EUROVALVE & Structural Cardiomyopathies

Solutions and dilemmas in the management of secondary mitral regurgitation

5 Thoughts on Assessment of Mitral Regurgitation

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Thought 1

What is etiology & mechanism?

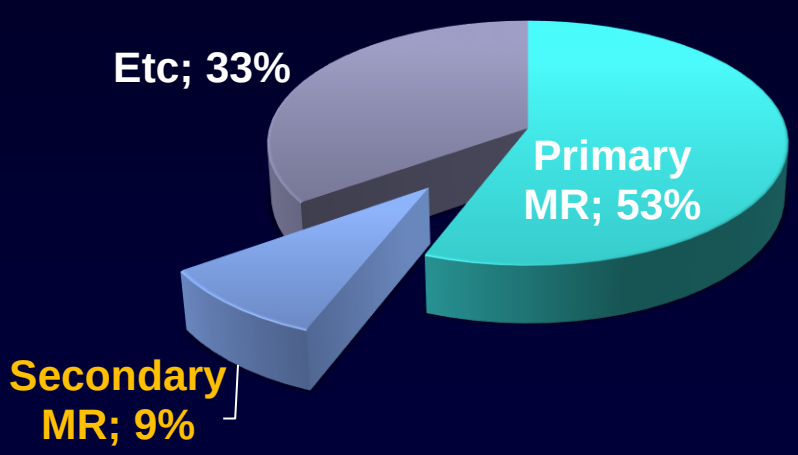
Secondary MR

- Distortion of the MV apparatus due to LV and/or LA remodeling
- One or both of the MV leaflets are pulled apically into the LV as a result of the outward displacement of the papillary muscles.
- The leaflets are apically displaced, tethered, and may have restricted mobility, especially the posterior leaflet.

2017 ASE Guideline for Native Valvular Regurgitation

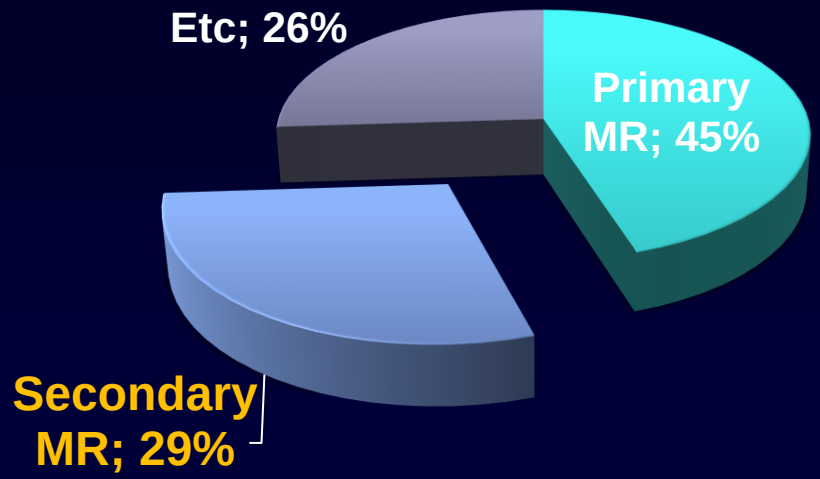
Increasing Prevalence of FMR

2011



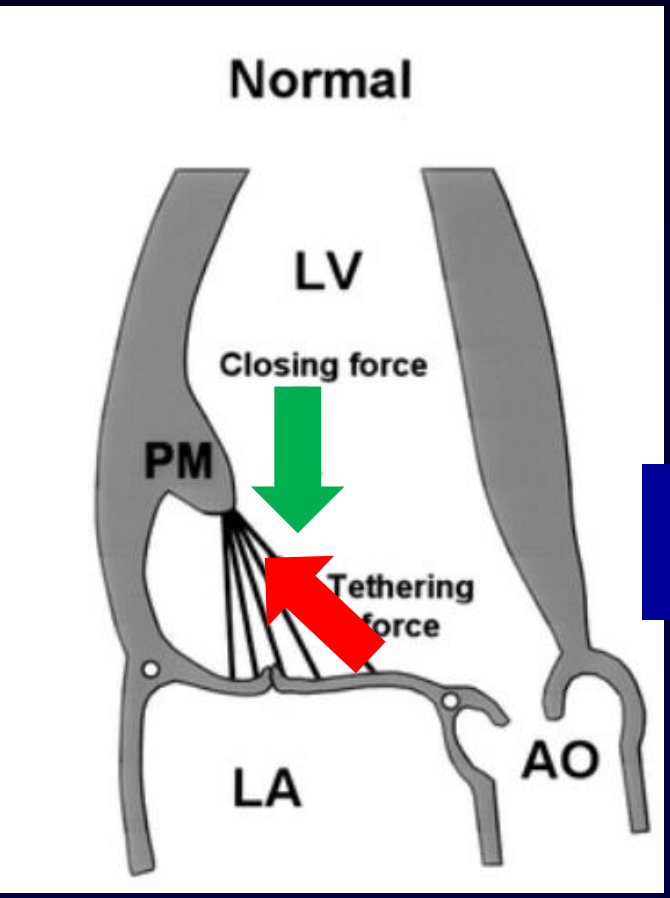
EuroHeart Survey

2018



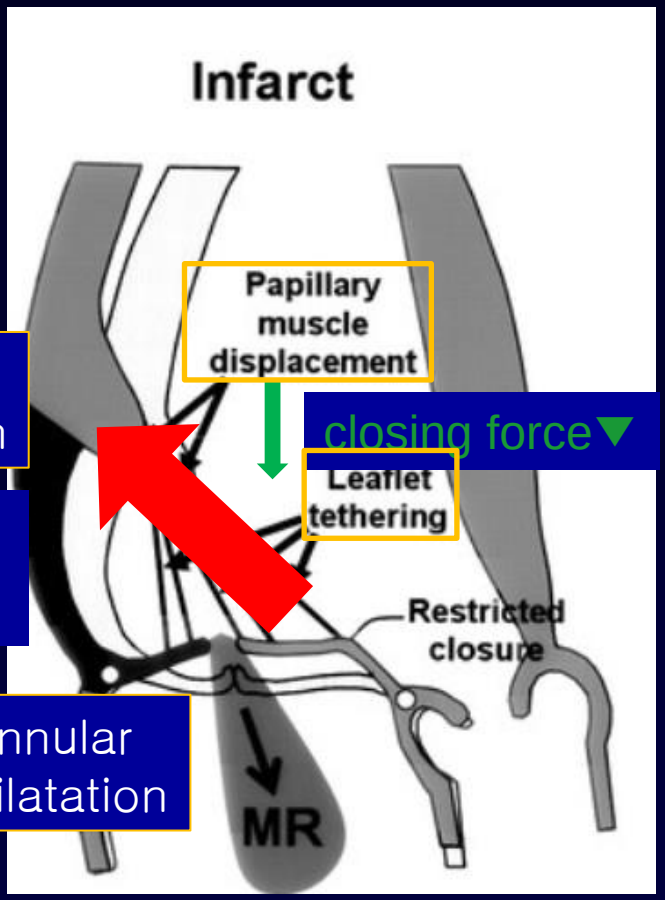
EORP VHD II Registry

Imbalance between Tethering & Closing force



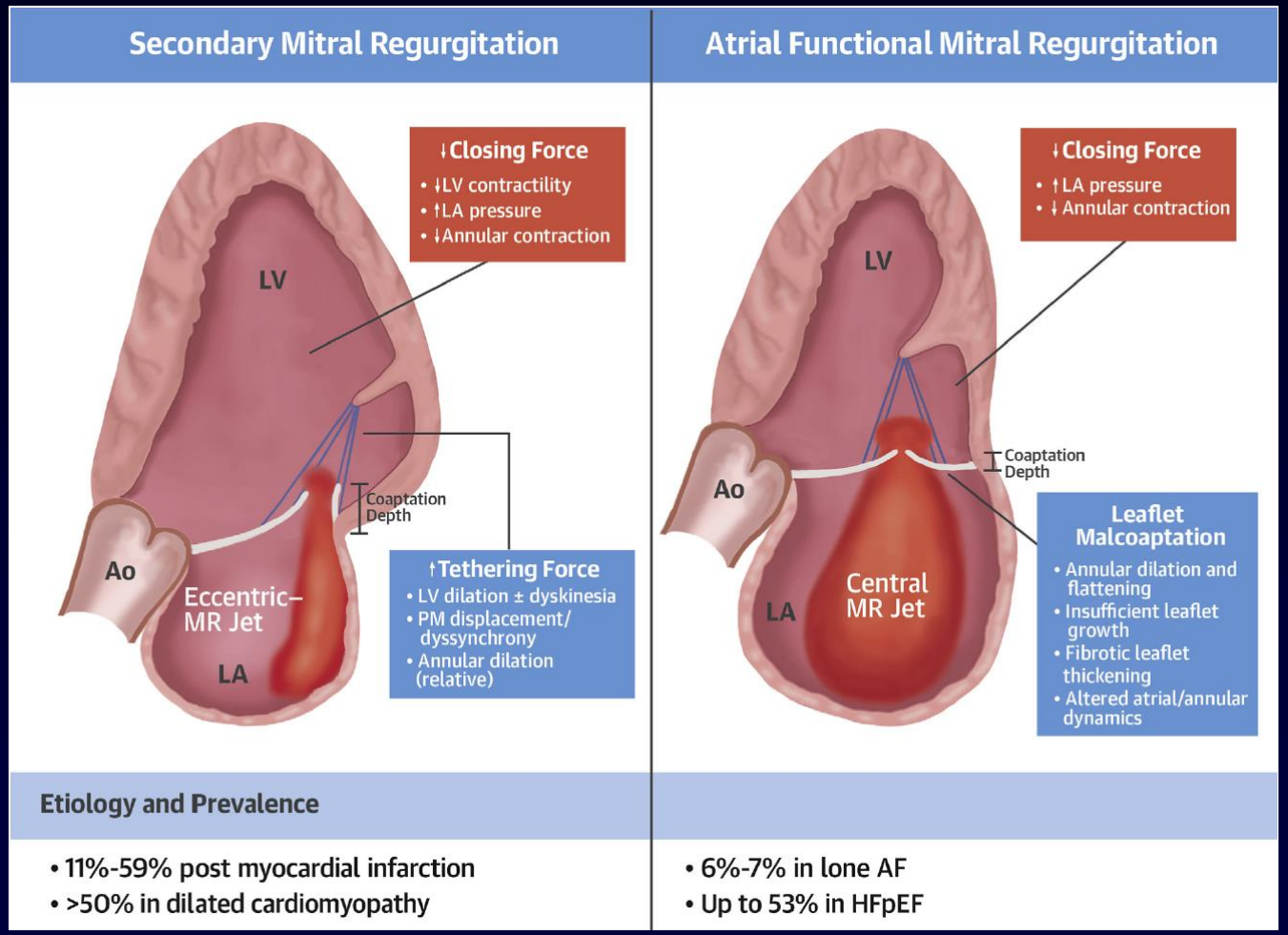
Ischemic LV distorsion

Tethering force▲



Annular dilatation

Atrial vs. Ventricular Functional MR

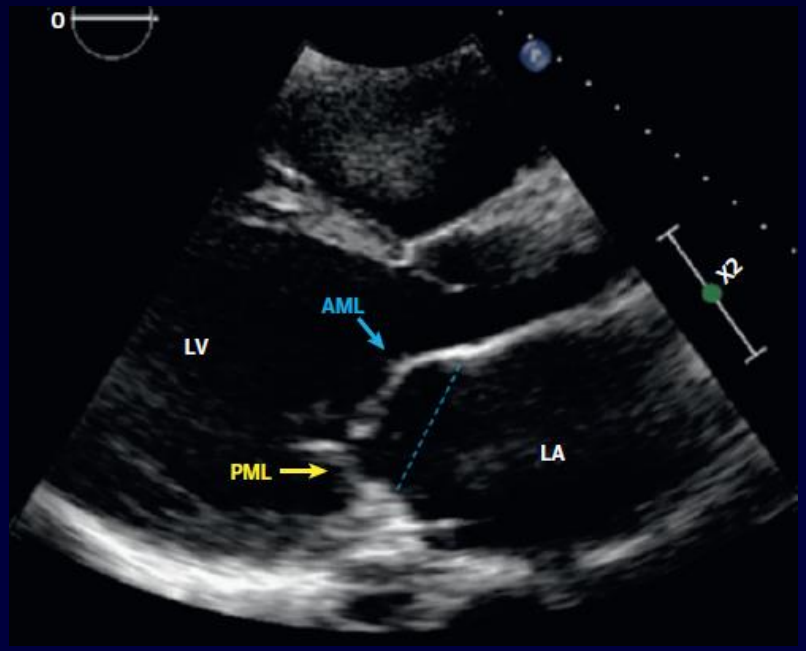


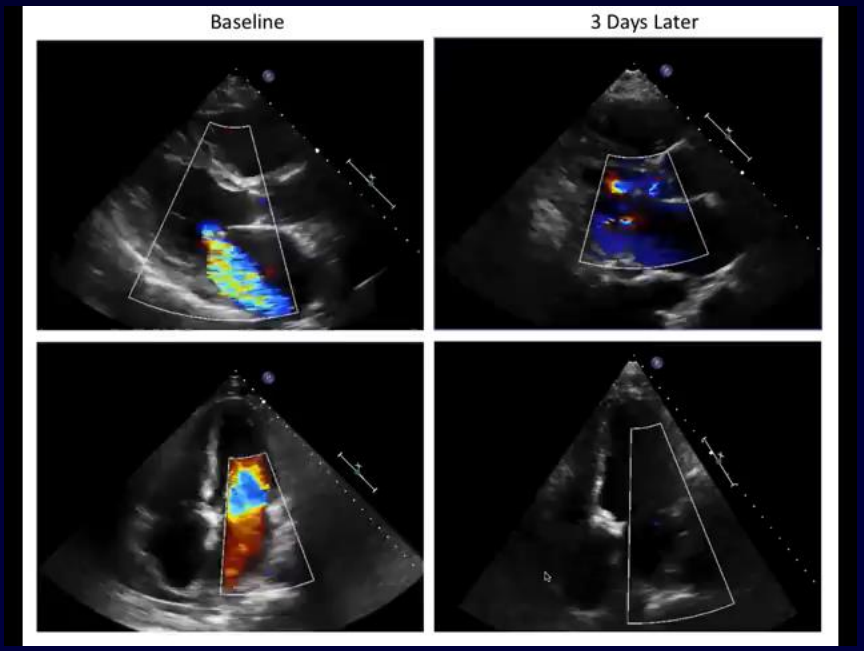
J Am Coll Cardiol 2019;73:2465–76

Pitfalls in assessing MR Etiology

- **The posterior leaflet is severely restricted/tethered, anterior leaflet overrides it with an obvious gap. This is pure secondary MR.**

J Am Coll Cardiol Img 2021;14:843-53



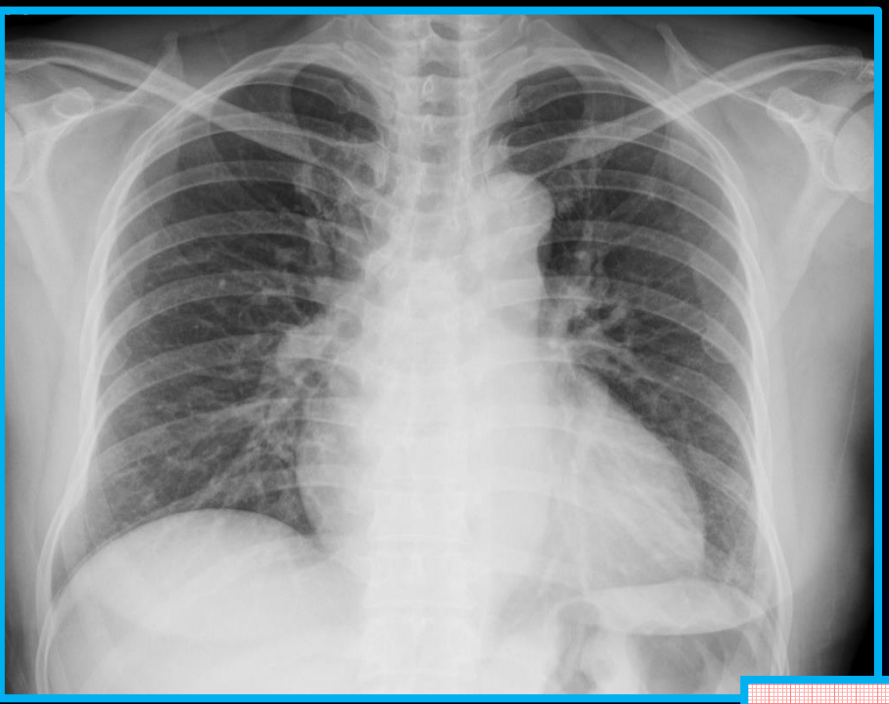


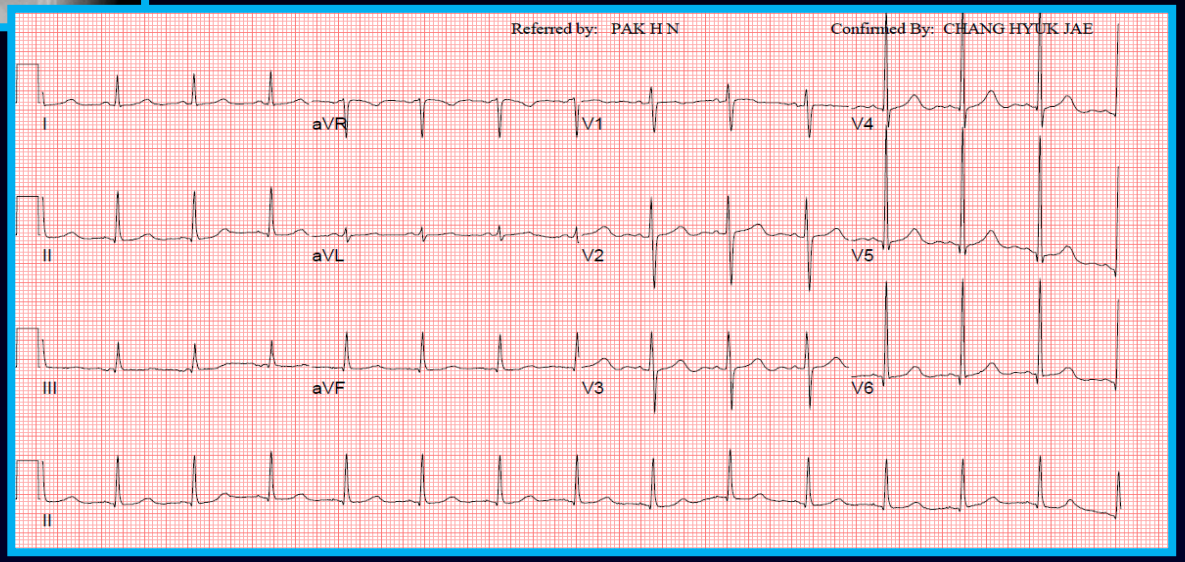
Thought 2

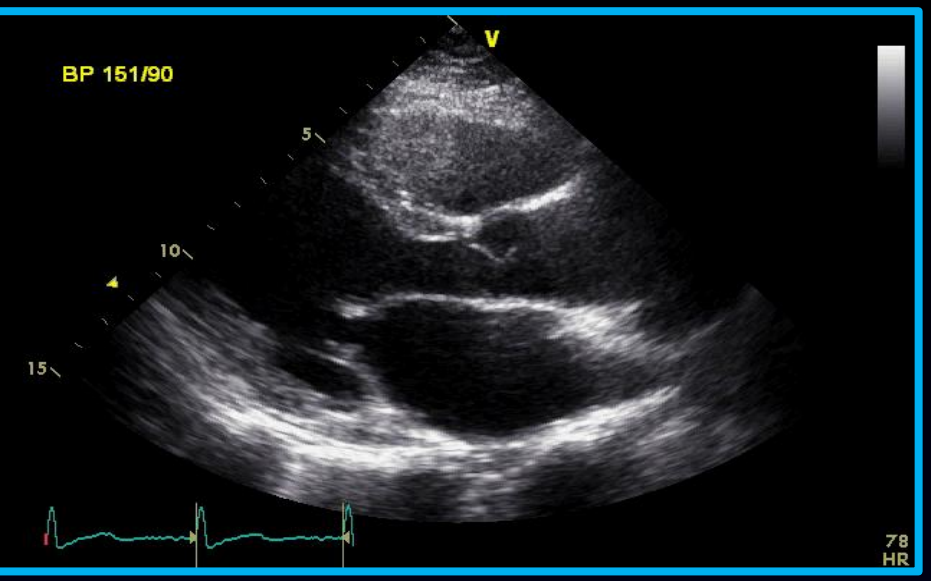
Severe MR can be reversible?

Case : 49 Year-old Woman

- C.C. : DOE (NYHA II) and palpitation
  Generalized edema
- D.. : 1 year
- PHx. : HTN (-) DM (-) Dyslipidemia (-)
- Referred to out-patient clinic
- BP : 150/90 mmHg HR 91 bpm
- PEx. : Systolic murmur at apex




Referred by: PAK H N
Confirmed By: CHANG HYUK JAE
I
aVR
V1
V4
II
aVL
V2
V5
III
aVF
V3
V6
II


BP 151/90
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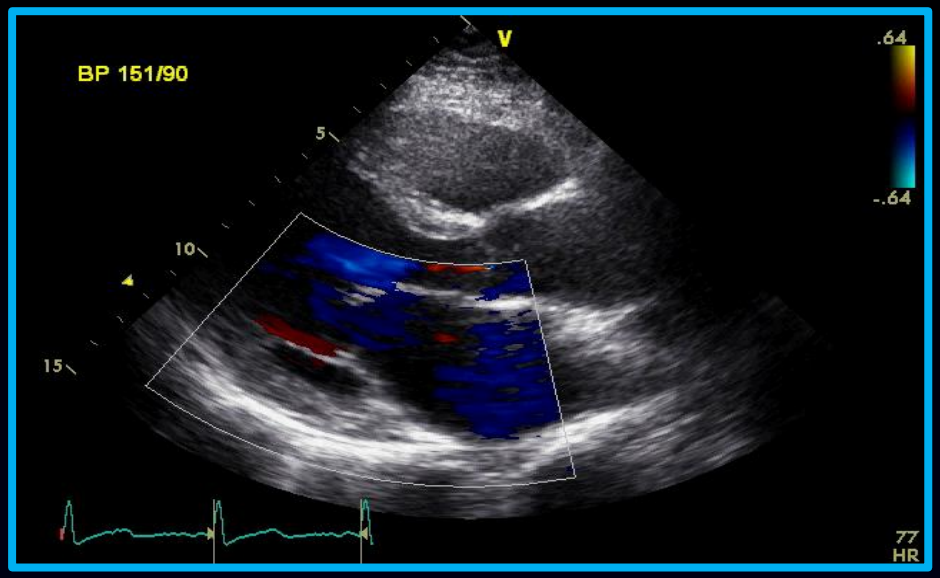
10
15
78
HR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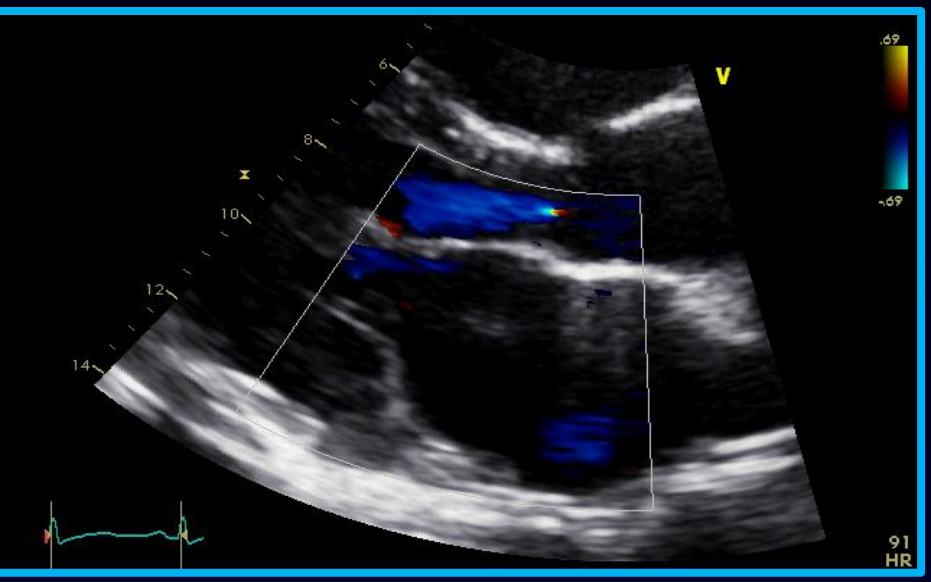
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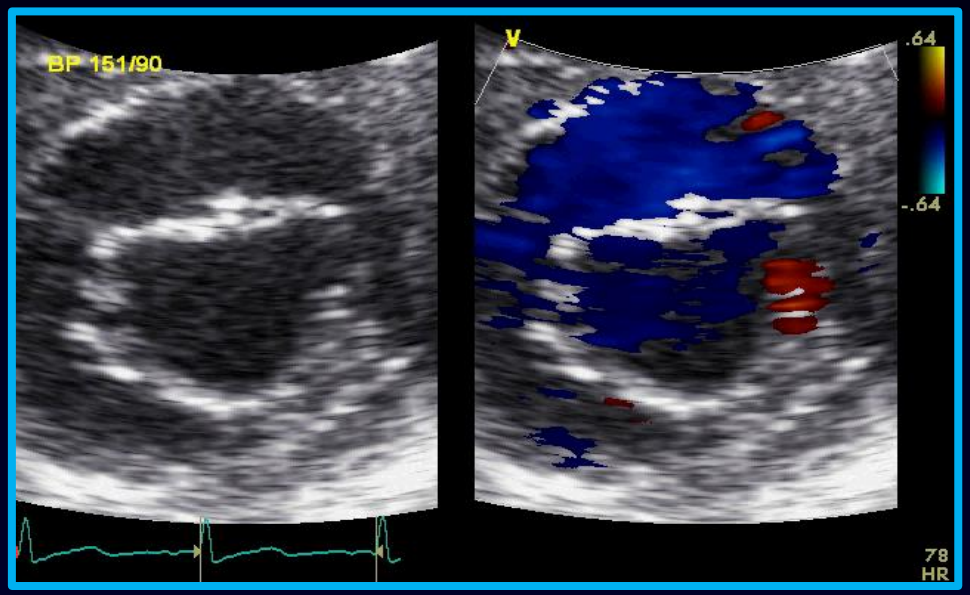
91
HR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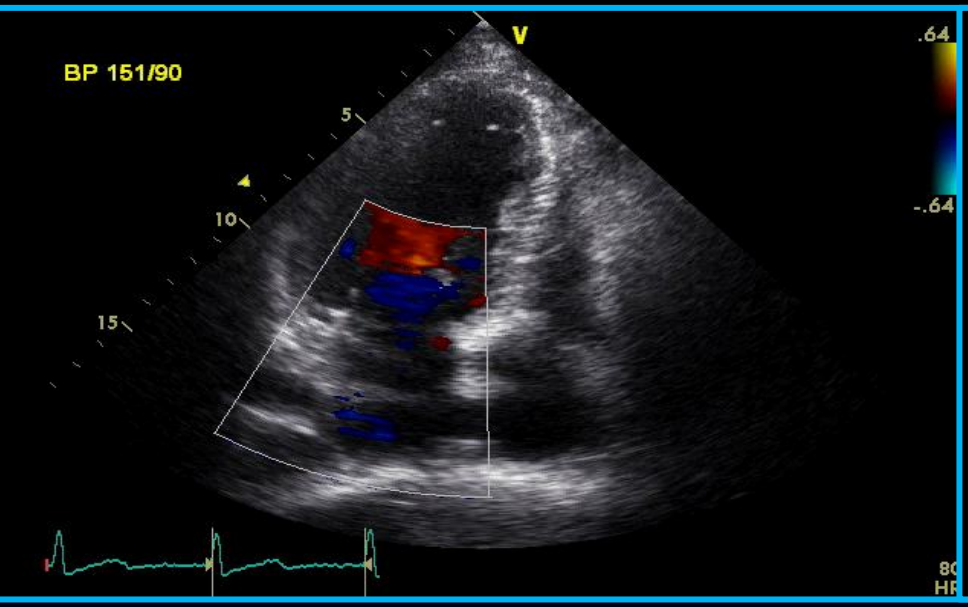
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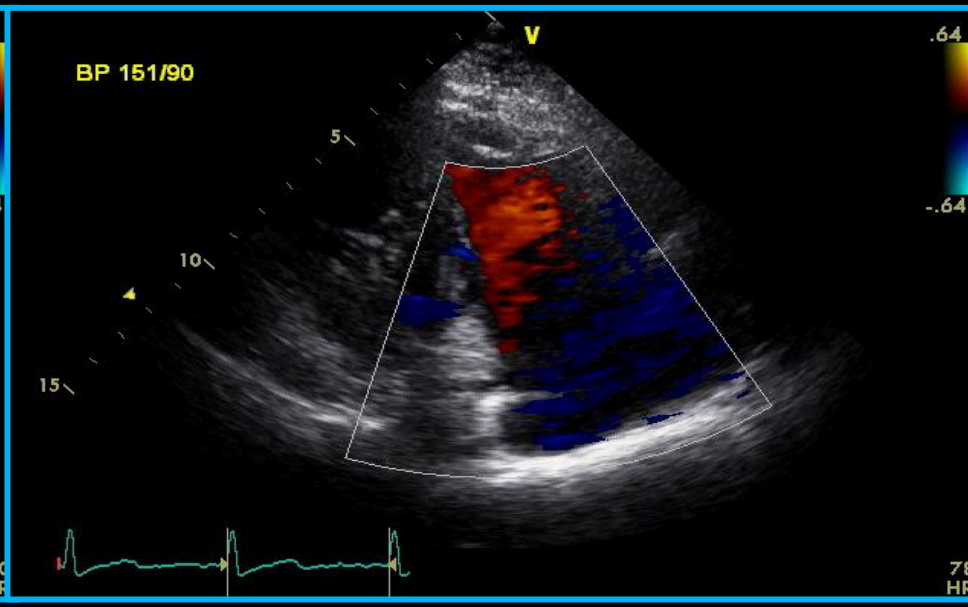
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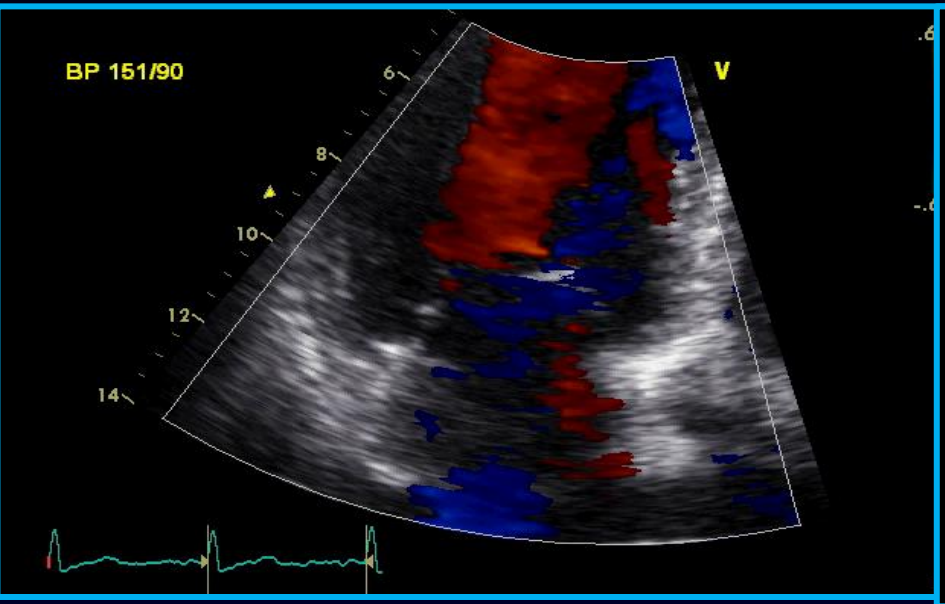
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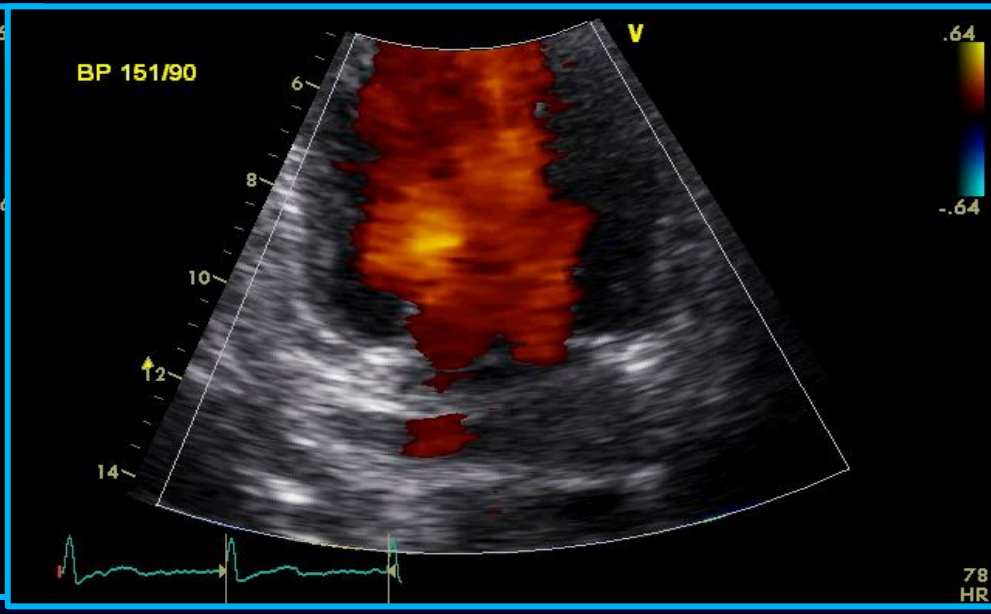
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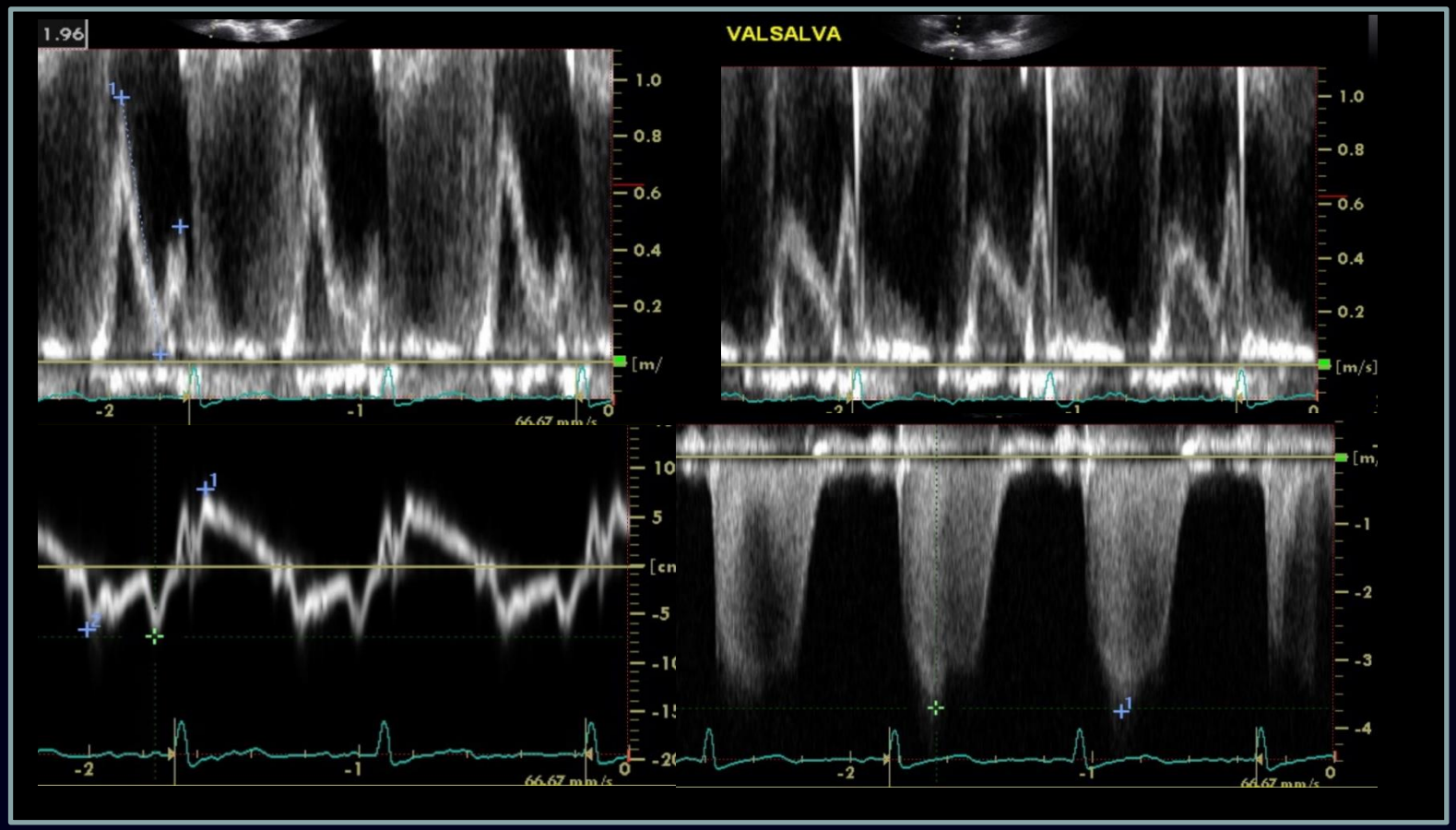
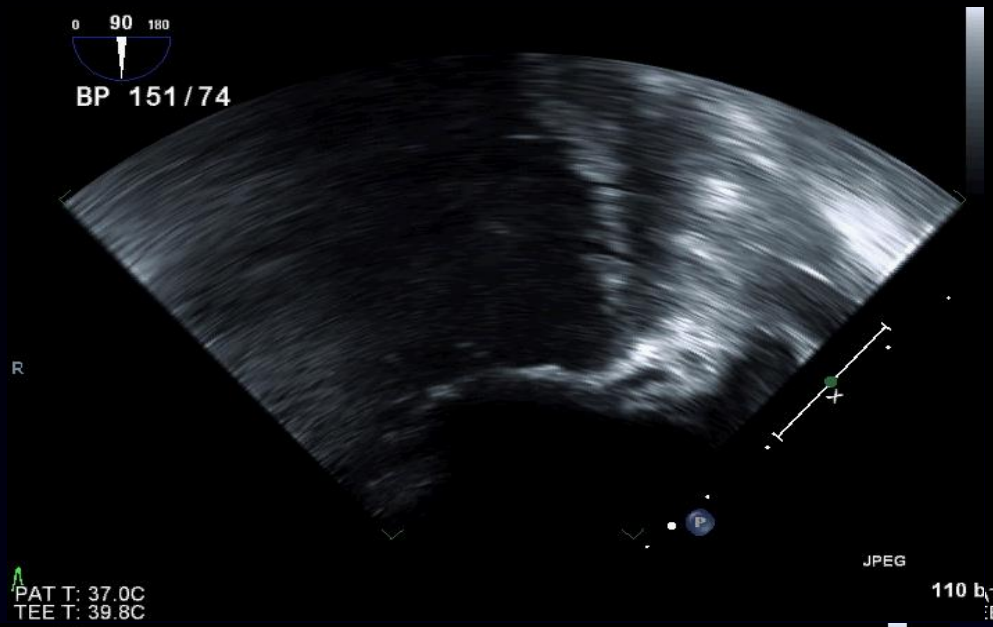


LVEDD/SD 60/43 mm, LVEF 58 %

E/e’ 16, RVSP 60 mmHg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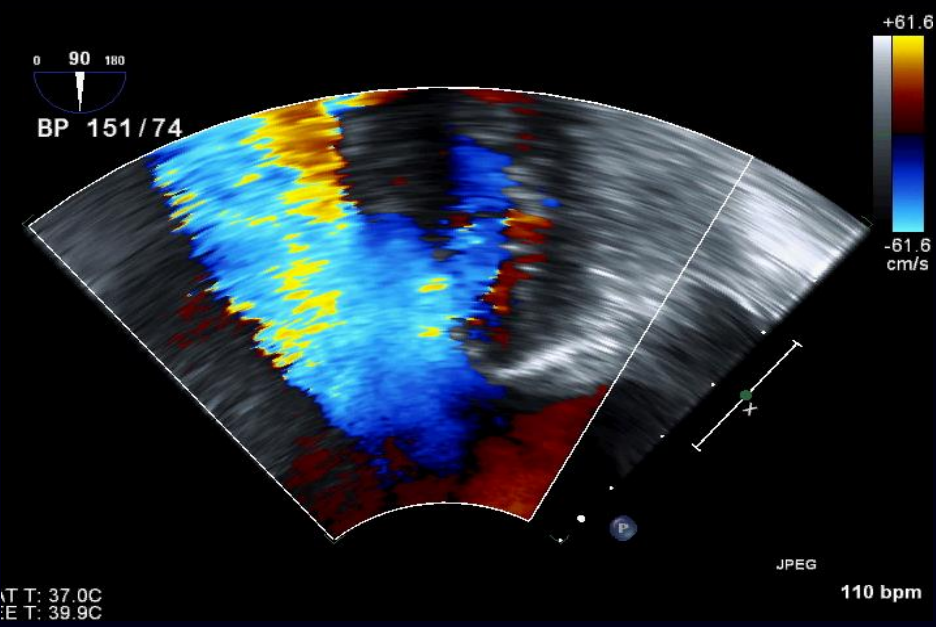
R
JPEG
PAT T: 37.0C
TEE T: 39.8C
110 b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BP 151/74
+61.6
-61.6
cm/s
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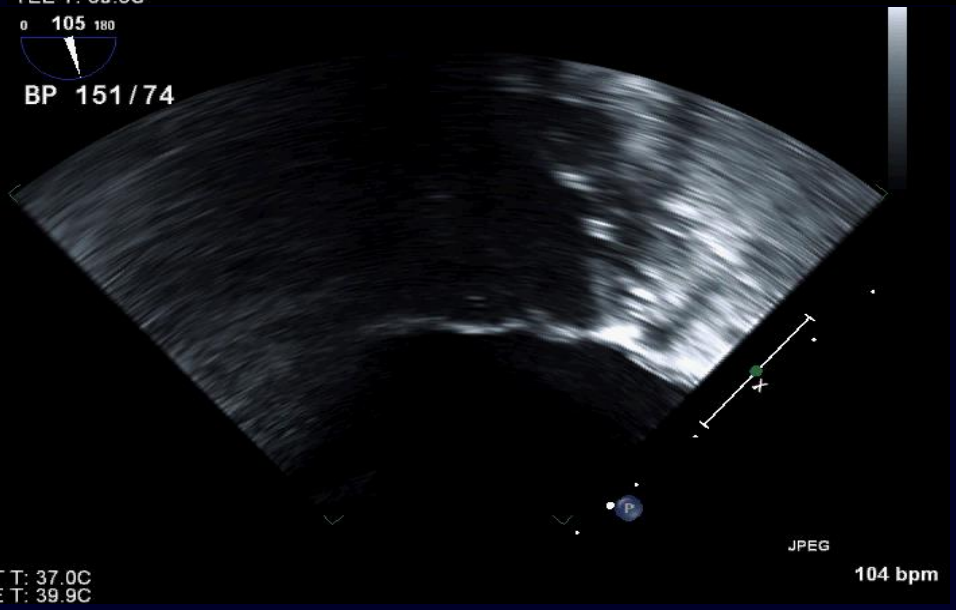
110 bpm
T T: 37.0C
E T: 39.9C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BP 151/74
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104 bpm
T T: 37.0C
E T: 39.9C

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1	백혈구수 wbc count	6.87	4~10	*1000
2	혈색소(광전비색법)hb	▼ 7.8	12~16	g/dl
3	헤마토크리트 hct	▼ 25.4	36~48	%
4	적혈구수 rbc count	▼ 3.35	3.82~5.4	*1000000
5	혈소판수 platelet count	163	150~400	*1000
6	MCV	▼ 75.8	80~100	fl
7	MCH	▼ 23.3	26~33	pg
8	MCHC	▼ 30.7	31~35	g/dl
9	RDW	▲ 14.9	11.5~14.5	fl
10	mpv	9.9	~	%
11	pdw	▼ 11.0	12~18	fl
12	Seg.neutrophil	63.1	50~70	%
13	Eosinophil	▲ 5.7	1~4	%
14	Basophil	0.4	0~1	%
15	Lymphocyte	▼ 24.5	25~40	%
16	Monocyte	6.3	3~8	%

2014/4/6 7.8

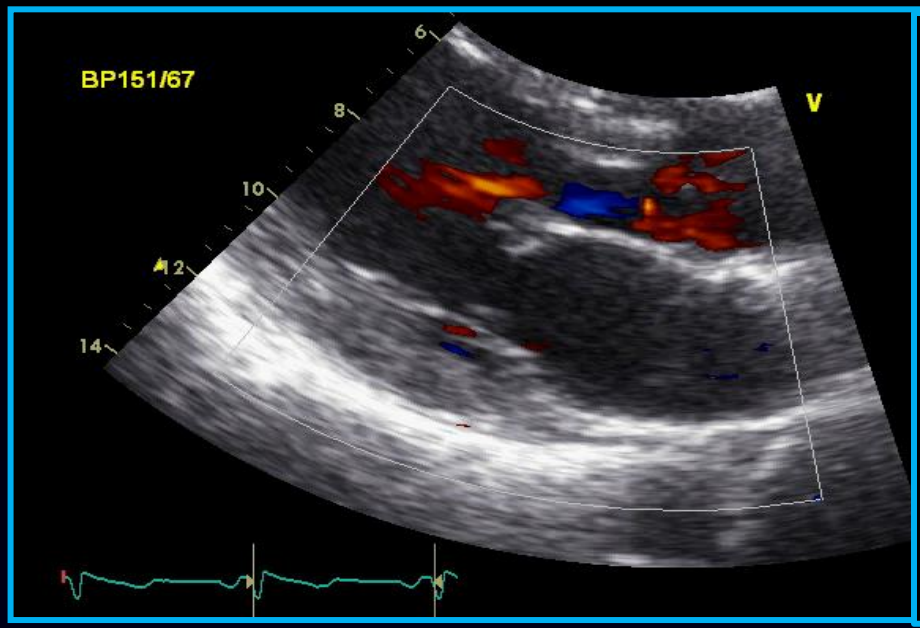
2014/4/21 8.7

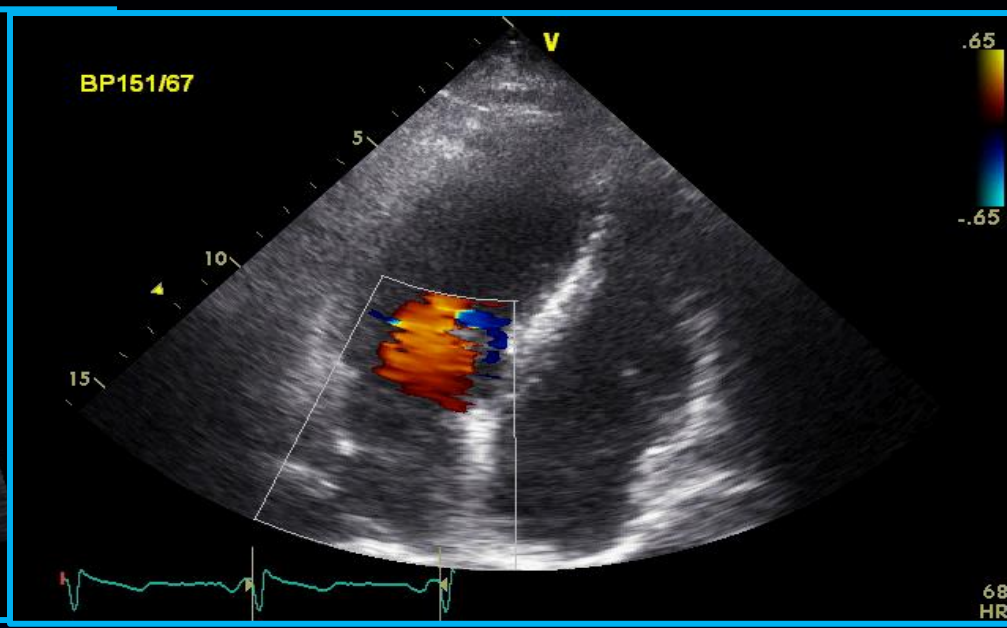
2014/5/22 10.2

2014/7/3 13.1

Adenomyosis & Hypermenorrhea

➔ OBGY ➔ IUD insertion





Decreased MR to trivial

Normalized LV chamber size and normal EF

Normalized estimated LV filling pressure

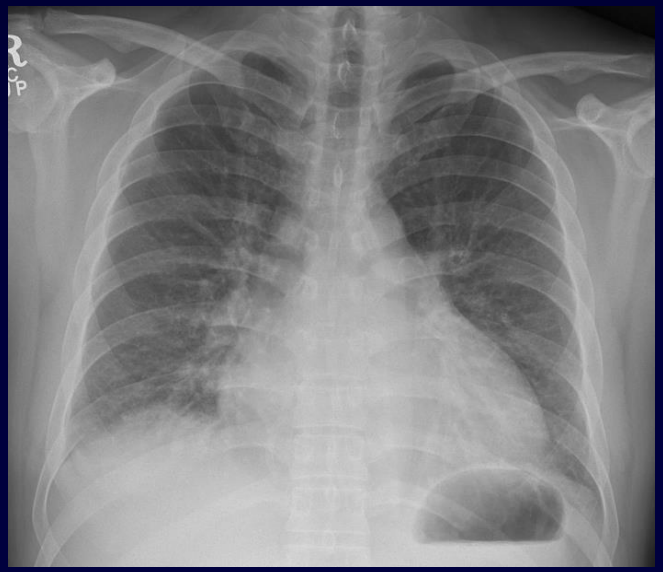
Normalized RVSP

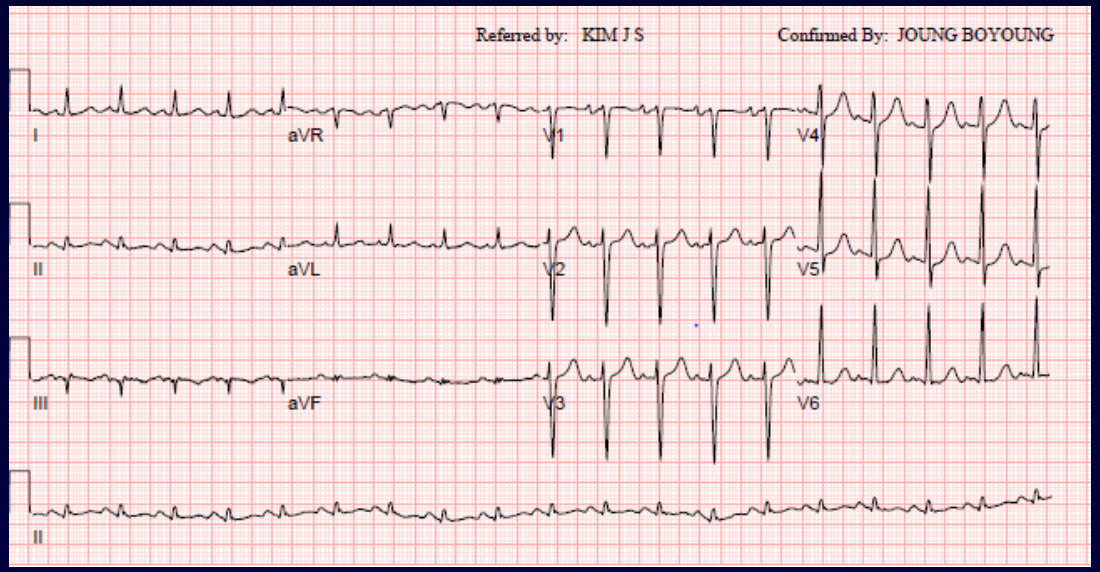
Cause of Dynamic MR

- Hypertension
- Volume status
- Anemia
- Hyperthyroidism
- CAD
- Arrhythmia
- HCMP

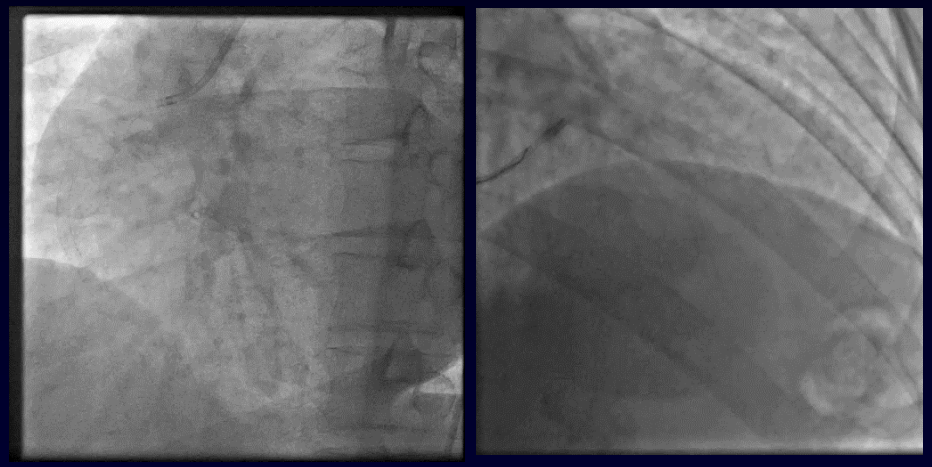
CASE: 78 YO Man

- C.C. : DOE and Orthopnea (NYHA III)
- P.Hx : STEMI S/P PTCA with stent at RCA (2017.5) and LAD (2017.10)
  HTN (+) DM (-), Alcohol (+) social, Smoking (+) ex
  S/P Thoracentesis 2017.10
- V.S. : BP 116/80 mmHg, HR 104 BPM
- LAB. : Hb 14.9, BUN/Cr 33.4/1.03, NT-proBNP 3,191 pg/mL



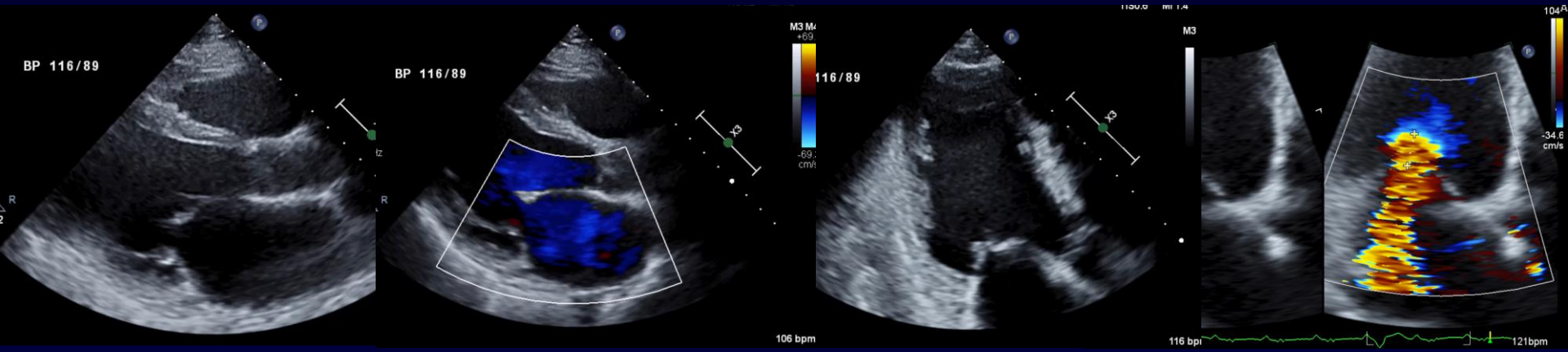


2017.5



2017.5

2017.10



LVEDD/ESD 65/59 mm, LVEF 21%, EROA 0.63 cm2, RV 63 ml, RVSP 78 mmHg

Medications (outside hospital)

Aspirin 100 mg qd

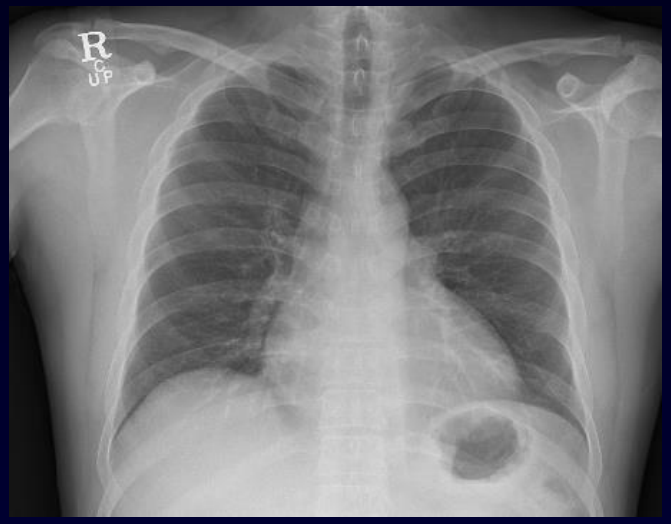
Clopidogrel 75 mg qd

Sigmart 5 mg tid

Rosuvastatin 20 mg qd

Furosemide 40 mg bid

Spironolactone 25 mg qd

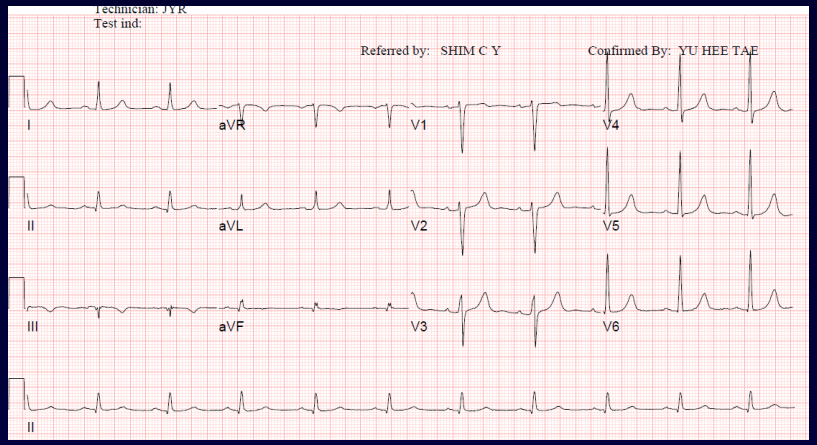


Medication add-on

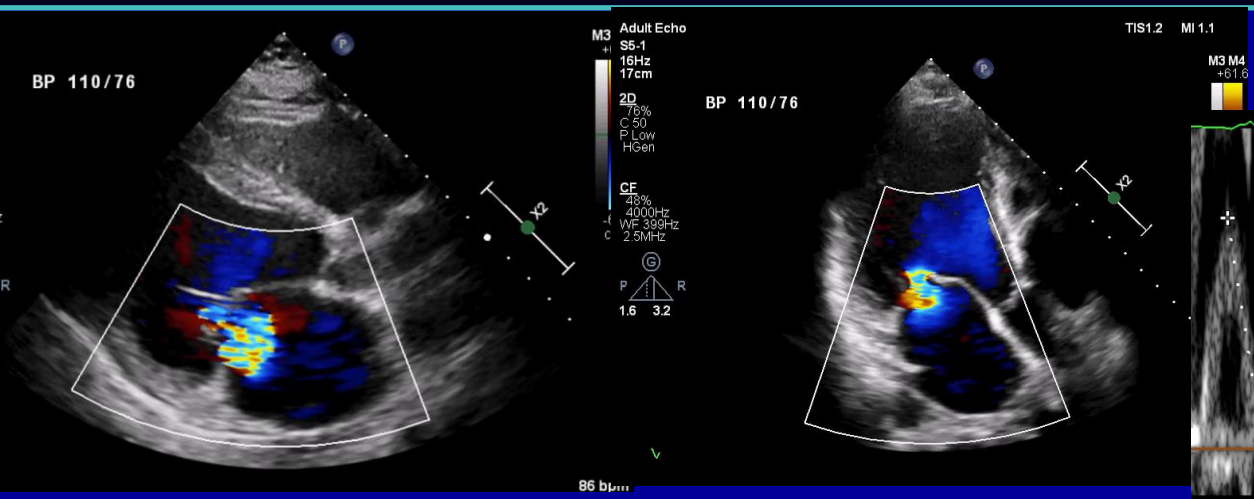
Ivabradine 5 mg bid ➔ 7.5 mg bid

Carvedilol 3.125 mg bid

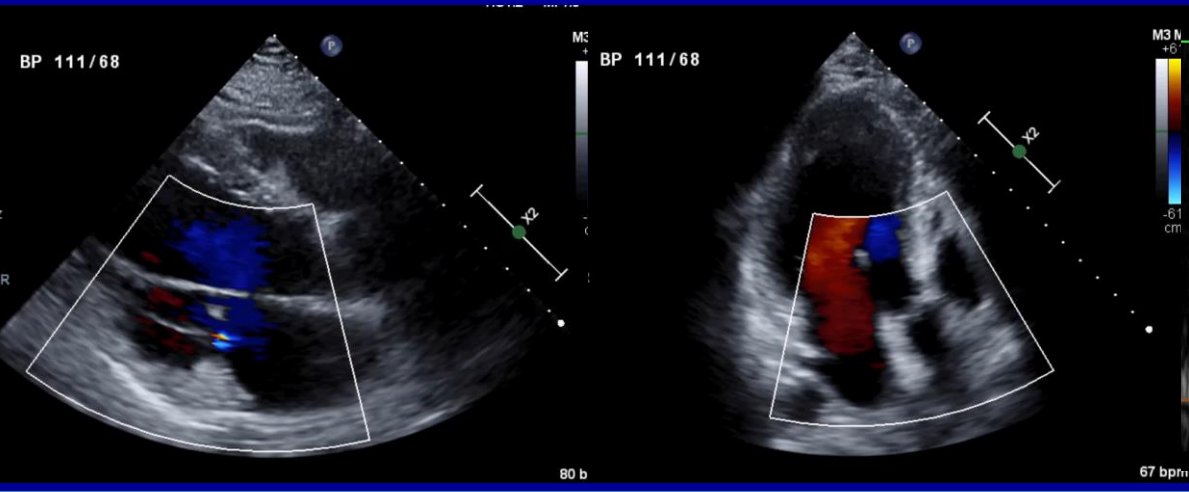
Valsartan ➔ Sacubitril/Valsartan 50 mg bid



NYHA I, NT-proBNP 187 pg/ml

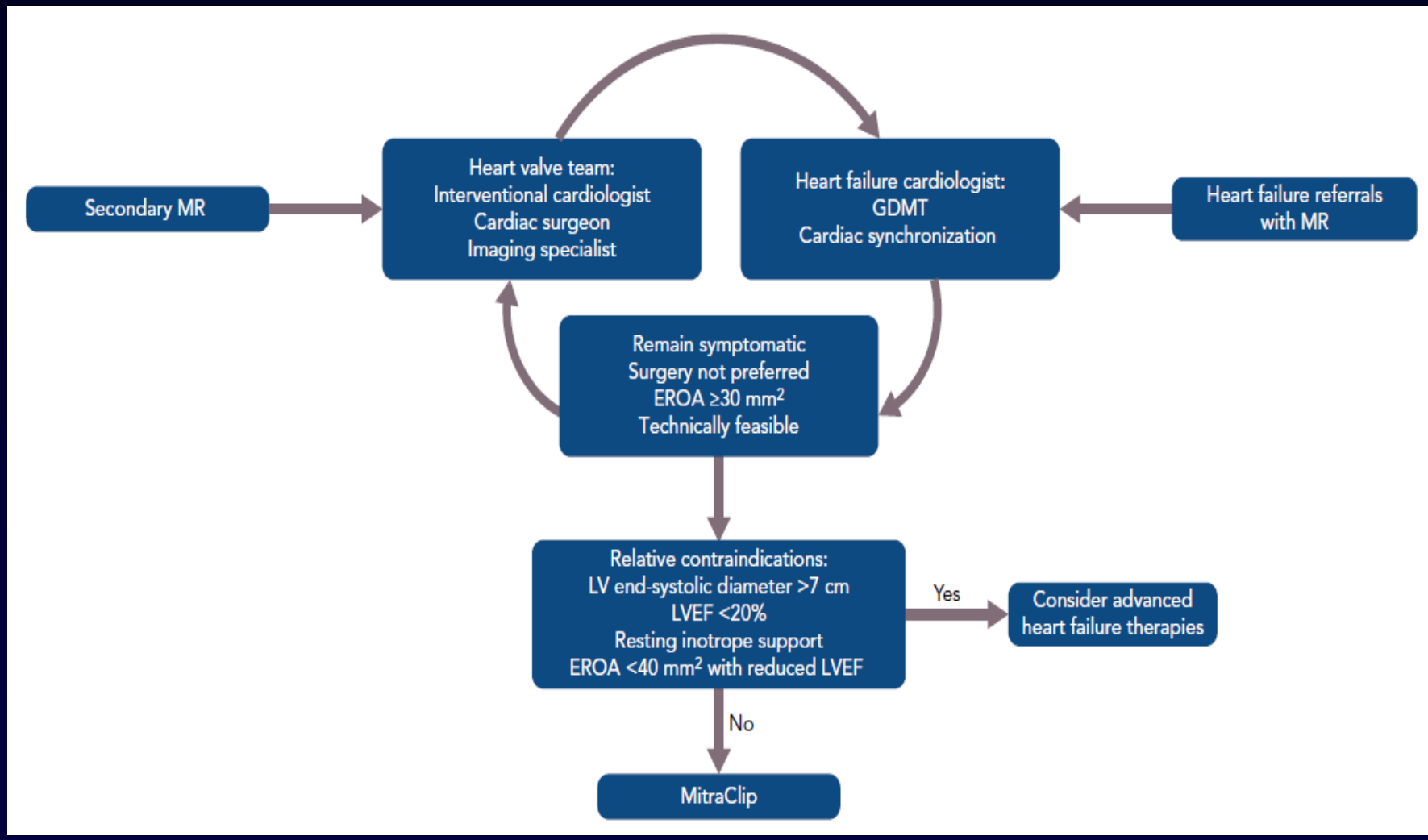


GDMT for 6 months



GDMT for 18 months

Management of Secondary MR



Thought 3

How severe?

- Quantification of DMR & FMR is same?

- What is limitation of current quantification tool?

How to assess FMR

	Primary MR*	Secondary MR*	
		Regional LV dysfunction	Global LV dysfunction
Etiology	Myxomatous or calcific leaflet degeneration	Inferior myocardial infarction	Nonischemic cardiomyo… anterior or mul… infarcti…
LV remodeling	Global, if severe chronic MR	Primarily inferior wall	Gl…
LA remodeling	Moderate to severe if chronic MR	Variable	
Annulus	Dilated, preserved dynamic function	Mild to no dilation…	…, flattened, nondynamic
Leaflet morphology:			
• Thickening	Yes/moderate, severe	No…	No/mild
• Prolapse or flail	Usually present		No
• Calcification	Variable		No/mild
Tethering pattern	None	…ic	Symmetric
Systolic tenting	None	…ncreased	Markedly increased
Papillary muscle distance	No…	Increased posterior papillary-intervalvular fibrosa distance	Increased interpapillary muscle distance
MR jet direct…	…al	Posterior	Usually central
CW…	…ate systolic (if MVP) or …niform if flail or with calcific degeneration	Density usually uniform throughout systole	Biphasic pattern, with increased density in early- and late-systolic flow and midsystolic dropout
PIS…	Often hemispheric	Often not hemispheric	Often not hemispheric; may be biphasic

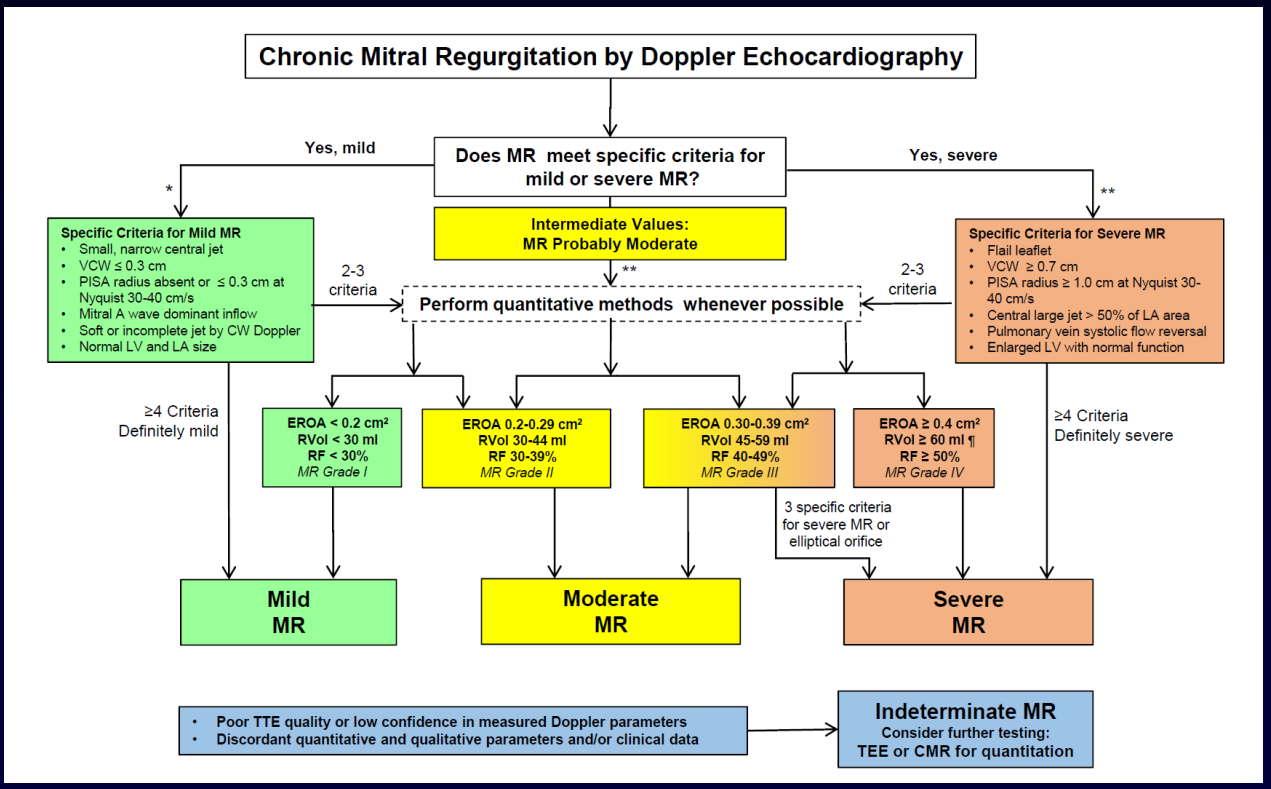
*Primary and secondary MR may coexist.

J Am Soc Echocardiogr. 2017 Apr;30(4):303-371

Evaluation of Secondary MR

- Echocardiography
  - Vena contracta width, PISA
- Severe in “Secondary MR”
  - EROA > 20mm^2, RV > 30ml → >40mm2, >60ml
- Assessment of LV systolic function is complicated
- Stress echo for dynamic MR
  - Exercise induced EROA increase > 13mm^2
  - Poor prognosis (death, hospitalization)

Severity

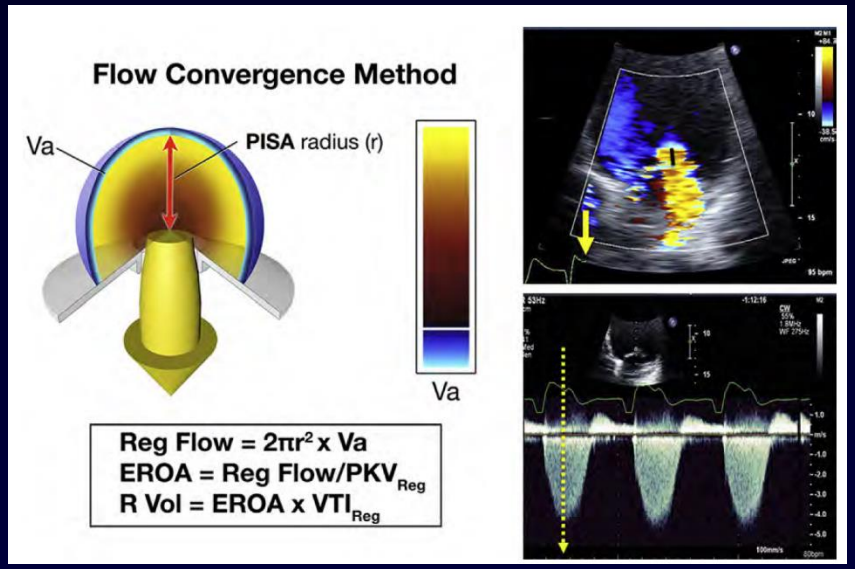


- **Semi-quantification**
  - **Flail leaflet**
  - **Vena contracta**
  - **PISA radius**
  - **Central jet area**
  - **PV systolic flow reversal**
  - **Enlarged LV**
  - **Mitral inflow**
- **Quantification**
  - **ERO, RV, RF**

2017 ASE guideline

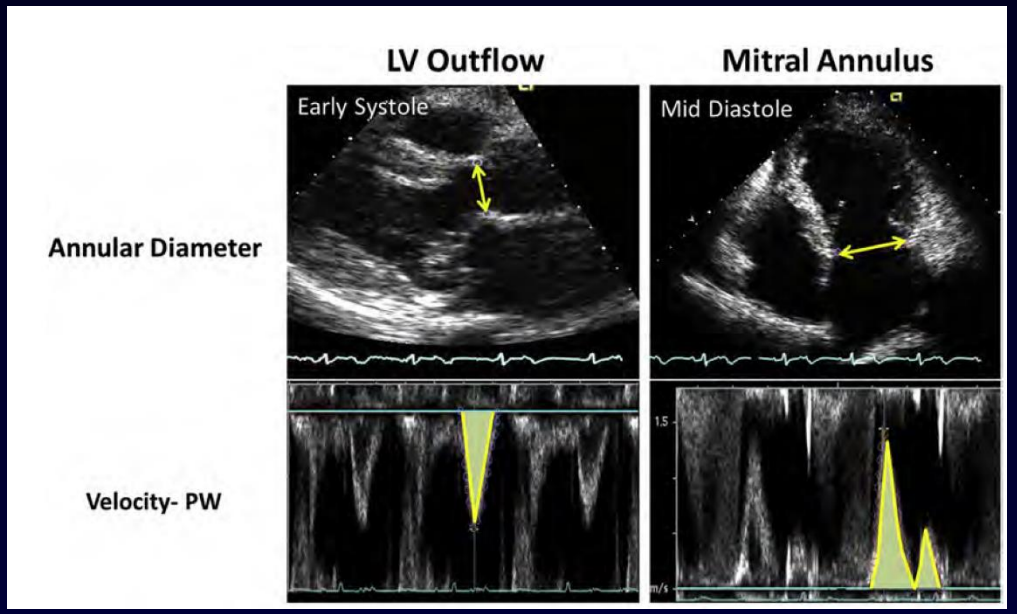
MR quantification

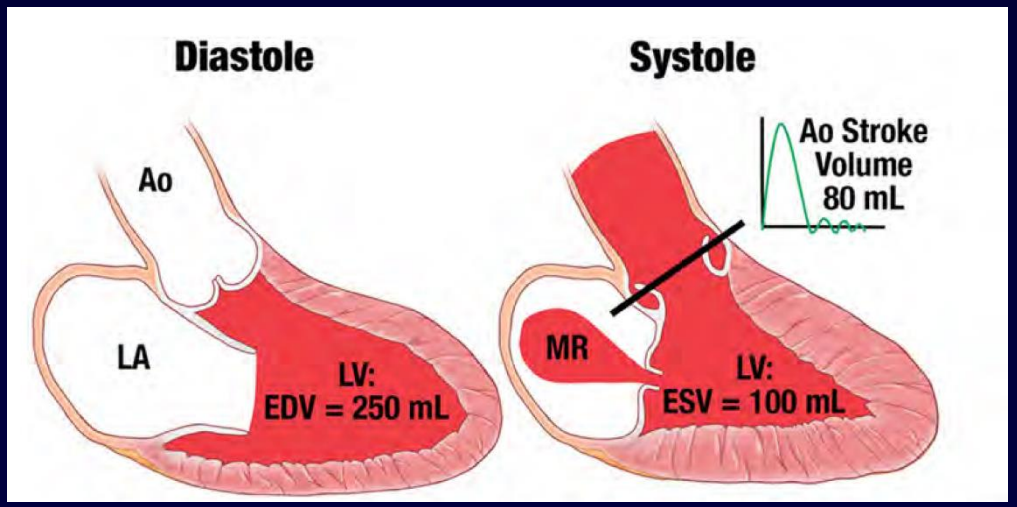
PISA methods



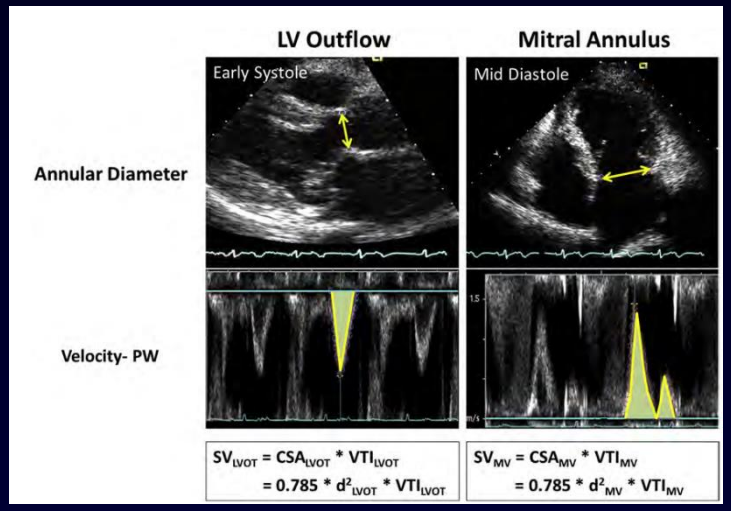
2017 ASE guideline

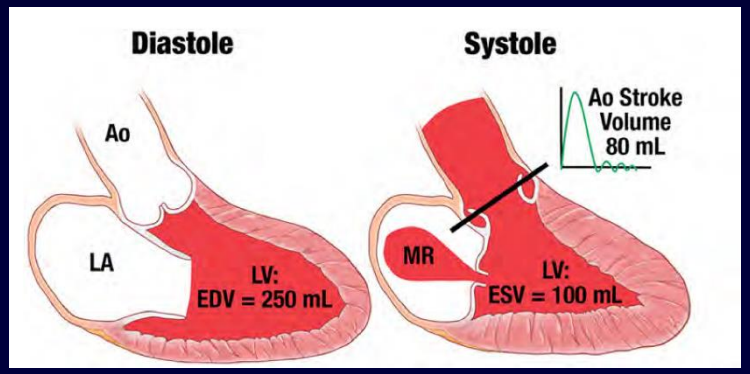
Volumetric methods





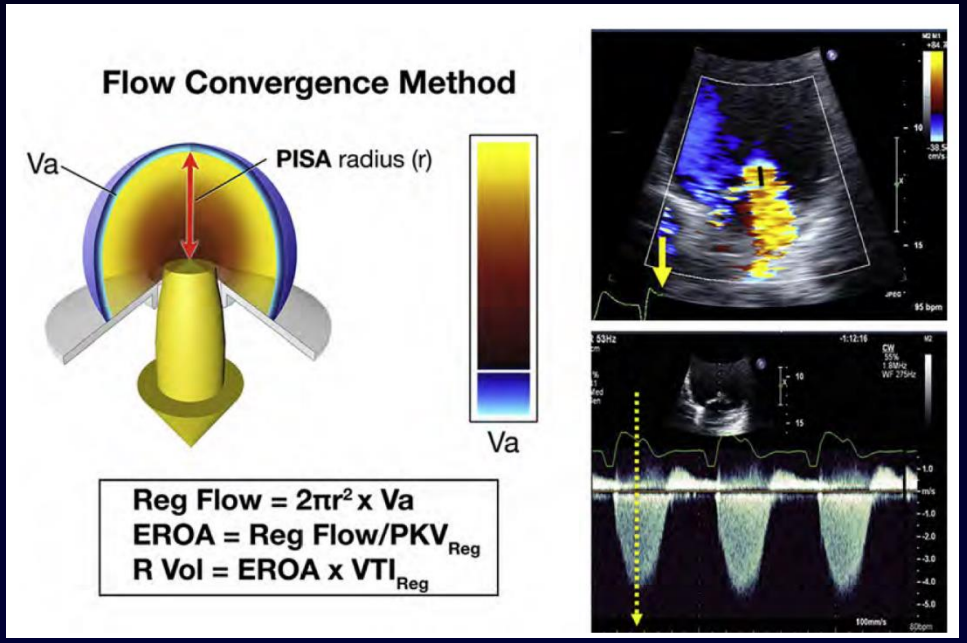
Limitation in MR quantification

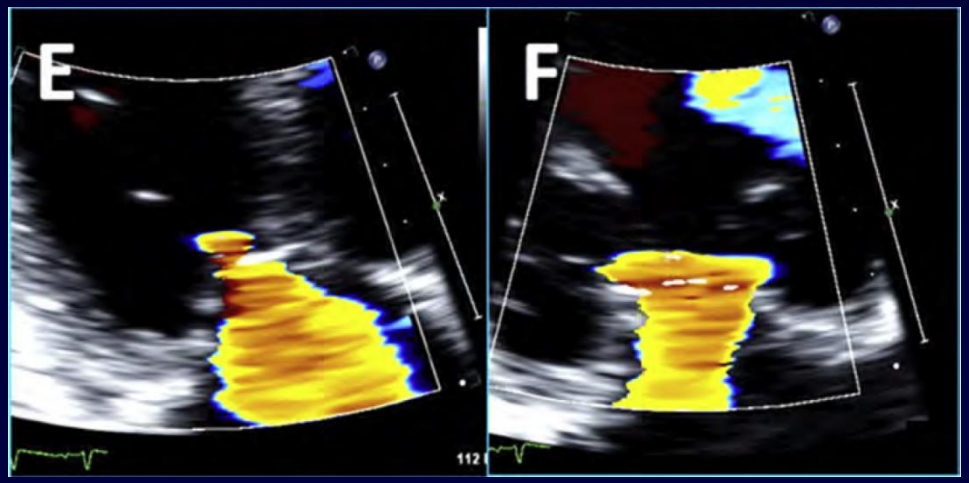




- Assumption
  - Not combined multivalvular disease
  - Round-shape LVOT and MA
- Small errors in each measurement can magnify error
- PW Doppler method and LV volume method frequently showed different results

Limitation in MR quantification



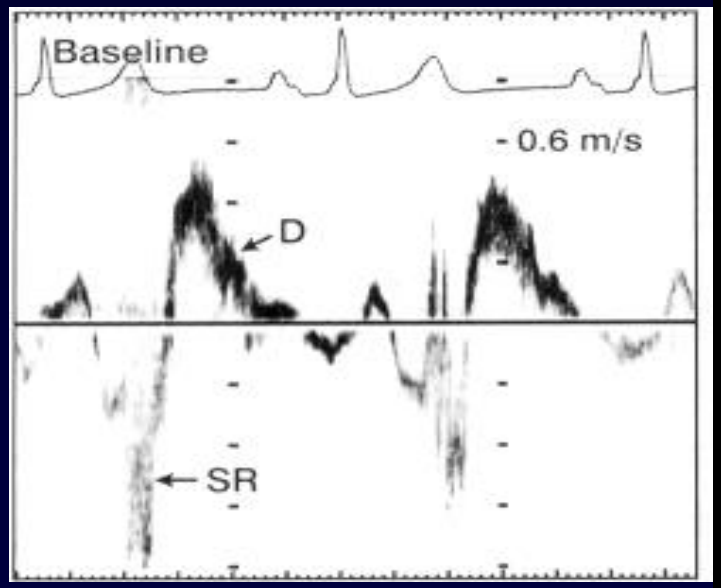


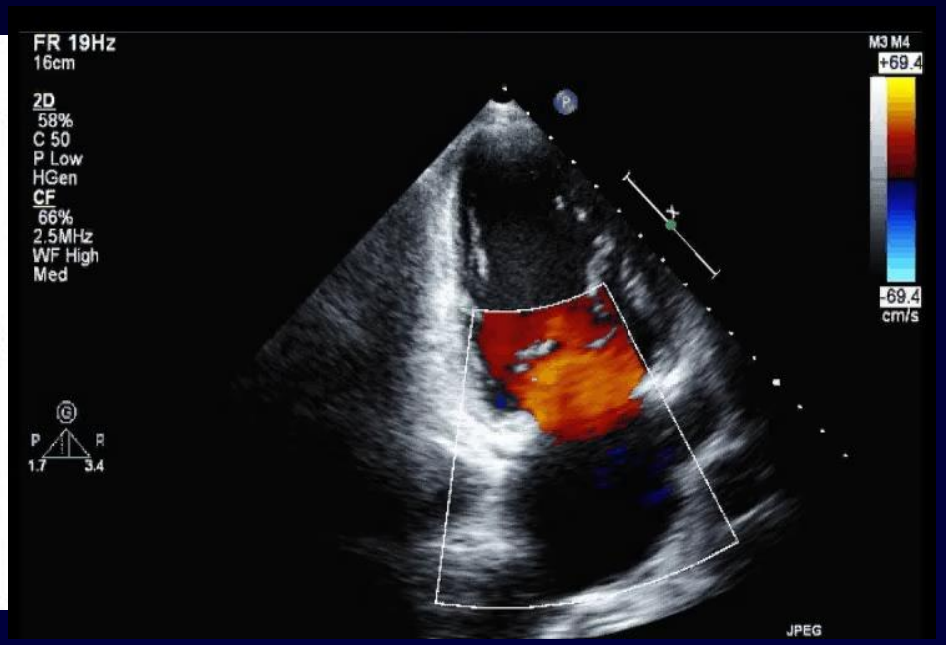
Assumption in PISA

- Hemispheric proximal convergence zone with radius R
- Regurgitation is not dynamic

Pulmonary vein reversal flow

- Simple and useful method for evaluation of “severe” MR
- Not available in every patient
- Influenced by direction of flow, LA pressure and cardiac rhythm (AF)





FMR is different with DMR

- **FACT 1: Patients with EROA > 0.2 cm^2 have two-fold increase in mortality risk and four-fold increase in the risk of HF.**

Study (Ref. #)	N	Type of Study	LVEDV, ml	LVEF Cutoff	Etiology of MR	Echo Core Lab	Method of Grading MR	MR as Independent Predictor of Mortality
Grigioni et al. (10)	303	Single center, observational	NR	NR	Post-MI	No	QD, PISA	ERO ≥0.2 cm^2 and ERO 0.01–0.19 cm^2
Koelling et al. (11)	1,421	Single center, observational	NR	<35%	Secondary MR 59% ischemic	No	Jet area	Moderate/severe vs. none/mild
Trichon et al. (12)	2,057	Single center, observational	NR	<40%	59% ischemic	No	LV angiogram	Graded worsening for all degrees of MR
Lancellotti et al. (13)	98	Single center, observational	146 ± 18	<45%	Ischemic	No	PISA	ERO ≥0.2 cm^2
								transplant
Rossi et al. (17)	1,256	Multicenter, observational	NR	NR	Secondary MR 62% ischemic	No	VCW, PISA	VCW >0.4 cm and ERO >0.2 cm^2
Deja et al. (18)	1,209	Substudy of multicenter RCT	222 ± 69	<35%	Ischemic	No	ASE grading	Graded worsening for all degrees of MR

Theoretical considerations support the concept that lesser degrees of MR could have an adverse hemodynamic effect in secondary MR wherein the LV is already damaged.

- **FACT 2: Measurement of PISA underestimates the true EROA due to crescent shape of PISA in secondary MR.**

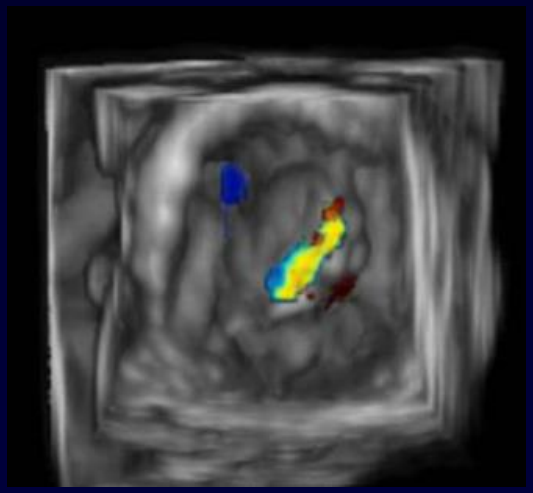
Grayburn PA et al. J Am Coll Cardiol 2014;2792-801.

Underestimation of EROA by PISA

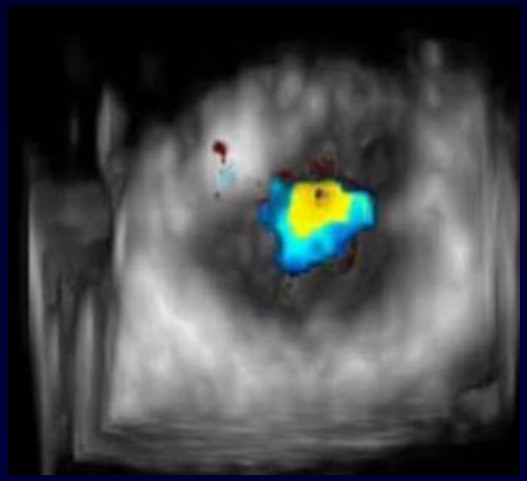
- **EROA shape in secondary MR is usually "crescentic"**

Kwan J et al. Circulation 2003.
Little SH et al. JACC Imaging 2008.
Yosefy C et al. Am J Cardiol 2009.

Marsan NA et al. JACC Imaging 2009.
Shanks M et al. Circ CV Imaging 2010.
Garyburn PA et al. Circulation 2012



Functional MR

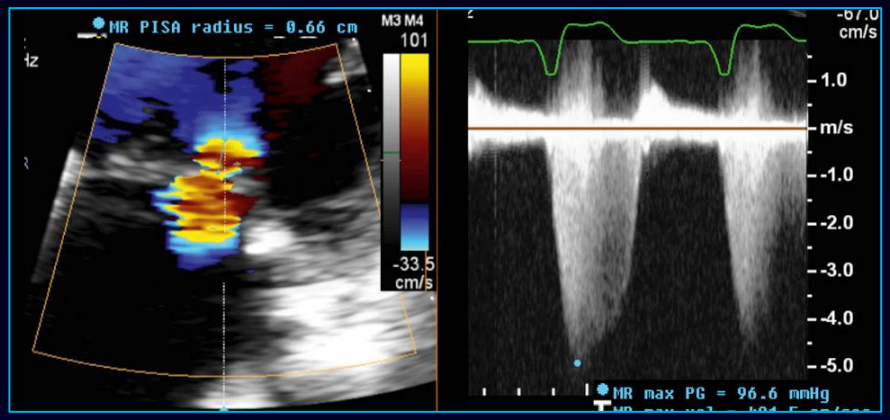


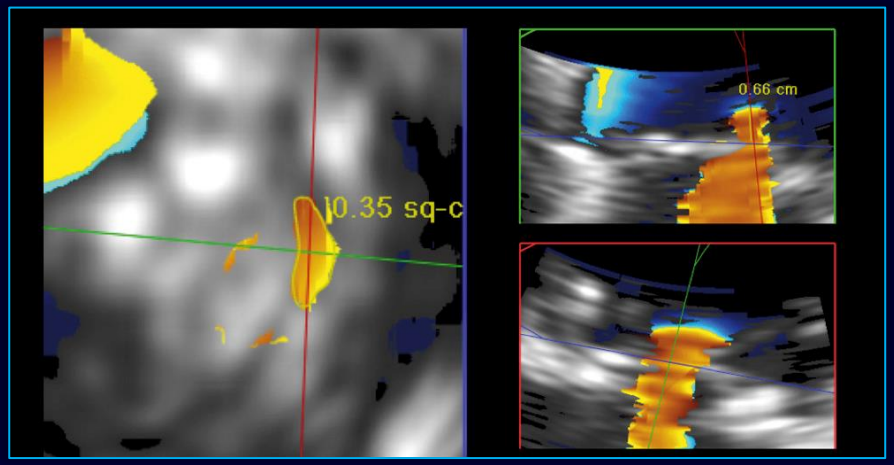
Primary MR (Prolapse)

EROA highly elongated in FMR, more focal in MVP

Matsumura Y et al. Am Heart J. 2008

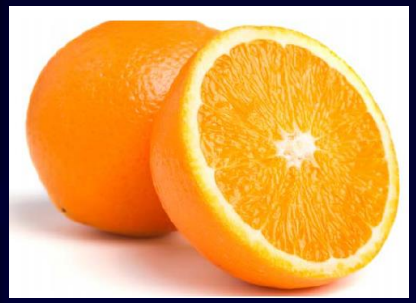
An Example: EROA Underestimation by PISA





Underestimation

By 2D PISA radius and CW Doppler



EROA = 0.18 cm²

By 3D color Doppler

EROA = 0.35 cm²

Grayburn PA et al. J Am Coll Cardiol 2014;2792-801.

Integrating multiple qualitative, semi-quantitative, and quantitative parameters

Qualitative Doppler

MR jet

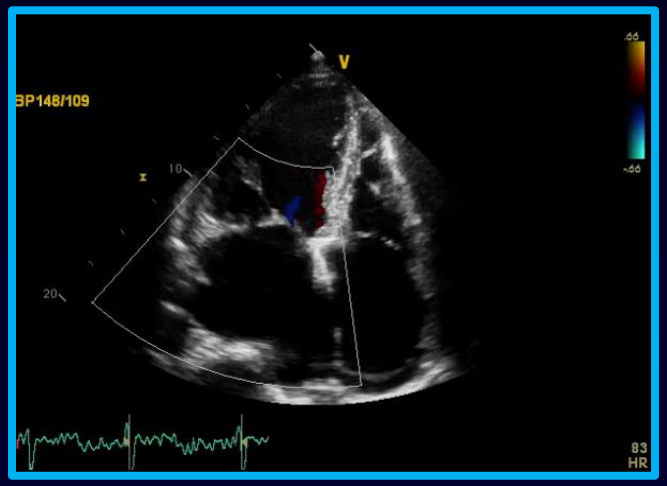
Semi-Quantitative

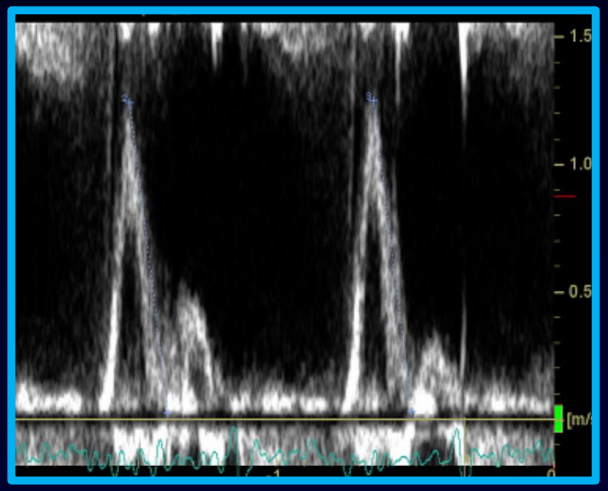
Mitral inflow

	MR severity*			
	Mild	Moderate		Severe
Structural				
MV morphology	**None or mild leaflet abnormality** (e.g., mild thickening, calcifications or prolapse, mild tenting)	Moderate leaflet abnormality or moderate tenting		**Severe valve lesions** (primary: flail leaflet, ruptured papillary muscle, severe retraction, large perforation; secondary: severe tenting, poor leaflet coaptation)
	…mal	Normal or mild dilated		Dilated‡
	…ral, narrow, often	Variable		Large central jet (>50% of LA) or eccentric wall-impinging jet of variable size
Flow convergence‖	**Not visible, transient or small**	Intermediate in size and duration		**Large throughout systole**
	…/parabolic	Dense but partial or parabolic		Holosystolic/dense/**triangular**
		Intermediate		≥0.7 (>0.8 for biplane)¶
	…minance (may be … in LV dysfunction or AF)	Normal or systolic blunting#		Minimal to no systolic flow/ **systolic flow reversal**
Mitral inflow**	**A-wave dominant**	Variable		E-wave dominant (>1.2 m/sec)
Quantitative††,‡‡				
EROA, 2D PISA (cm^2)	<0.20	0.20-0.29	0.30-0.39	≥0.40 (may be lower in secondary MR with elliptical ROA)
RVol (mL)	<30	30-44	45-59††	≥ 60 (may be lower in low flow conditions)
RF (%)	< 30	30-39	40-49	≥50

Semi-Quantitative

Mitral inflow



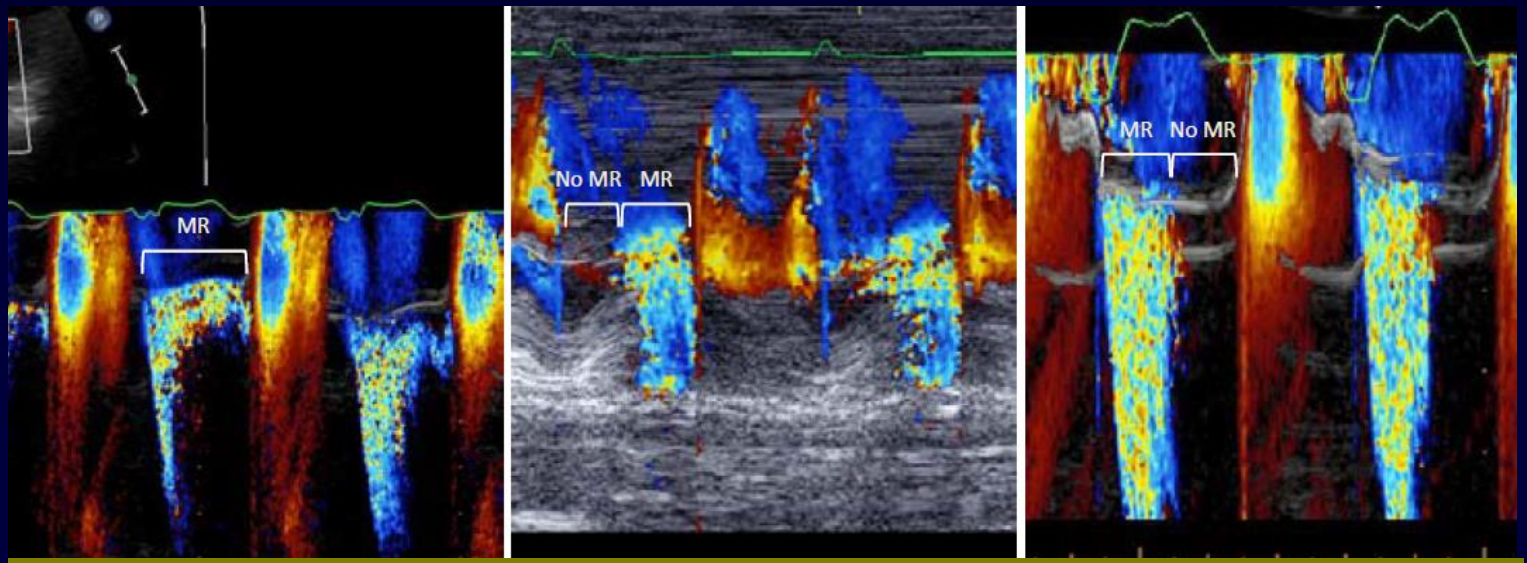


Advantages	Pitfalls
E velocity ≥ 1.2 m/sec : A simple supportive sign of severe MR (volume load)	**Depending on LV relaxation and filling pressures**
Dominant A-wave inflow pattern virtually excludes severe MR	**High E velocity not specific for severe MR in secondary MR, atrial fibrillation and mitral inflow stenosis**

Qualitative Doppler

Duration of MR is Important

- **Usually Not Severe**
  - MR limited to late systole (MVP)
  - MR limited to early systole (Ventricular dyssynchrony)
- Single frame measures (VC or PISA) can overestimate

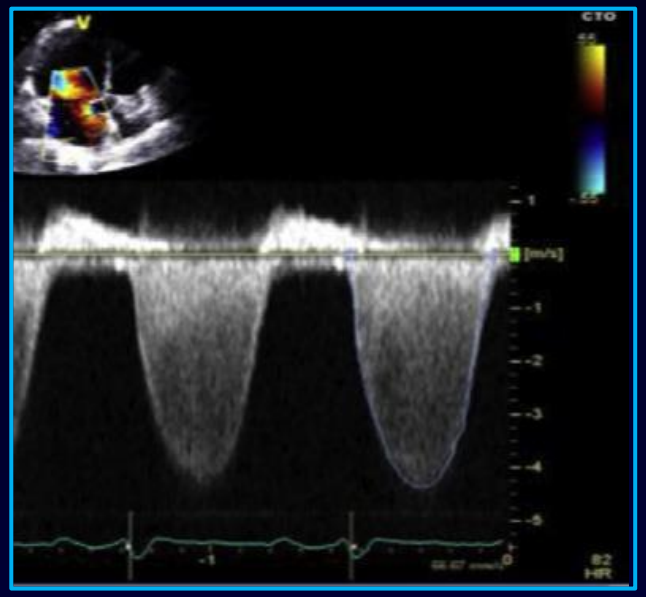


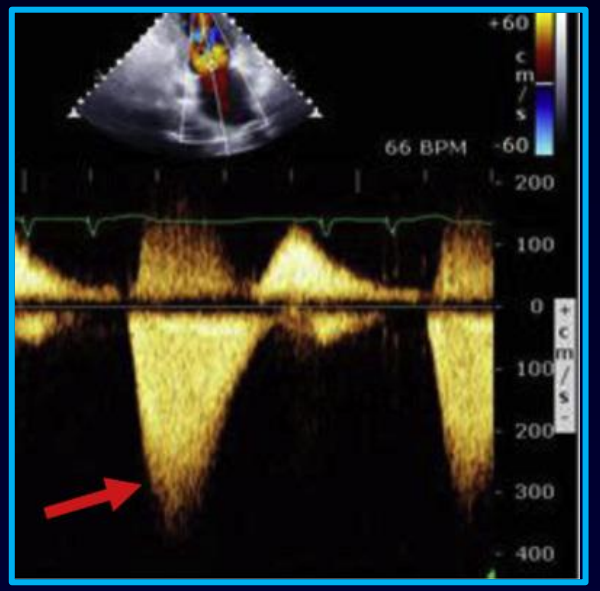
Holosystolic MR | Late Systolic MR | Early Systolic MR

Qualitative Doppler

CWD jet

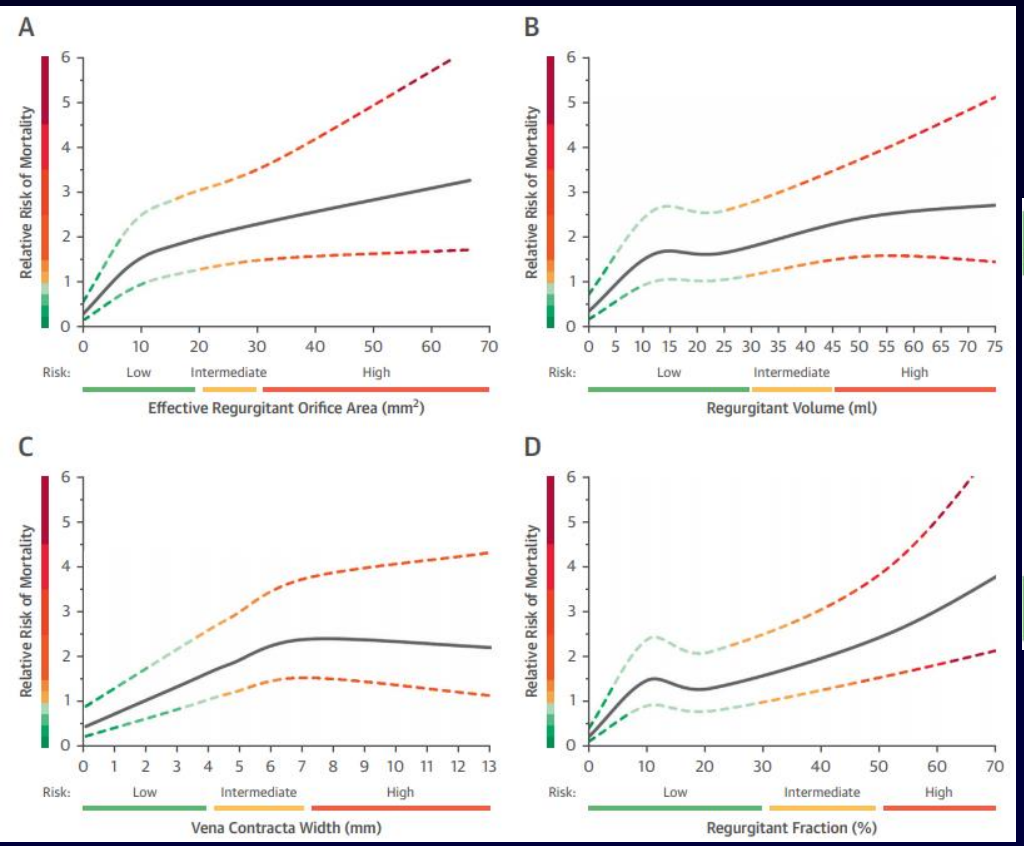
Shape & Density

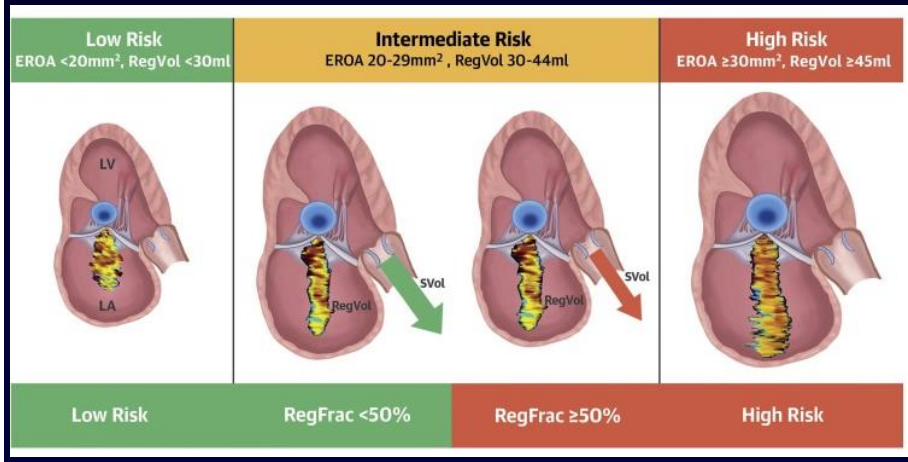




Advantages	Pitfalls
Simple	Qualitative
Density is proportional to the number of RBCs reflects the signal	Perfectly central jets may appear denser than eccentric jets of higher severity
Faint or incomplete jet is compatible with mild MR	Density is gain dependent
A triangular contour denotes a large regurgitant pressure wave and hemodynamic significance	A contour with a early peak velocity is not sensitive for severe MR

Grading Functional MR





J Am Coll Cardiol 2019;73:2506–17

Thought 4

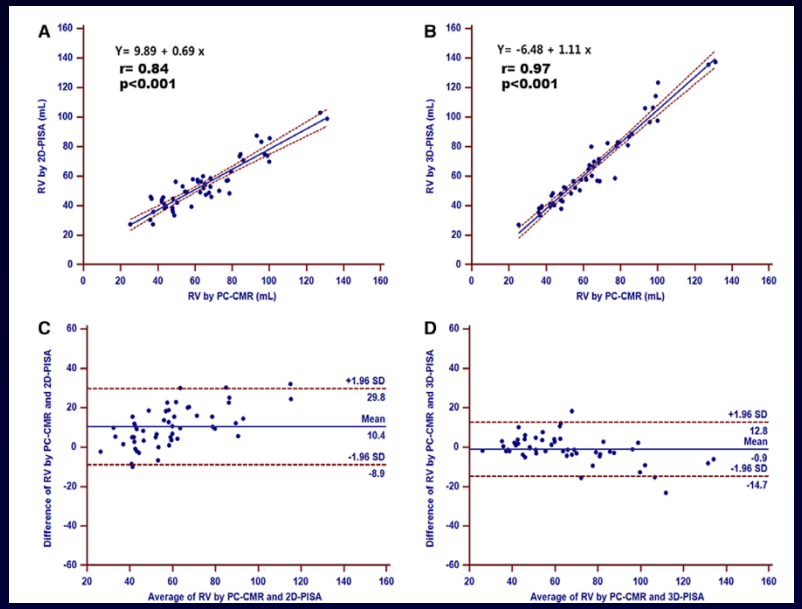
Is there any solutions for FMR assessment?

3D MR quantification

Valvular Heart Disease

Differential Effect of 3-Dimensional Color Doppler Echocardiography for the Quantification of Mitral Regurgitation According to the Severity and Characteristics

Jaehuk Choi, MD*; Ran Heo, MD*; Geu-Ru Hong, MD, PhD; Hyuk-Jae Chang, MD, PhD; Ji Min Sung, PhD; Sang Hoon Shin, MD; In Jeong Cho, MD; Chi-Young Shim, MD, PhD; Namsik Chung, MD, PhD



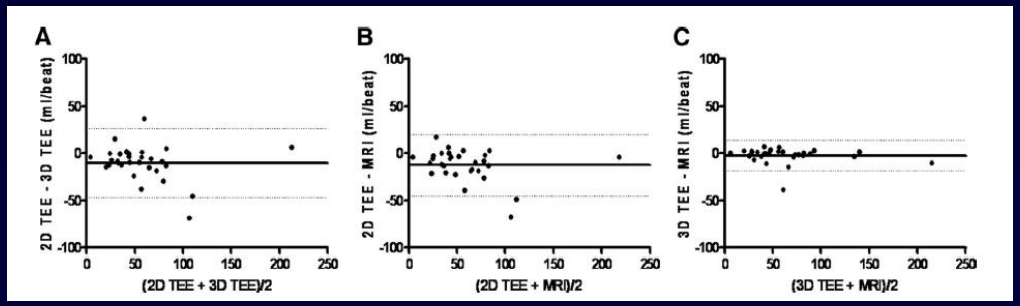
Circ Cardiovasc Imaging. 2014;7:535-544.

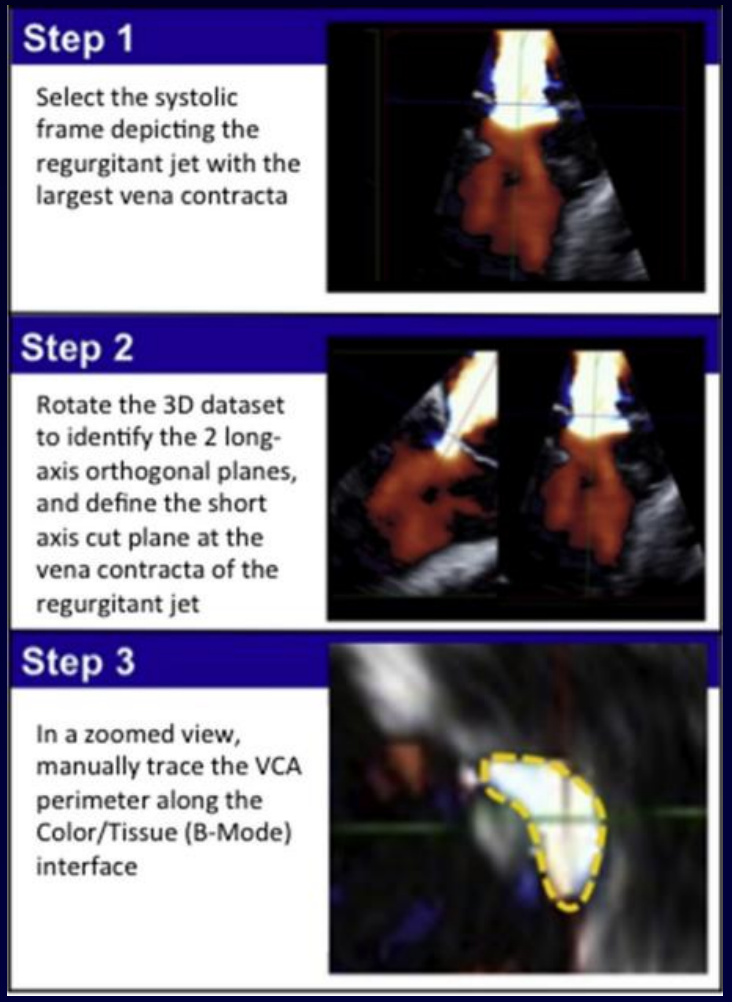
3D VCA Measurement of MR

Quantitative Assessment of Mitral Regurgitation

Comparison Between Three-Dimensional Transesophageal Echocardiography and Magnetic Resonance Imaging

Miriam Shanks, MD; Hans-Marc J. Siebelink, MD, PhD; Victoria Delgado, MD; Nico R.L. van de Veire, MD, PhD; Arnold C.T. Ng, MBBS; Allard Sieders, MD; Joanne D. Schuijf, PhD; Hildo J. Lamb, MD, PhD; Nina Ajmone Marsan, MD; Jos J.M. Westenberg, PhD; Lucia J. Kroft, MD, PhD; Albert de Roos, MD, PhD; Jeroen J. Bax, MD, PhD

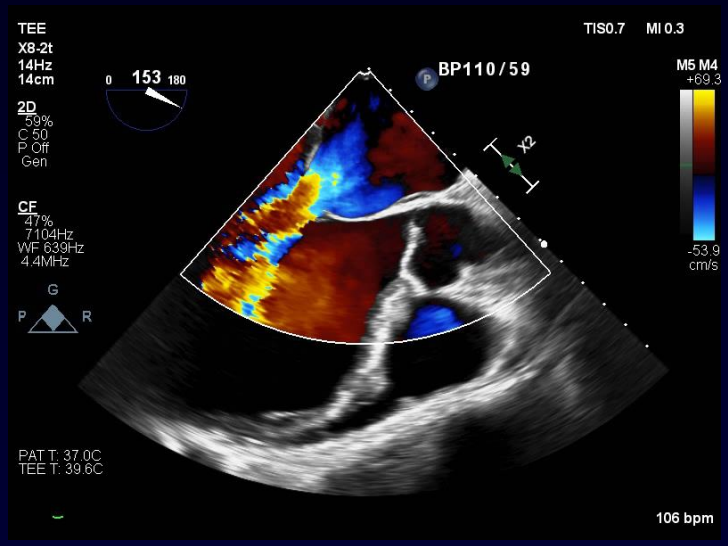


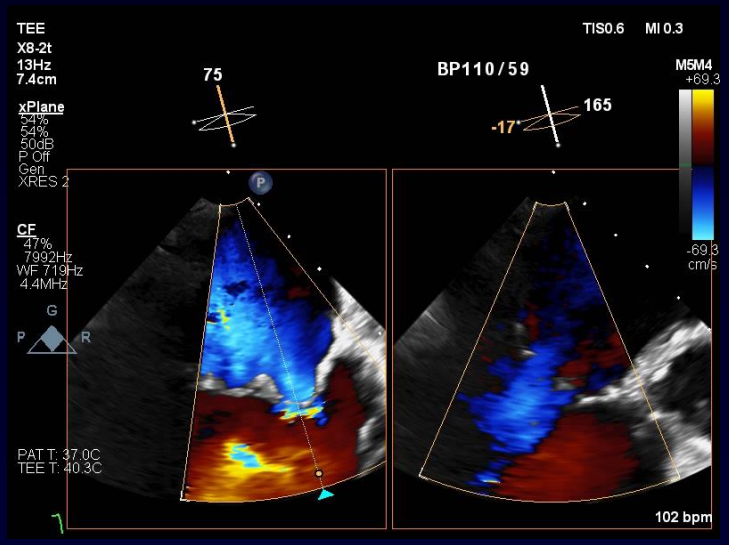


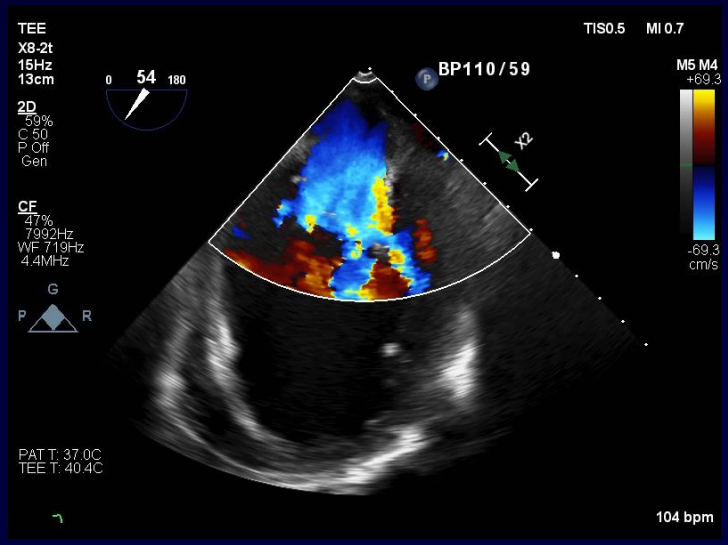
Circ Cardiovasc Imaging. 2010;3:694-700.

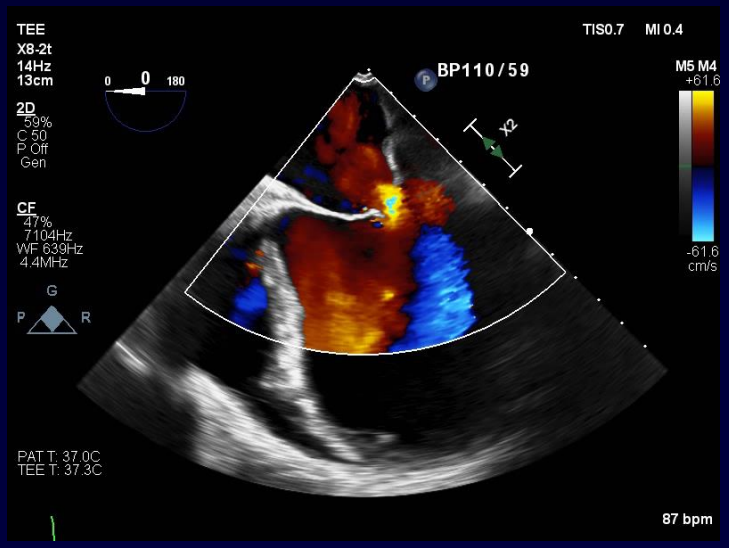
J Am Coll Cardiol Intv 2019;12:582–91

3D VCA Measurement of MR

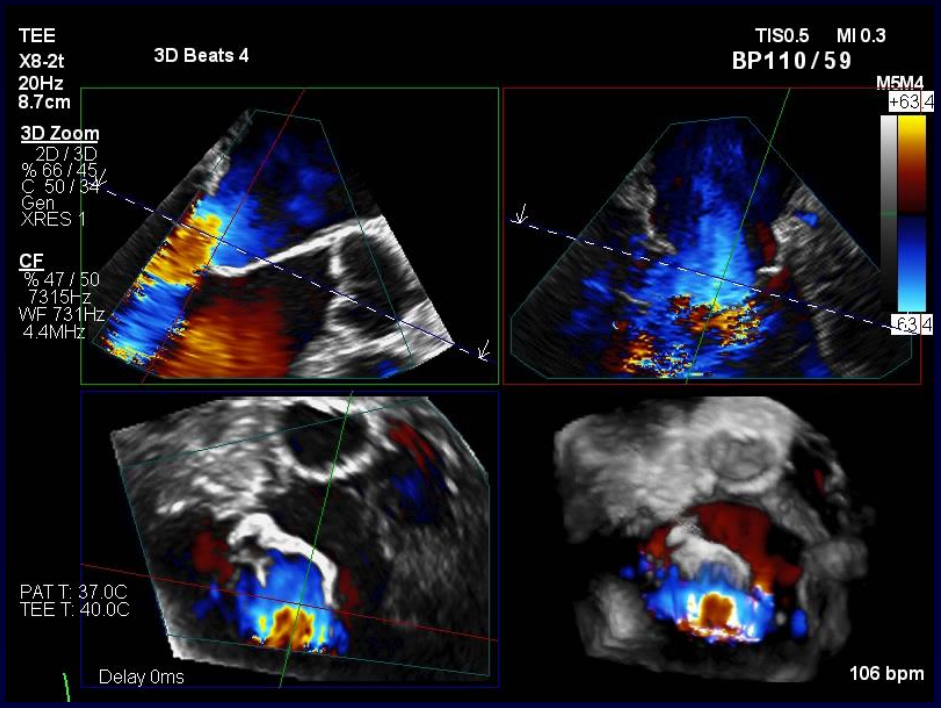


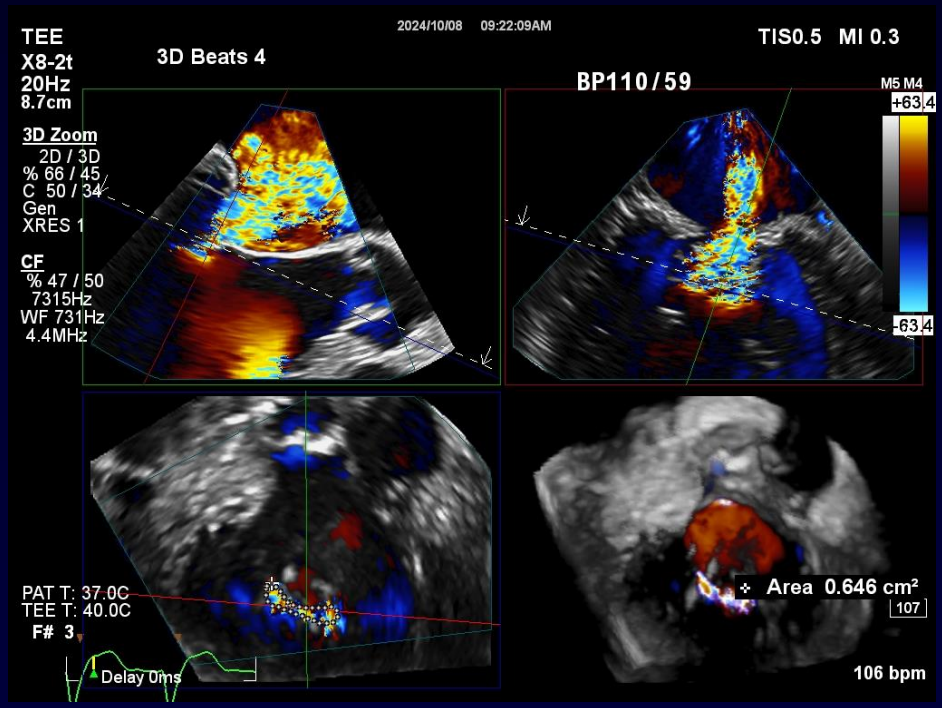






3D VCA Measurement of MR





3D VC area: 0.64cm^2

3D VCA Measurement of MR

ASE GUIDELINES AND STANDARDS

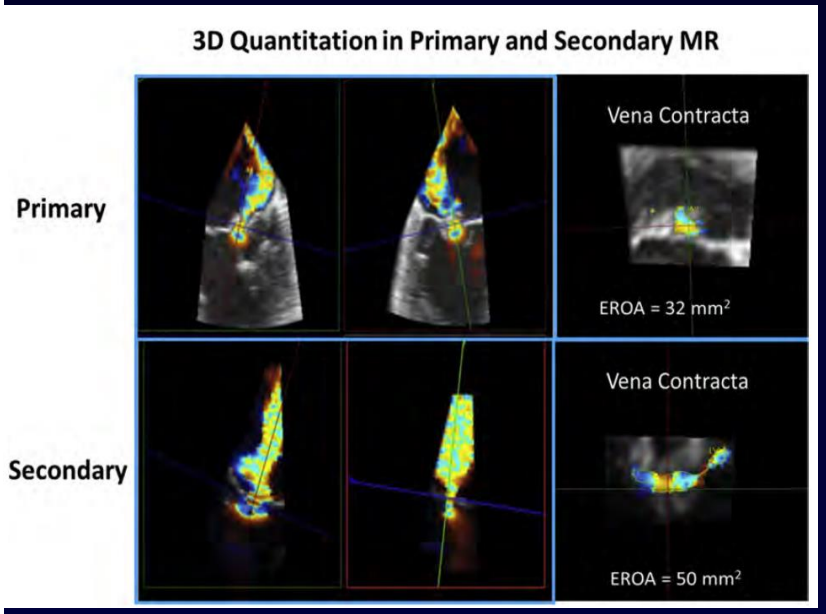
Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance

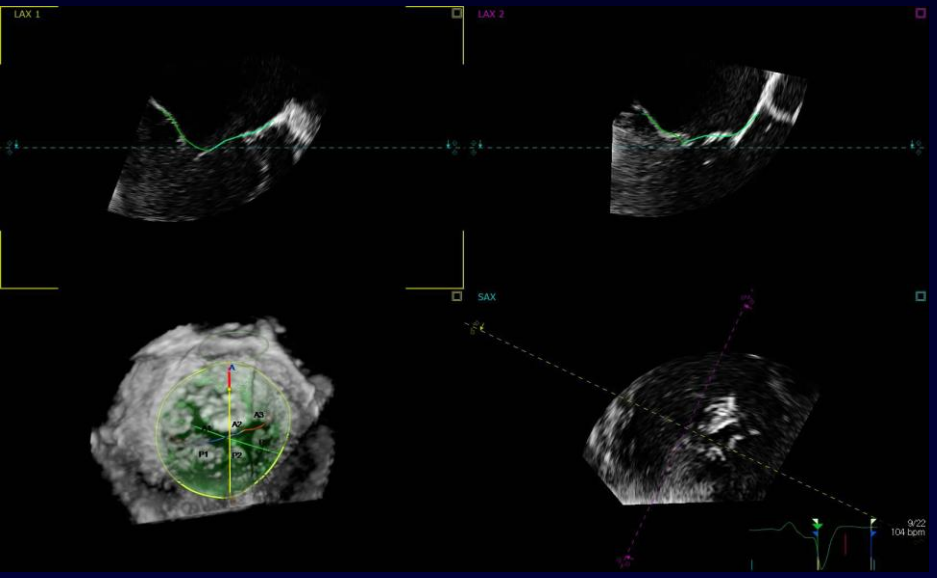
Severe 3D VCA > 0.4 cm^2

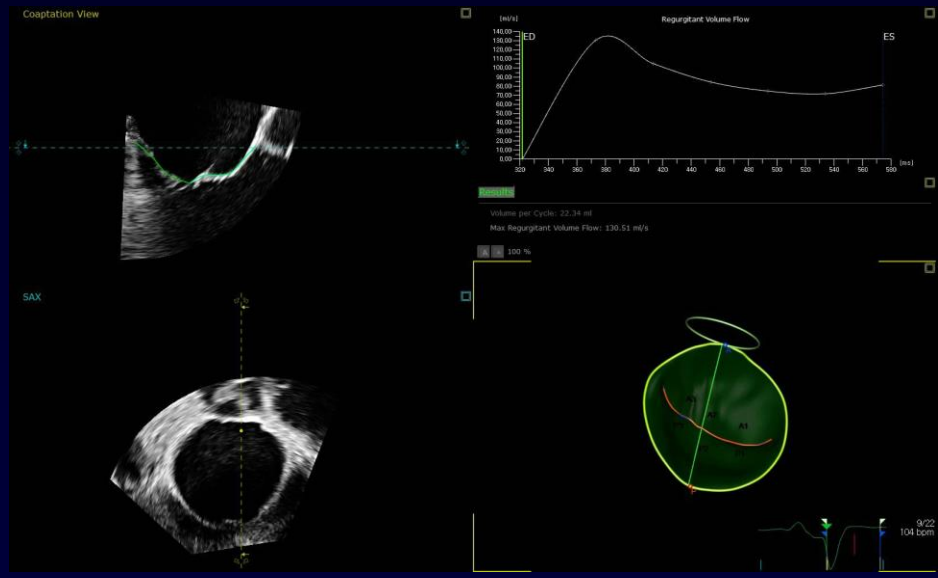
Table 7 Echocardiographic and Doppler parameters for grading MR severity by TEE or TTE after transcatheter MV interventions*

Parameter	Mild	Moderate	Severe
Structural			
Morphology	Device appropriately positioned/expected or normal valve motion	No specific criteria	Abnormal device position/flail valve (single leaflet detachment, dehiscence, incomplete TMVR expansion etc.)
LA and LV volumes	Reduction in size from baseline or normalization	Minimal change	Enlarged with no change/ worsening from baseline, particularly in primary MR
Qualitative			
Color Doppler jet (size, number, eccentricity)	One or two small, narrow jets	More than mild but does not meet severe criteria	Large central jet/multiple jets/ eccentric jet(s) of any size wrapping around LA
Flow convergence size†	None or small	Intermediate	Large
Mitral inflow pattern	A-wave dominant	No specific criteria	No specific criteria
Pulmonary vein flow pattern‡	Normal	Blunted systolic flow	Systolic flow reversal
CW Doppler of MR jet (density, contour)	Faint, parabolic contour	No specific criteria	Dense, triangular contour
Semi-quantitative			
Vena contracta width (cm)	Single jet with VCW ≤0.3	Single jet with VCW 0.4-0.6	Any jet with VCW ≥0.7 or ≥2 moderate jets
Quantitative			
Vena contracta area by 3D planimetry (cm^2)§	Single jet with VCA <0.2	Single jet with VCA 0.2-0.39	Any jet with VCA ≥0.4 or ≥2 moderate jets
EROA by PISA (cm^2)	<0.2 Not recommended after edge to- edge repair or in PVR	0.2-0.39 Not recommended after edge-to-edge repair or in PVR	≥0.4 Not recommended after edge-to-edge repair or in PVR
Regurgitant volume (mL)	<30	30-59‖	≥60‖ (May be lower in low flow states)
Regurgitant fraction (%)	<30%	30-49	≥50%



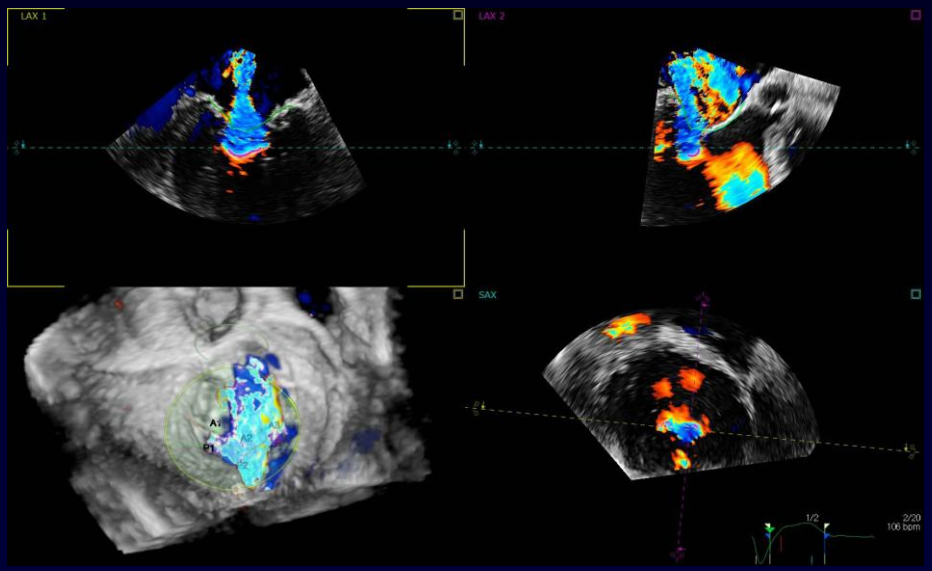
Beyond the 3D Assessment : 4D assessment of MR (4D-CFQ)

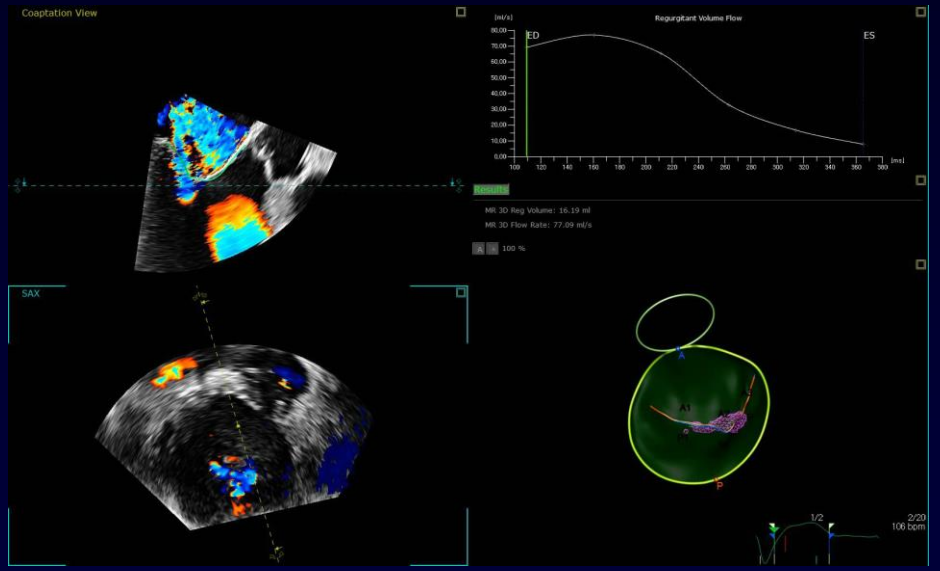




RV: 22.3ml, Maximal flow rate: 130.5ml/s

4D quantification of MR





3D MR regurgitant volume: 16.2ml

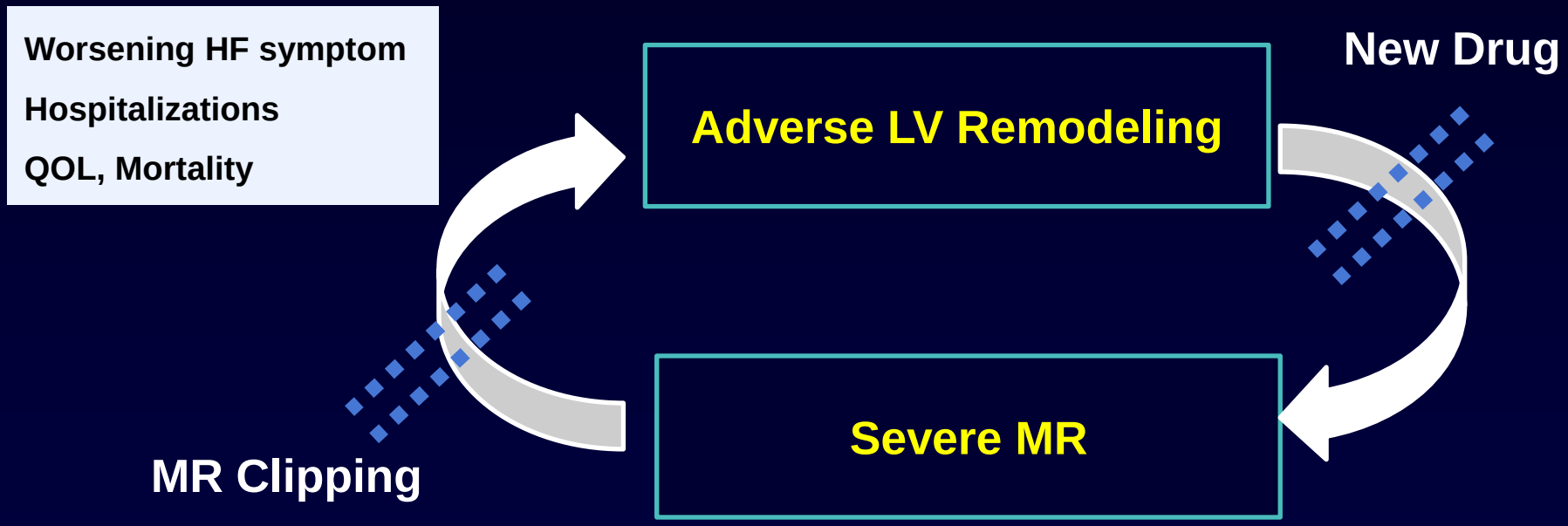
Thought 5

Assessment of FMR related with intervention.

- **Clipability**
- **Post intervention assessment**

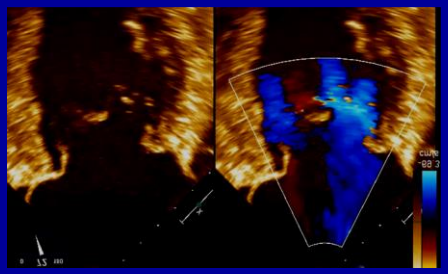
Consideration #1 before deciding MR Clipping

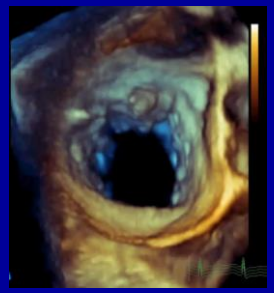
MR and Heart Failure



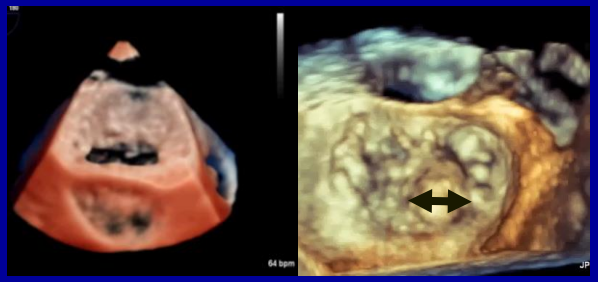
Characterization of Valve Morphology

Location of pathology

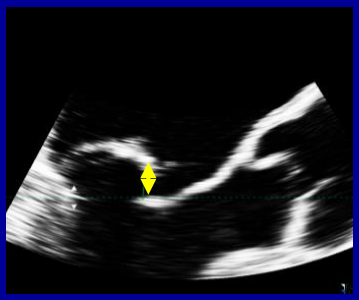




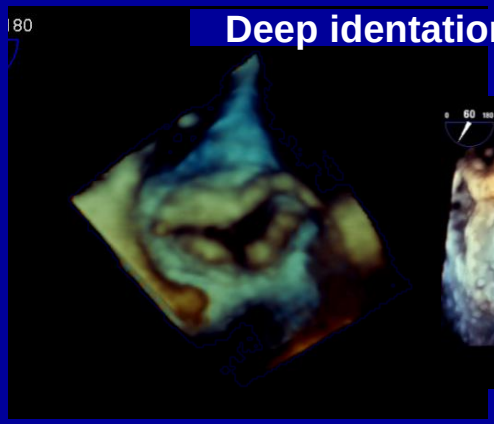
Flail width

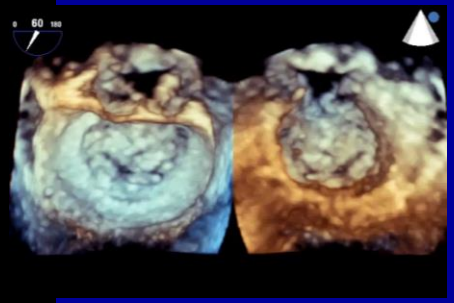


Flail gap

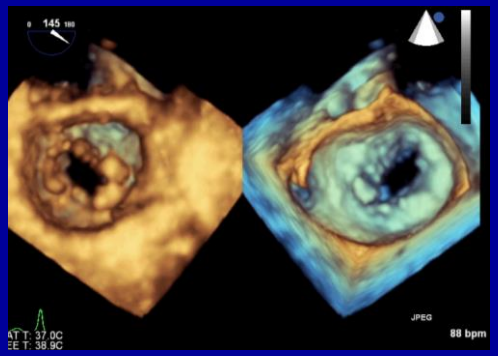


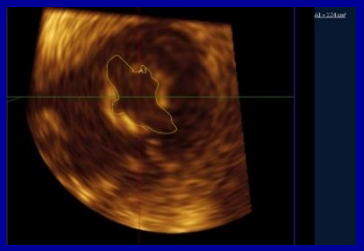
Deep identations/Clefts





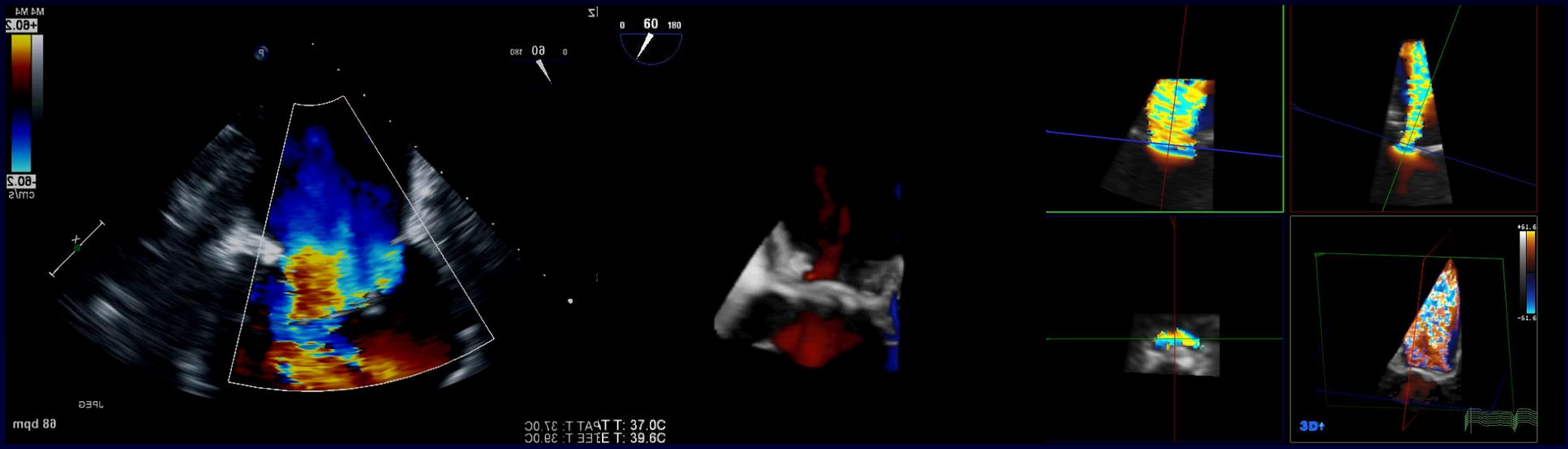
Severe Calcification / Small MVA





MVOA = 3.7 cm^2

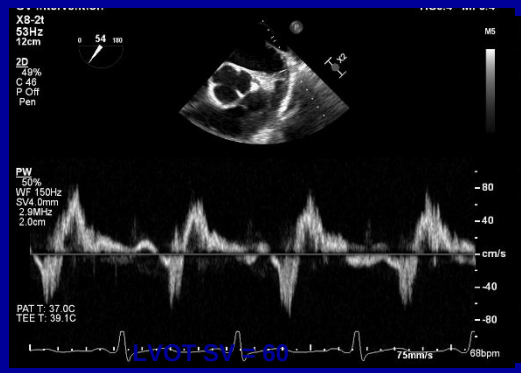
Characterization of MR jet

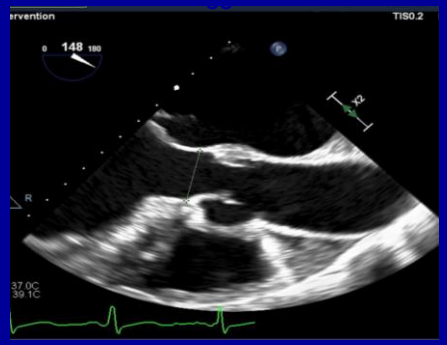


- MR jet location / direction
- MR jet number
- MR severity: 3D color Doppler VCA

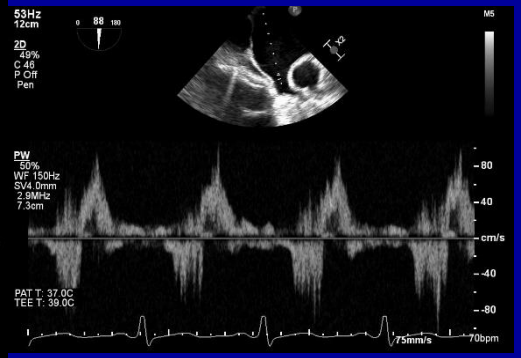
Characterization of Hemodynamics

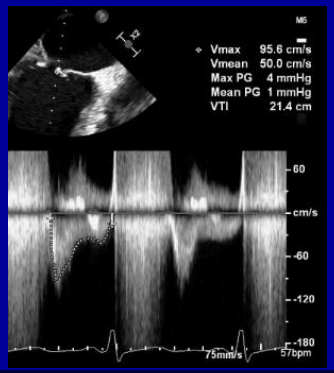
LUPV



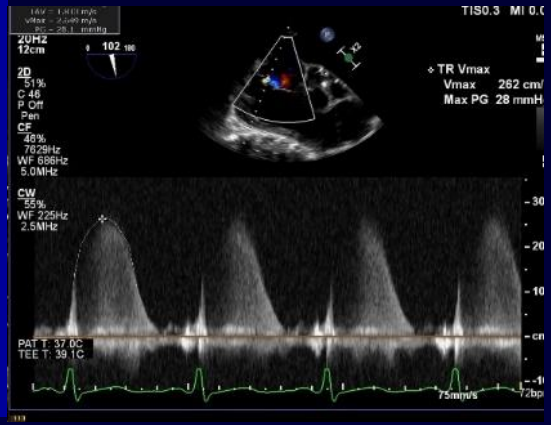


RUPV





- Systolic flow reversal in right and left pulmonary veins
- Peak / mean diastolic gradients
- LVOT Stroke Volume
- PASP



Take Home Messages

- Functional (2ndary) MR: sick heart → sick valve
- Main mechanism of FMR: Insufficient leaflet area relative to tha t demanded by tethering geometry ← “tethering”
- Accurate assessment of FMR is still challenging
- Integrate multiple qualitative, semi-quantitative, and quantitati ve echocardiographic parameters
- Special consideration is needed for evaluation of secondary M R including 3D VCA, 4D CFQ.
- Actively consider further testing (TEE or CMR) for evaluation o f MR if indicated.

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(Hybrid Meeting)

Nov 8-9, 2024

Mayfield resort, Seoul, Korea

Directors: Geu-Ru Hong, Mani Vannan, Patrizio Lancellottii

Official website: Echo360.co.kr

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Mayfield Hotel, Korea

Directors / Co-Directors

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Mani A Vannan
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Thank you for your attention