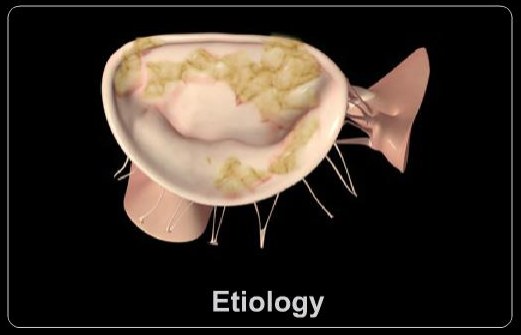
Mitral Stenosis

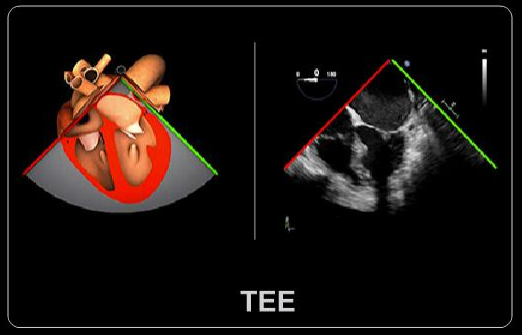
Dr Annette Vegas FRCPC, FASE
Professor Anesthesiology

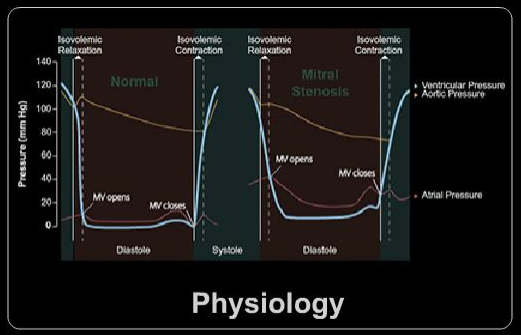
PIE
Toronto General Hospital Department of Anesthesia
Perioperative Interactive Education
http://pie.med.utoronto.ca/TEE/
UHN Toronto General Toronto Western Princess Margaret Toronto Rehab

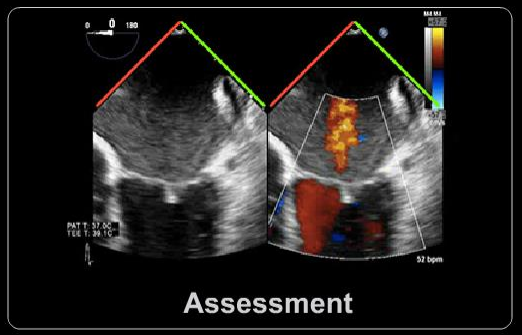
Outline

- Etiology
- Physiology
- Echocardiography
  - Valve
  - Secondary
- Assessment





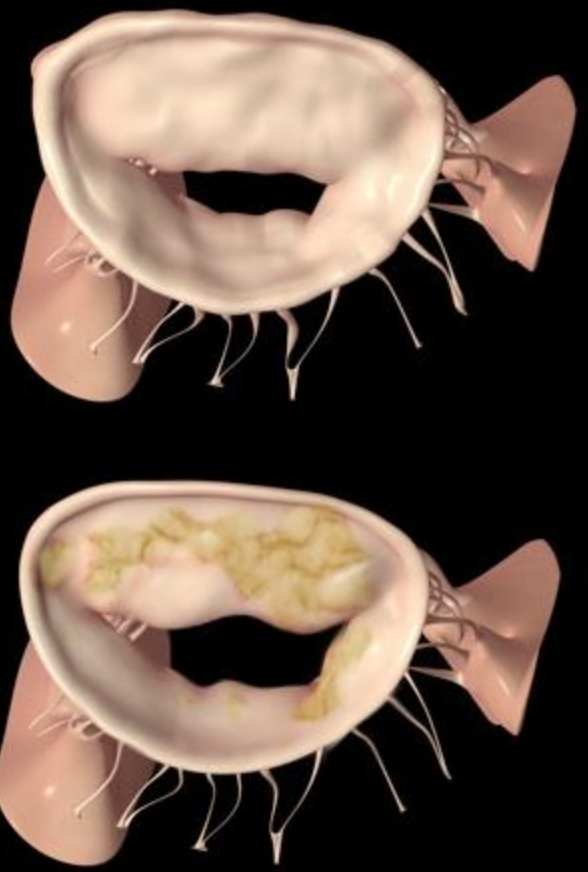




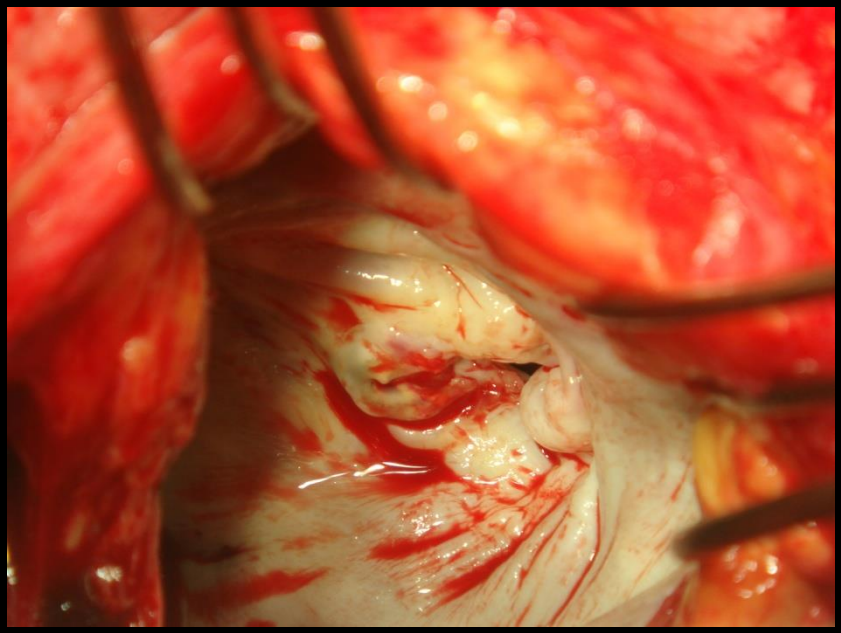
http://pie.med.utoronto.ca/TEE/TEE_content/TEE_assessment_cardiacValves.html

Etiology

- Rheumatic (75%)
- Calcific
- Congenital
  - Parachute MV
  - Shone complex
- Inflammatory
  - Lupus
  - Rheumatoid arthritis
- Mass

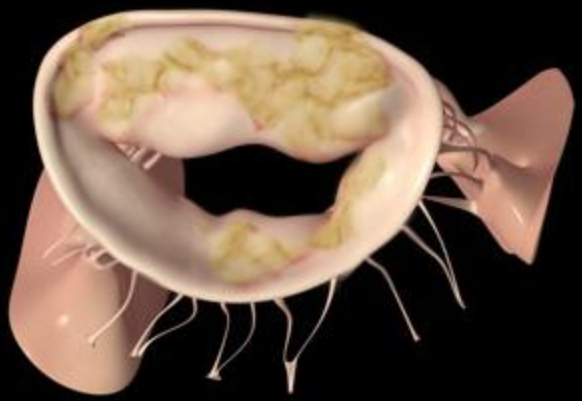


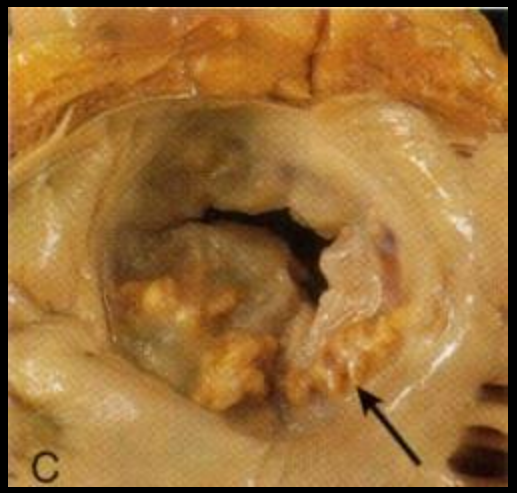
Rheumatic MV



- Leaflet thickening + calcification
- Commissural fusion
- Chordal shortening + fusion = funnel shape

Calcific MV Pathology



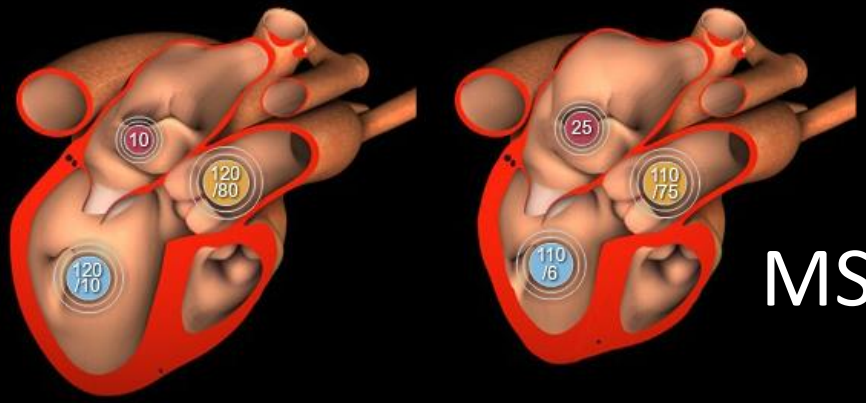


- Annular calcification
  - Posterior leaflet
- Leaflet base rather then tip
- No commissural fusion
- Directly involves AV

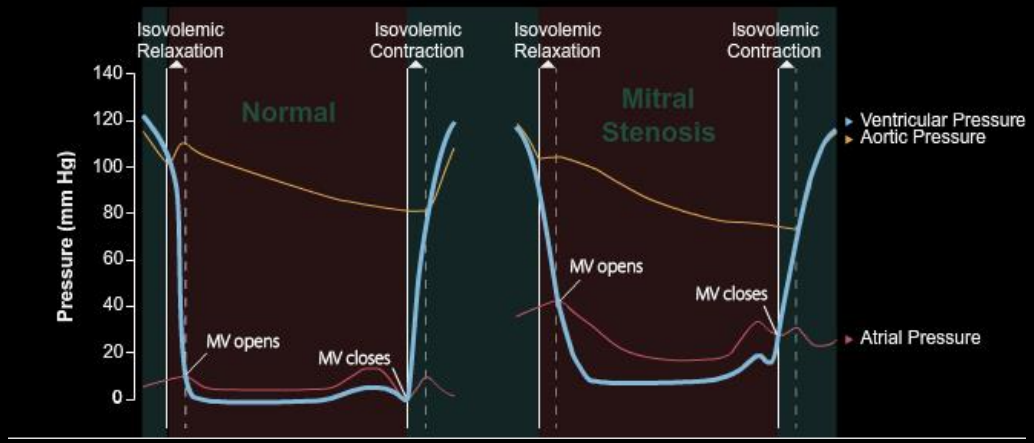
Physiology MS

- Diastole
- LV relaxes, LVP < LAP, MV opens

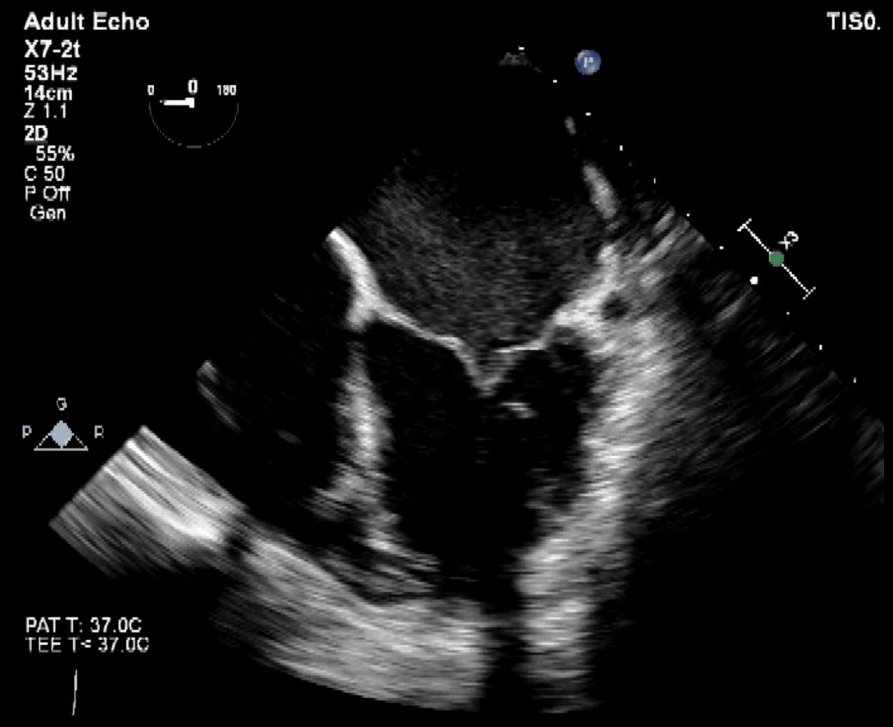
Normal: rapid =

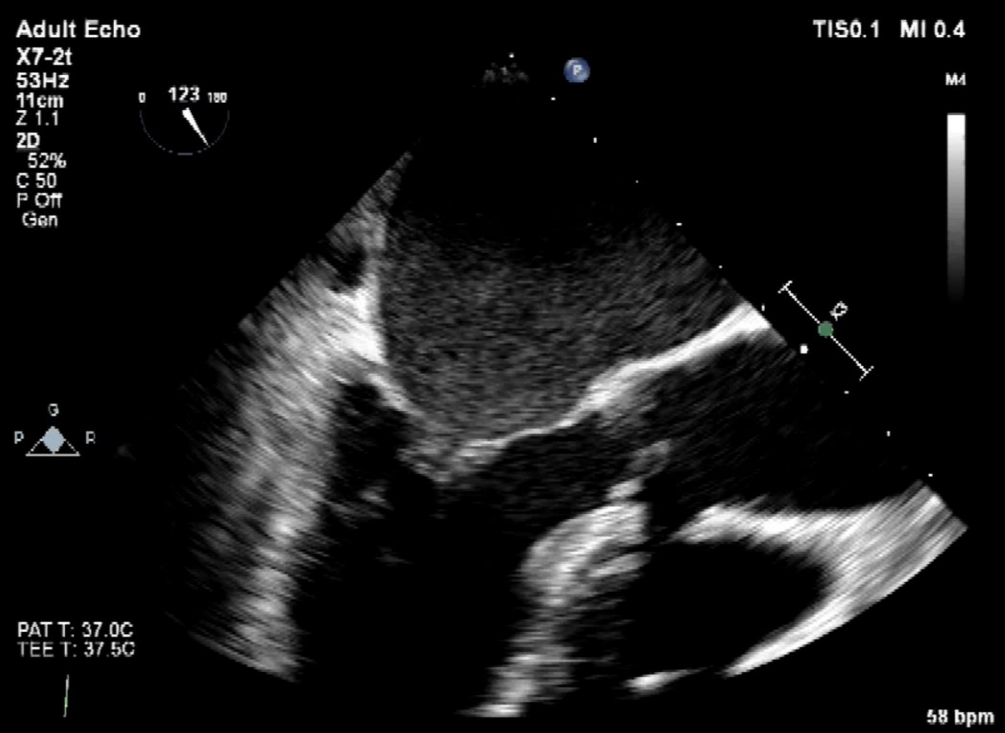


MS: ↑ LAP



Rheumatic MV 2D TEE

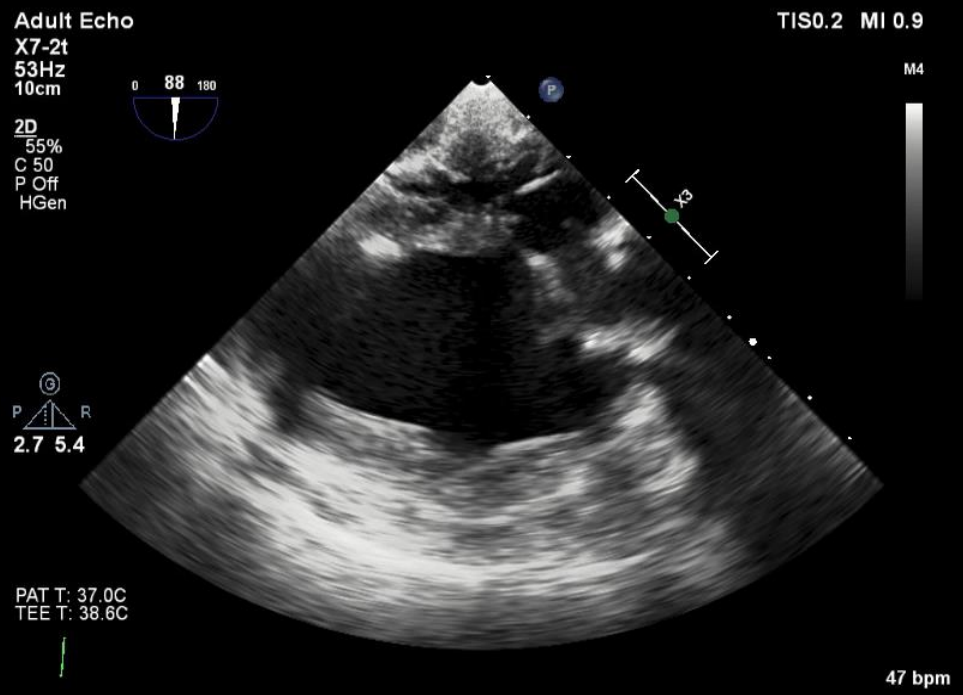




- Thickened leaflet (>3mm)
- Restricted motion
  - At tips
  - Diastolic doming (hockey stick)
- Commissural fusion

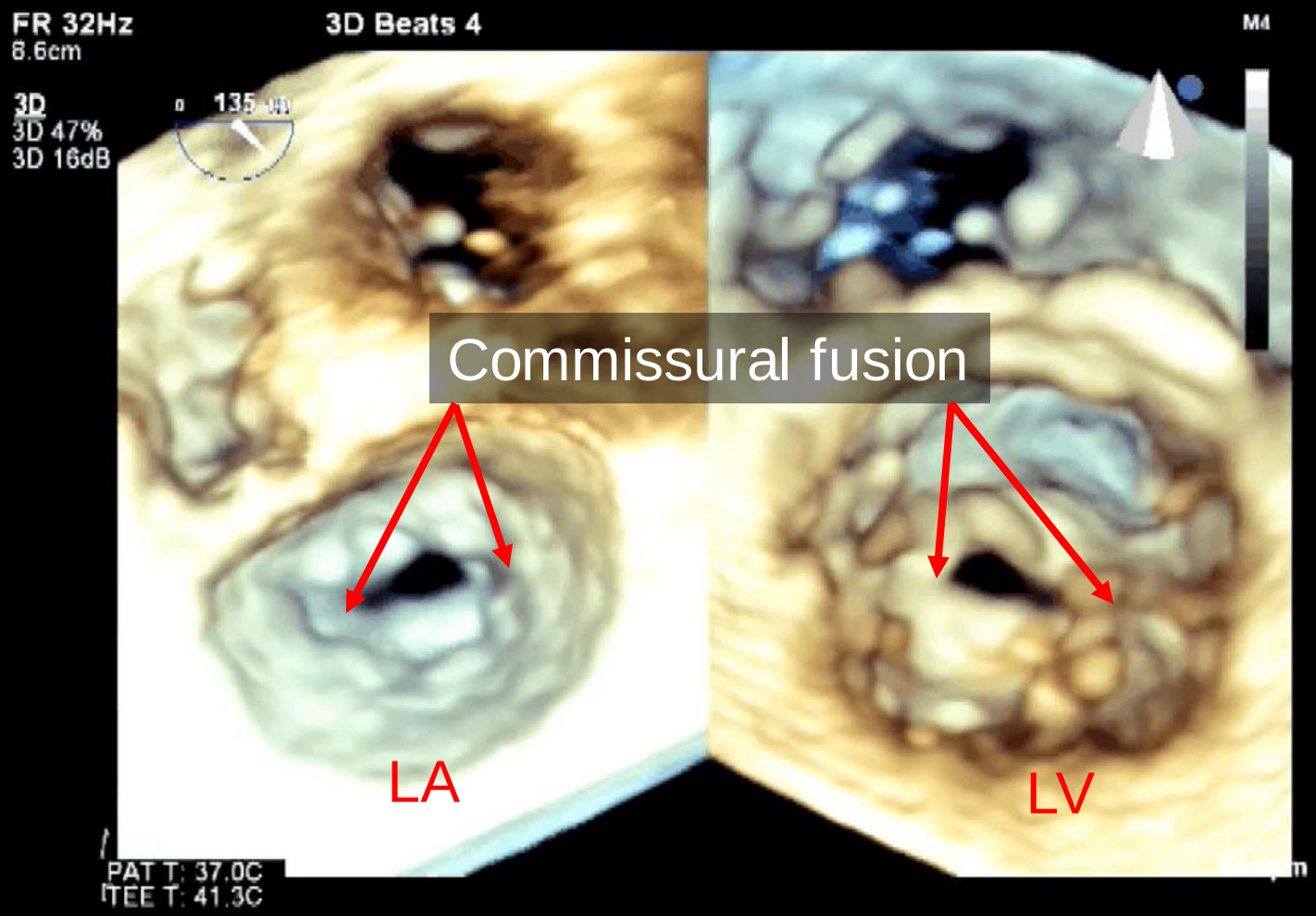
PIE

Rheumatic MV 2D TEE

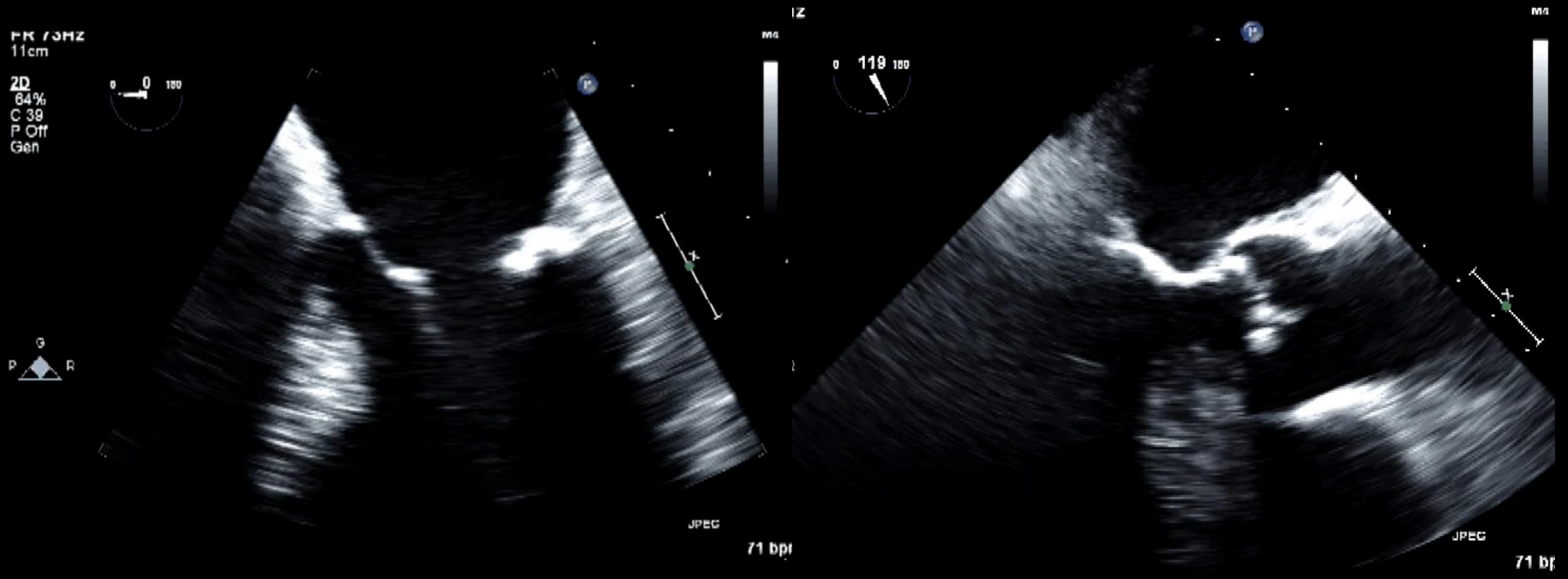


- Chordae
  - Thick
  - Short
- Restricted leaflet motion

Rheumatic MV 3D TEE

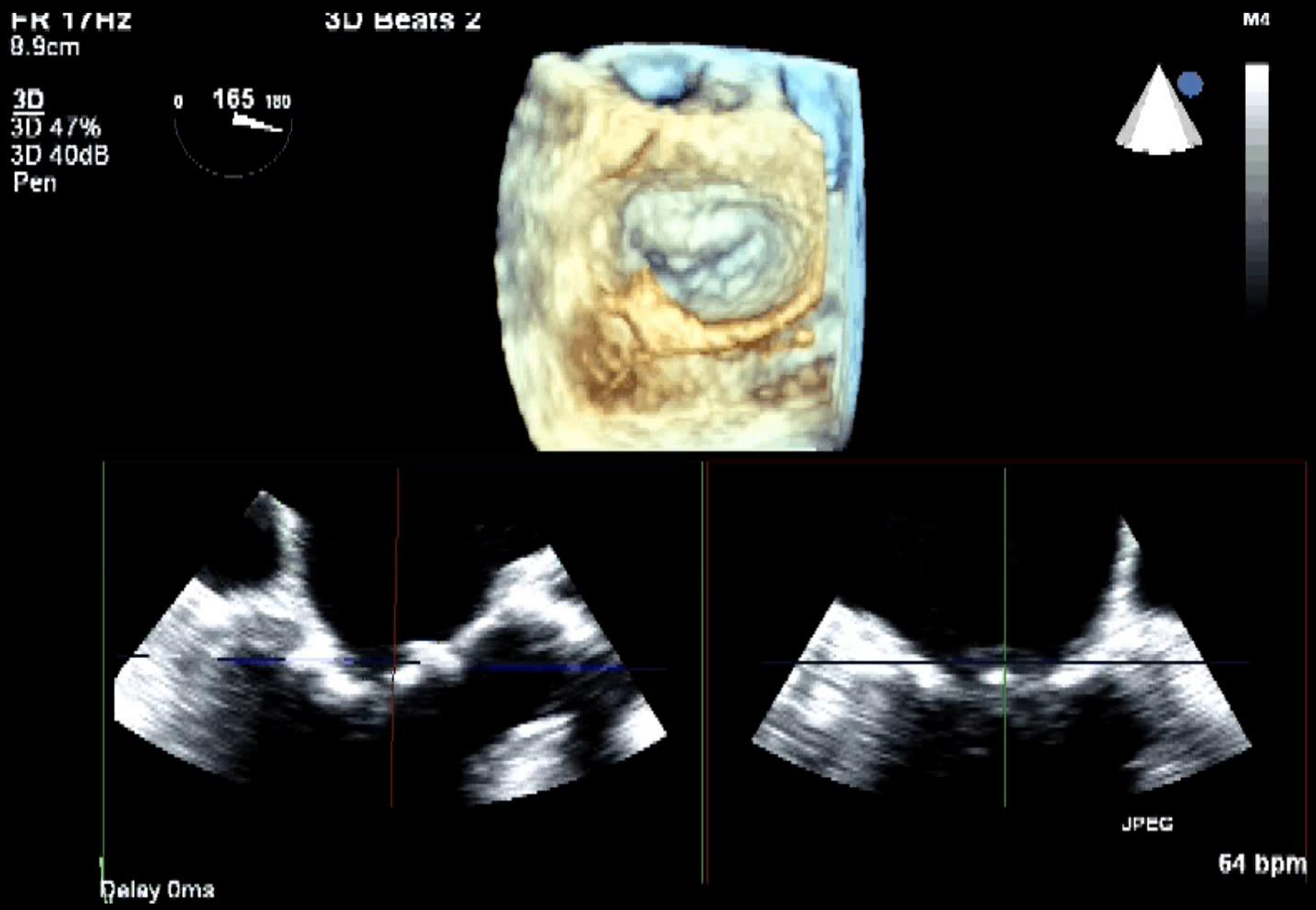


Calcific MV 2D TEE

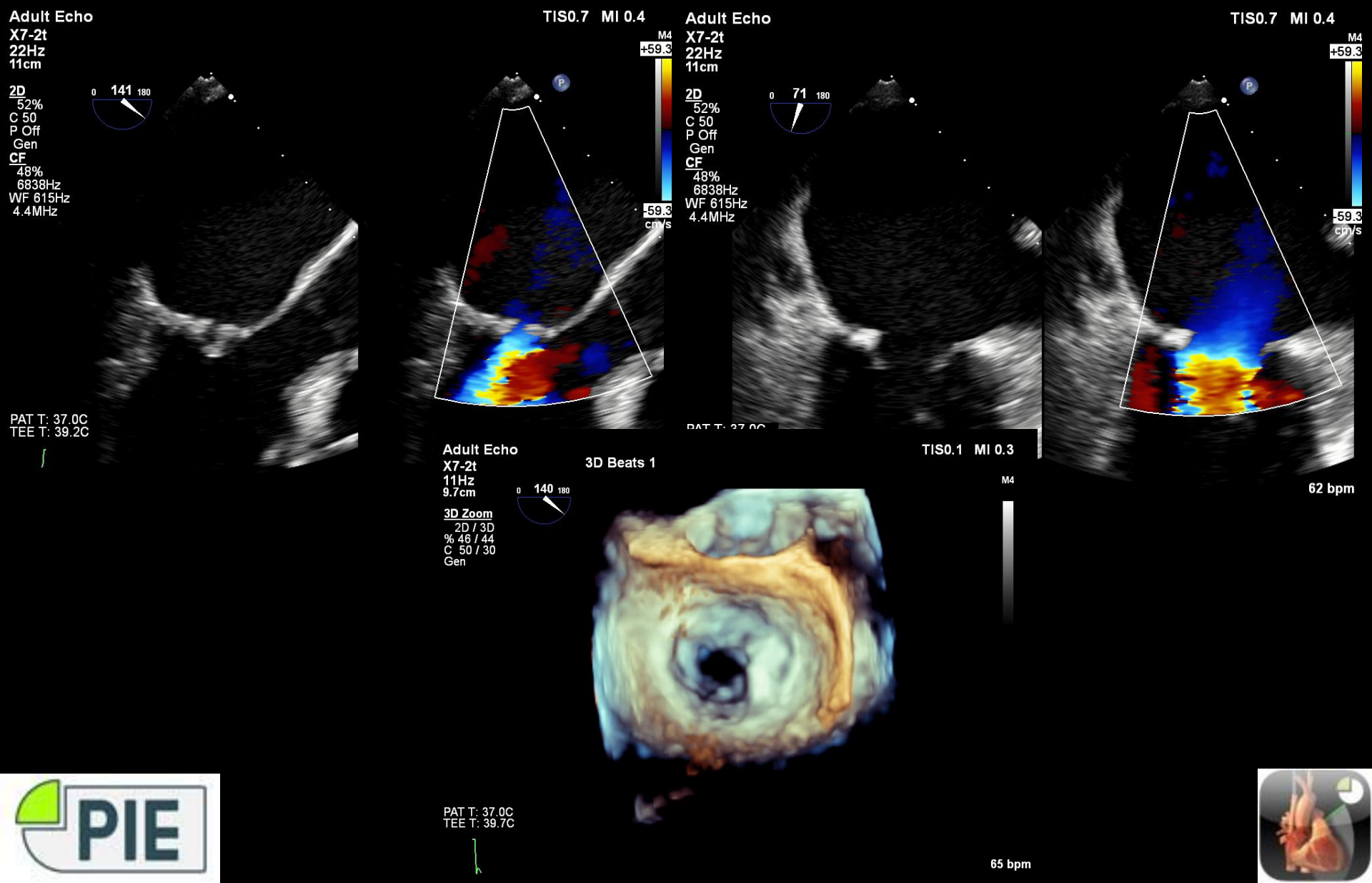


- Restricted motion
  - At base
  - No diastolic doming
- No Commissural fusion

Calcific MV 3D TEE



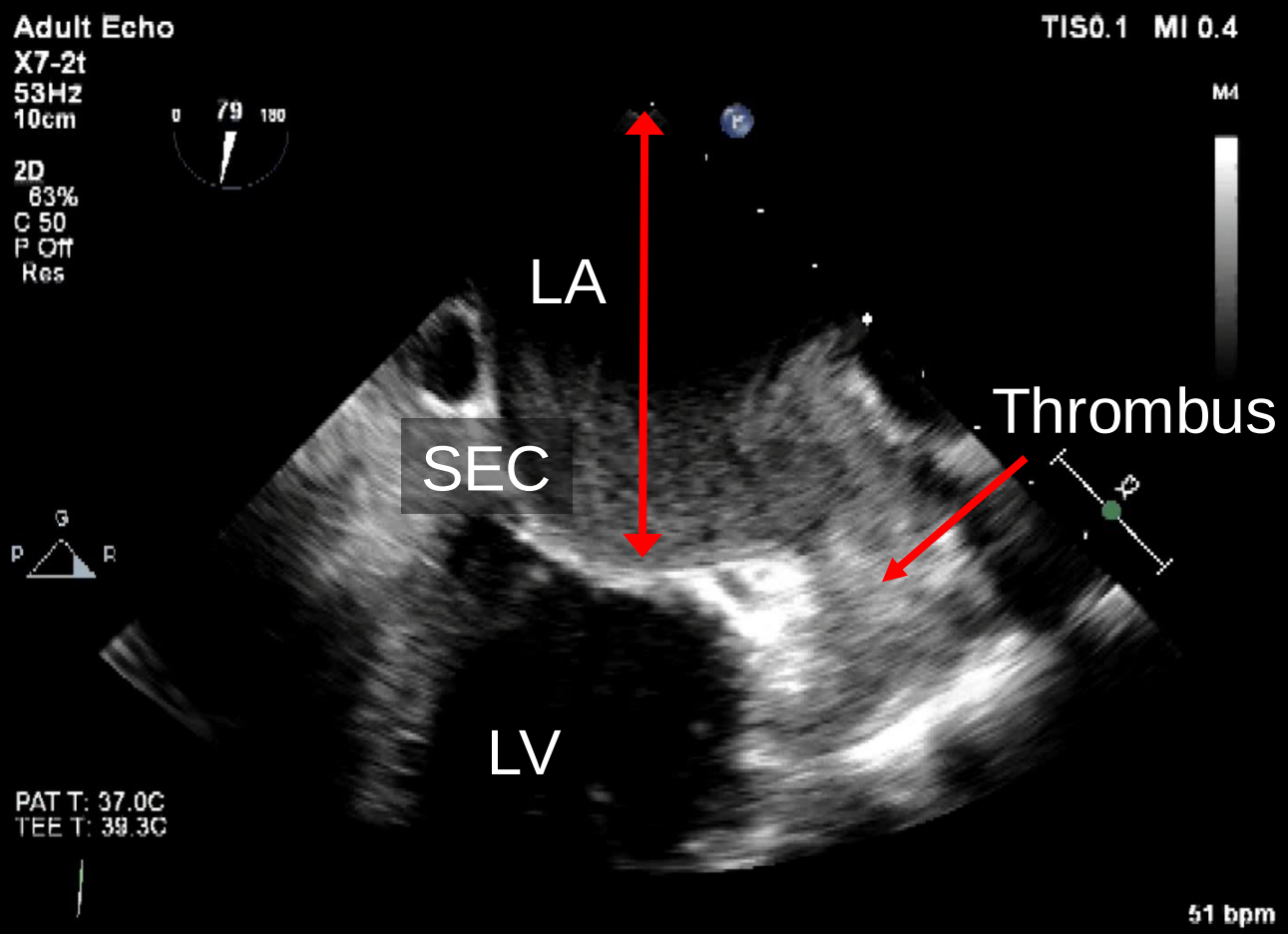
Calcified Rheumatic



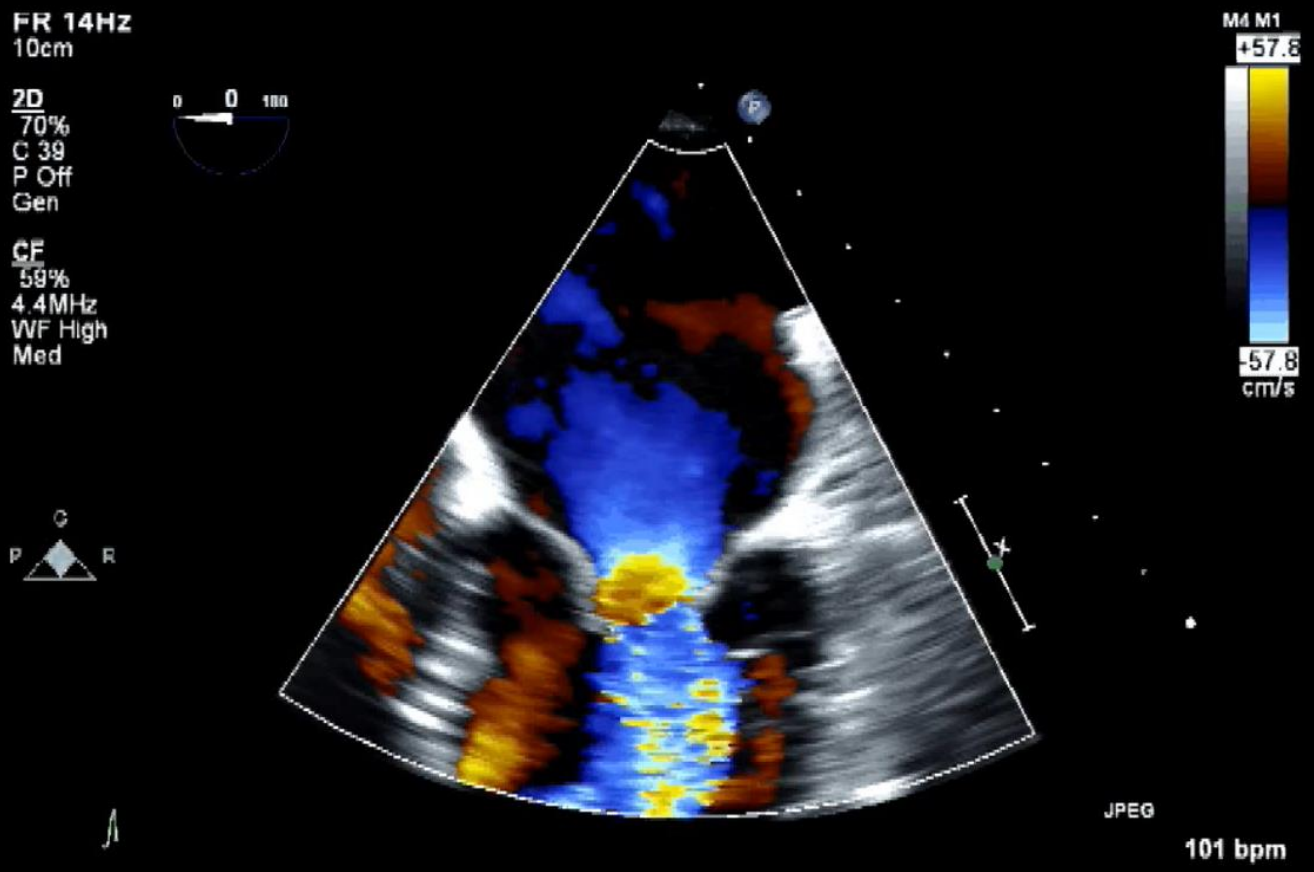
MS Secondary Changes

- Left Atrium
  - Enlarged
  - Spontaneous echo contrast (SEC)
  - Thrombus
- MV (MR)
- Pulmonary hypertension
  - RV dilatation
  - RVSP

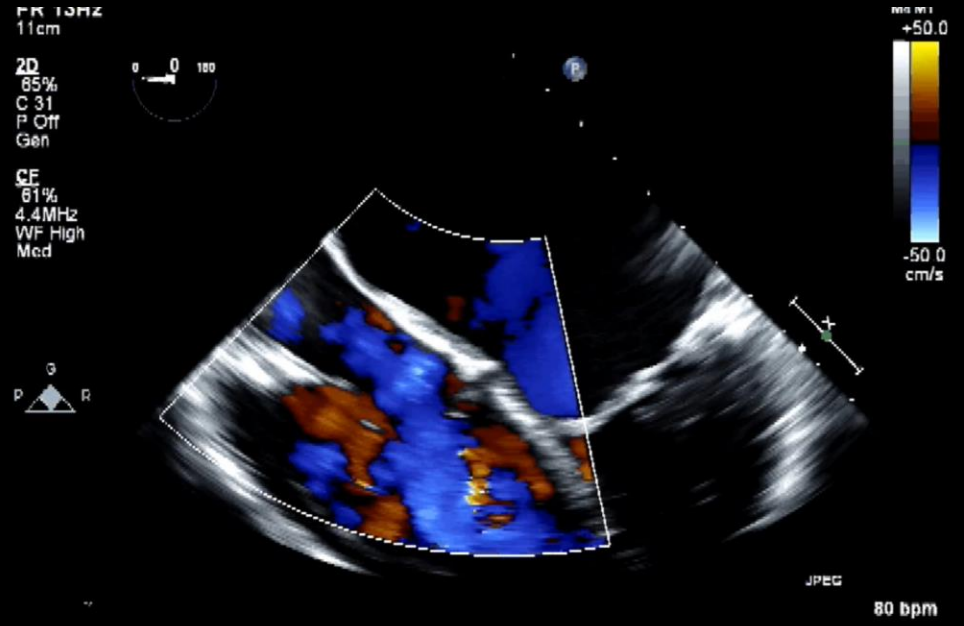
Secondary Changes LA

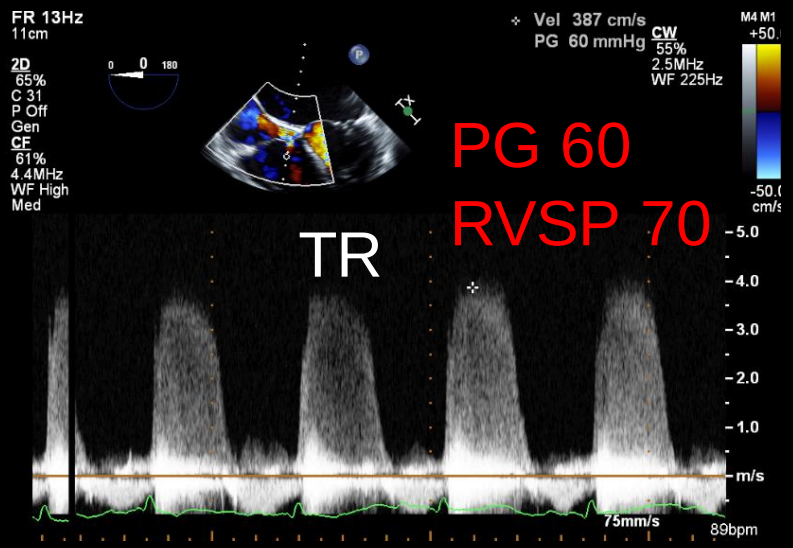


Secondary Changes MR



Secondary Changes PAP





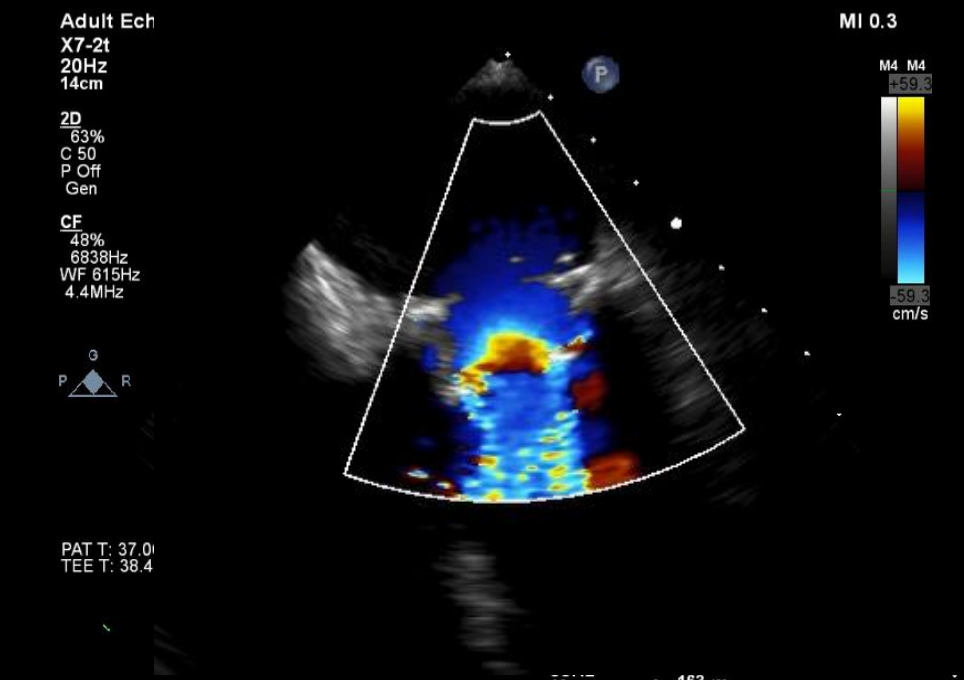
- IAS shift to R
- RV dilatation
- TR
  - Estimate RVSP

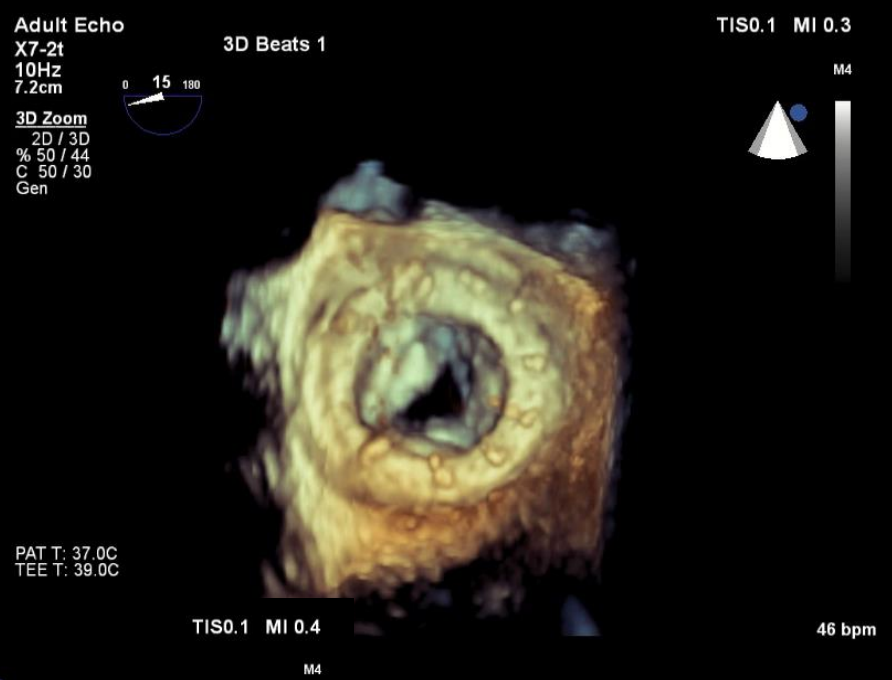
↑ PAP

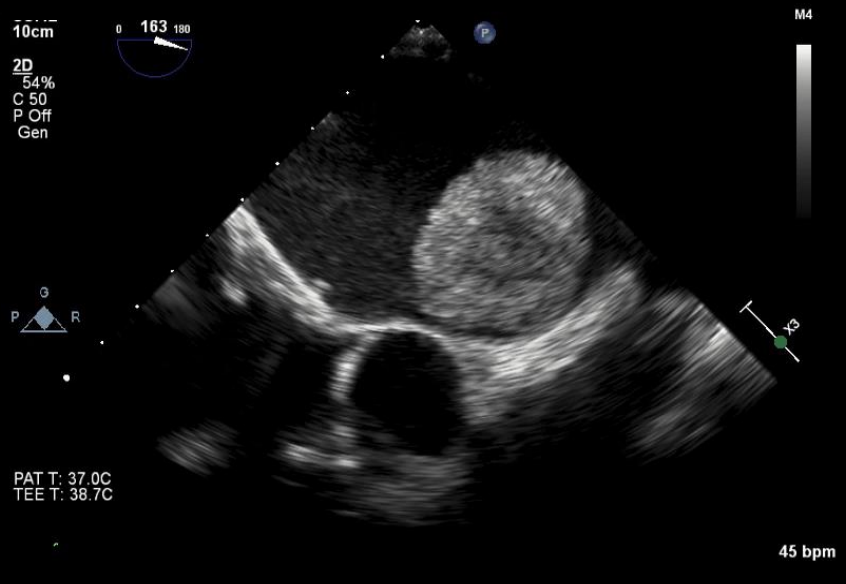
- Not measure of MS severity
- Does reduce survival

PIE

Secondary Changes







MS Assessment

Method

Area (cm^2)

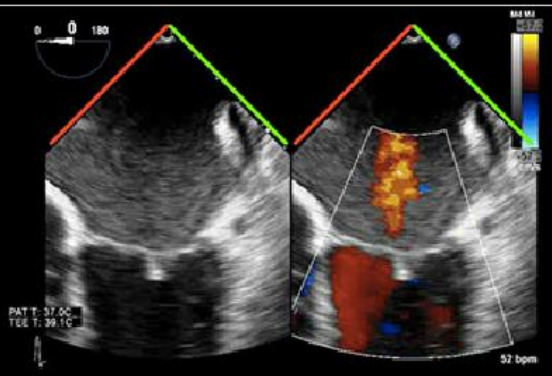
Mean Gradient (mmHg)

Pressure Half-time (ms)

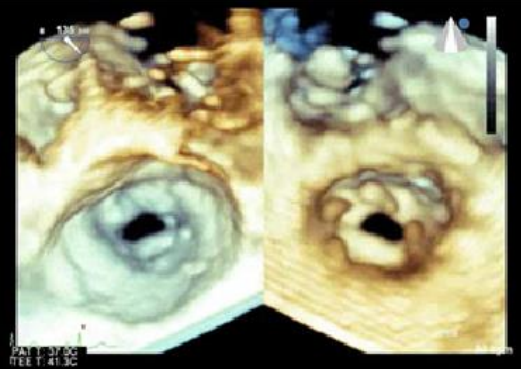
Systolic PAP (mmHg)

Intro MS Assessment

Spectral Doppler



Color Doppler



MV Area

PIE

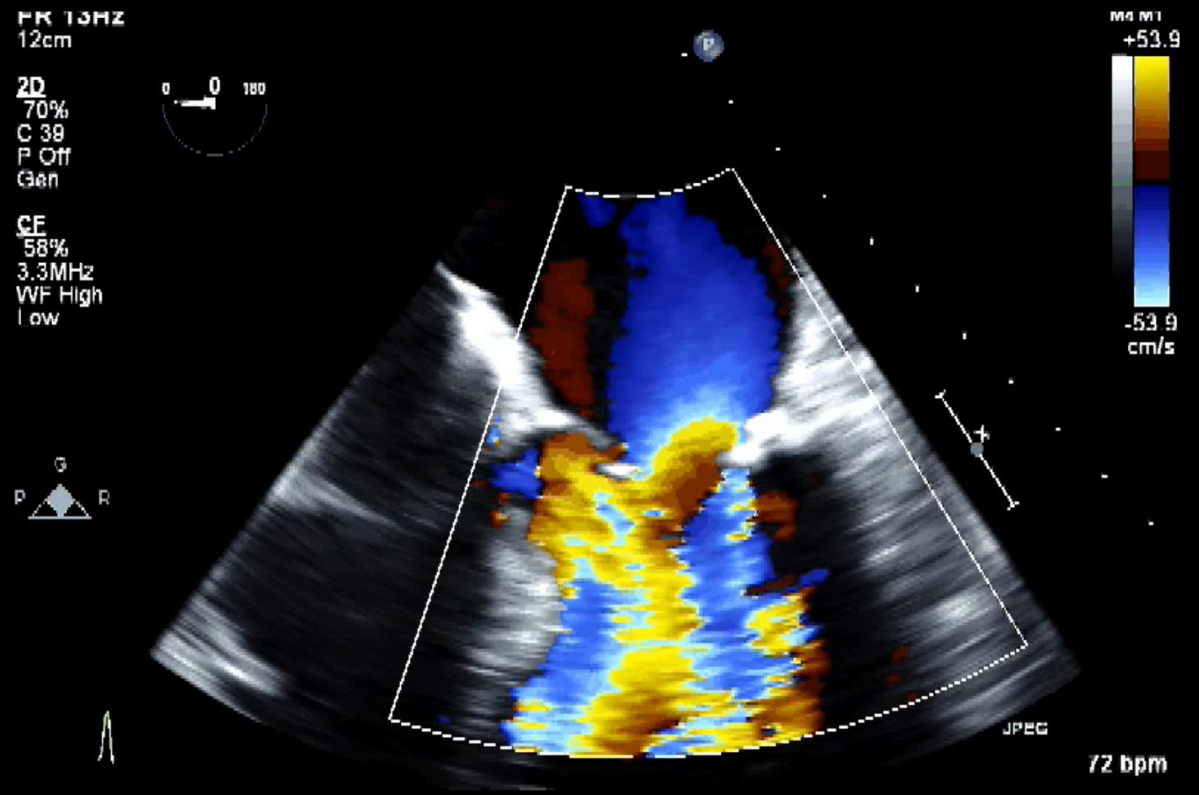
Severity MS

	Mild	Moderate	Severe
MVA* (cm^2)	> 1.5	1 – 1.5	< 1
Mean PG** (mmHg)	< 5	5 - 10	> 10
PAP** (mmHg)	< 30	30 - 50	> 50

- *specific, **supportive
- Only f HR 60-80 NSR
- No single value defines severity

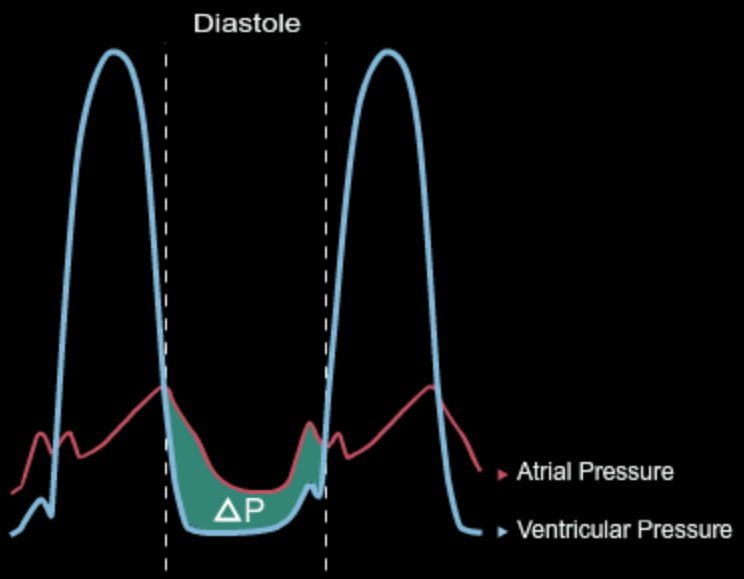
Baumgartner H, et al. J Am Soc Echocardiogr 2009;22:1-23

MS Color Doppler

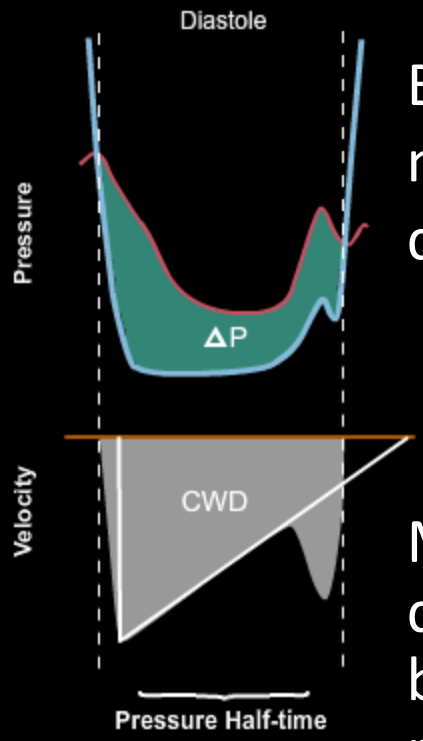


- Diastolic flow
- Turbulent antegrade
  - Nyquist 50-60cm/s
- Flow acceleration in LA

MS Spectral Doppler



PG between LA → LV determines rate of pressure equalization in diastole



Echocardiography does not measure pressure but does measure velocity

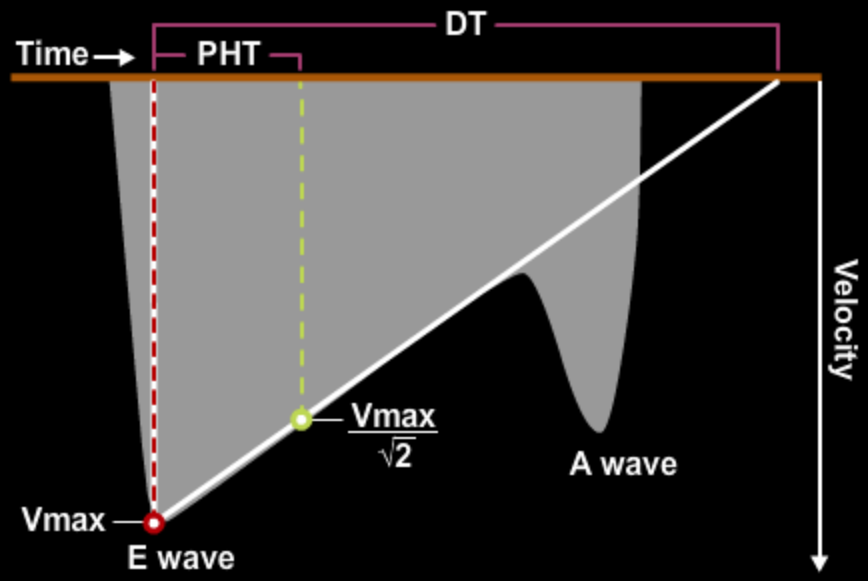
Bernoulli equation
($\Delta P = P_{LAP} - P_{LV} = 4V^2$)

MV inflow velocity is directly related to the PG by the Bernoulli equation, record with CWD

PIE

MS Spectral Doppler

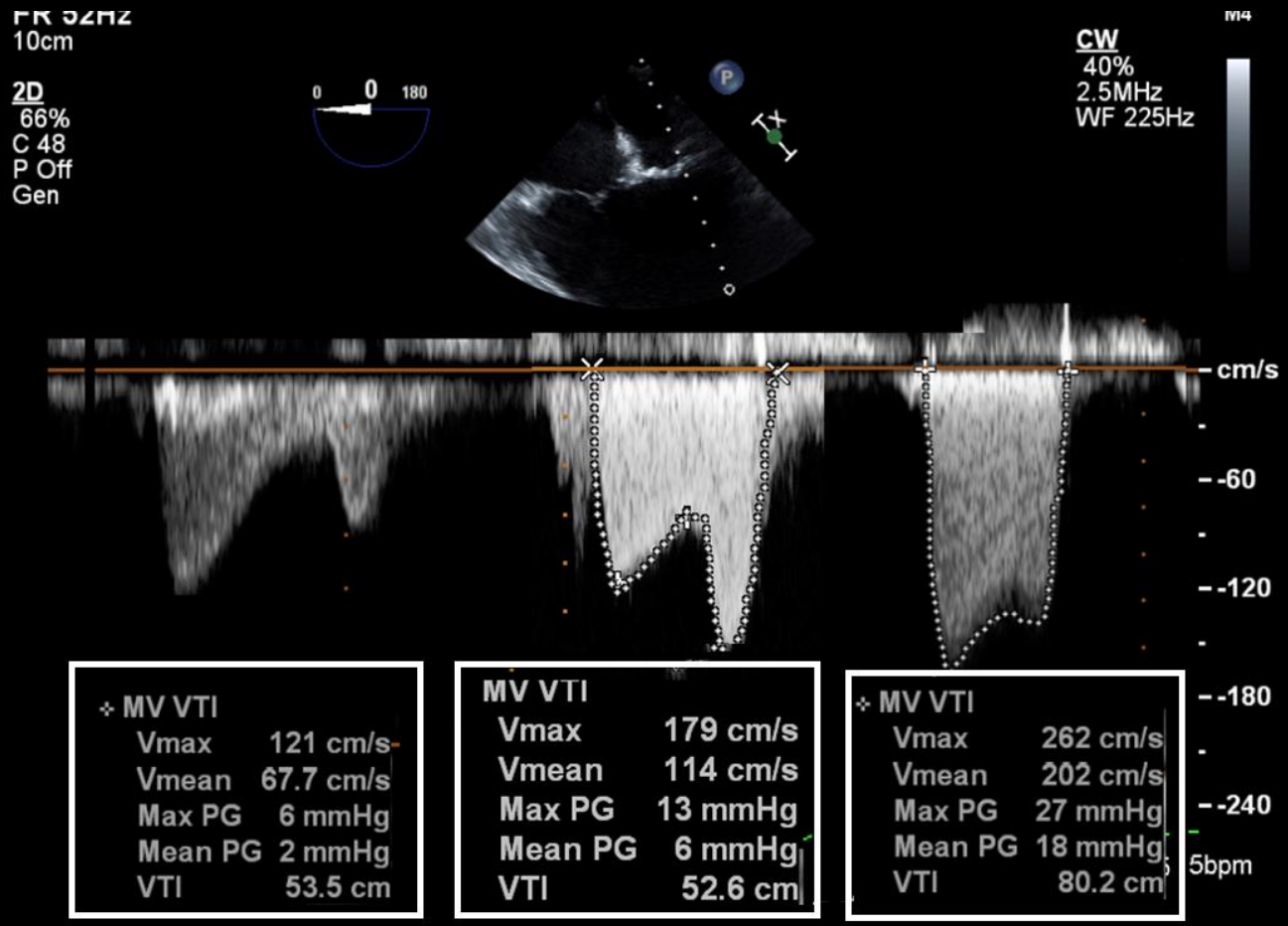
- High E wave velocity
- Flattened E wave slope
- Fusion E and A wave
- PG: mean, peak
- MVA: PHT, DT



MR

- Higher E velocity
- Peak PG > 20mmHg
- Mean PG < 10mmHg

MS Spectral Doppler



Mild
< 5

Moderate
5-10

Severe
>10

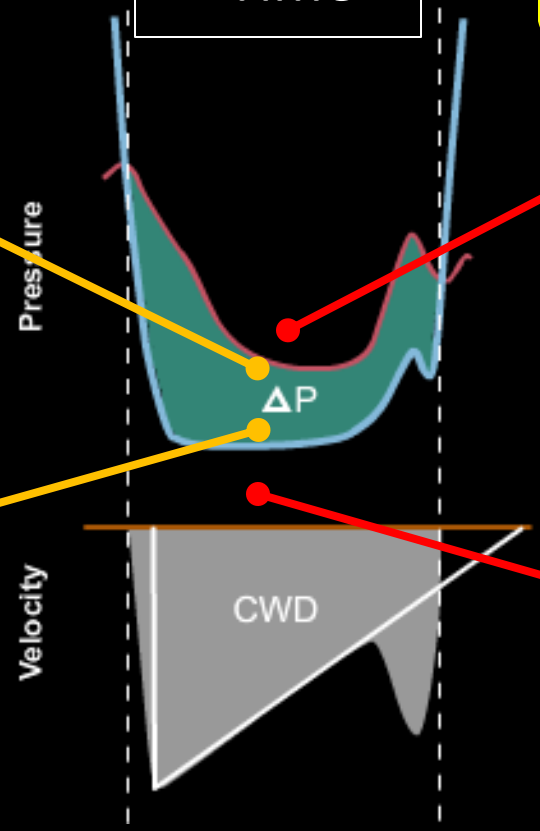
MS PG Limitations

- Δ P
- Time

Underestimate MS
(Low PG, Small MVA)

↓ LAP
- ↓ HR
- ASD

↑ LVEDP
- ↓ CO
- AI
- LVH: HBP, AS
- Diastolic dys



Overestimate MS
(High PG, Large MVA)

↑ LAP
- MR
- Diastolic dys

↓ LVEDP
- ↑ CO
- ↑ HR

MVA

Anatomic	
Planimetry	2D TG Basal SAX, 3D
Functional	
Pressure Half Time	220 ÷ PHT (ms)
Deceleration Time	759 ÷ deceleration time (ms)
Continuity Equation	$\frac{\pi r^2 \times VTI_{LVOT}}{VTI_{mitral}}$
PISA	$\frac{2\pi r^2 \times Valiasing \times \alpha / 180}{Peak\ Vmitral}$

MVA Limitations

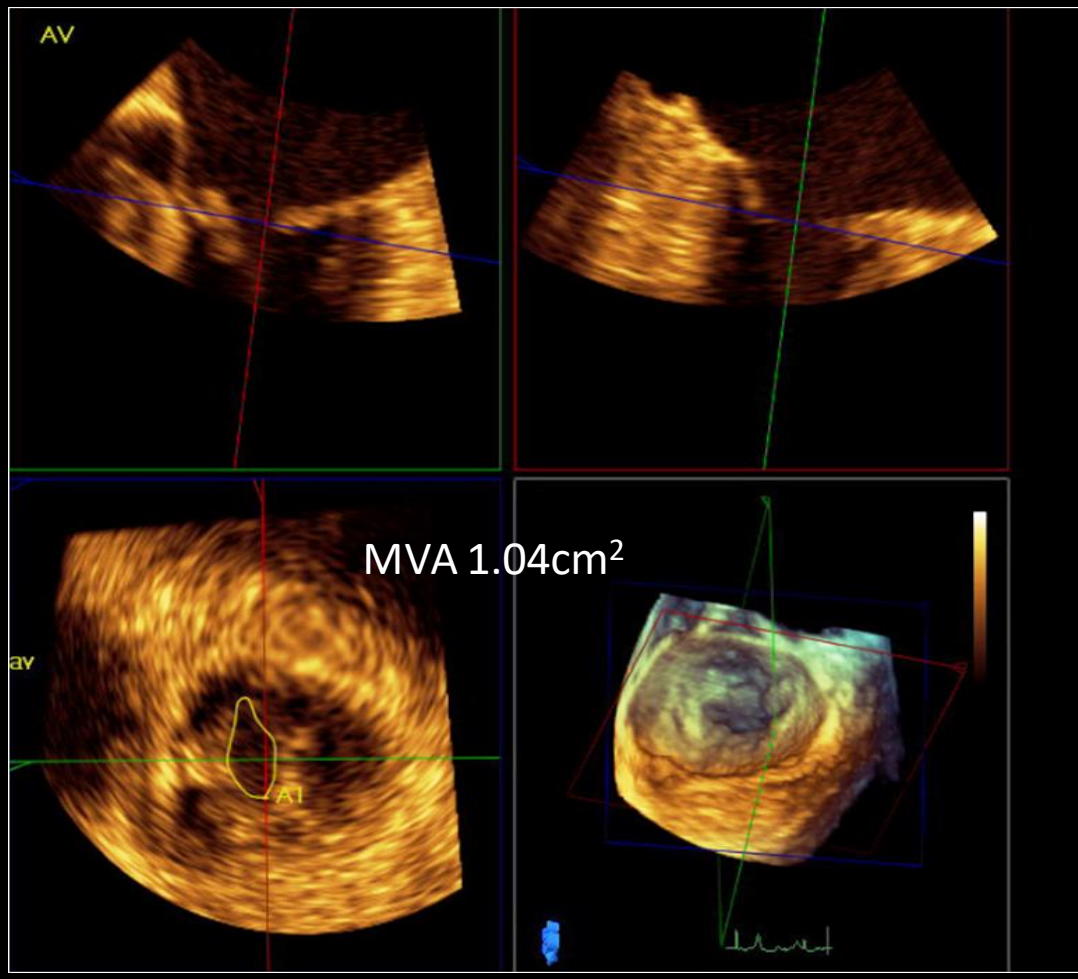
MVA	Avoid in	Use in
Planimetry	Heavily calcified	
PHT	AI, LV dysfunction, ASD, diastolic dysfunction	MR, AF
Continuity Equation	AI, LVOT obstruct, MR, AF, intracardiac shunt	Calcific MS
PISA		AI, MR, prosthetic, AF

MS with Multivalve Lesions

Lesion	PG	MVA
MR	High peak PG, use mean	• Underestimate MVA by continuity and PHT
AI	Low flow/PG	• Overestimate MVA • Continuity (↑ AV flow) • ↓ PHT (from ↑ LVEDP)
AS	Low flow/ PG	• Overestimate MVA, prolong PHT from impaired LV relax
TR		• Gorlin formula invalid

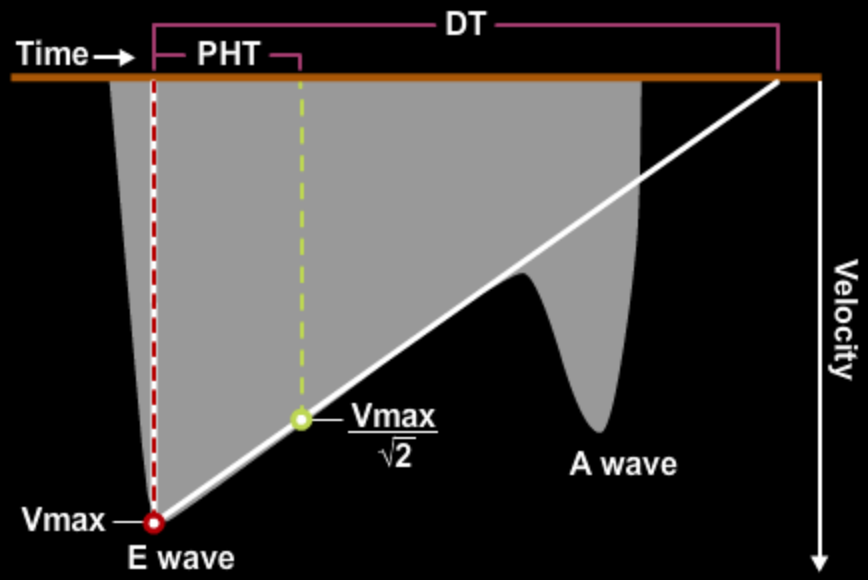
MS MV Area Planimetry

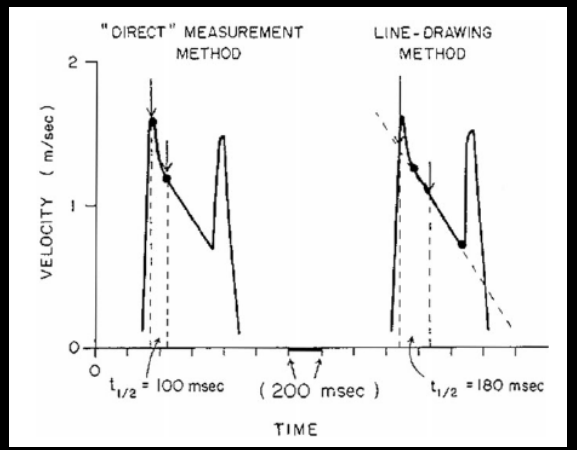
- Anatomic measure
- Trace open MV orifice in mid-diastole
- Identify leaflet tips
- Repeat measures in AF
- Unreliable in calcific MS due to shadowing
- Underestimate ↑HR



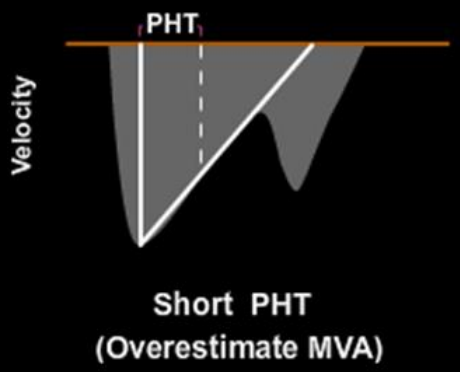
MS MVA Pressure Half-Time

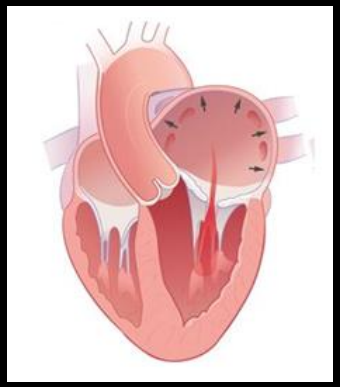
- Time (in ms) from peak MV to half initial value
- MVA = 220/PHT
  - x Normal
  - x Post BMV
  - x Post Prosthetic
- If bimodal use mid part
- Deceleration time
  - Time from peak to 0
  - PHT = 0.29DT
  - MVA = 759/DT

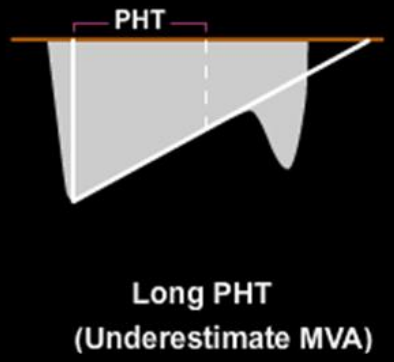




MS MVA PHT Limitations





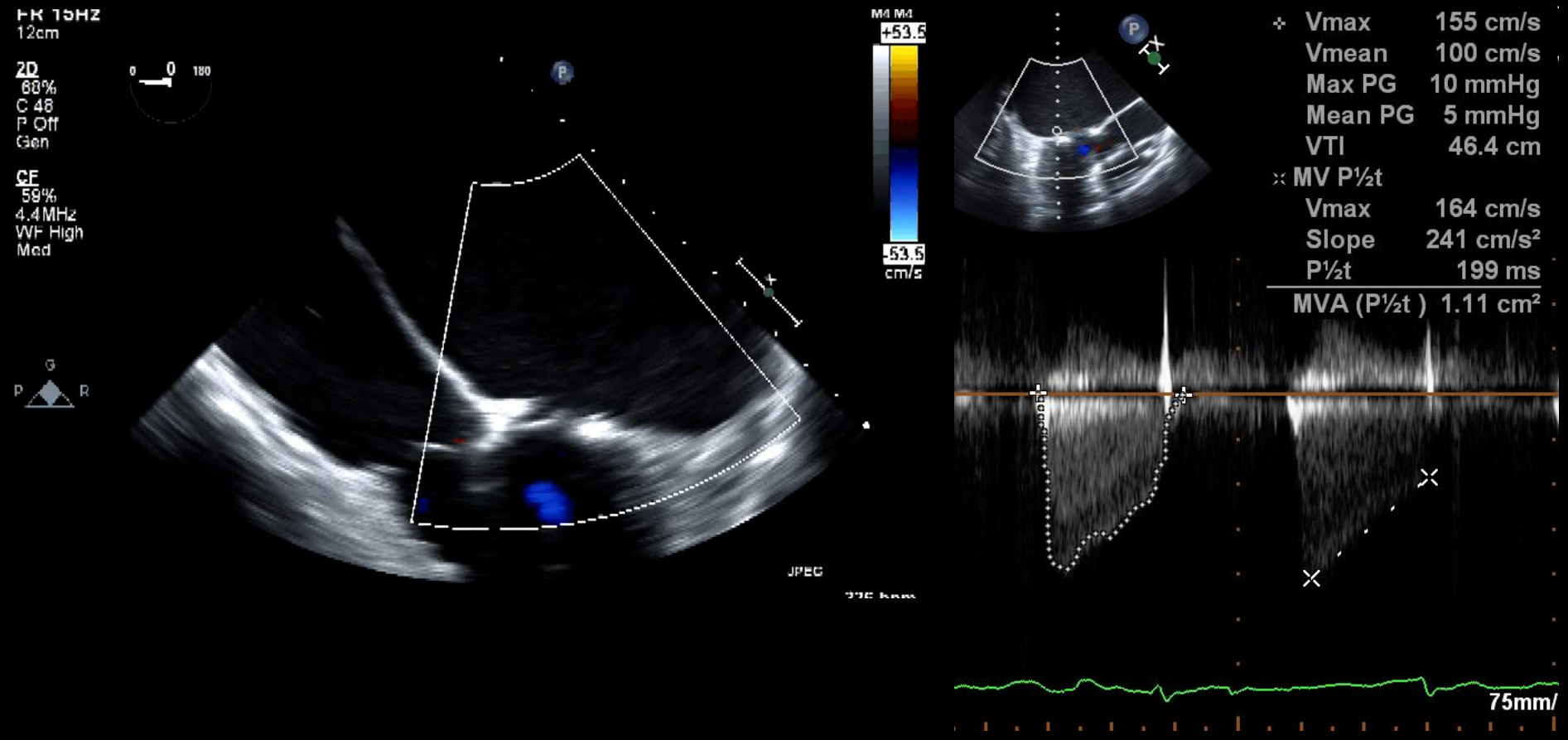


- ↑ LVEDP/ ↓ compliance
  - AI
  - Cardiomyopathy/LVH
  - Diastolic dysfxn (aging)
- ↓ LAP compliance
  - ASD
  - MR
  - AF, ↑ HR

- Large LA
- Abnormal relaxation

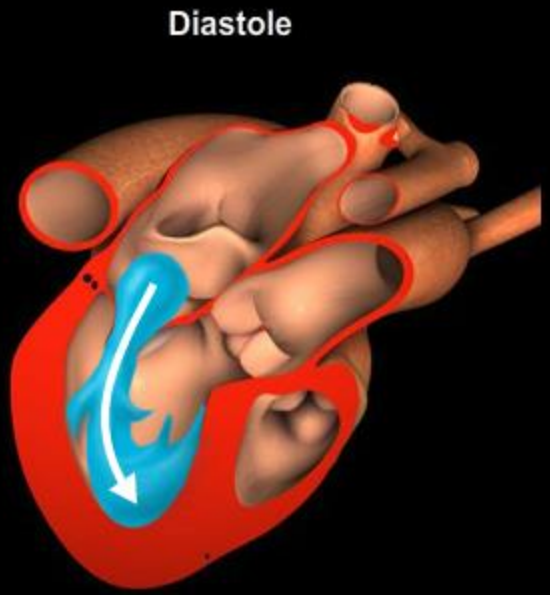
Avoid PHT in
- Elderly
- Calcific
- Diastolic dysfunction
- ? Post CPB, BMV

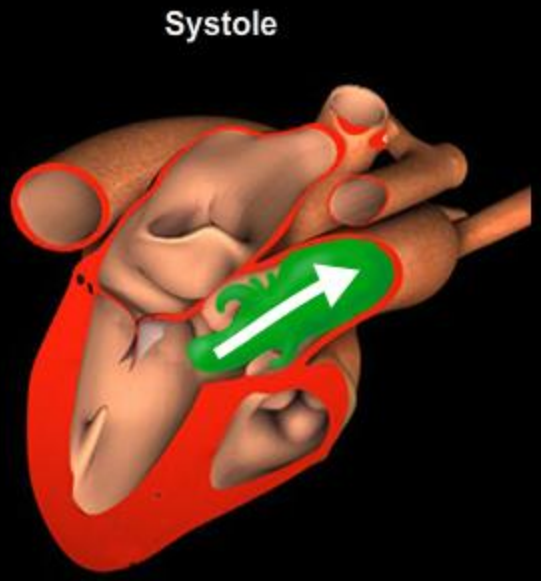
MVA PHT



MV mean PG 5mmHg, MVA 1.11cm^2

MS MVA Continuity





Continuity Equation

MV Flow (SV) = AV Flow (SV)

(SV = CSA x VTI)

$CSA_{MV} \times VTI_{MV} = CSA_{AV} \times VTI_{AV}$

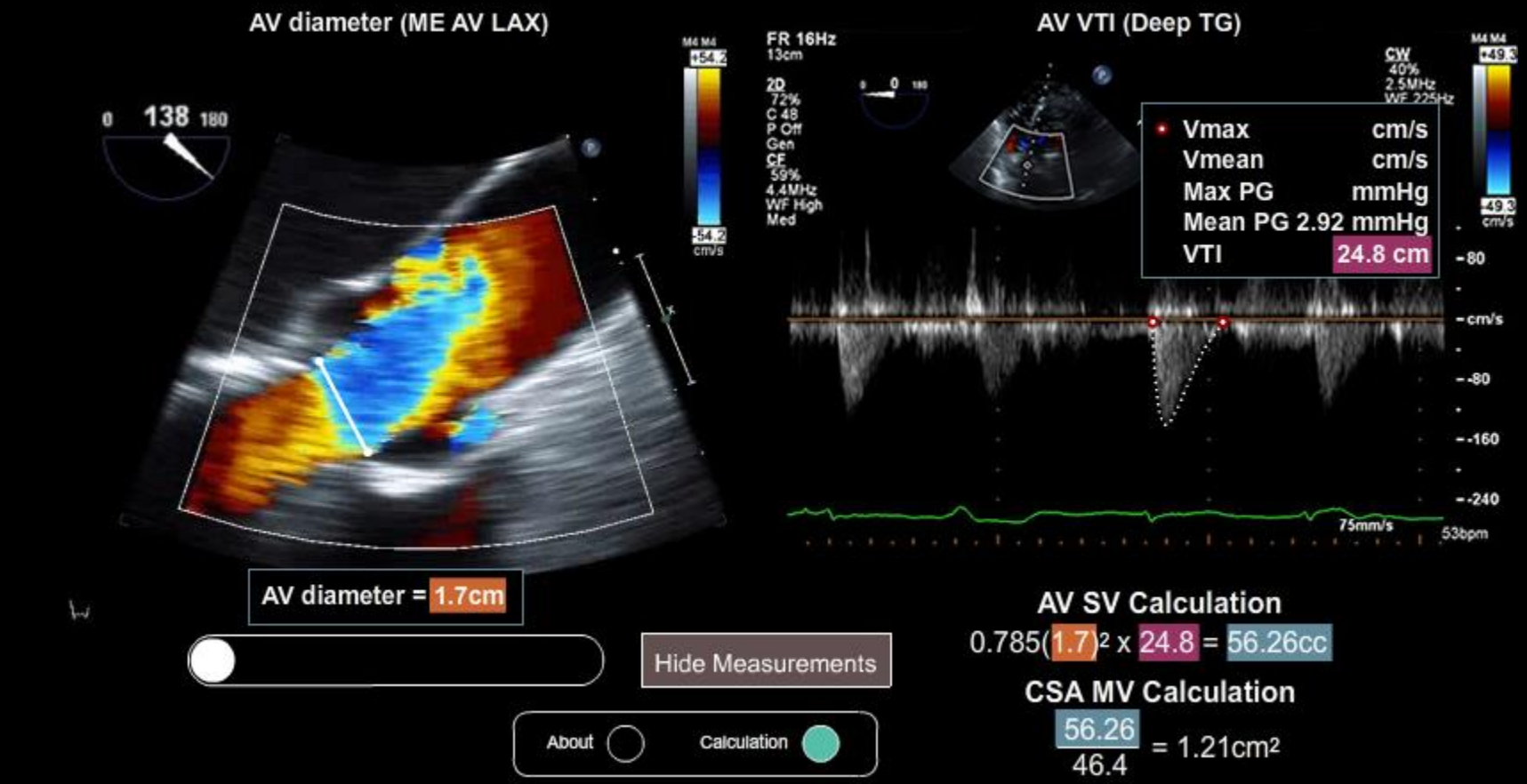
$$CSA_{MV} = \frac{CSA_{AV} \times VTI_{AV}}{VTI_{MV}}$$

Avoid if

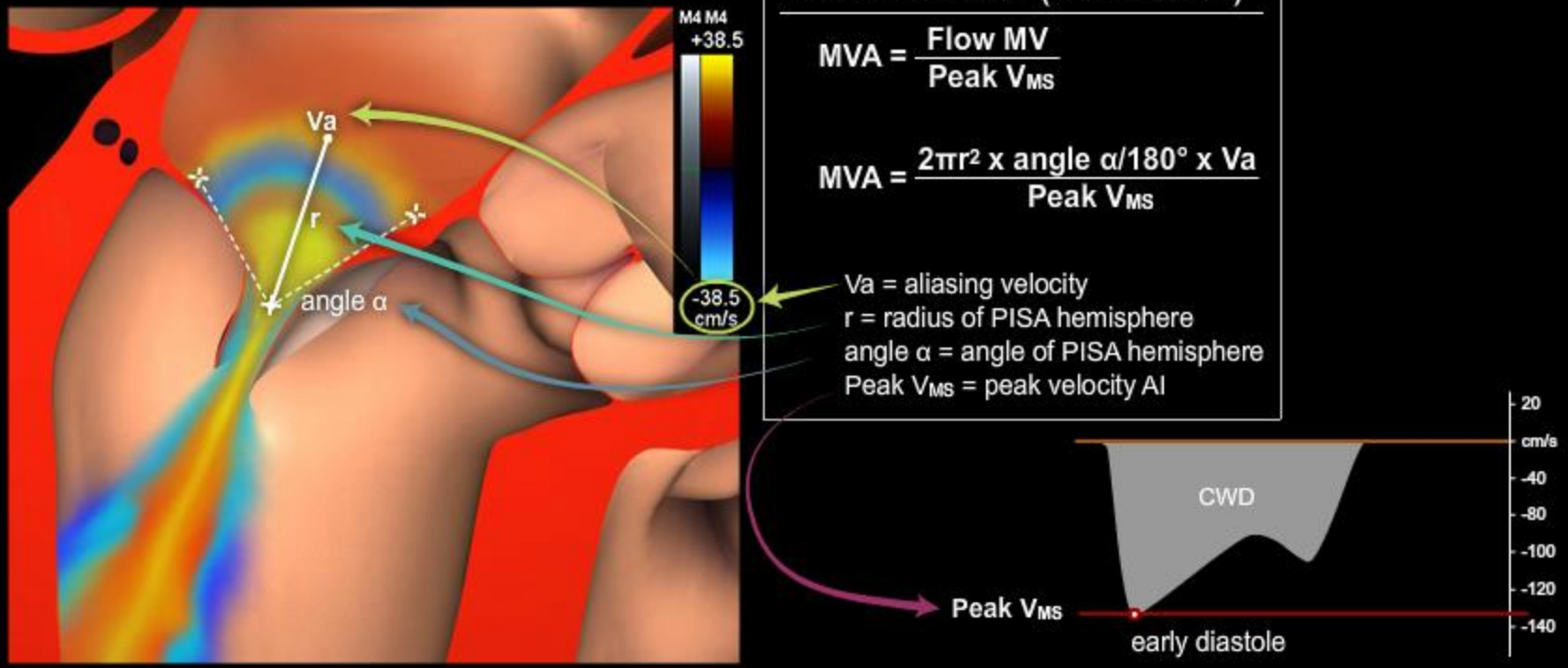
- AI (overestimate),
- MR (underestimate)
- ASD
- AF

PIE

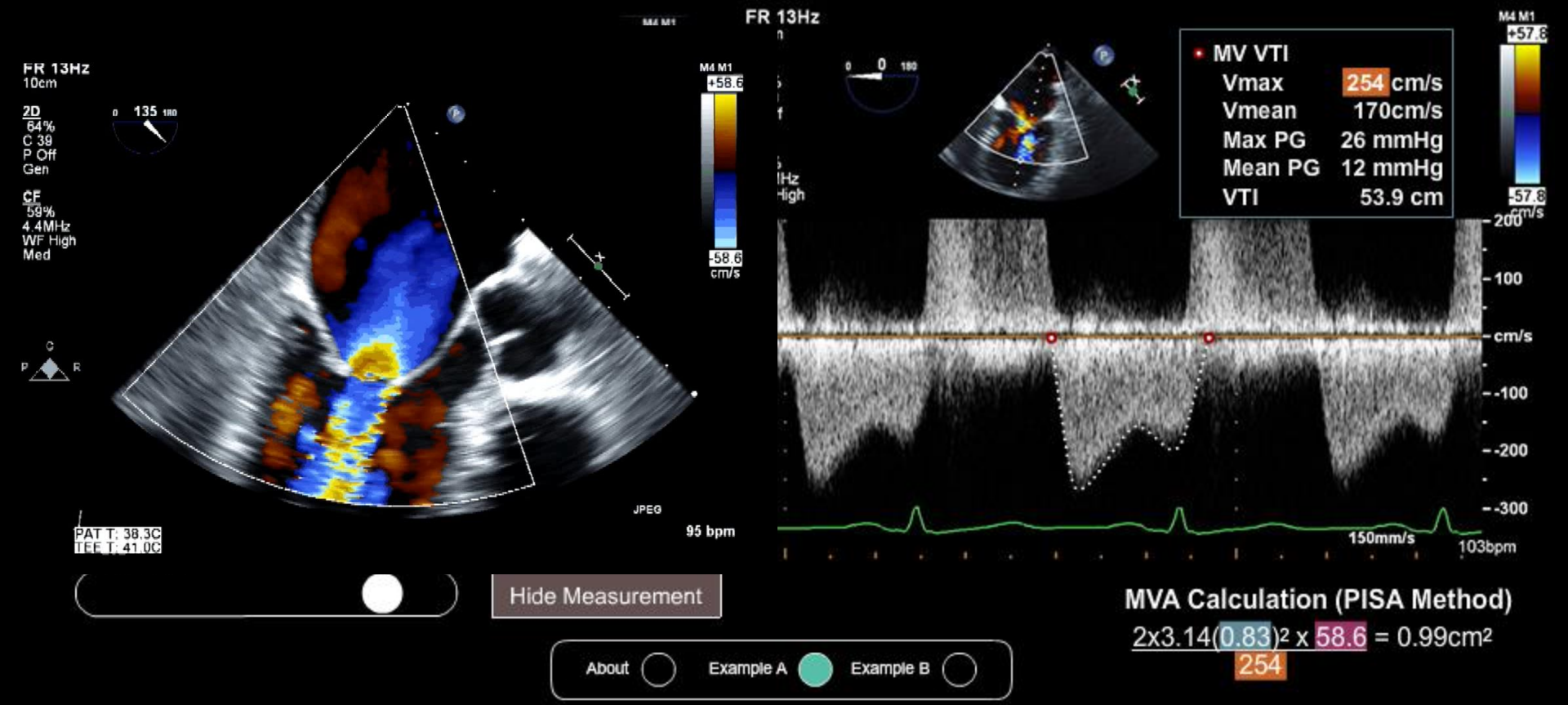
MVA Continuity



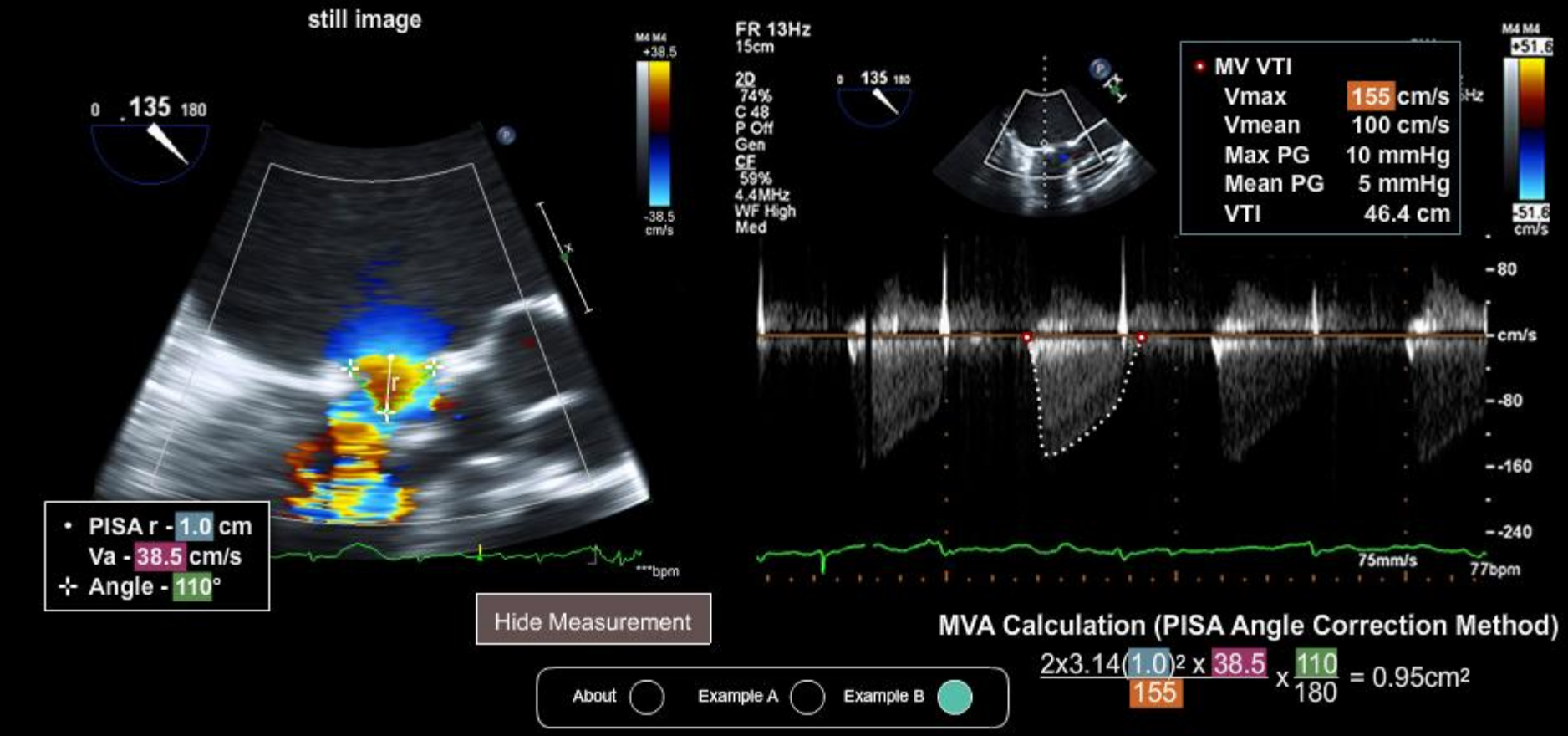
MVA PISA


M4 M4
+38.5
-38.5
cm/s
Va
r
angle α
MVA calculation (PISA Method)
MVA = Flow MV / Peak VMS
MVA = 2πr² x angle α/180° x Va / Peak VMS
Va = aliasing velocity
r = radius of PISA hemisphere
angle α = angle of PISA hemisphere
Peak VMS = peak velocity AI
CWD
Peak VMS
early diastole
20
cm/s
-40
-80
-100
-120
-140

MVA PISA


FR 13Hz
10cm
2D
64%
C 39
P Off
Gen
CF
59%
4.4MHz
WF High
Med
M4 M1
+58.6
-58.6
cm/s
PAT T: 38.3C
TEE T: 41.0C
JPEG
95 bpm
FR 13Hz
MV VTI
Vmax 254 cm/s
Vmean 170cm/s
Max PG 26 mmHg
Mean PG 12 mmHg
VTI 53.9 cm
+57.8
-57.8
200
100
cm/s
-100
-200
-300
150mm/s
103bpm
Hide Measurement
About
Example A
Example B
MVA Calculation (PISA Method)
2x3.14(0.83)² x 58.6 = 0.99cm²
254

MVA PISA


still image
FR 13Hz
15cm
2D
74%
C 48
P Off
Gen
CF
59%
4.4MHz
WF High
Med
MV VTI
Vmax 155 cm/s
Vmean 100 cm/s
Max PG 10 mmHg
Mean PG 5 mmHg
VTI 46.4 cm
PISA r - 1.0 cm
Va - 38.5 cm/s
Angle - 110°
Hide Measurement
About
Example A
Example B
MVA Calculation (PISA Angle Correction Method)
2x3.14(1.0)² x 38.5 / 155 x 110 / 180 = 0.95cm²

MV Interventions in MS

Class	2014 AHA/ACC Guidelines MV Interventions in MS	Level of Evidence
I	**PBC** for symptomatic patients, severe MS (MVA ≤1.5 cm2, stage D) and favorable valve morphology without LA thrombus or moderate-to-severe MR	A
	MV surgery (repair, commissurotomy, or valve replacement) for severely symptomatic patients (NYHA class III to IV), severe MS (MVA ≤1.5 cm2, stage D), not high risk for surgery or not candidates or failed PBC	B
	Concomitant **MV surgery** for severe MS (MVA ≤1.5 cm2, stage C or D) undergoing other cardiac surgery	C
IIa	**PBC** reasonable asymptomatic very severe MS (MVA ≤1.0 cm2, stage C) and favorable valve morphology without LA thrombus or moderate-to-severe MR	C
	MV surgery reasonable severely symptomatic (NYHA class III to IV), severe MS (MVA ≤1.5 cm2, stage D), with other operative indications	C
IIb	**PBC** consider asymptomatic, severe MS (MVA ≤1.5 cm2, stage C) favorable valve morphology without LA thrombus or moderate-to-severe MR with new onset of AF	C
	PBC consider symptomatic MVA > 1.5 cm2 with hemodynamically significant MS based on PCWP > 25 mm Hg or mean MV gradient > 15 mm Hg during exercise.	C
	PBC consider severely symptomatic (NYHA class III to IV), severe MS (MVA ≤1.5 cm2, stage D), suboptimal valve anatomy and not candidates/high risk for surgery	C
	Concomitant **MV surgery** consider moderate MS (MVA 1.6 – 2.0 cm2) undergoing other cardiac surgery	C
	MV surgery + LAA excision consider for severe MS (MVA ≤1.5 cm2, stages C and D) with recurrent embolic events despite adequate anticoagulation.	C

MS Management Wilkins Score

Based on valve morphology

Grade	Mobility	Thickening	Calcification	Subvalvular Thickening
1	Highly mobile valve with only leaflet tips restricted	Leaflets near normal in thickness (4–5 mm)	A single area of increased echo brightness	Minimal thickening just below the mitral leaflets
2	Leaflet mid and base portions have normal mobility	Midleaflets normal, considerable thickening of margins (5–8 mm)	Scattered areas of brightness confined to leaflet margins	Thickening of chordal structures extending to one-third of the chordal length
3	Valve continues to move forward in diastole, mainly from the base	Thickening extending through the entire leaflet (5–8 mm)	Brightness extending into the mid-portions of the leaflets	Thickening extended to distal third of the chords
4	No or minimal forward movement of the leaflets in diastole	Considerable thickening of all leaflet tissue (>8–10 mm)	Extensive brightness throughout much of the leaflet tissue	Extensive thickening and shortening of all chordal structures extending down to the papillary muscles

The total score is the sum of the four items and ranges between 4 and 16.

Low score ≤ 8, good outcome

PIE

Wilkins, GT, et al. Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. *Br Heart J, 1988 60*(4), 299-308.

MS Management Cormier Score

Based on leaflet calcification and subvalvular

Echocardiographic group	Mitral valve anatomy
Group 1 √	Pliable non-calcified anterior mitral leaflet and mild subvalvular disease (i.e. thin chordae ≥10 mm long)
Group 2 √	Pliable non-calcified anterior mitral leaflet and severe subvalvular disease (i.e. thickened chordae <10 mm long)
Group 3 X	Calcification of mitral valve of any extent, as assessed by fluoroscopy, whatever the state of subvalvular apparatus

Iung, B, Cormier, B, et al. (1996). Immediate results of percutaneous mitral commissurotomy. A predictive model on a series of 1514 patients. *Circulation 1996, 94*(9), 2124-2130.

MS Management 3D TEE Score

Divides leaflets into 3 portions, scores each

	Leaflets					
	Anterior leaflet			Posterior leaflet		
	A1	A2	A3	P1	P2	P3
[a]Thickness (0–6)	0–1	0–1	0–1	0–1	0–1	0–1
[a]Mobility (0–6)	0–1	0–1	0–1	0–1	0–1	0–1
[b]Calcification (0–10) (0=no, 1–2=calcified)	0–2	0–1	0–2	0–2	0–1	0–2
	[b]Subvalvular apparatus					
	Proximal third		Middle third		Distal third	
Thickness (0–3) (0=normal, 1=thickened)	0–1		0–1		0–1	
Separation (0–6) (0=normal, 1=partial, 2=no)	0–2		0–2		0–2	

[a] Normal=0, mild=1–2, moderate=3–4, severe >5

[b] Normal=0, mild=1–2, moderate=3–5, severe >6

Mild	Moderate	Severe
<8	8 - 13	≥14

Soliman O I, et al. New Scores for the Assessment of Mitral Stenosis Using Real-Time Three-Dimensional Echocardiography. *Curr Cardiovasc Imaging Rep 2011, 4*(5), 370-377.

Selected Readings

- Cherry AD, Maxwell CD, Nicoara A. Intraoperative Evaluation of Mitral Stenosis by Transesophageal Echocardiography. Anesth Analg 2016;123:14-20.
- Baumgartner H, et al. Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice. J Am Soc Echocardiogr 2009;22:1-23.
- Wunderlich NC, Beigel R, Siegel RJ. Management of Mitral Stenosis Using 2D and 3D Echo-Doppler Imaging. JACC: Cardiovasc Imaging 2013;6:1191-1205.
- Alaa Mabrouk SO, Tanaka H, et al. Comparison of mitral valve area by pressure half-time and proximal isovelocity surface area method in patients with mitral stenosis: effect of net atrioventricular compliance. Eur J Echocardiogr 2011;12:283–290.
- Wilkins, GT, et al. Percutaneous balloon dilatation of the mitral valve: an analysis of echocardiographic variables related to outcome and the mechanism of dilatation. *Br Heart J, 1988 60*(4), 299-308.
- Iung, B, Cormier, B, et al. (1996). Immediate results of percutaneous mitral commissurotomy. A predictive model on a series of 1514 patients. *Circulation 1996, 94*(9), 2124-2130.
- Soliman O I, et al. New Scores for the Assessment of Mitral Stenosis Using Real-Time Three-Dimensional Echocardiography. *Curr Cardiovasc Imaging Rep 2011, 4*(5), 370-377.

PIE

Question 1

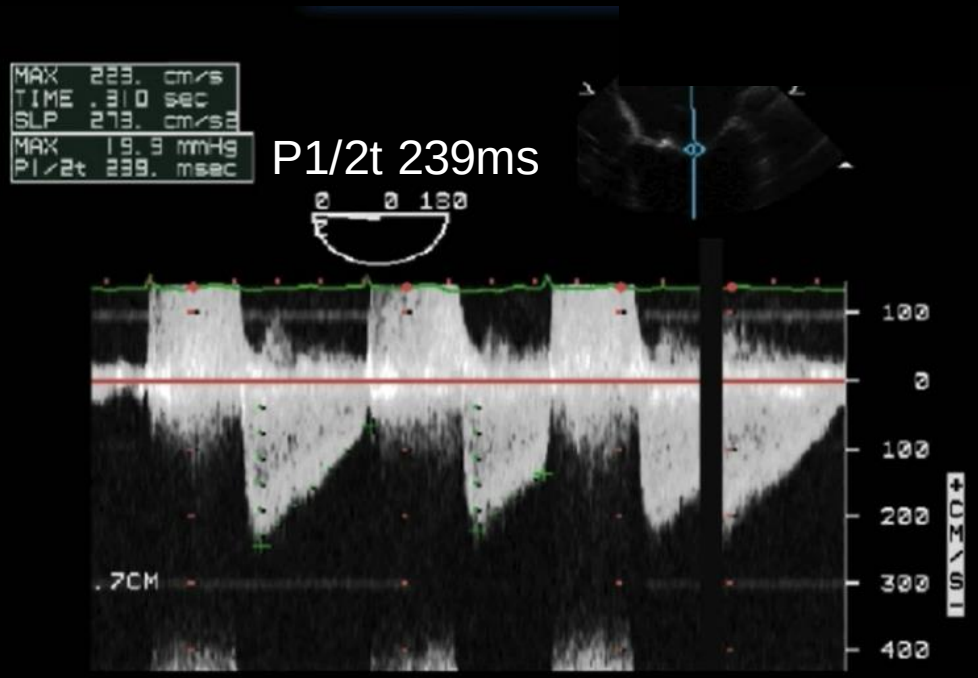
Which of the following is not a finding in rheumatic MS ?

1. Commissural fusion
2. Annular + leaflet base calcification
3. Chordal shortening + fusion
4. Leaflet tip calcification
5. Diastolic doming

Question 2

What is the calculated MVA ?

1. 0.72
2. 0.92
3. 1.08
4. 1.20
5. 1.40



Question 3

Which of the following is true ?

A. Mean gradient is underestimated with tachycardia
B. MR underestimates MS severity by mean PG
C. Pressure half time is decreased with reduced cardiac output
D. AI overestimates MVA by PHT method

Question 4

Severe MV stenosis is diagnosed when the normal MVA is reduced by at least ?

1. 25%
2. 33%
3. 50%
4. 66%
5. 75%

Question 5

Which secondary finding is not consistent with the isolated MS ?

1. Dilated left atrium
2. Dilated right ventricle
3. Dilated left ventricle
4. Dilated tricuspid valve annulus

Question 6

What is the calculated MVA (in cm^2) based on the information provided:

r 1.7cm, Valias 25cm/s, Vmax 250cm/s, α angle 100

1. 0.8
2. 1.0
3. 1.2
4. 1.4

$$MVA = 2\pi r^2 \times Va/Vmax \times \alpha/180$$
$$= 2(3.14)\ (1.7)^2 \times (25/250) \times 100/180$$
$$= 1.0$$