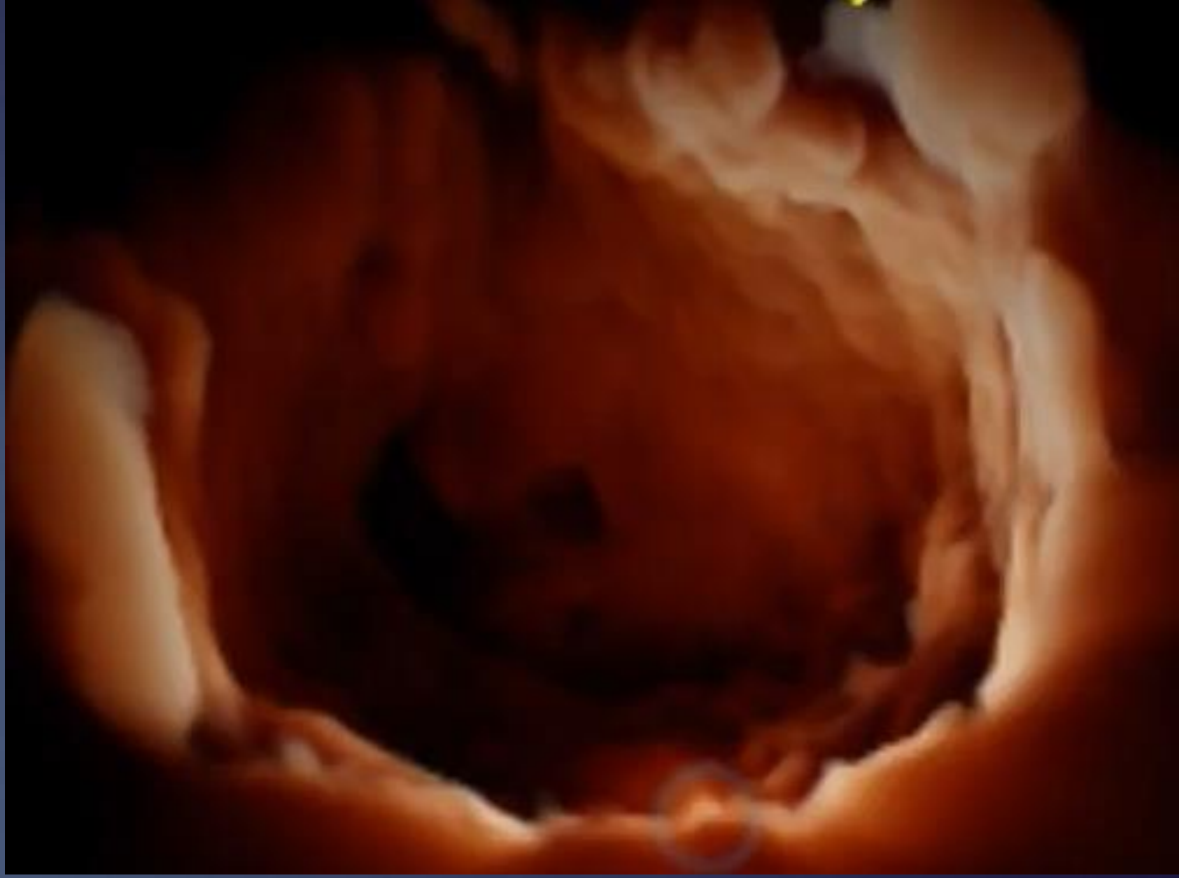
Echo Evaluation of Mitral Stenosis

Rheumatic Vs Calcific

Kate Sturwohld



ECHO AUSTRALIA

17-19 March 2025

Learning Objectives

1

2D features rheumatic Vs calcific mitral stenosis

2

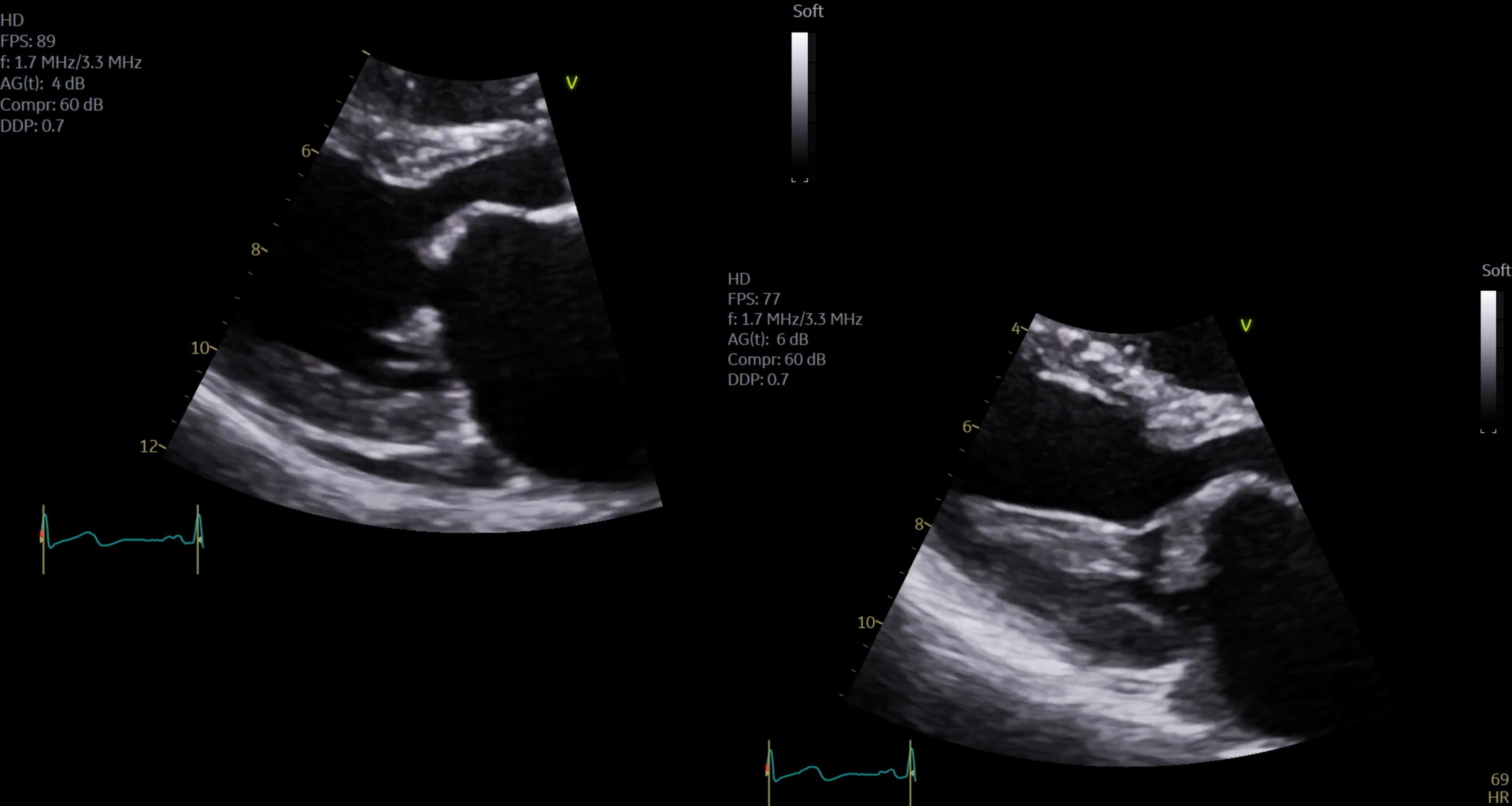
Echo parameters to grade severity of rheumatic MS

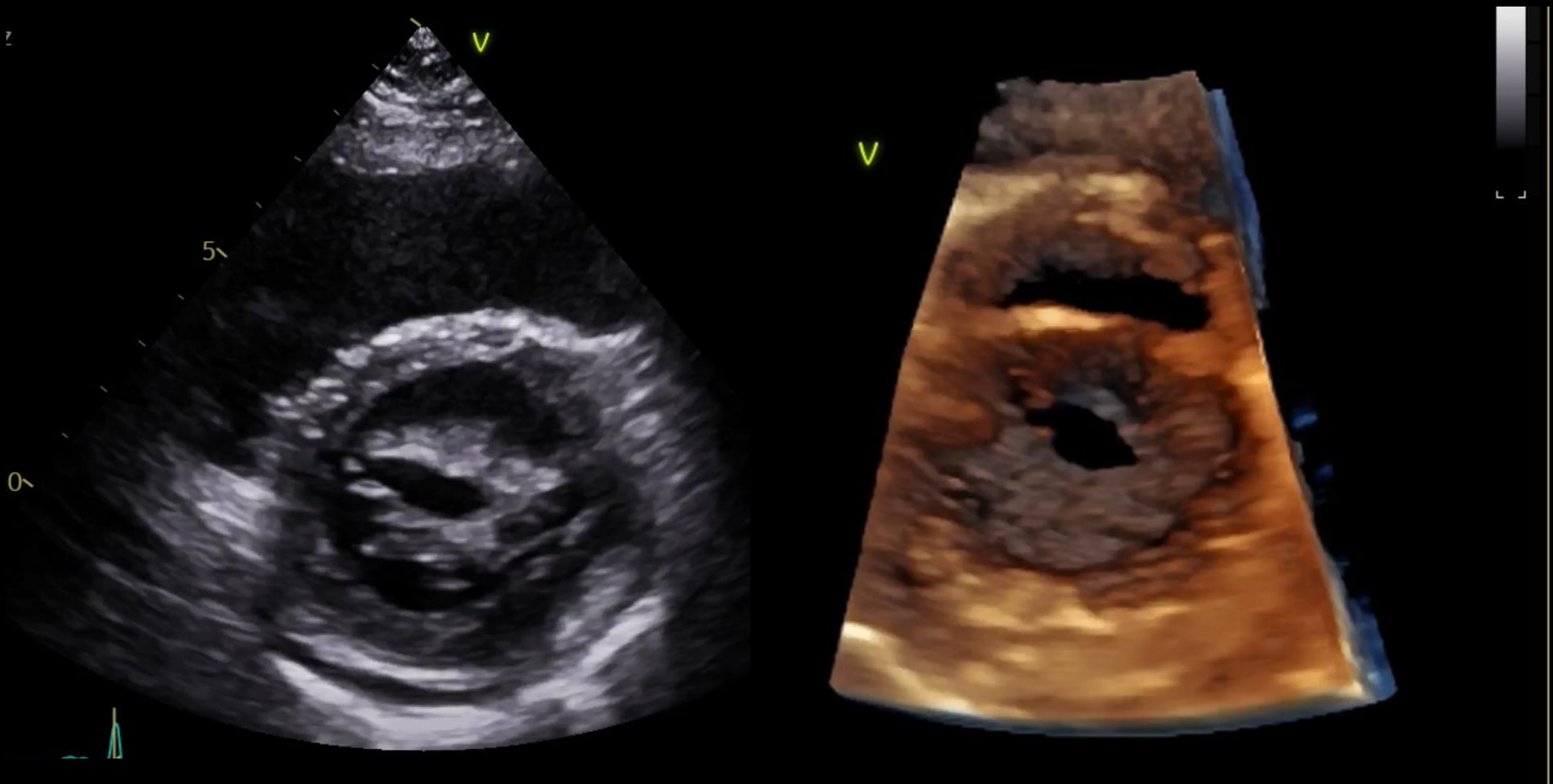
3

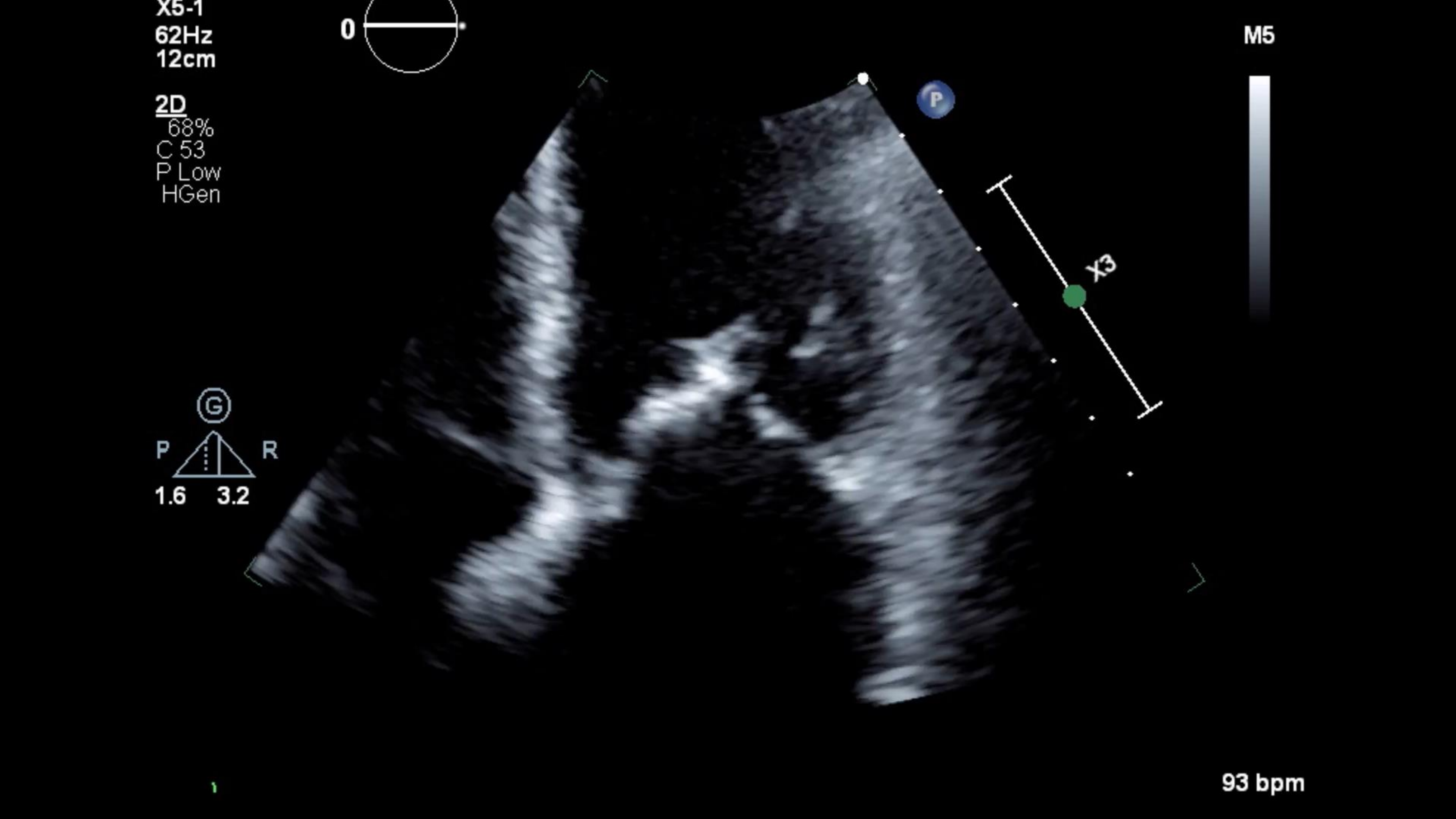
Echo parameters to grade severity of calcific MS

Rheumatic MS:
What does it look like?

- Commissural fusion
- Thickened leaflets
- Thickened chordae
- Diastolic doming (hockey stick appearance) – **NOT ALWAYS PRESENT**
- Fibrosed, immobile leaflets
- **Thickening begins at free margins of MV and extends toward its base**


HD
FPS: 89
f: 1.7 MHz/3.3 MHz
AG(t): 4 dB
Compr: 60 dB
DDP: 0.7
Soft
V
6
8
10
12
HD
FPS: 77
f: 1.7 MHz/3.3 MHz
AG(t): 6 dB
Compr: 60 dB
DDP: 0.7
Soft
V
4
6
8
10
69
HR


V
5
0
V


X5-1
62Hz
12cm
0
2D
68%
C 53
P Low
HGen
M5
P
X3
G
P
R
1.6
3.2
93 bpm

Degenerative Calcific MS

Euro Heart Survey on Valvular Disease

- 1:8 cases of MS (majority of which severe) were due to mitral annular calcification (MAC)

MAC seen in patients with:

- HTN
- HCM
- AS
- Renal failure
- Chest radiation
- MVP
- Most common in elderly

MAC is a predictor of:

- MI
- Vascular death
- Stroke
- AF
- CAD

Calcific:
What does it look like?

Mitral annular calcification (MAC) - Calcification any region of the annulus can cause a ‘shelf’ at the mitral annulus

MAC most common posteriorly

Post radiation calcification also affects anterior leaflet

MAC is probably **not** confined to the thin annulus

Calcium can extend onto bases of leaflets and affect leaflet mobility/structure

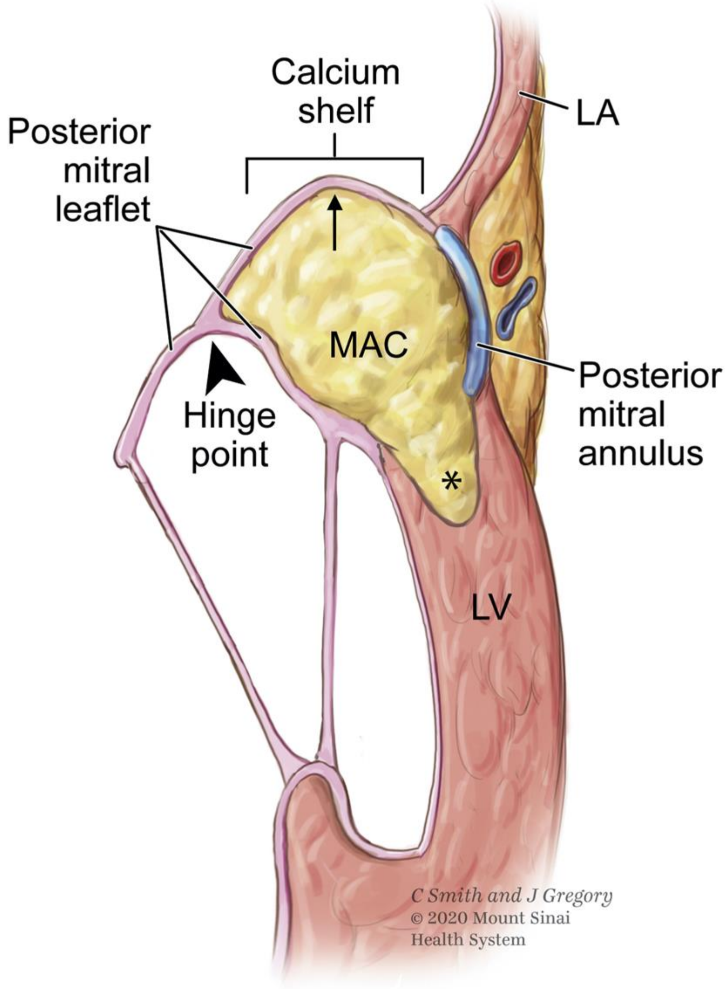
MAC causes valvular stenosis when calcifications extends onto leaflets and displaces hinge points

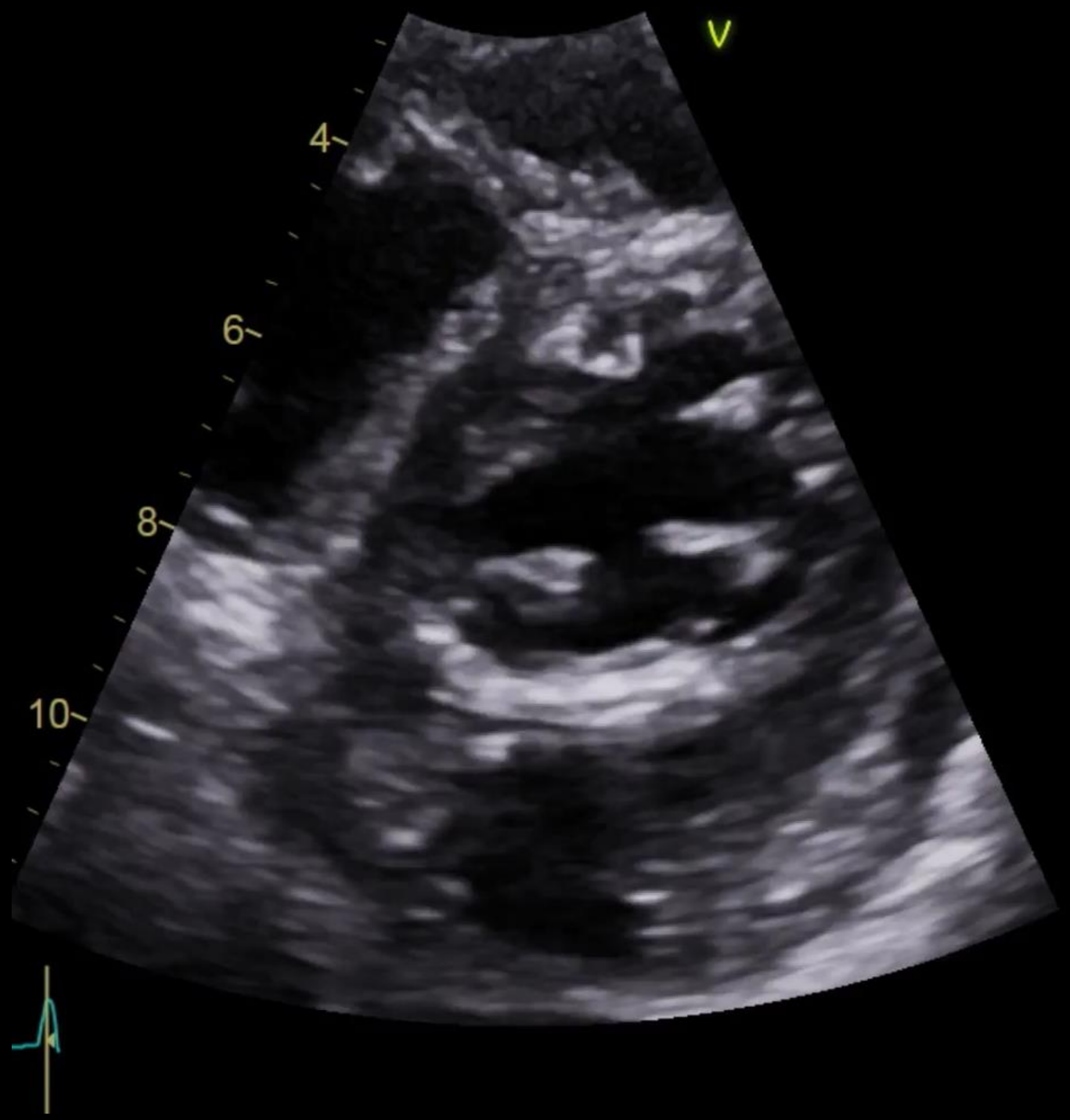
Not all MAC causes stenosis

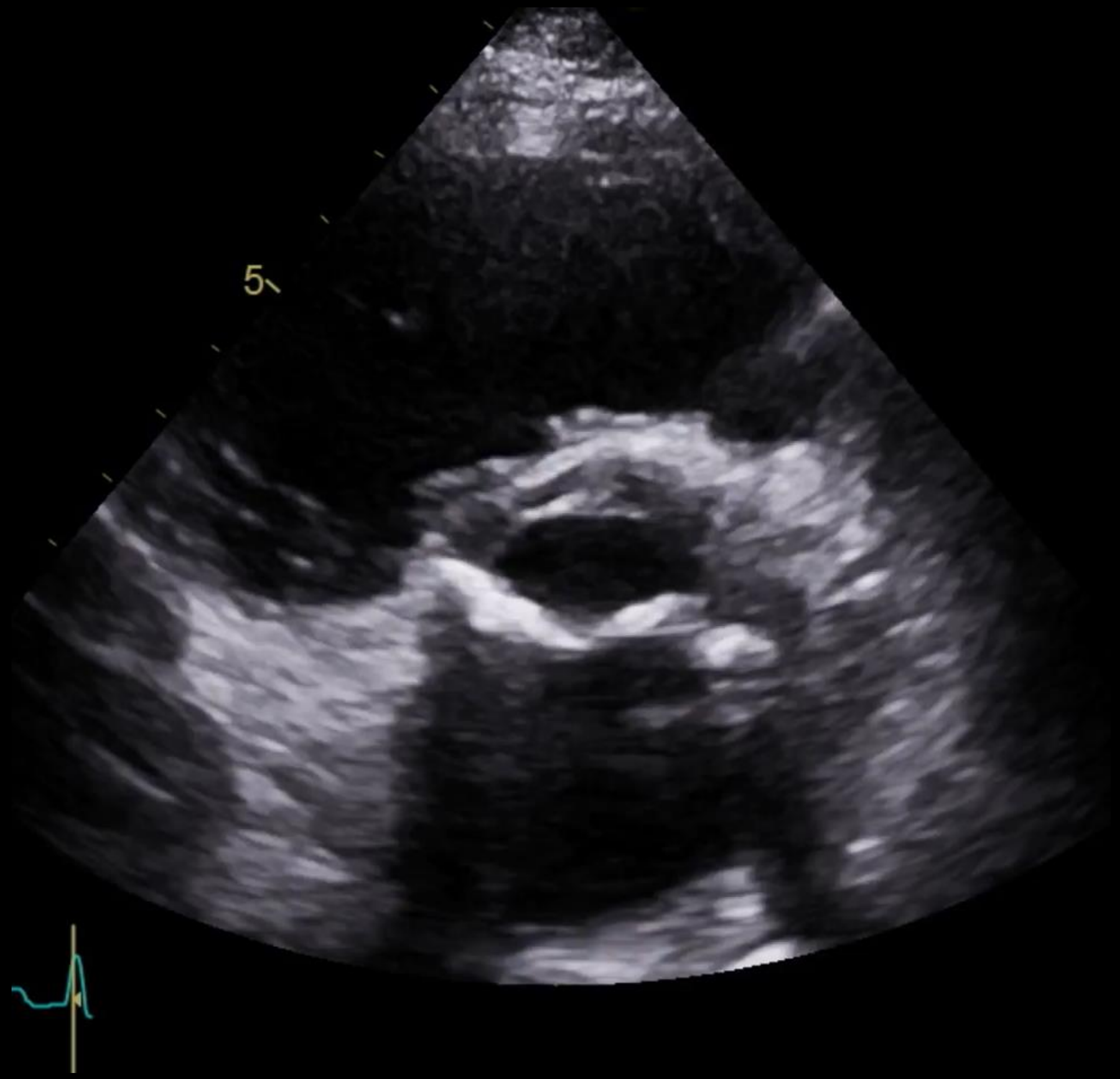
Anterior involvement may predict smaller MVA

Posterior MAC

- Sibiger. Mitral Annular Calcification and Calcific Mitral Stenosis: Role of Echocardiography in Hemodynamic Assessment and Management. J Am Soc Echocardiogr 2021 Sep;34(9):923-931.




V
4
6
8
10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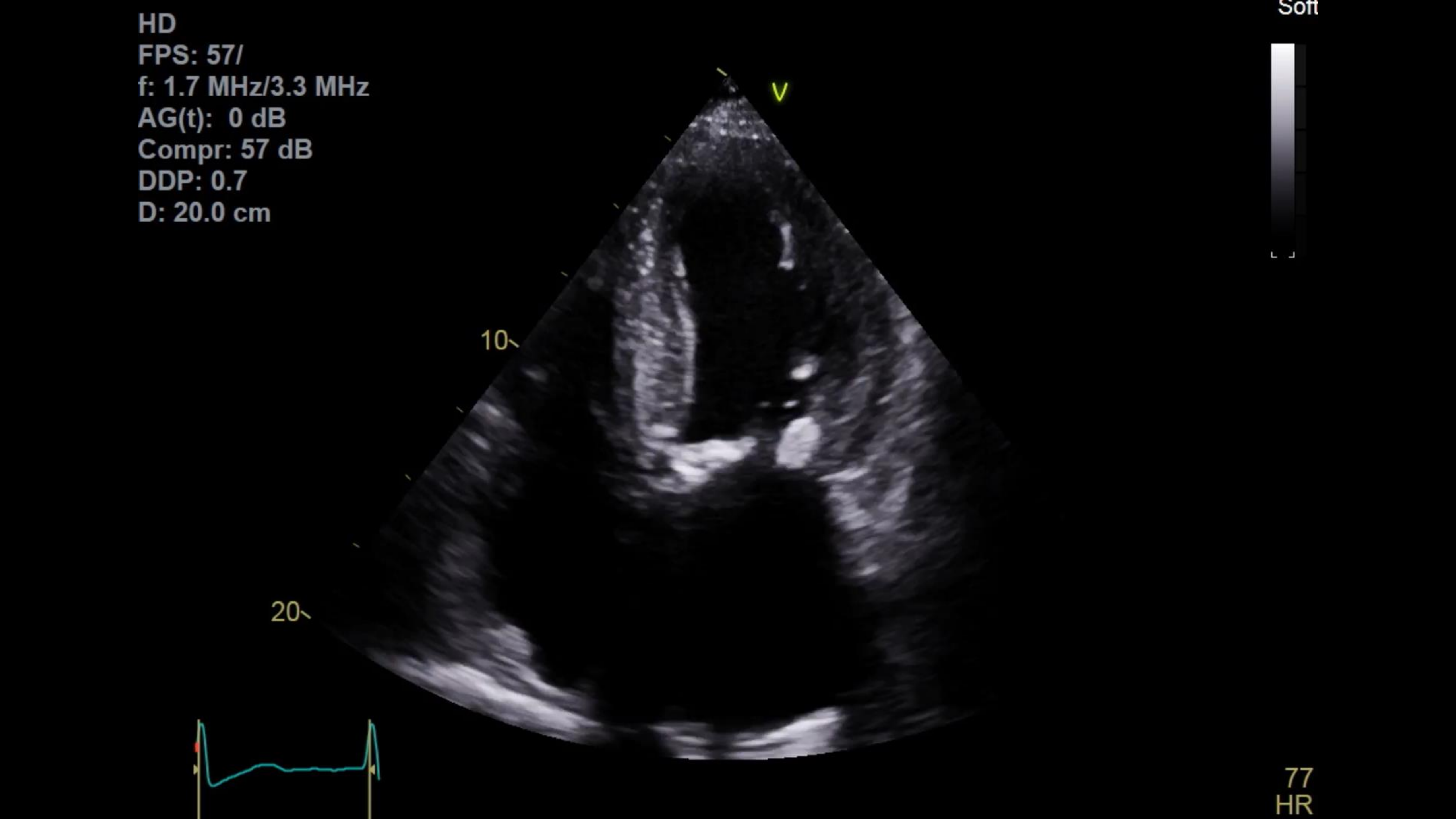
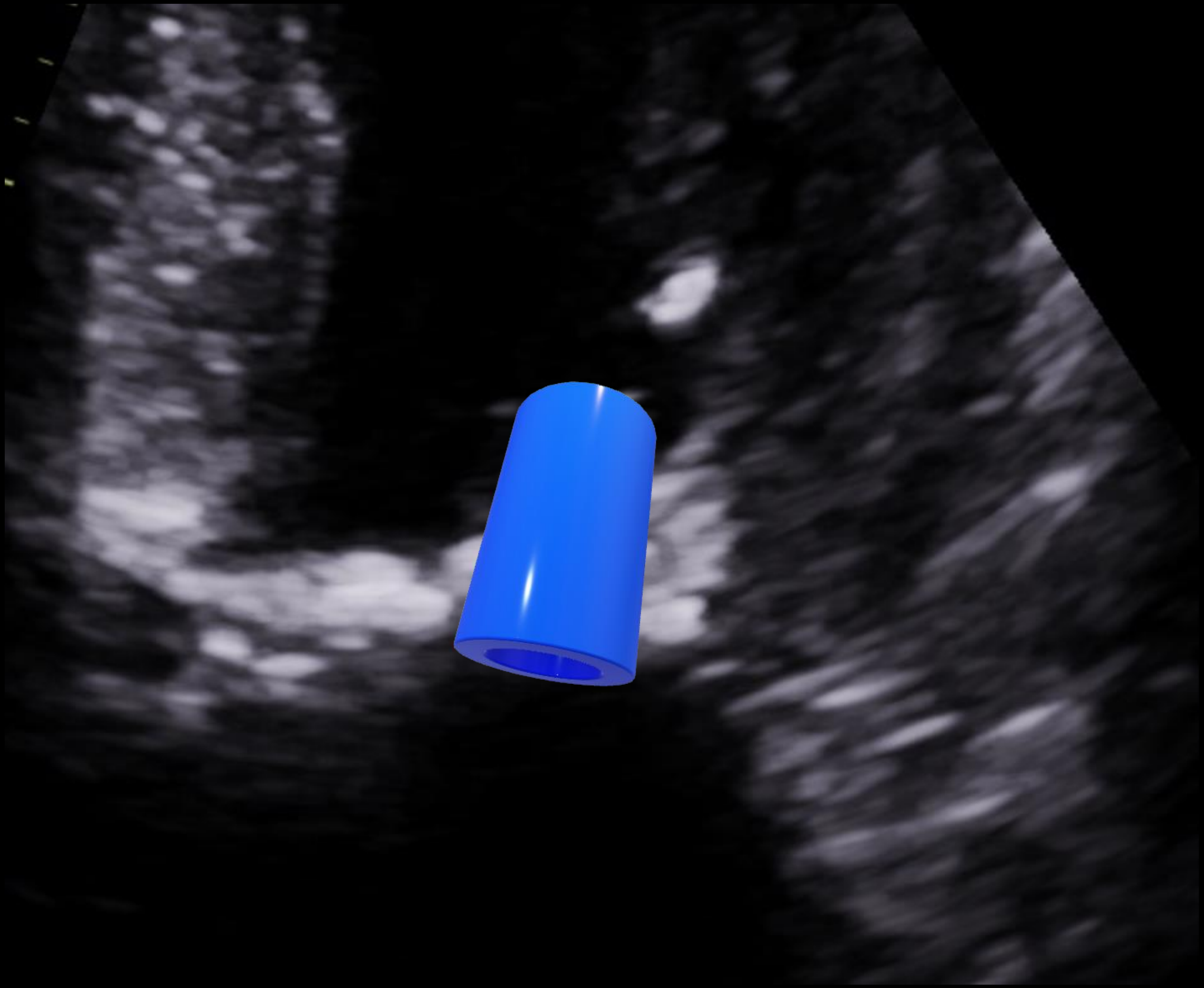

HD
FPS: 57/
f: 1.7 MHz/3.3 MHz
AG(t): 0 dB
Compr: 57 dB
DDP: 0.7
D: 20.0 cm
Soft
V
10
20
77
HR

Rheumatic Vs Degenerative

Rheumatic	Calcific
• Thickening at free edges • Commissural fusion • **Funnel shaped stenosis** • **Fish mouth orifice**	• Calcification at leaflets bases and annulus • Leaflet hinge points displaced • **Tubular stenosis** • **Crescent shaped orifice**




MV Area (Planim): 1.31 cm²
6
8
10


4
6
8

Geometry of valve

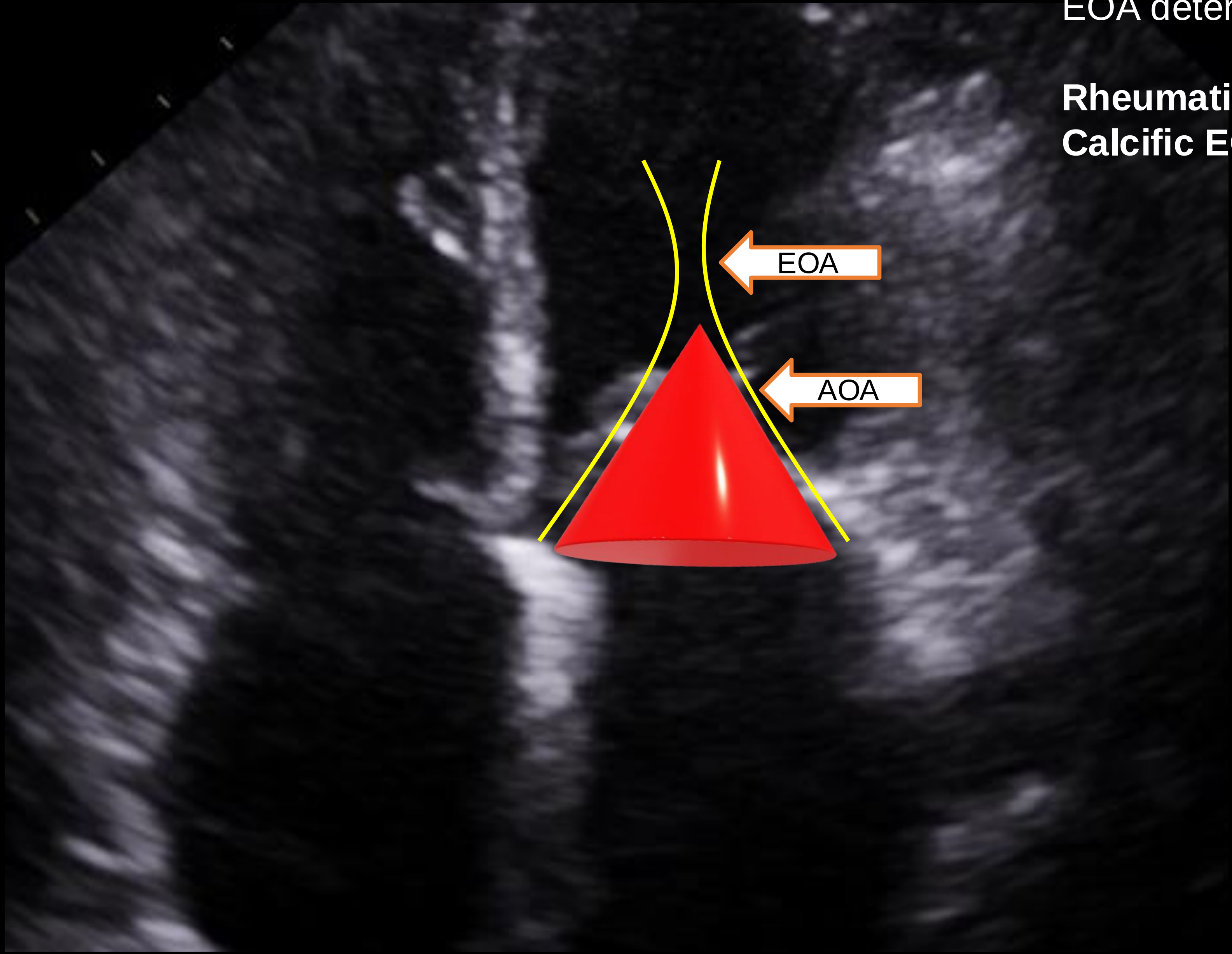
Rheumatic MS:

- Funnel shaped stenosis the CSA decreases from annulus to the valve with smallest effective orifice area (EOA) at the vena contracta (after passing through the valve!)
- EOA is smaller than anatomic orifice area (AOA)

Calcific MS:

- Tunnel/tubular shape, area roughly the same at annulus and leaflets
- EOA = or > AOA
- If Ca^{2+} extends to more than ½ of either leaflet the stenosis will not be tubular shaped and EOA may be < AOA

EOA Determines MPG



EOA determines the MPG

Rheumatic EOA < AOA
Calcific EOA = AOA

GUIDELINES AND STANDARDS | VOLUME 36, ISSUE 1, P3-28,
JANUARY 2023

PDF [6 MB] Figures

Recommendations for the Use of Echocardiography in the Evaluation of Rheumatic Heart Disease: A Report from the American Society of Echocardiography

Natesa G. Pandian, MD (Chair) • Jin Kyung Kim, MD, PhD, FASE (Co-Chair) •
Jose Antonio Arias-Godinez, MD • ... Ashwin Venkateshvaran, PhD, RCS, RDCS, FASE •
Marcelo Luiz Campos Vieira, MD, PhD • Stephen H. Little, MD, FASE • Show all authors

How bad is the stenosis?

How bad is the stenosis?

Table 1 Classification of Mitral Stenosis Severity

	Progressive (Mild)	Progressive (Moderate)	Severe
Valve area (cm^2)	>2.5	2.5-1.6	≤1.5
Pressure half-time (milliseconds)	<100	100-149	≥150
Mean gradient (mmHg)*	<5	5-9	≥10
Systolic pulmonary artery pressure (mmHg)	<30	30-49	≥50

*At a heart rate of 60-80 beats per minute

2020 ACC/AHA Guideline for the Management of Patients With Valvular Heart Disease: A Report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines

Catherine M. Otto et al

The transmitral mean pressure gradient should be obtained to further determine the hemodynamic effect of the MS and is usually >5 mm Hg to 10 mm Hg in severe MS; however, because of the variability of the mean pressure gradient with heart rate and forward flow, it has not been included in the criteria for severity.

Mean Pressure Gradient (MPG)

Pure rheumatic MS

- Relationship between MVA and MPG predictable
- MPG 5 – 10mmHg when MVA ≤ 1.5 cm^2 and **HR 60-80 bpm in sinus rhythm**

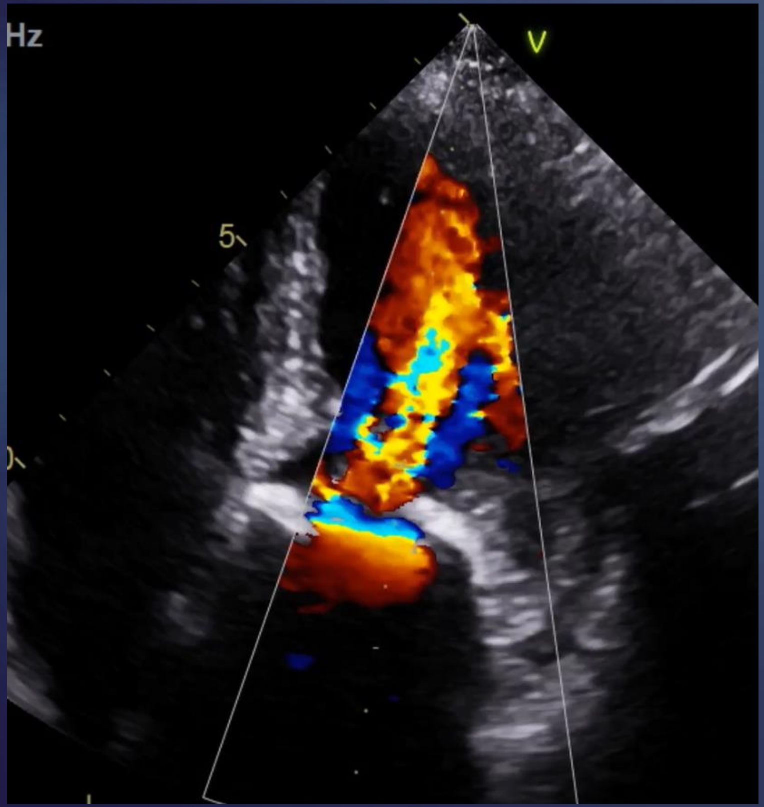
MAC

- Less predictable – multiple confounding factors
- **Reduced LA operational compliance** caused by:
  - MAC, comorbidities (diabetes, HTN, obesity, CAD), decreased LV compliance (diastolic dysfunction)
  - Results in increased LA pressure (tall LA v wave with steep y descent)
  - Coexistent MR (increases MPG)
- **MPG reduced out of proportion to MVA**

Comparison

- **For a given MVA the mean gradients may be lower in calcific than rheumatic valves**

Mean pressure gradient (MPG)



ASE previously recommended MPG as a "Supportive Sign"… why?

MPG affected by:

- Heart rate (reference ranges apply to HR between 60 and 80bpm)
- Cardiac output
- Mitral regurgitation
- LV and LA compliance

ALWAYS report the MPG with a HR

ALWAYS align CW Doppler cursor to inflow!

Mitral Valve Area

1. Planimetry: 2D or 3D

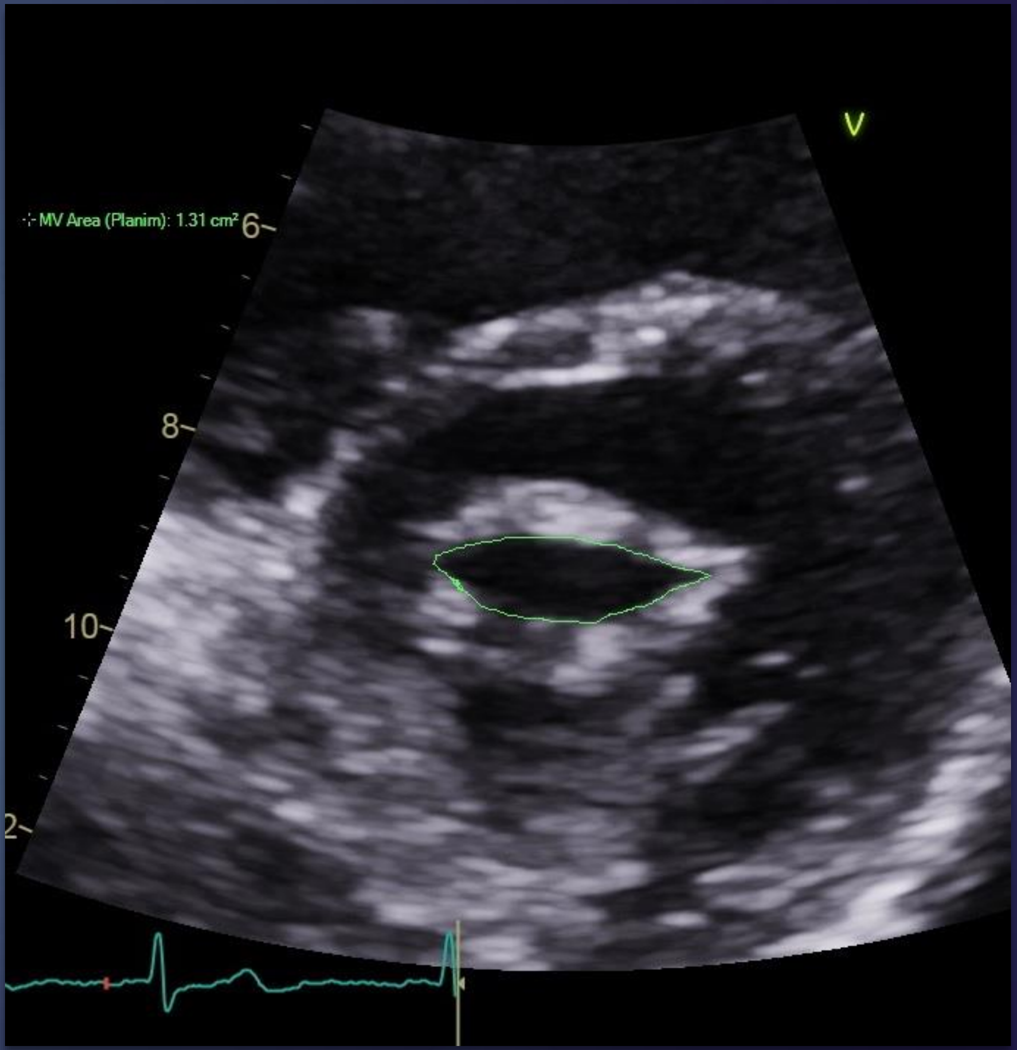
2. Pressure half time method

3. Continuity equation

4. PISA

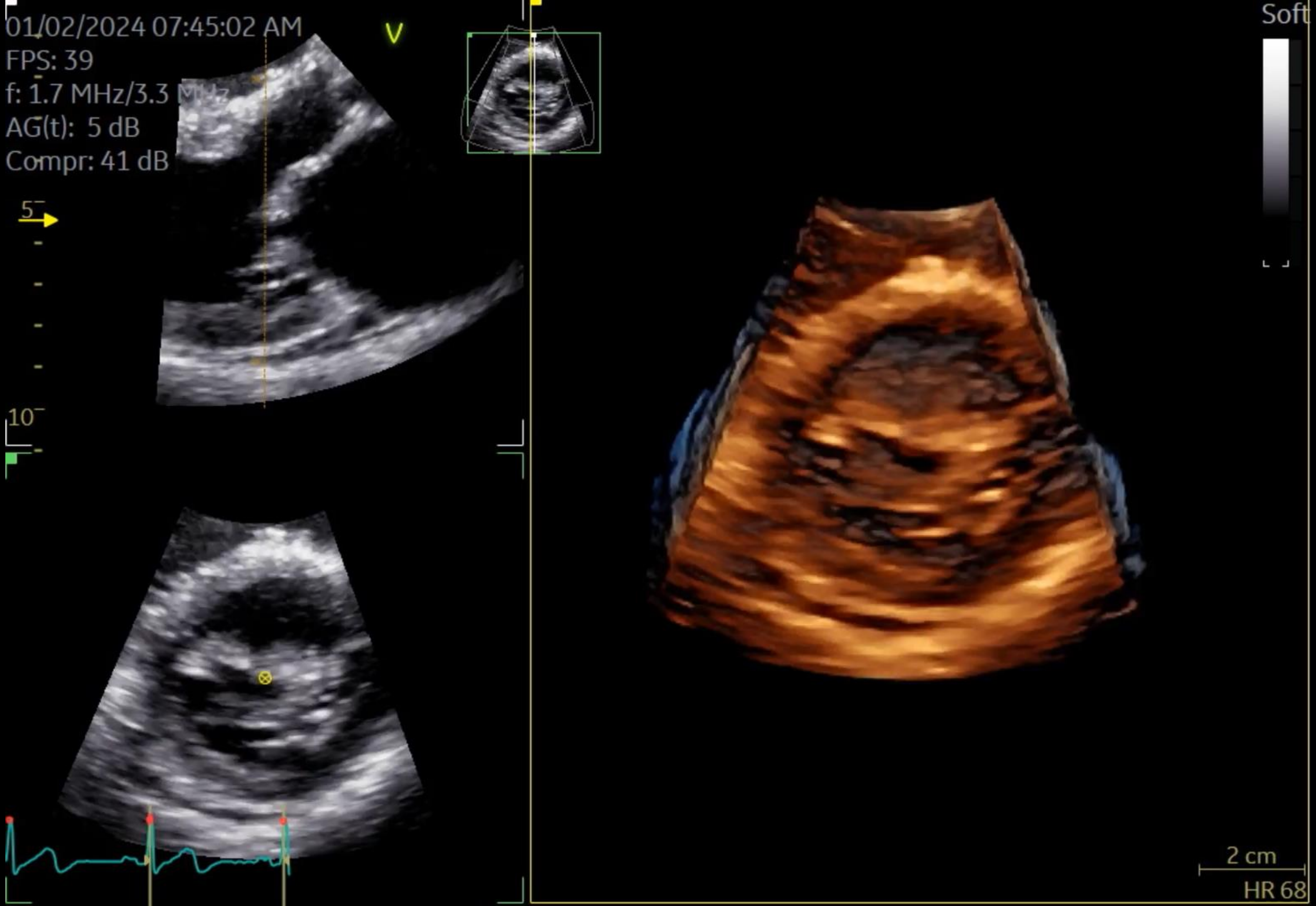
Planimetry – rheumatic MS

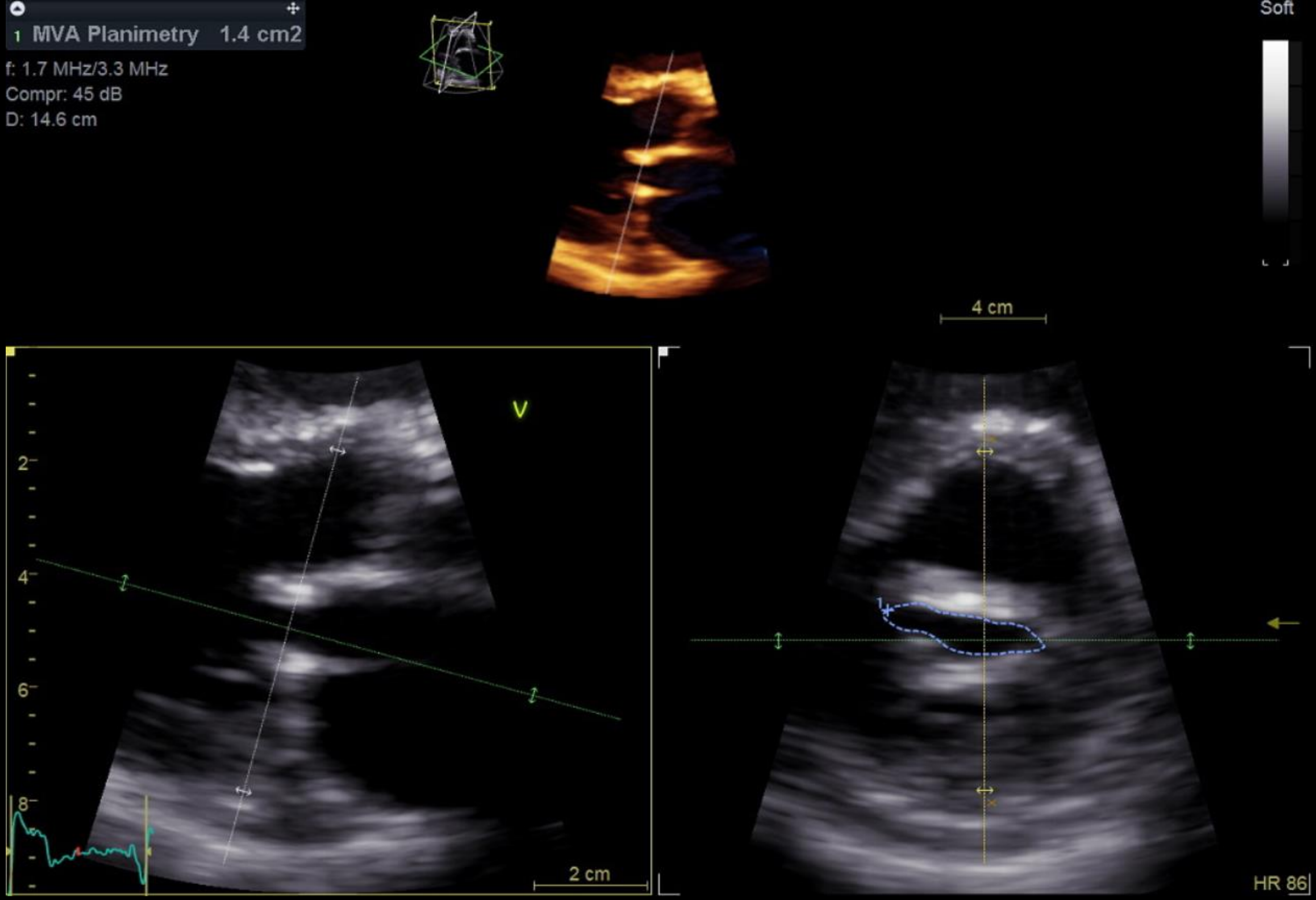
- **Gold Standard (rheumatic)**
- **Anatomical area** of valve
- **Most accurate method** – no assumptions regarding flow conditions, chamber compliance or associated lesions
- Parasternal short axis view
- Pan from papillary level slowly toward base of LV to find smallest CSA at tips of mitral valve
- Trace inner margin, including commissures (if open)
- **Use 3D**



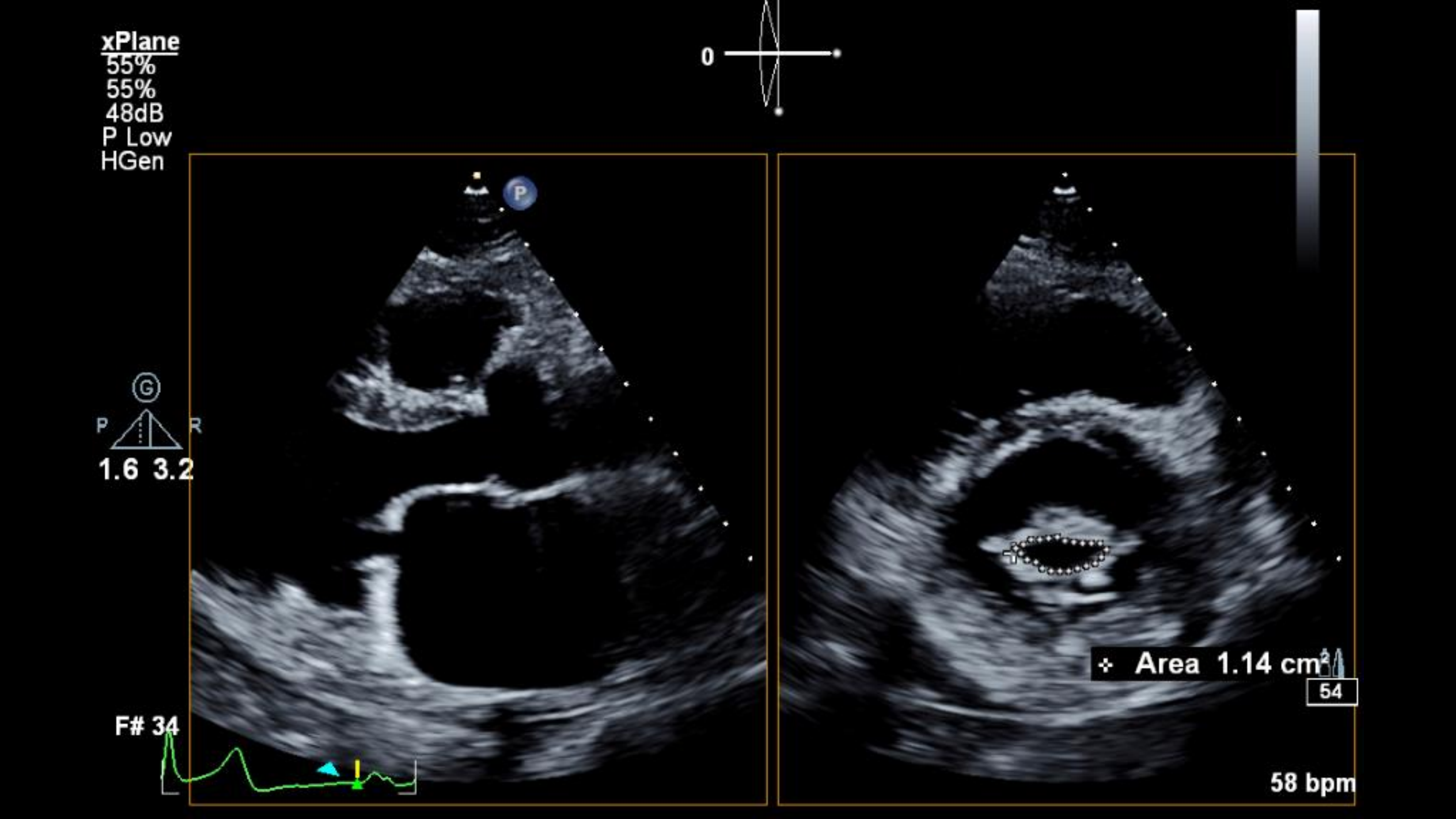
Planimetry: technical considerations

- Hi Res Zoom must be used
- 2D gain just sufficient to visualise the whole contour of the mitral orifice
- Excessive causes underestimation of valve area
- Measure in mid-diastole
- Measurement plane should per perpendicular to mitral orifice
- Use highest frequency possible
- **3D imaging allows more reliable planimetry**


01/02/2024 07:45:02 AM
V
FPS: 39
f: 1.7 MHz/3.3 MHz
AG(t): 5 dB
Compr: 41 dB
5
10
Soft
2 cm
HR 68



1 MVA Planimetry 1.4 cm2
f: 1.7 MHz/3.3 MHz
Compr: 45 dB
D: 14.6 cm
Soft
4 cm
V
2
4
6
8
2 cm
HR 86

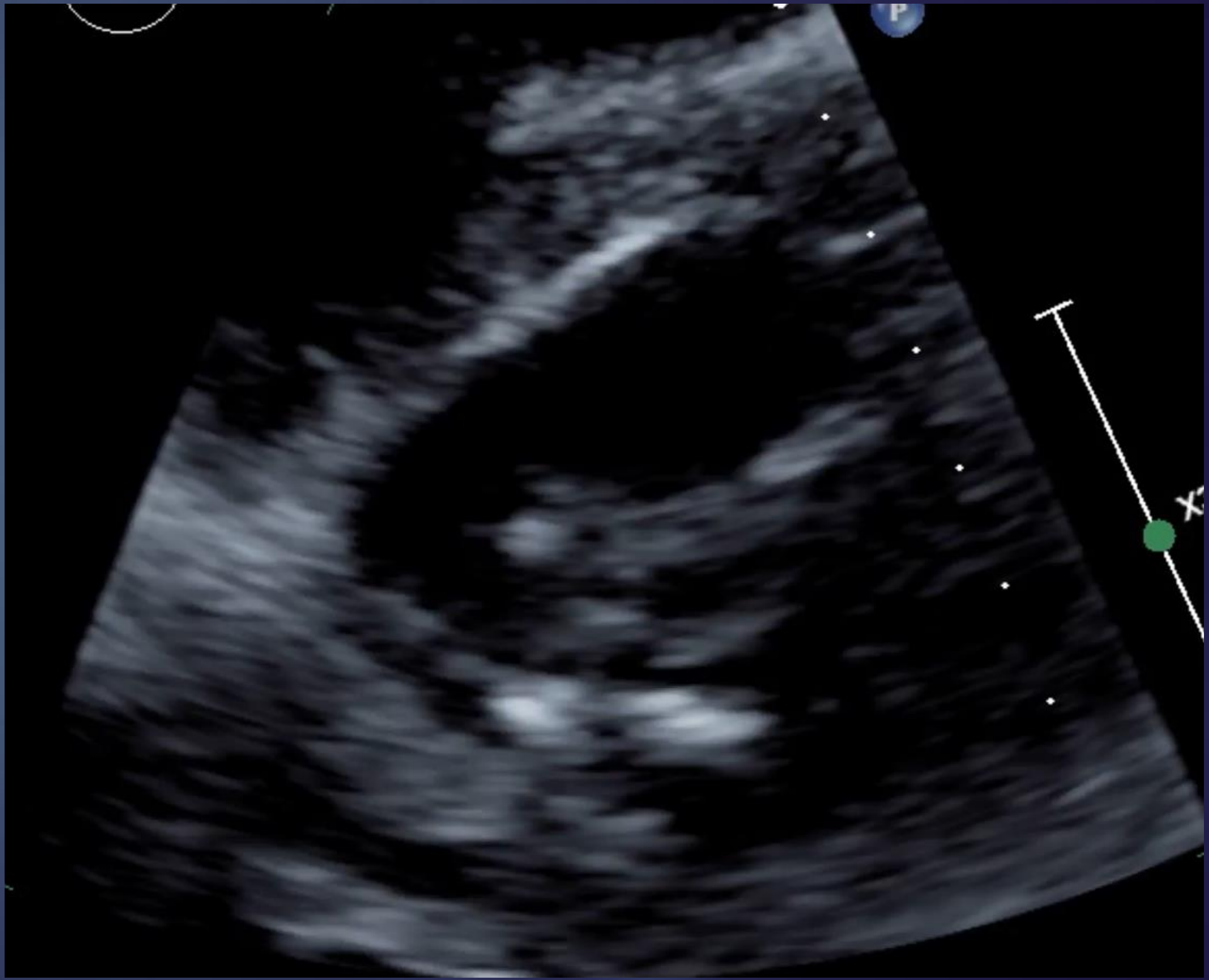

xPlane
55%
55%
48dB
P Low
HGen
0
P
G
P R
1.6 3.2
F# 34
Area 1.14 cm²
54
58 bpm

Limitations – planimetry rheumatic

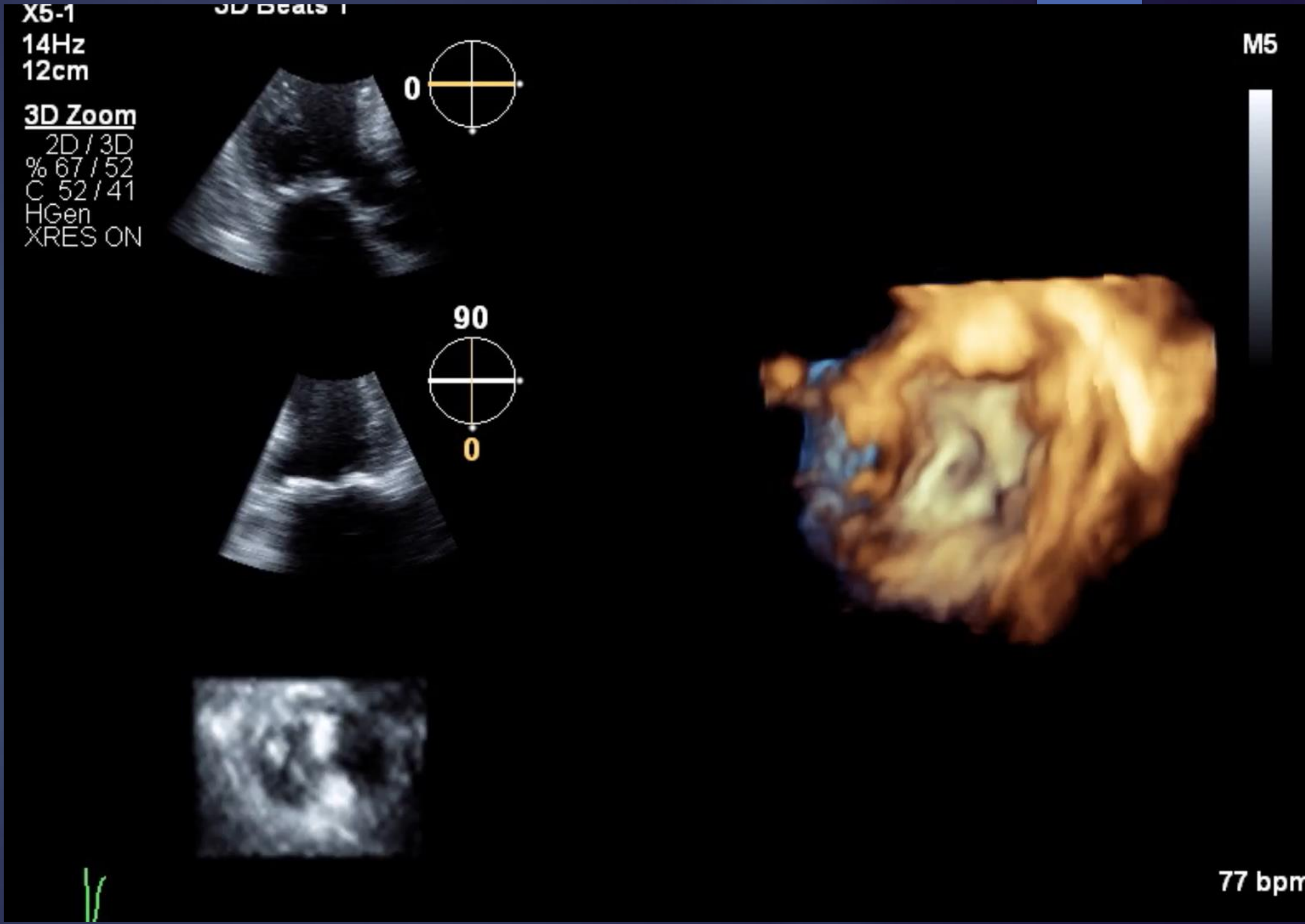
- Accurate measurement requires technical expertise
- Severe distortion of valve anatomy, particularly severe calcification at leaflet tips
- Poor acoustic windows

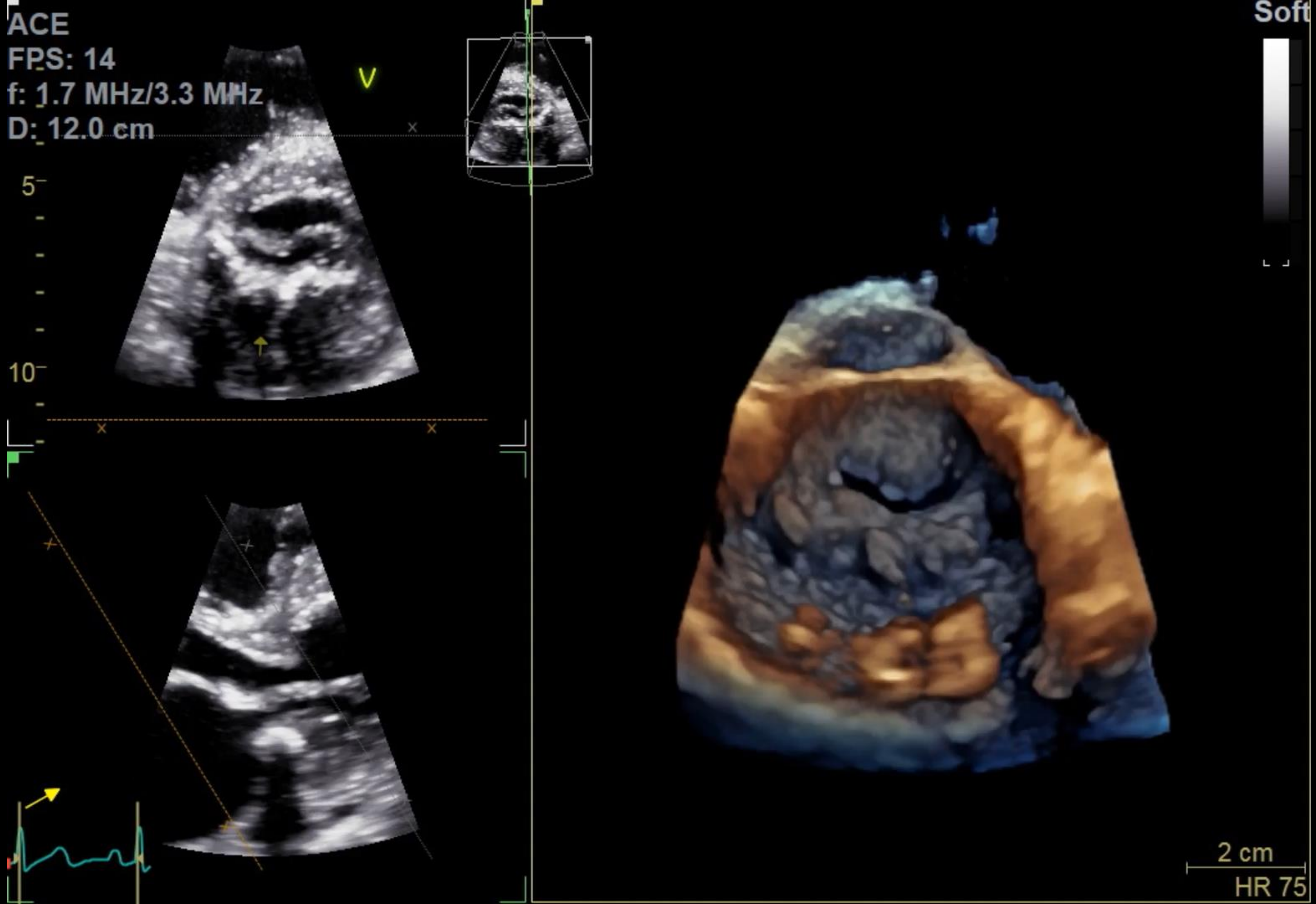
Planimetry – calcific MS

- Acoustic shadowing by calcification
- Geometry of the valve affected
- Where to measure???
- Narrowing may be most severe at leaflet base or annular level…
- Image quality



3D challenging

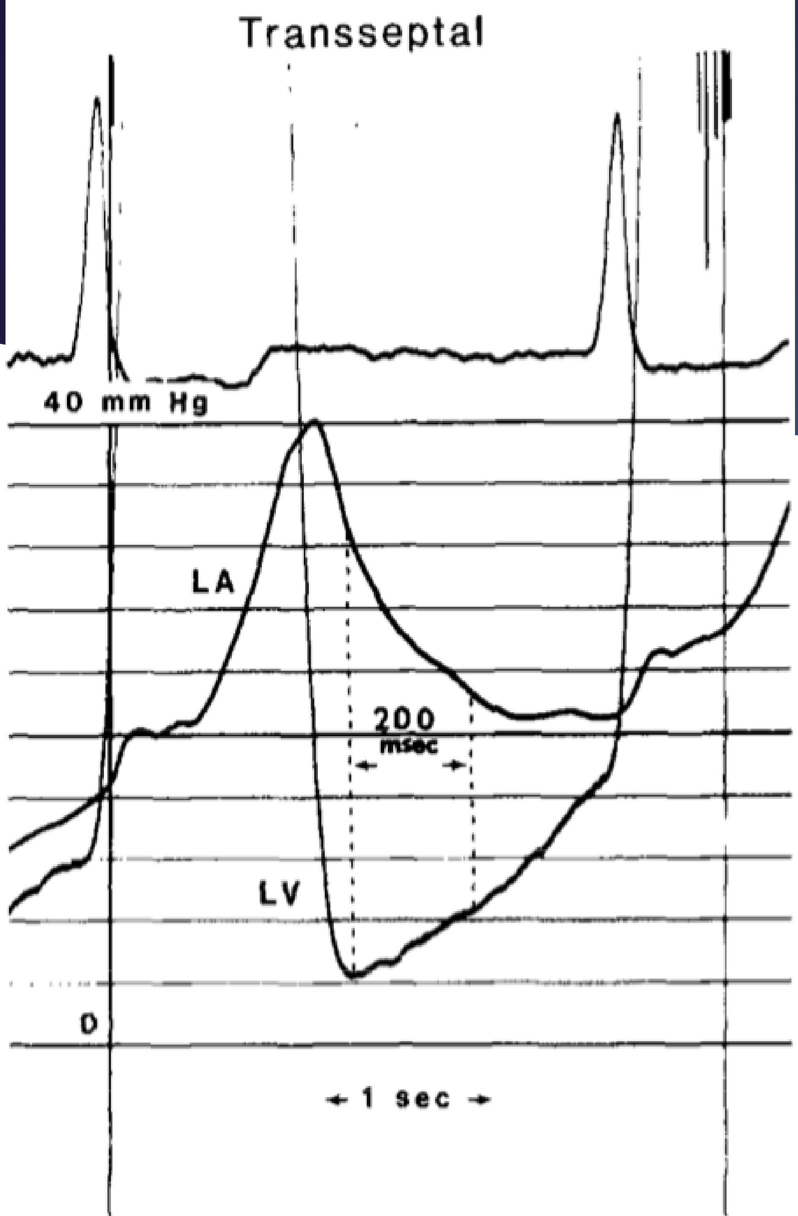



ACE
FPS: 14
f: 1.7 MHz/3.3 MHz
D: 12.0 cm
V
5
10
Soft
2 cm
HR 75

1. Planimetry: 2D or 3D

Rheumatic	Calcific
• **Gold standard** • 3D even better than 2D • Achievable in vast majority of patients	• Where to measure? – minimum stenosis often not at leaflet tips • Valve /annulus geometry altered • Acoustic shadowing • Unreliable in degenerative MS

2. Pressure half time method

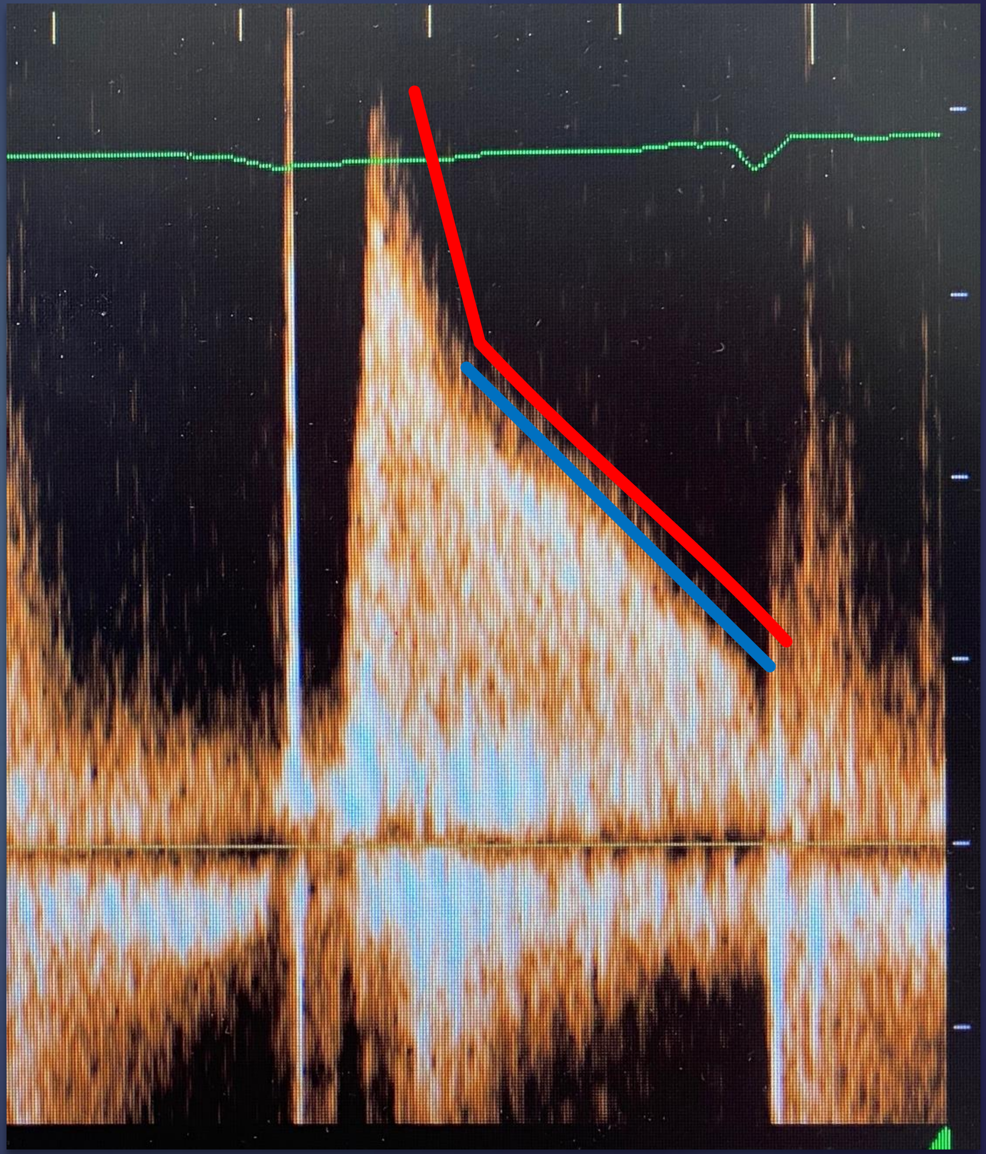


Pressure tracings that demonstrate gradient between LA and LV with micromanometer catheters and a transeptal approach.

Value and limitations of Doppler pressure half-time in quantifying mitral stenosis: A comparison with micromanometer catheter recordings. *American Heart Journal*, Feb 1991.

- Cath lab simultaneous recordings of LV and LA pressure in Rheumatic MS
- P1/2T was constant for any given individual even with exercise and changes in flow rate
- P1/2T concept adapted to trans-mitral Doppler
- Hatle et al studies discovered a linear relationship with P1/2T of 220ms equal to a valve area of 1 cm^2
- **MVA = 220 ÷ P1/2t**

If the slope is non-linear always measure the **mid diastolic slope**



Limitations

- Arrhythmias
  - Sinus tachycardia – E/A fusion, P1/2t cannot be measured
    - Rate control then redo study
  - AF – average many beats with adequate R-R interval, avoid beats with short diastolic filling time
- Significant AR
  - Increased LVEDP causes a reduced PG across mitral valve at end diastole
  - Results in shortened pressure half time
  - Overestimate MVA
- Significant MR
  - Increased E velocity prolongs P1/2t
  - LA volume overload shorten P1/2t …

Limitations

- Acute change in LA compliance
  - P1/2t MVA inaccurate for 24 - 48 hours post PBMV
- Reduced atrial compliance: Short P1/2t can be seen despite severe MS
- Diastolic function (LV compliance also affects decel. time / p1/2t)
- P1/2t less accurate in the elderly

Limitations

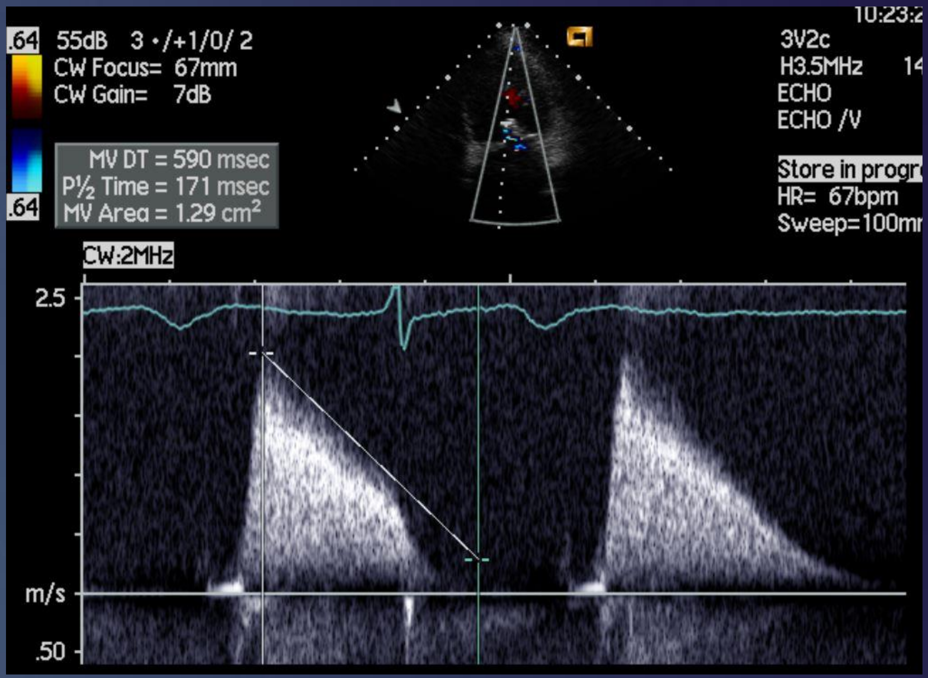
- Atrial septal defect
  - ASD + MS = Lutembacher syndrome
  - MPG underestimated
  - MVA by P1/2t overestimated

- P1/2t MVA **does not work if valve is not stenosed**
  - **Also not for MV repair, replacement or TEER**

- **Machine should not provide an MVA from every diastolic function assessment!**

P1/2t Calcific MS

- Comorbidities affect LV and LA compliance
- **P1/2t overestimates MVA compared to continuity equation and invasive measurements**
- **NOT RECOMMENDED**



2. Pressure half time method

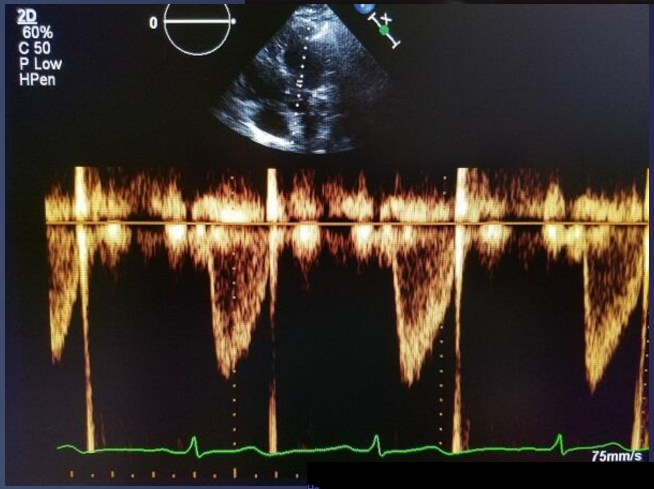
Rheumatic	Calcific
• MVA = 220 / pressure half time • Strong correlation • Validated with explanted valves • **Need to know the many limitations!**	• Overestimates valve area • Most limitations apply to this patient population! • LA compliance is usually low • LV compliance also affected (elderly, diastolic dysfunction, LVH…) • Geometric differences in the stenosis may also affect P1/2t

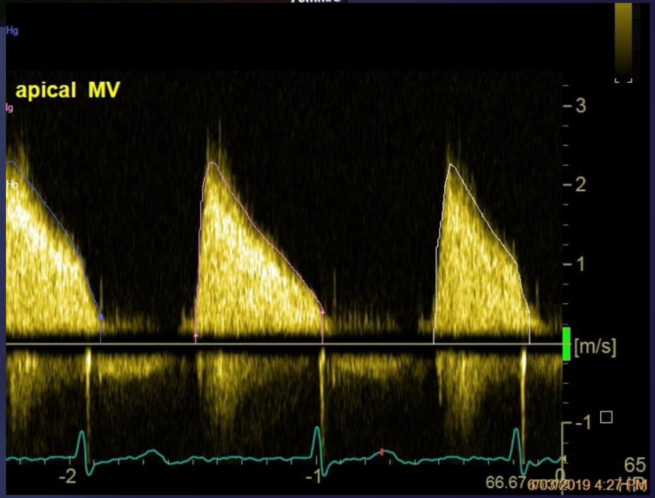
3. Continuity equation

- Conservation of mass principle
- **If no AR or MR then:**

$$SV_{MV} = SV_{LVOT} \qquad (SV = \text{stroke volume})$$

- **MVA = $(CSA_{LVOT} \times VTI_{LVOT}) \div VTI_{MV}$**



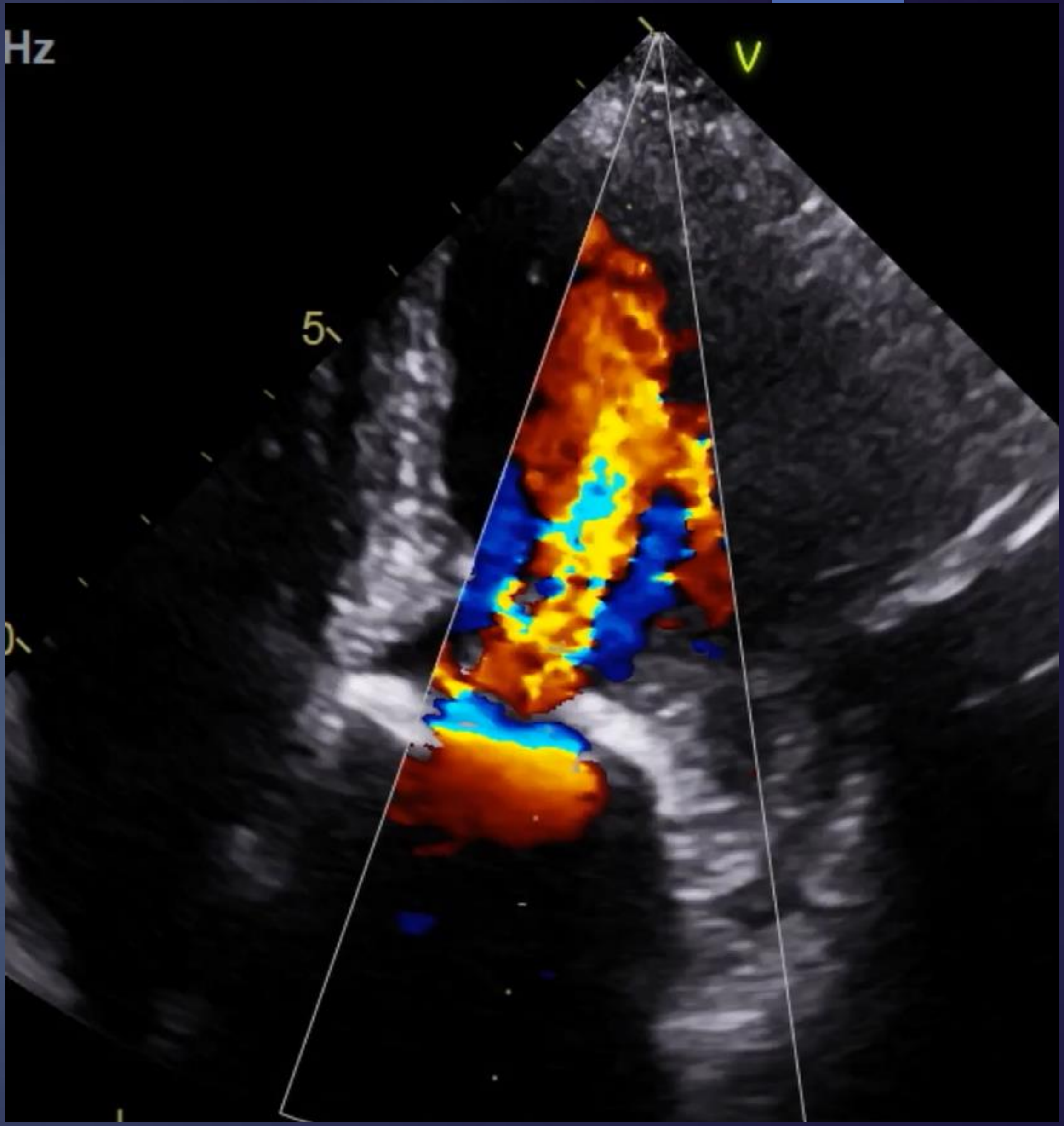


3. Continuity equation

Technical consideration:

- Cursor must be aligned to flow
  - May require off axis imaging
  - Use colour Doppler to align the CW cursor with stenotic LV inflow

- Limitations:
  - Regurgitation
  - AF – average 5 or more beats, attempt to HR match LVOT and MV Doppler
  - LVOT diameter with extensive calcification…

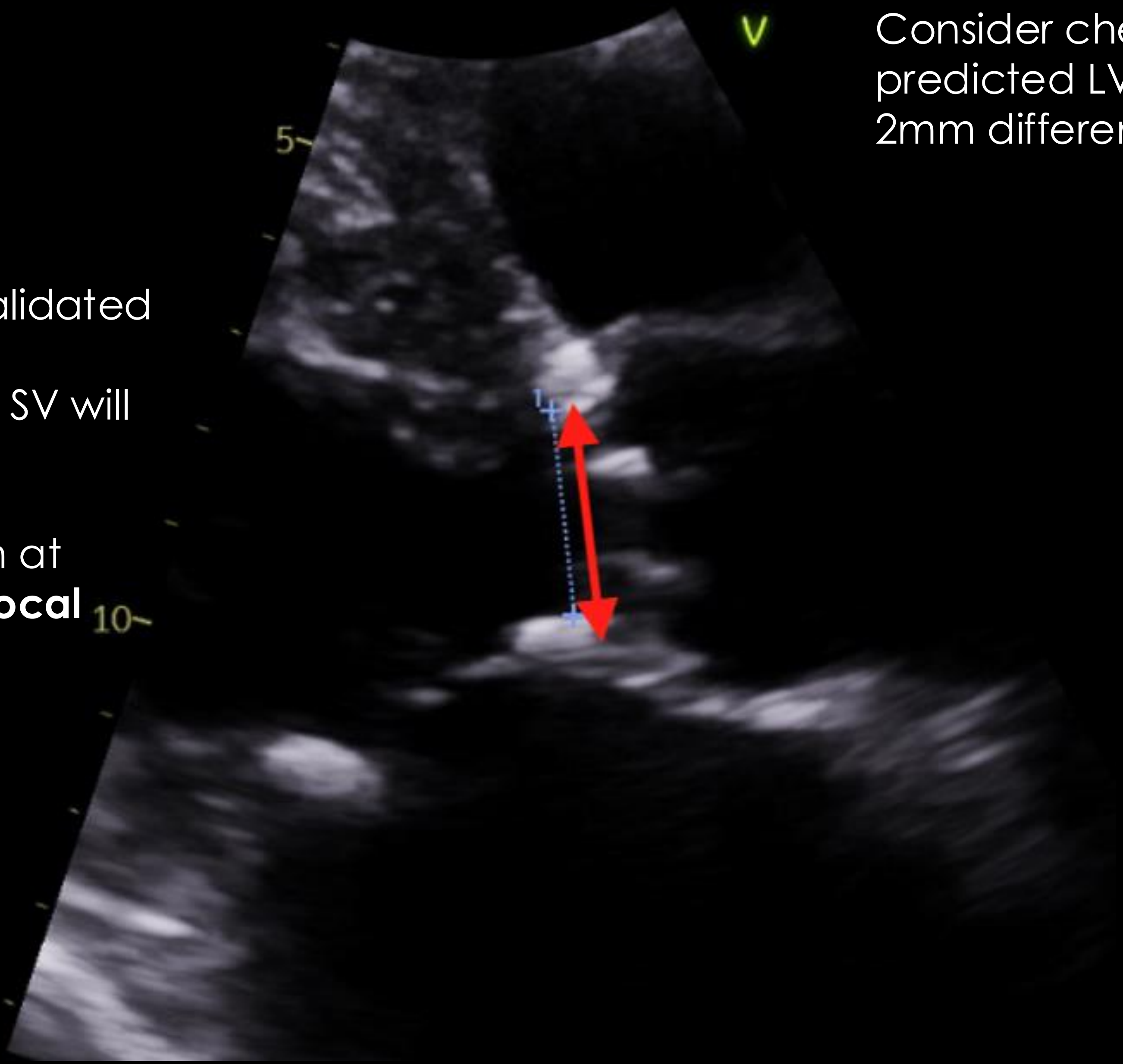


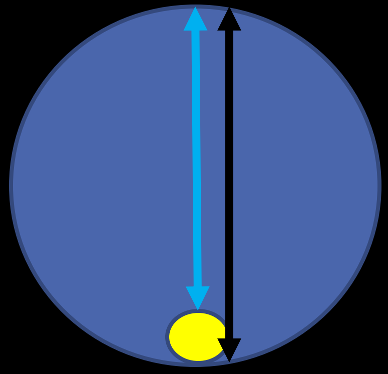
LVOT diameter = (5.7 x BSA) + 12.1

Consider checking LVOTd with predicted LVOT formula. If > 2mm different re-measure!

Leaflet insertion points is validated against MRI stroke volume.
The further away the more SV will be underestimated.

Measure to leaflet insertion at mitral. **Do not measure to focal calcification.**





3. Continuity equation

Rheumatic	Calcific
• Planimetry and P1/2t work well / recommended • Continuity useful to validate	• **Preferred method** of MVA **IF** no more than mild AR or MR • Ca^{2+} extend to aorto-mitral curtain… LVOT diameter

4. PISA

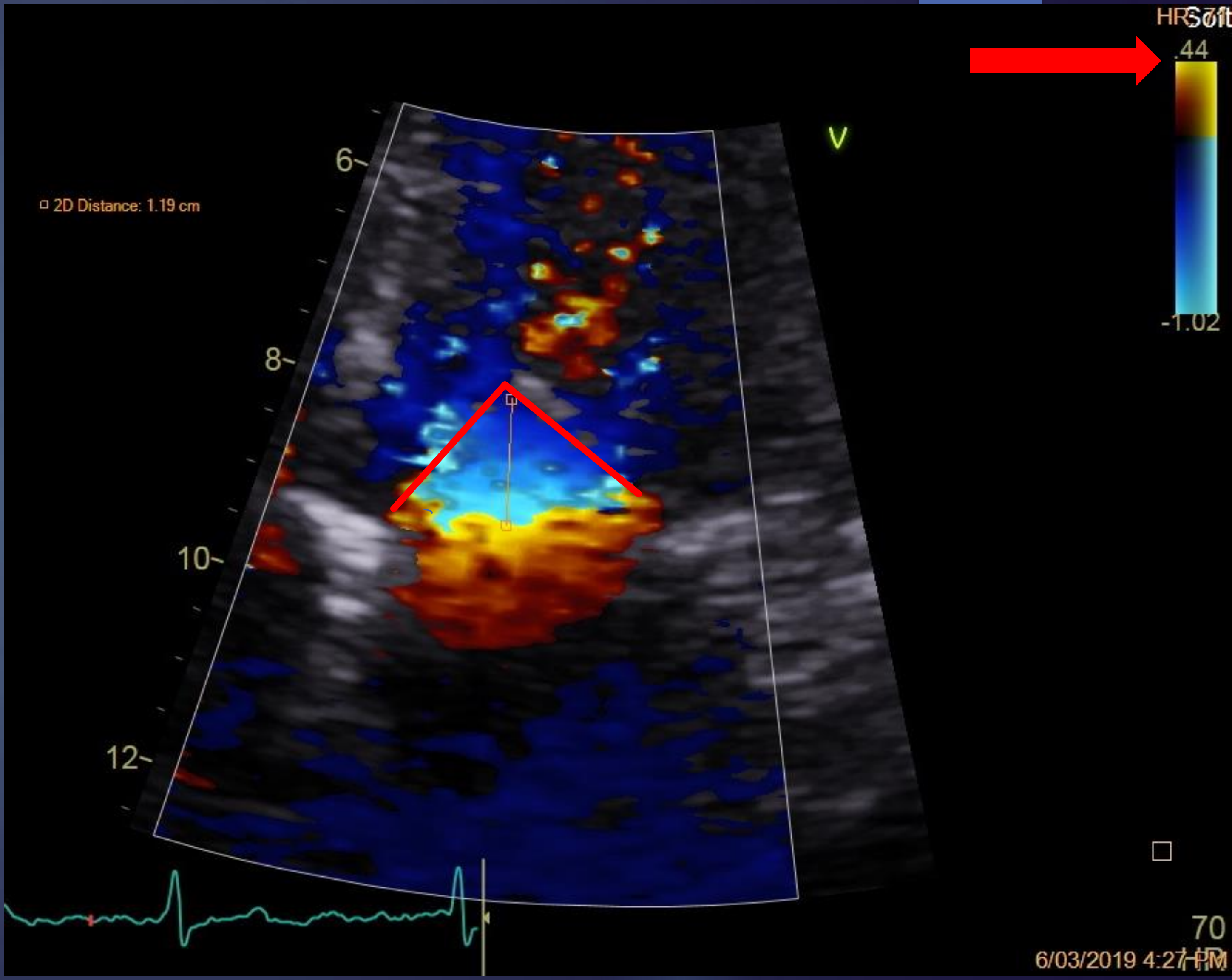
Proximal isovolumic surface area

- Same principle as continuity equation, conservation of mass through the valve

- Nyquist limit = 0.44 m/s
- r = 1.19 cm
- Peak E = 2.0 m/s
- Funnel angle (α) = 91°

EROc = $[(2\,\pi r^2 \times V_N) \div V_{max}] \times [\alpha \div 180]$

EROc = $[(6.28 \times 1.19^2 \times 0.44) \div 2.0] \times (91 \div 180)$
= $1.0\ cm^2$



MVA – PISA method

- Timing of radius should be same as peak E velocity
- Independent of flow conditions
  - Rate/rhythm
  - Regurgitation
  - Shunts
- Not validated in calcific mitral stenosis
- Technically challenging
- Pro:
  - Independent of flow conditions

4. PISA

Rheumatic	Calcific
• Independent of flow conditions • May be only method if planimetry not possible and significant AR • Technically challenging	• **Method not validated in calcific MS** • Tubular stenosis…

PASP

Pulmonary hypertension (PHTN) is commonly associated with MS

PASP reflects consequences of MS rather than severity itself

Increased LA pressure causes resistance to flow into LA and backward pressure on the pulmonary circulation

Wide range of PASPs for a given MVA

Important for clinical decision making

Calcific MS – common comorbidities can cause post-capillary PHTN

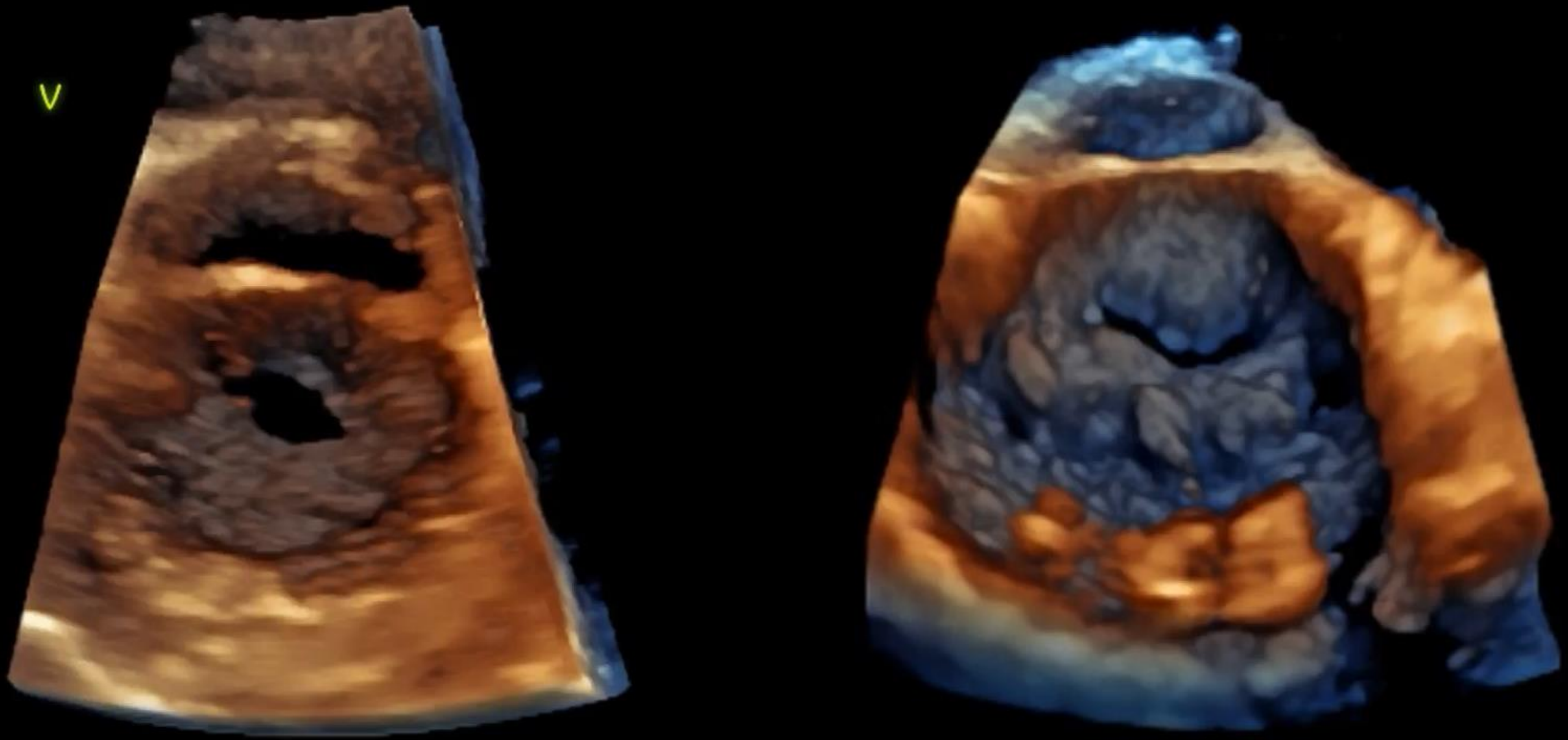
Rheumatic Vs Calcific MS

Rheumatic

- **Planimetry essential** – put in maximum effort!
- Pressure half time useful – keep in mind limitations
- Mean gradient – Quote WITH heart rate (and rhythm)
- PASP – wide range for given area

Calcific

- **Continuity MVA** IF < mild AR and/or MR
- MPG may be lower for MVA than if rheumatic
- P1/2t **will** underestimate severity
- Geometry of stenosis different


V

Reading / References

- Sibiger. Mitral Annular Calcification and Calcific Mitral Stenosis: Role of Echocardiography in Hemodynamic Assessment and Management. *J Am Soc Echocardiogr* 2021 Sep;34(9):923-931.

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