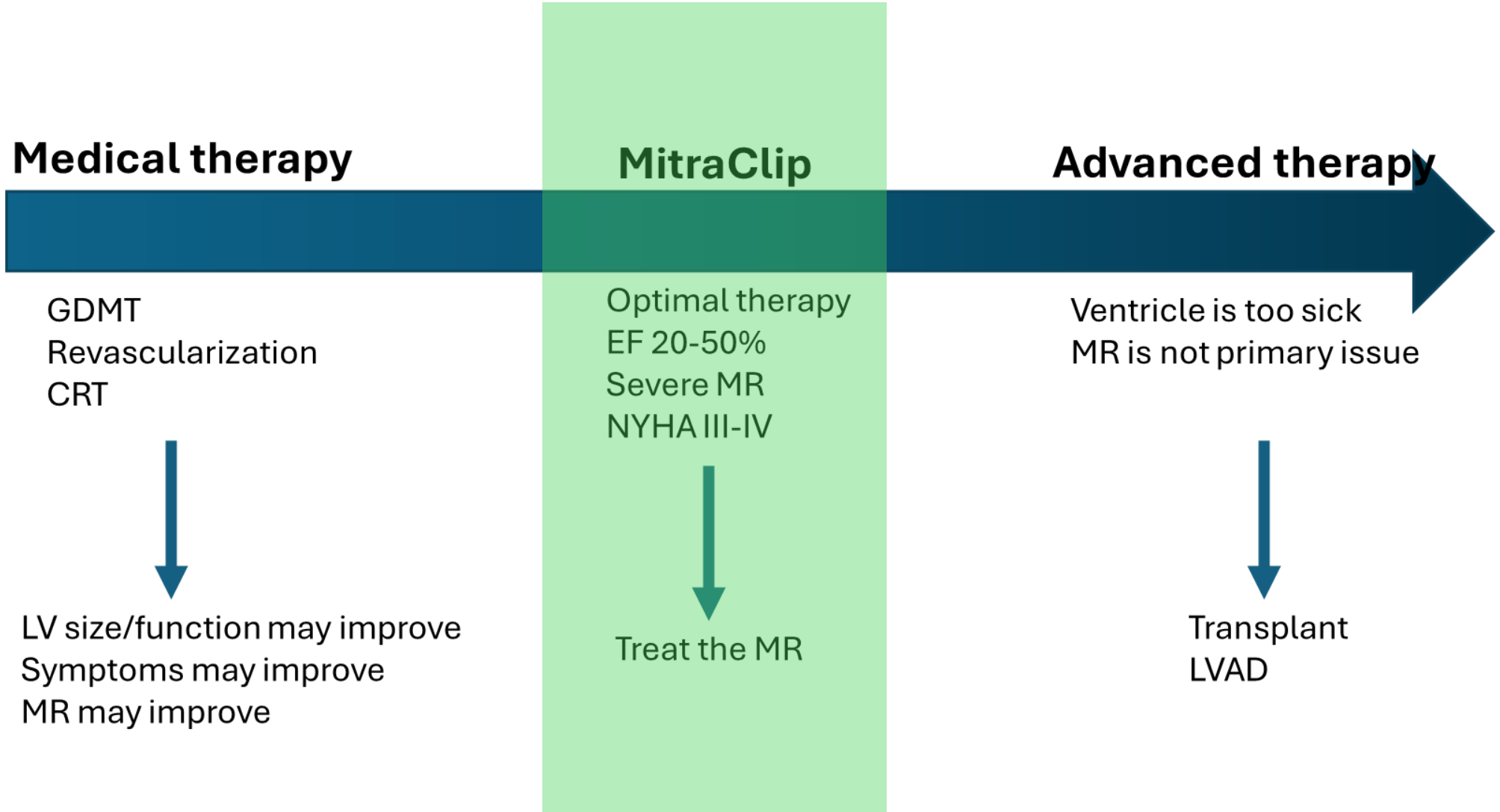
Severe LV dysfunction

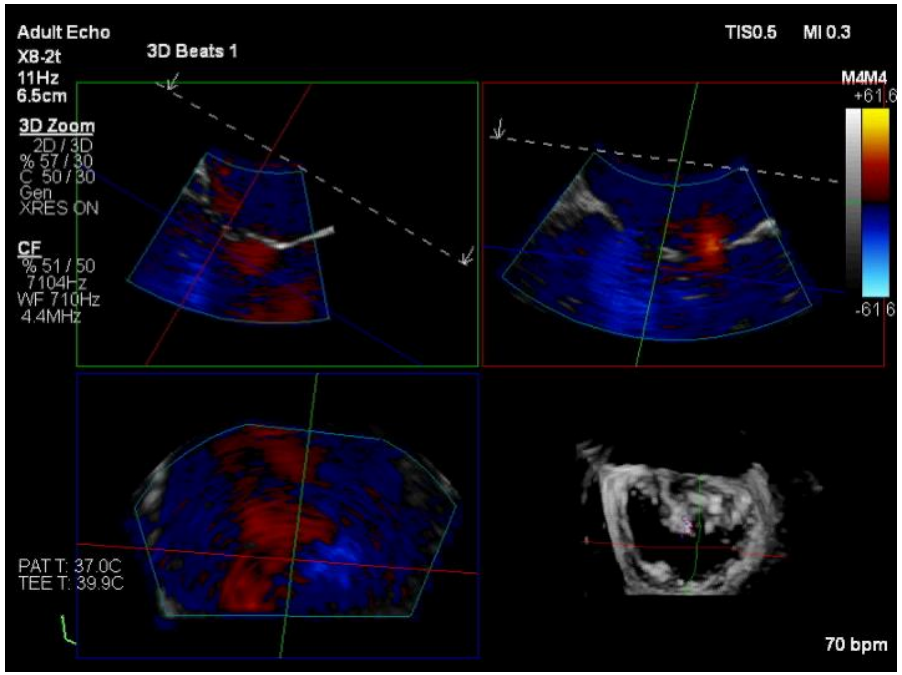


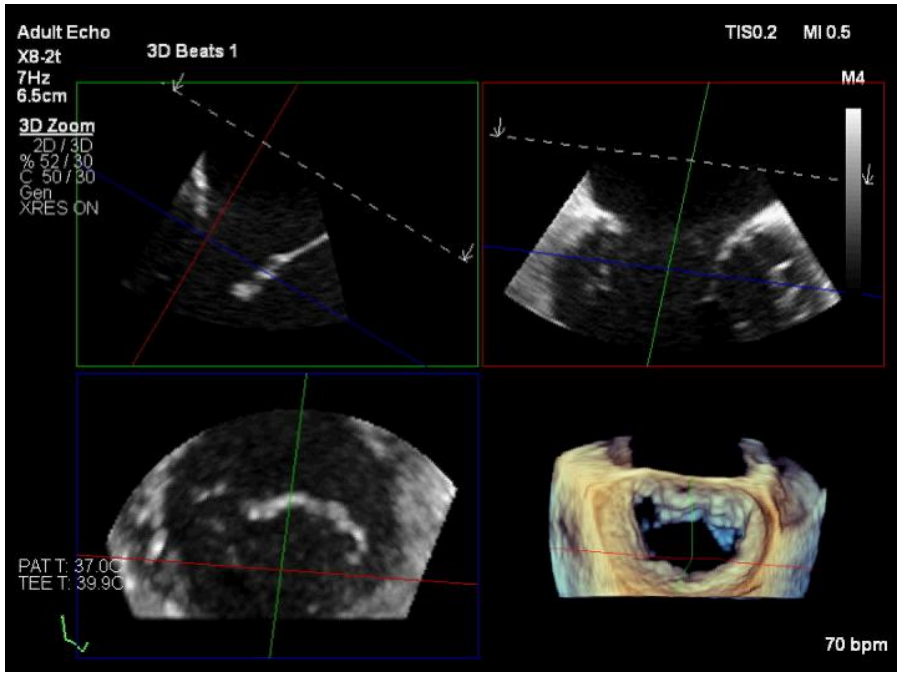
65 yo with ischemic cardiomyopathy and severe functional MR. Symptomatic despite optimization.

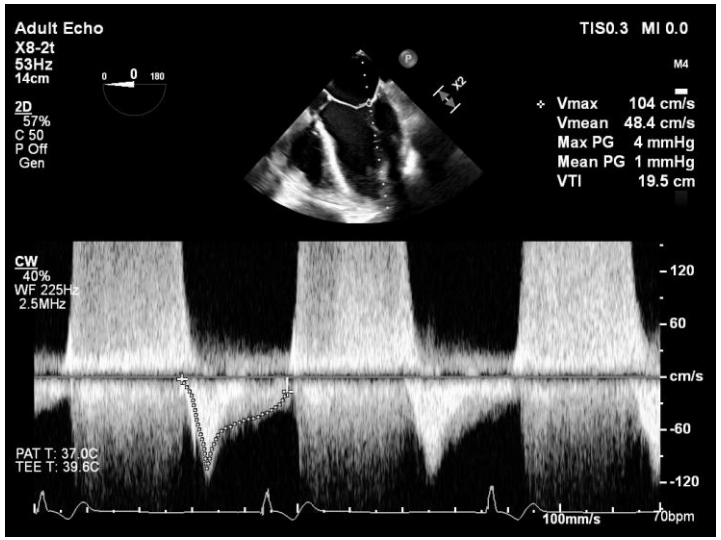


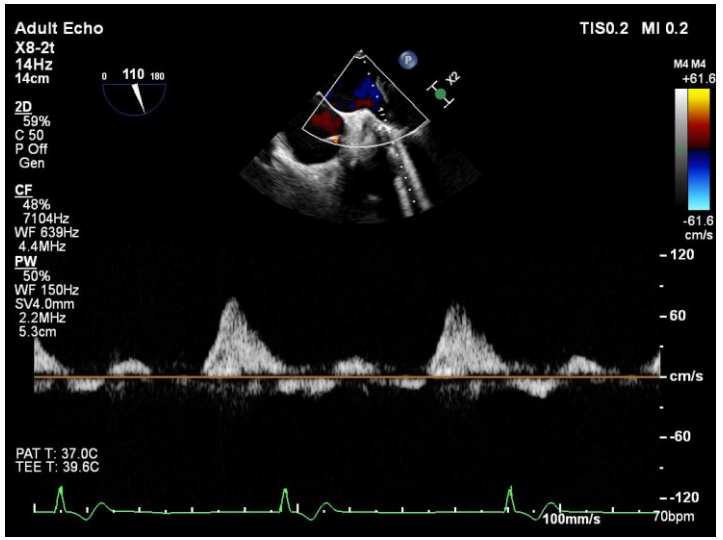



Medical therapy
MitraClip
Advanced therapy
GDMT
Revascularization
CRT
Optimal therapy
EF 20-50%
Severe MR
NYHA III-IV
Ventricle is too sick
MR is not primary issue
LV size/function may improve
Symptoms may improve
MR may improve
Treat the MR
Transplant
LVAD





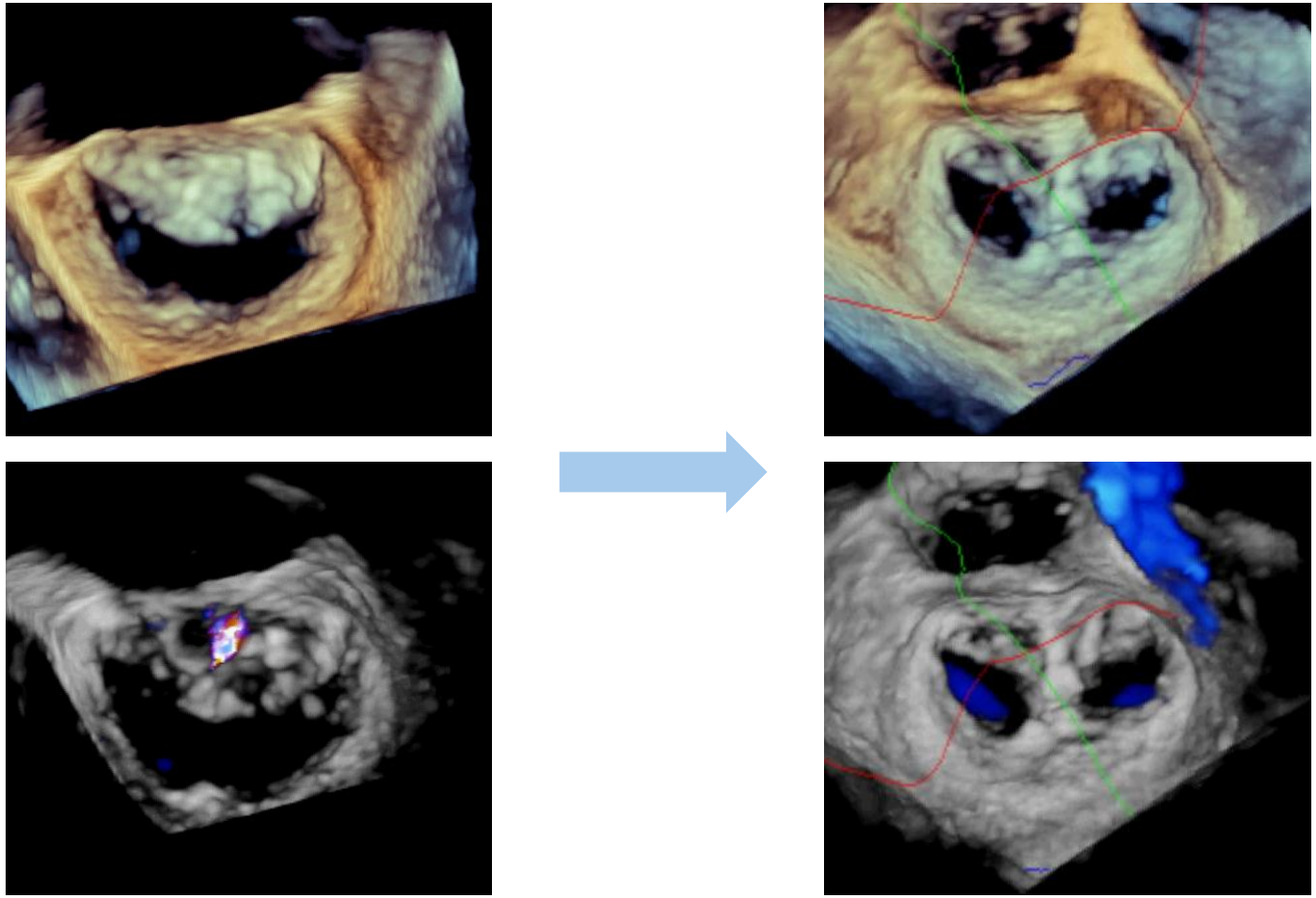




Central MR
Good leaflet length
Large valve, MG 1

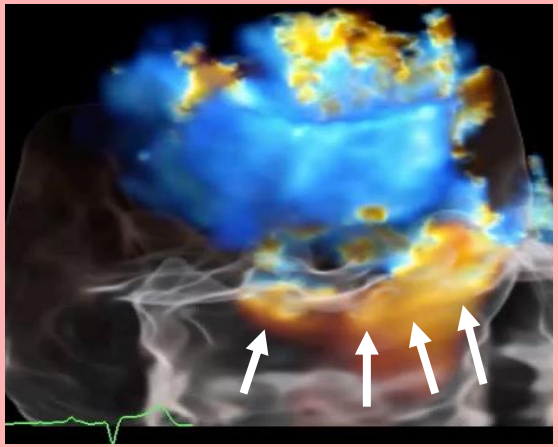
Good anatomy for M-TEER

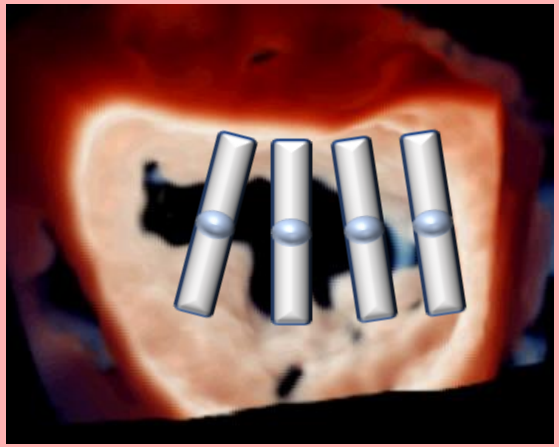
Successful MitraClip at A2/P2



Why might a patient not be a candidate for TEER?

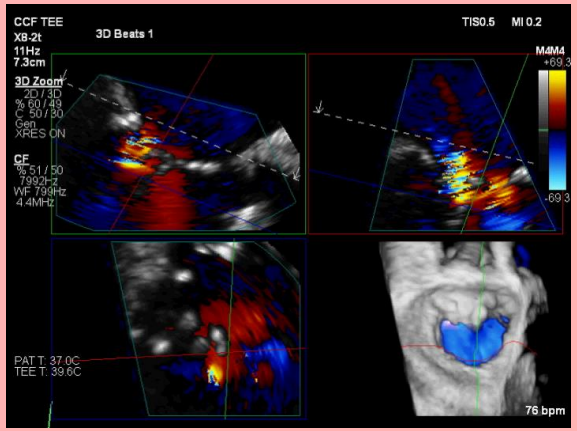
MR origin too wide

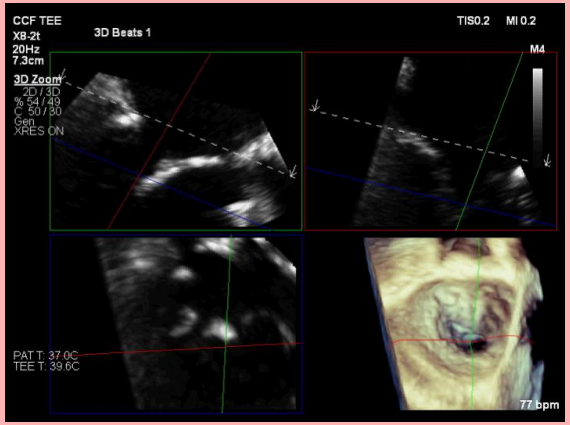




Can’t zipper the valve shut

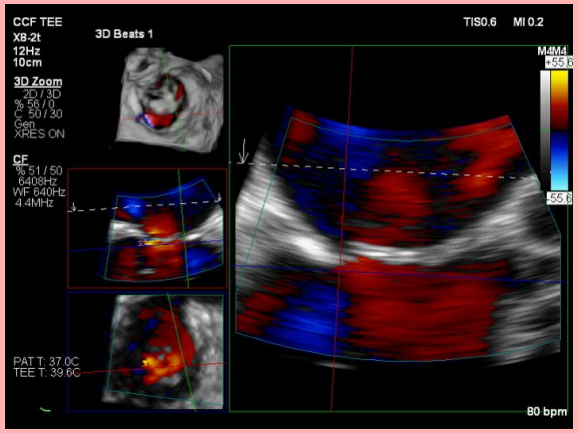
Mitral stenosis

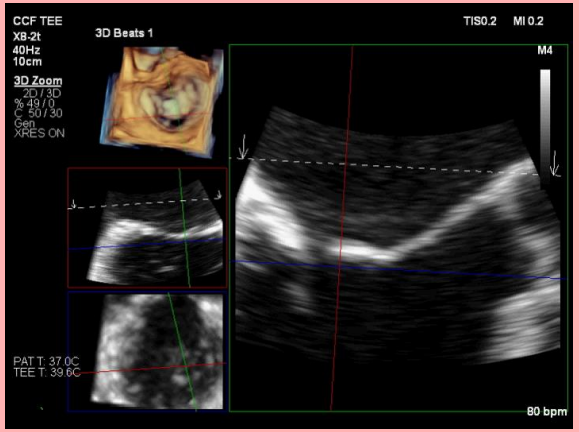




If MS present preprocedurally, TEER will only make worse

Posterior leaflet too short

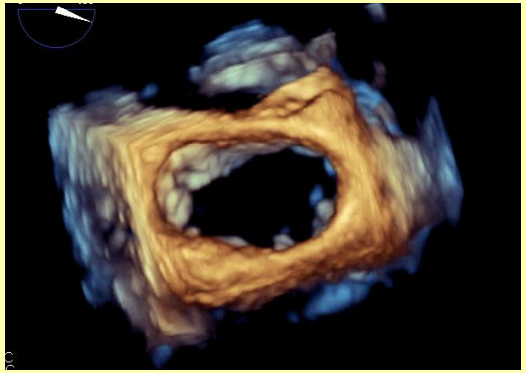


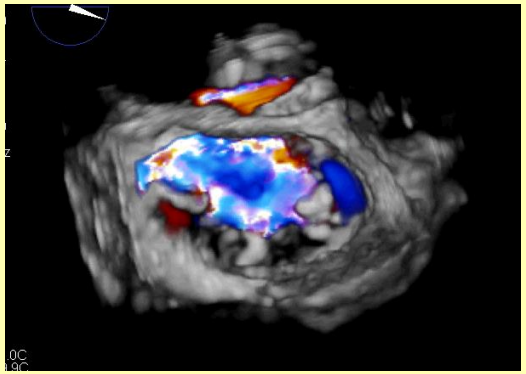


Goal, leaflet length > 7 mm

Anatomic considerations that may increase procedural complexity

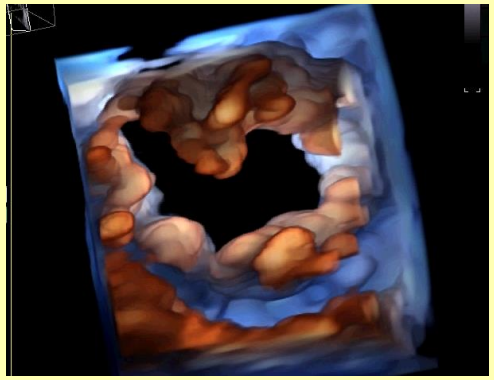
Commissures





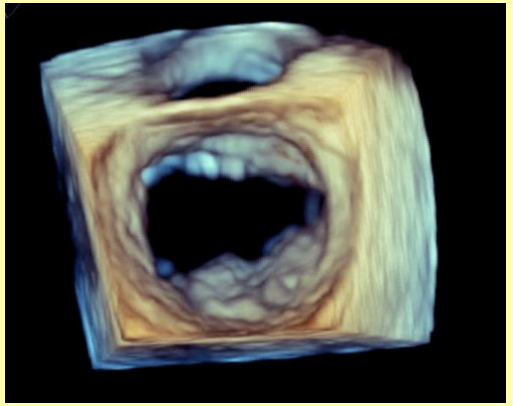
Commissural pathology more difficulty to image in 2D
More chordal interactions

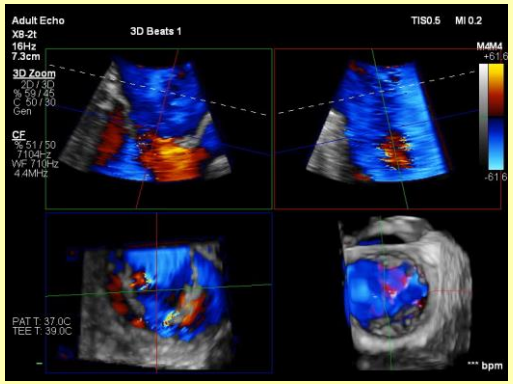
Chords



Prevent leaflet insertion
Device can become tangled

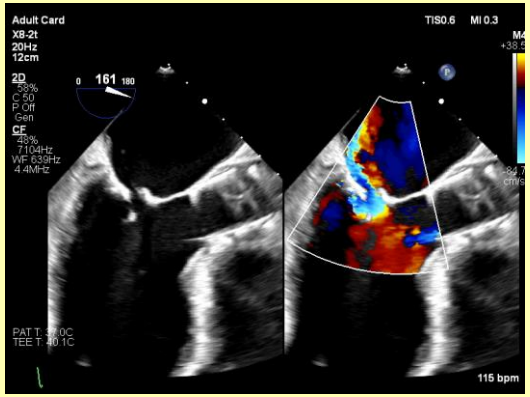
Clefts

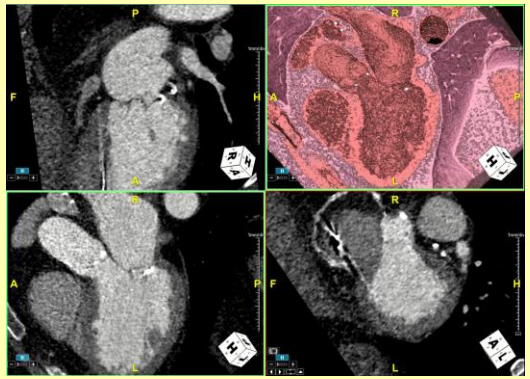




Avoid opening cleft, distorting valve

Calcification





Risk of mitral stenosis
Risk of leaflet tear

Summary

- TTE is the primary imaging modality used to diagnose and monitor mitral regurgitation
- Treadmill echo is useful when there's a discrepancy between clinical symptoms and MR severity
- TEE is useful to further define MR severity, MR mechanism and plan for intervention

Thank You