Quantification of Stenosis: Avoid these Pitfalls

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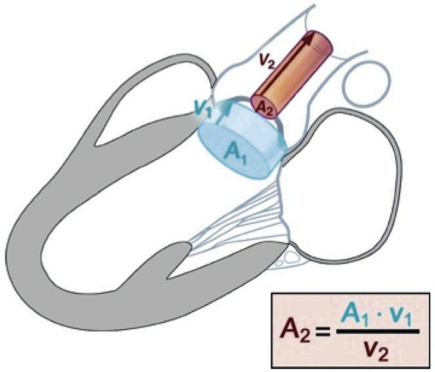
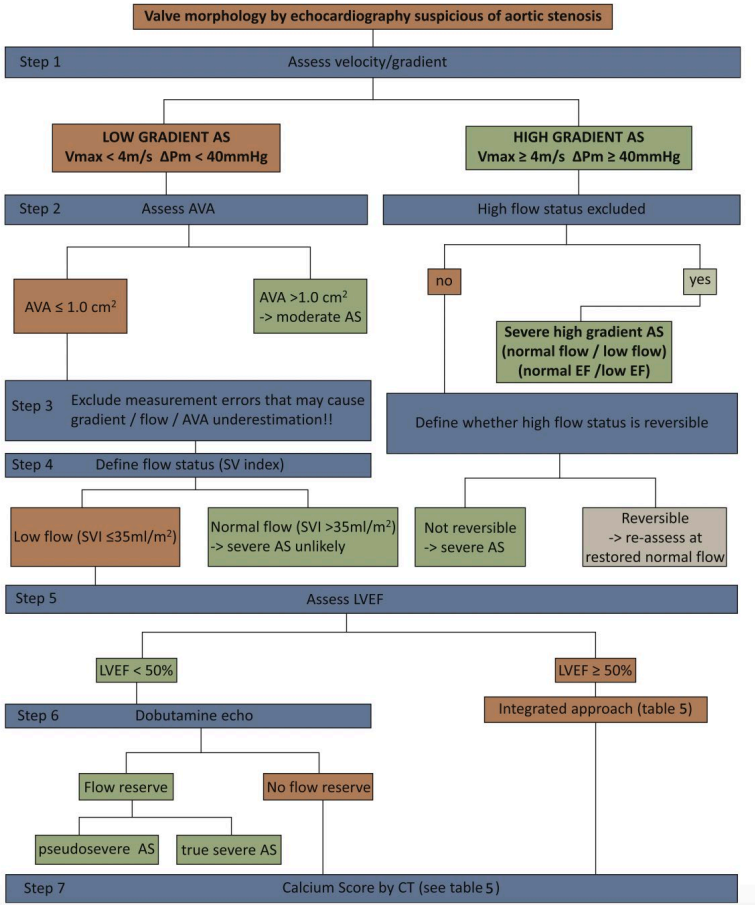
Objectives

- To review challenges in assessing aortic stenosis
- To discuss differences in assess mitral stenosis from rheumatic heart disease compared with mitral annular calcium
- To demonstrate the value of off-axis views to assess for pulmonic stenosis

Aortic Stenosis

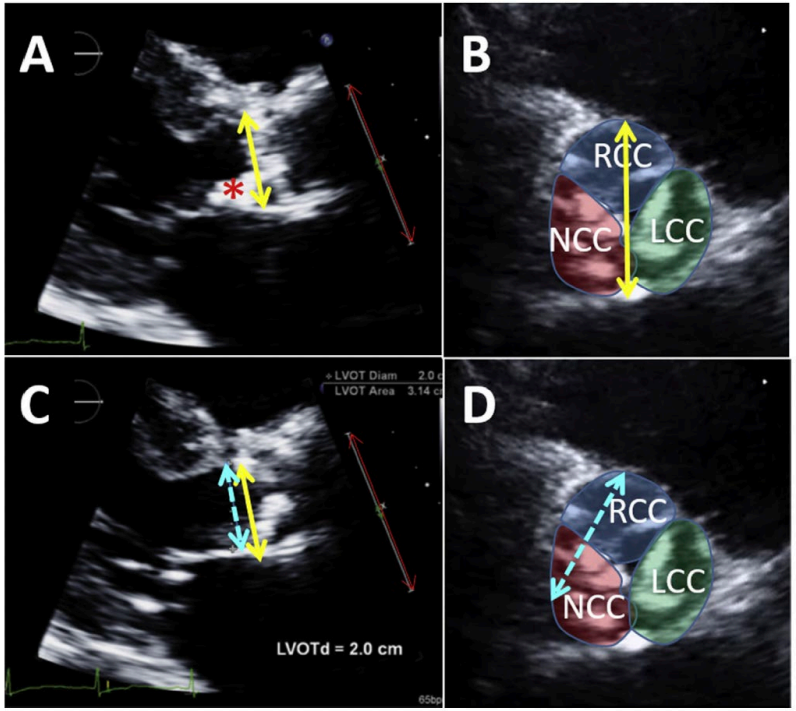
Recommendations on the Echocardiographic Assessment of Aortic Valve Stenosis: A Focused Update from the European Association of Cardiovascular Imaging and the American Society of Echocardiography





Baumgartner et al. J Am Soc Echocardiogr 2017;30:372-92

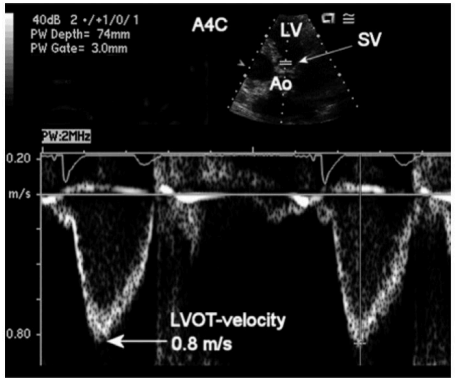
Aortic Stenosis : LVOT

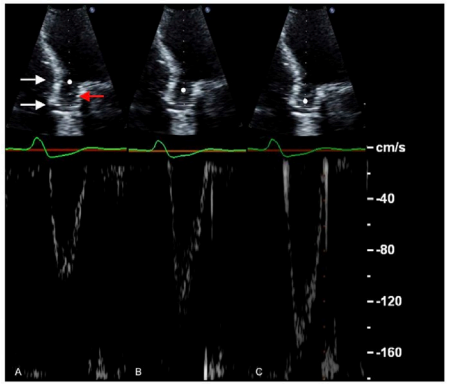


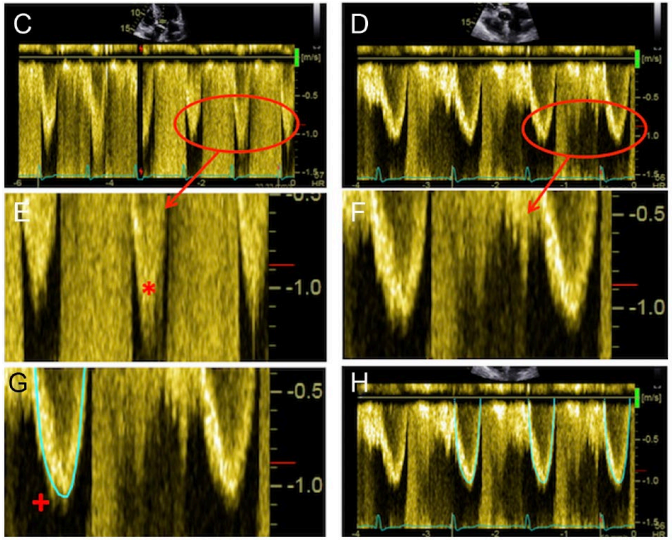
- Greatest potential for error in the calculation of AVA by the continuity equation is LVOT diameter, which must be squared to calculate LVOT area
- Use the mid systolic image that bisects the largest dimension
- If 2 leaflets are well seen, this may not be the optimal plane
- Measure at the annulus and exclude calcium if present
- AVA is <1.0 cm2 and indexed AVA is <0.6 cm2/m2 but DVI is >0.25, suspect underestimation of LVOT dimension

Hahn et al. JASE 2017;30(10):1038-40

Aortic Stenosis : LVOT







- LVOT measurement is overestimated, overestimating AVA
- When a smooth velocity curve can be obtained at the aortic annulus, this site is preferred for LVOT measurement
- Flow acceleration at the annulus level may occur so that it may be necessary to move the sample volume apically by 0.5–1.0 cm to obtain a laminar flow curve without spectral dispersion
- Applies to prosthetic valves

Shames et al. JASE 2012: 25 (6); 603-609
Ring L, et al. https://doi.org/10.1530/ERP-20-0035

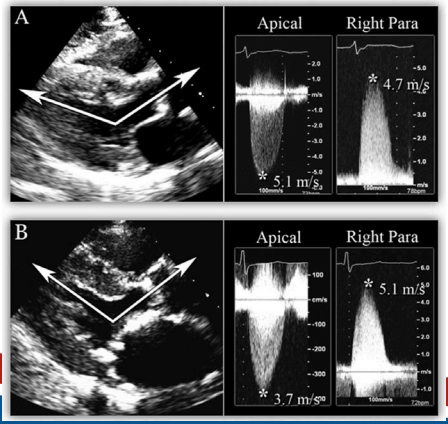
Aortic Stenosis : Maximal Gradient

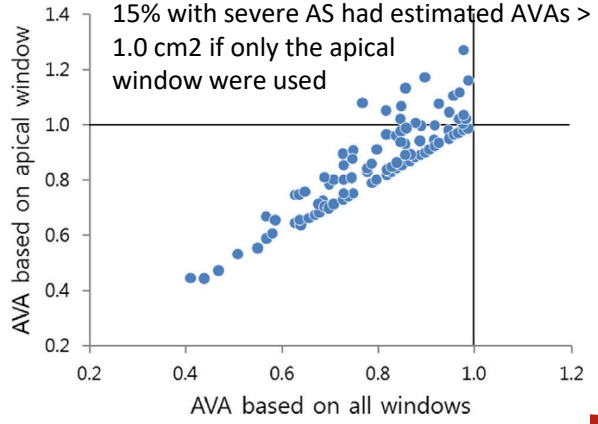
- A common source of error for maximal gradient measurement is misalignment of the beam
- CW Doppler assessment of AS peak jet velocity should be obtained in multiple views
- A dedicated small dual-crystal CWD transducer should also be used

Table 2 Location of highest peak velocity according to aortic root angulation

Window	All patients	Aortic root < 115°	Aortic root ≥ 115°	*P*
N	100	31	69	—
Apical	39 (39%)	6 (19%)	33 (48%)	.005
RPS	50 (50%)	20 (65%)	30 (43%)	.05
SSN	6 (6%)	2 (6%)	4 (6%)	1.00
RSC	5 (5%)	3 (10%)	2 (3%)	.17

RSC, Right supraclavicular; *SSN*, suprasternal notch.





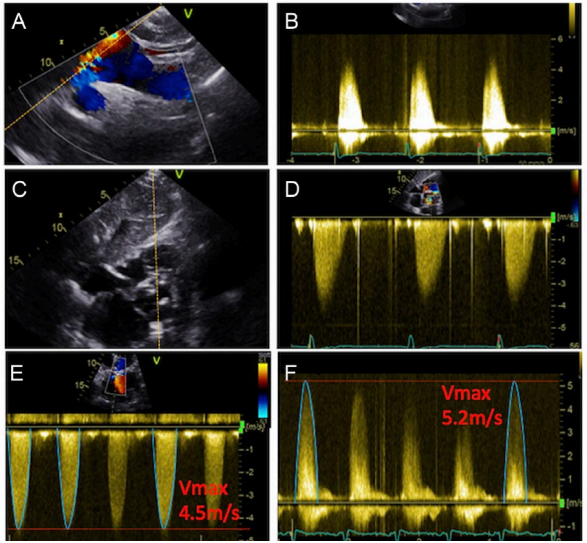
Thaden et al. J Am Soc Echocardiogr 2015;28:780-5

Aortic Stenosis : Maximal Gradients

Suprasternal

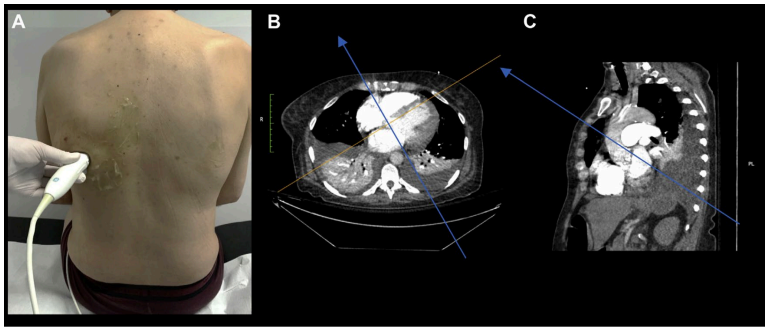
Subcostal

Apical 5
Apical 3



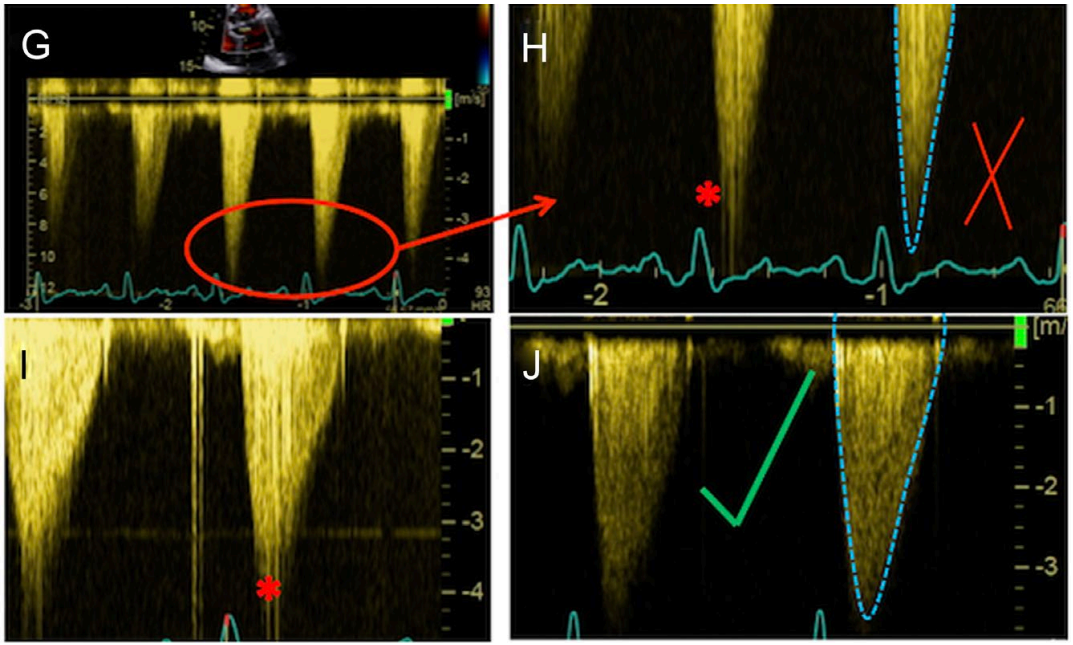
Right parasternal

Left Posterior Thoracic Acoustic Window: A Forgotten Approach for Aortic Stenosis Assessment



Ring L, et al. https://doi.org/10.1530/ERP-20-0035
Giannakopoulos G et al. https://doi.org/10.1016/j.cjco.2021.01.015

Aortic Stenosis : Maximal Gradients



- Don’t measure the dispersion as it overestimates the gradients
- Optimize the Doppler signal and trace the dense portion

Ring L, et al. https://doi.org/10.1530/ERP-20-0035

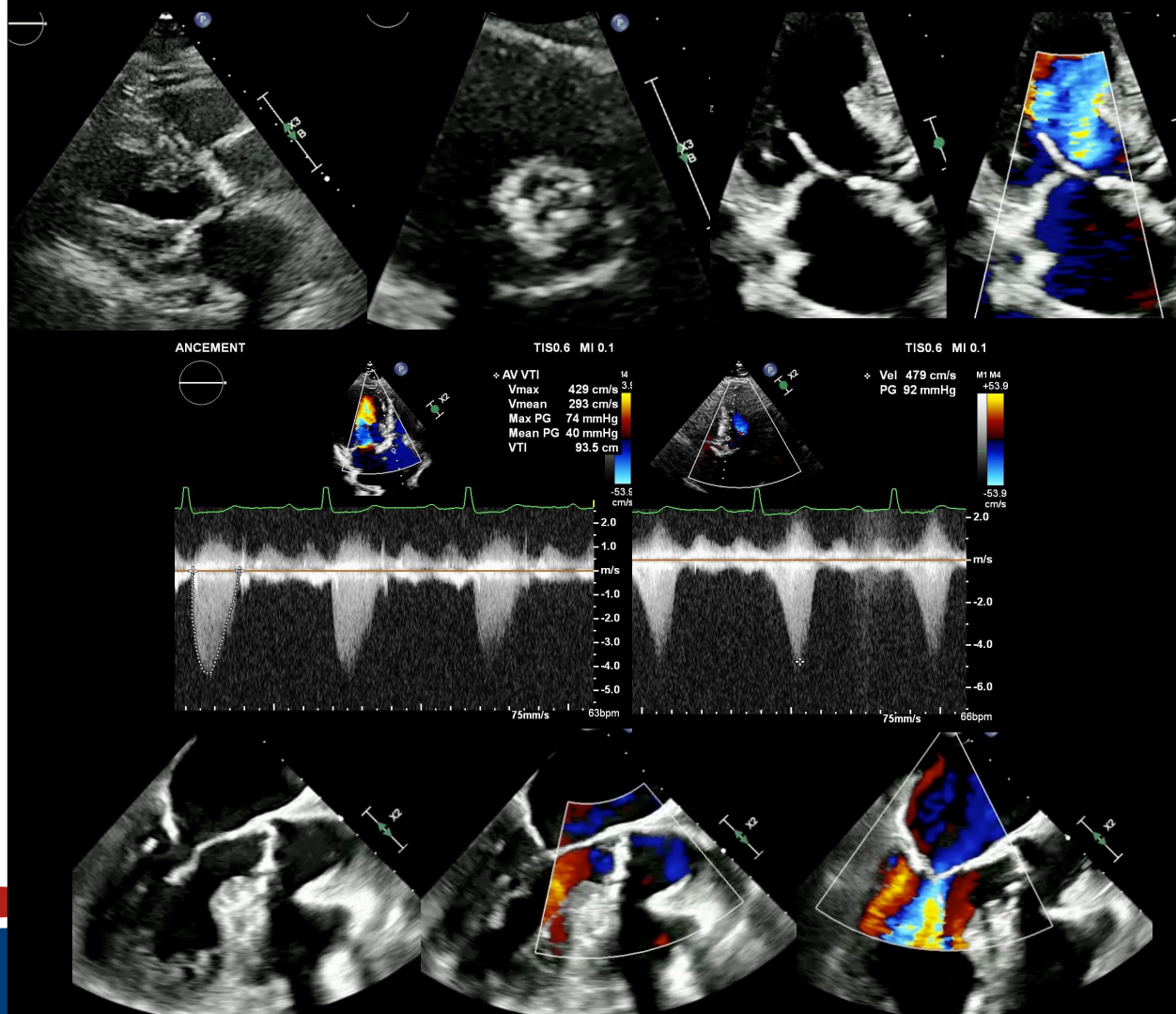
Aortic Stenosis : Low Flow, Low Gradient

When considering low flow, low gradient AS with preserved ejection fraction, important to exclude:

- Measurement errors
  - underestimation of LVOT area → flow
- Severe hypertension during examination.
- Inconsistency between AVA and velocity/gradient cut-offs in the range of AVAs between 0.8 and 1.0 cm^2
- Clinically moderate AS (despite an AVA < 1.0 cm2) in a patient with small body size.

Aortic Stenosis : Other causes

- Recognition of multiple AS mechanisms
- Evaluate Doppler profile

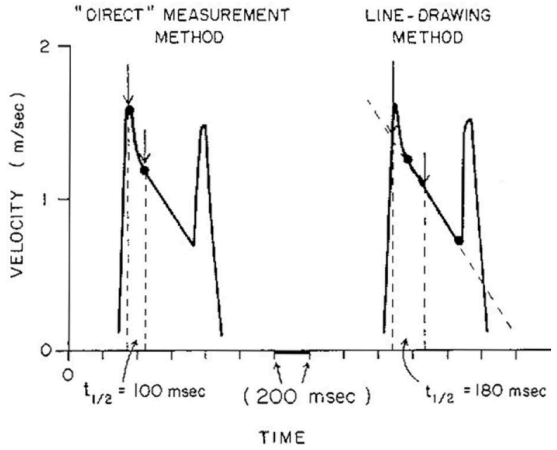


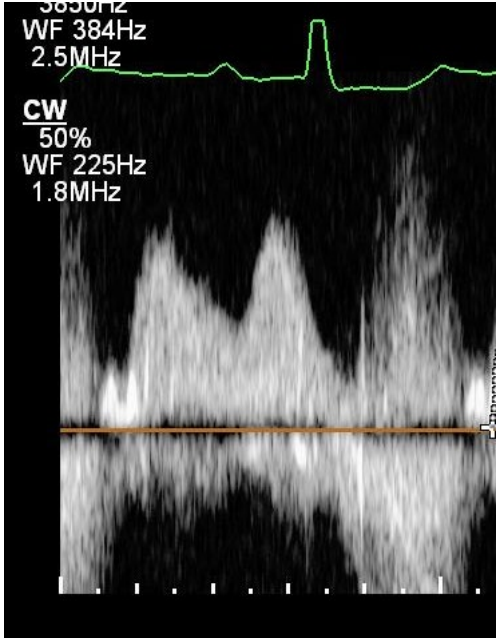
Aortic Stenosis : Other pitfalls*

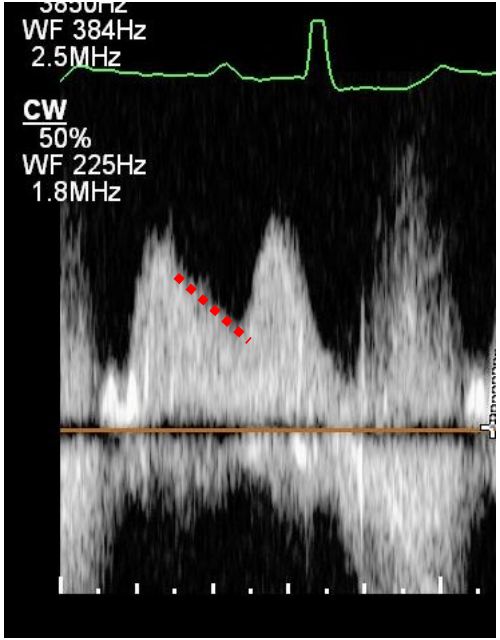
	Impact	AS assessment
Hypertension	• Can lead to under- or over-estimation of AS severity	• Re-evaluate AS when BP<140 mmHg
Aortic regurgitation	• Increase transvalvular flow and gradients • AVA is not a reliable predictor of outcomes	• Use DI • Some recommend max velocity
Mitral regurgitation	• AV Vmax and mean gradient may underestimate AS severity	• Use AVA
Mitral stenosis	• Low AS gradients underestimating severity	• Use AVA

*cardiac amyloid

Mitral Stenosis





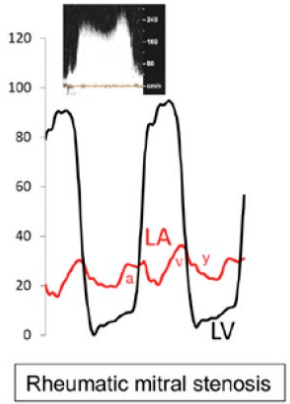


- PHT should be obtained from the second part of slope
- Heart rate affects diastolic filling so should report HR with measured gradients

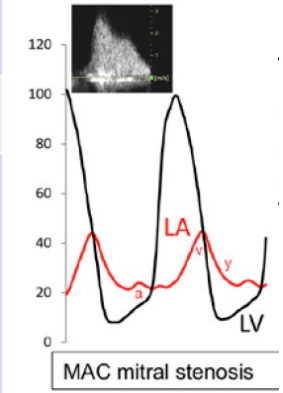
Mitral Stenosis

Rheumatic MS ≠ MAC MS

	Rheumatic	MAC
Morphology	• Funnel shape stenosis from fusion of the commissures with the greatest narrowing at the leaflet tips	• Tubular shape as it primarily involved the annulus and base of the leaflets
Stenosis	• True leaflet impedence	• Minimal valvular
Hemodynamics	• Blunted LA y descent • Persistent diastolic separation of LA and LV pressures • Normal LV EDP	• High LA v wave • Rapid y descent coupled with rapid equilibration of the LA-LV pressure gradient after MV opening • Elevated LV EDP



Rheumatic mitral stenosis

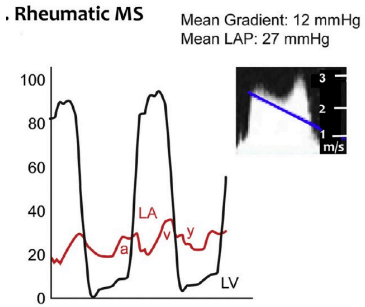


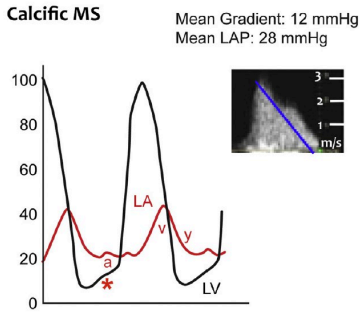
MAC mitral stenosis

Reddy et al. Circulation. 2019;140:523–525. DOI: 10.1161/CIRCULATIONAHA.11

Mitral Stenosis

Parameter	Rheumatic	MAC
Transmitral gradient (TMG)	• Elevated • Specific for severe MS • Predicts symptom improvement with intervention	• Comorbidities (HFpEF, LV diastolic dysfunction) can cause a large LA v wave from abnormal AV coupling and poor LA compliance. This increases the initial TMG, which with moderate stenosis results in a high MG overestimating valve obstruction severity • LA and MR could also increase v wave and early diastolic gradient without true stenosis.





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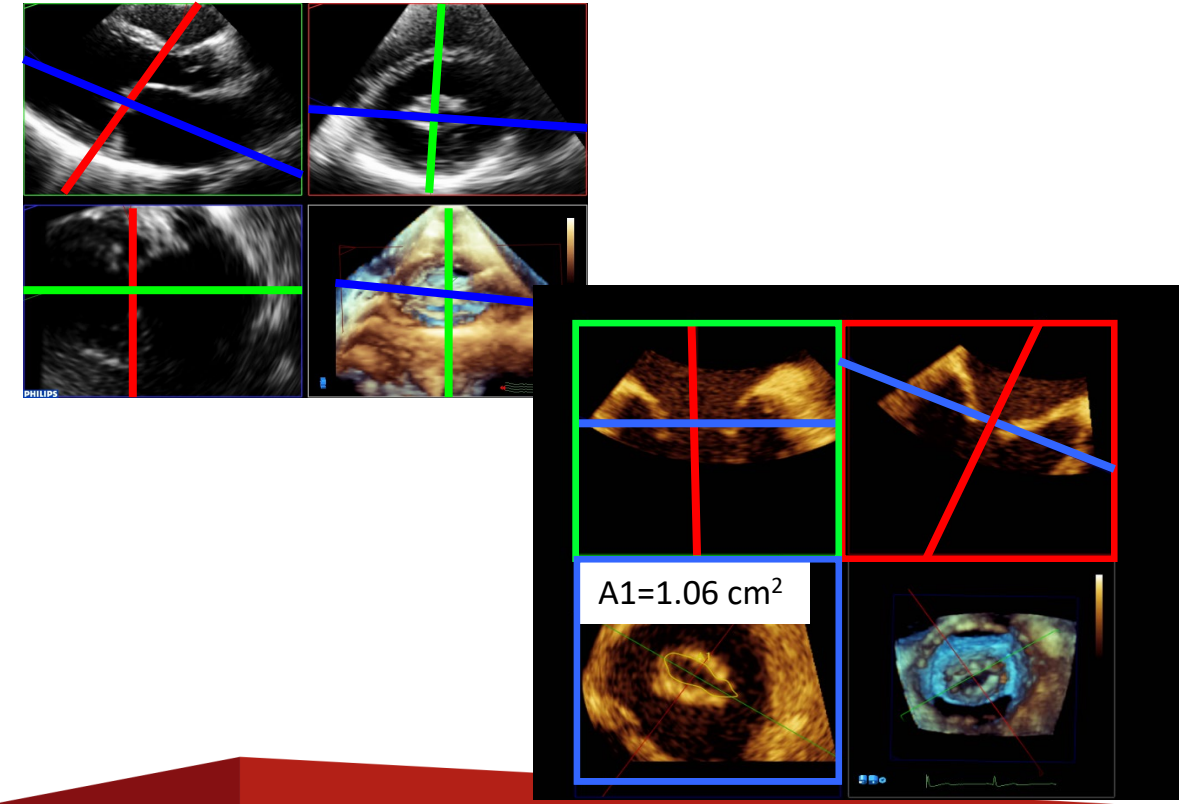
Mitral Stenosis

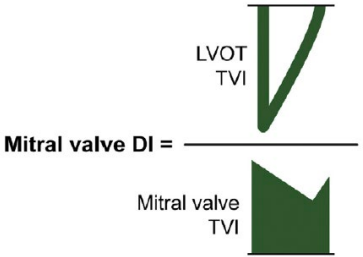


MVA

- Reliable in rheumatic MS because there is little calcification
- Less reliable in MAC

Mitral Stenosis

Parameter	MAC
MVA by pressure half-time (PHT)	• Reduced LV compliance in this patient population may decrease PHT overestimating MVA with Hatle formula (220/PHT)
MVA by Continuity Equation	• Preferred method to obtain MVA • VTI at the mitral inflow tract and LVOT are measured during different cardiac cycles • Problematic if AF present • LVOT measurement challenging with calcium and changes shape
Dimensionless index (DI)	• DI of 0.35 to 0.50 is consistent with severe calcific MS (MVA < 1.5 cm2) • DI < 0.35 suggests very severe calcific MS • Needs to be validated



Silbiger J Am Soc Echocardiogr 2021;34:923-31.

Mitral Stenosis

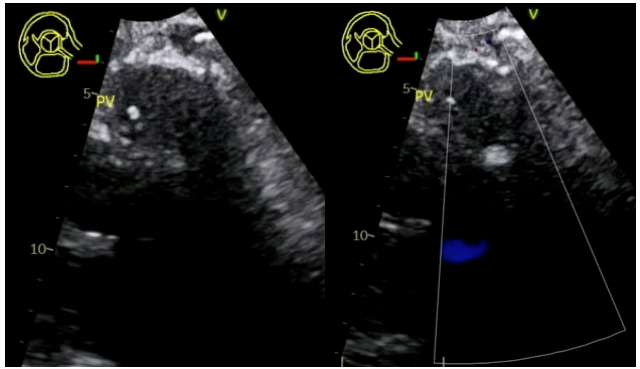
To avoid overestimated MAC stenosis severity if there is an elevated TMG

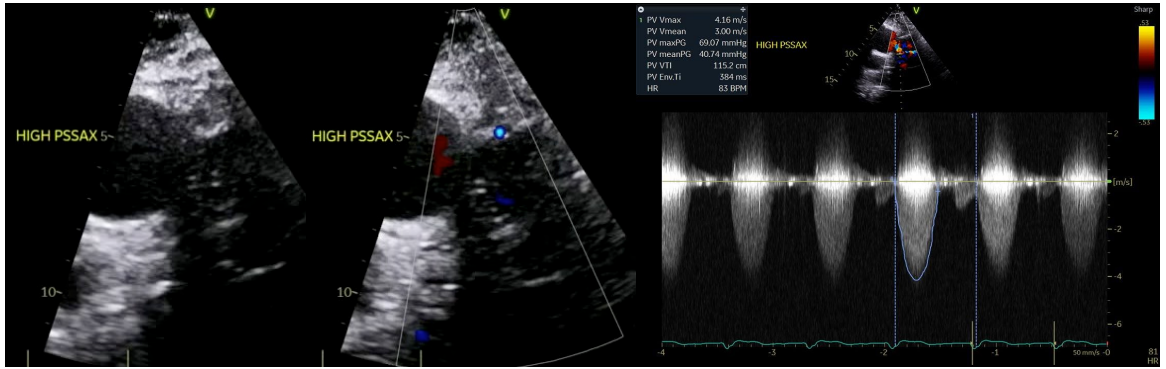
1. Examine the contour of the transmitral flow velocity curve

- Rheumatic – slow fall in velocity because of valvular impedance to passive flow and equal E and A velocities
- MAC – high initial E velocity, a rapid fall in velocity, and a high E:A ratio

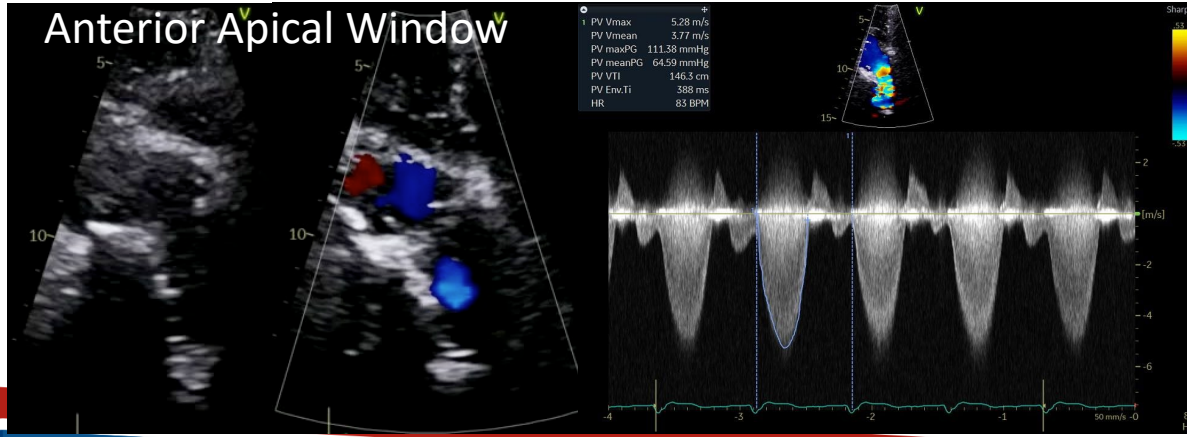
2. Cath to determine absolute LA and LV pressures, contour of v wave and y descent, response to exercise or nitroprusside

Pulmonic Stenosis

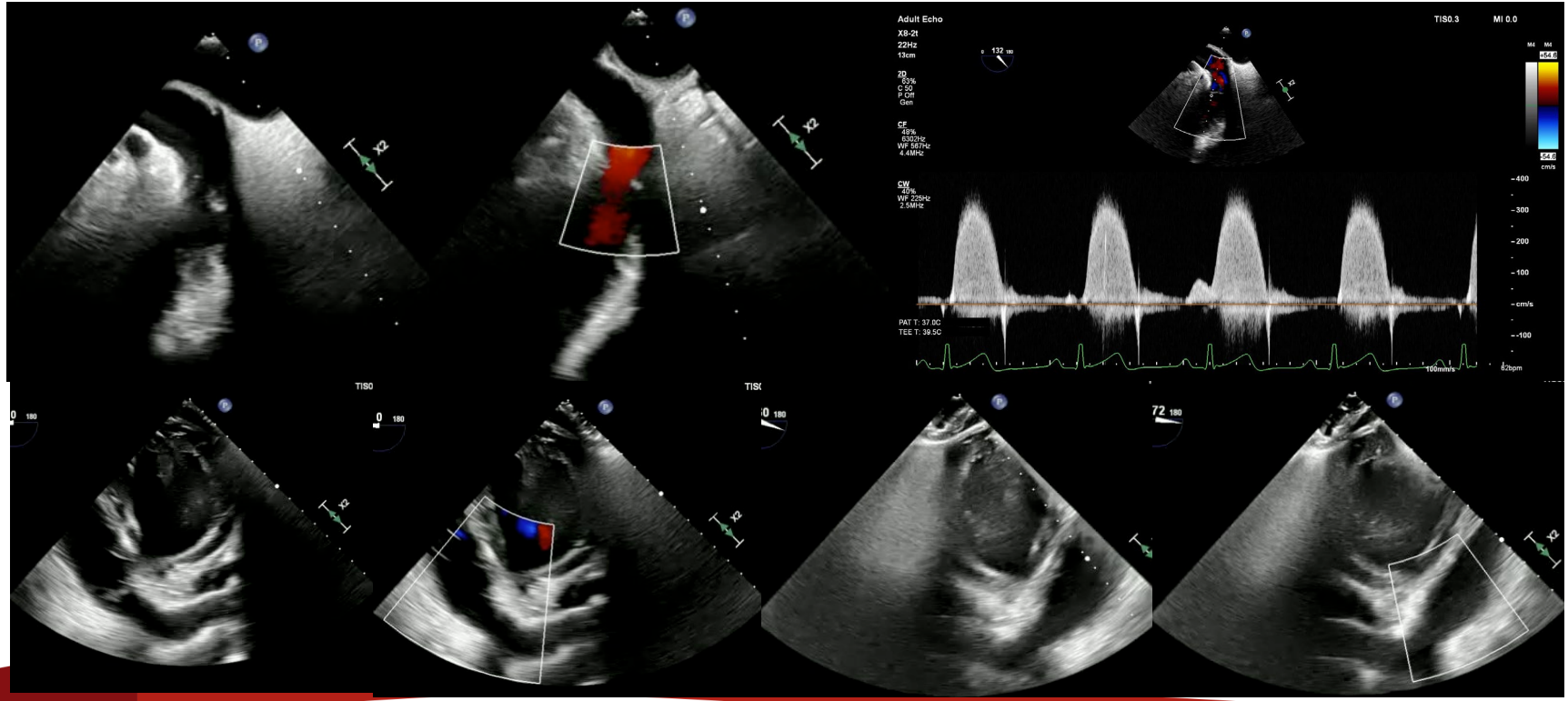




- Gradients are often underestimated
- Through interrogation with off-axis planes



Pulmonic Stenosis – Other TEE views



Summary

- LVOT Doppler location and contour should be examined to ensure it is not overestimated
- AS gradients should be assessed using multiple windows with the blind probe
- Rheumatic MS morphology differs from MAC related stenosis affecting valve hemodynamics making transvalvular gradients less reliable
- MAC MVA best assessed using continuity although there are limitations
- DI hold promise for MAC stenosis assessment
- Off-axis imaging windows should be used to assess PS

Thank you for listening!