Medtronic
Engineering the extraordinary

Echocardiography considerations

Detecting low-flow, low-gradient aortic stenosis

Aortic stenosis variations

Incidence/prevalence

Low-flow, low-gradient AS is defined by AVA ≤ 1.0 cm^2 but with gradients in non-severe range (<40mmHg).[1]
Up to 30% of AS cases match this definition as follows:[2]

Low-flow, low-gradient AS with preserved LVEF[3]

- 5-15% of AS cases
- More common in women and the elderly

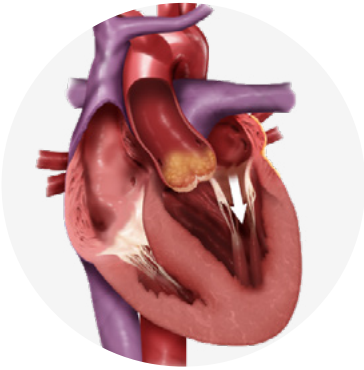
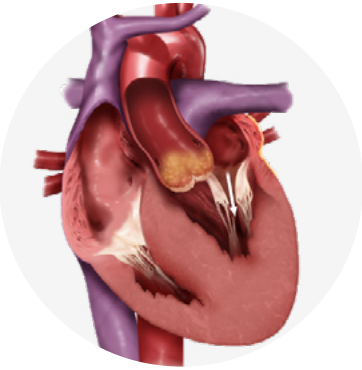
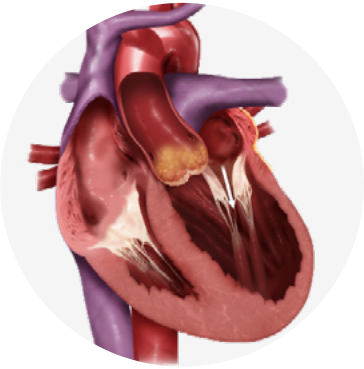
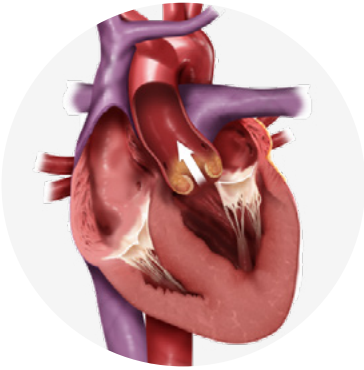
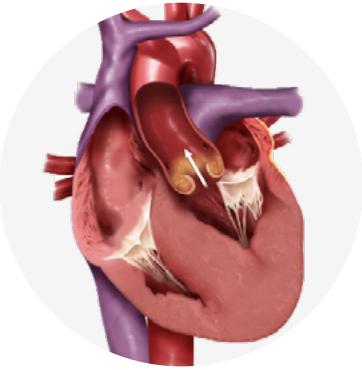
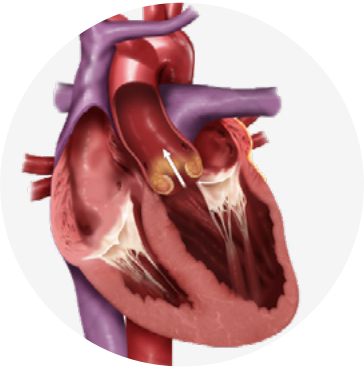
Low-flow, low-gradient AS with reduced LVEF[3]

- 5–10% of severe AS cases
- More common in males with CAD

1 Otto CM, et al. *Circulation*. 2021;143:e35-e71.
2 Awtry E, et al. *Circulation*. 2011;124:e739-e741.
3 Dahou American College of Cardiology 2015.

Aortic stenosis variations

Illustrations refer to examples of Severe AS with the AVA < 1.0 cm^2

	Normal LVEF Normal flow High gradient	Low-flow, low-gradient AS with preserved LVEF	Low-flow, low-gradient AS with reduced LVEF
Diastole			
Systole			

Aortic stenosis diagnosis

Pitfalls in assessing severity

Related to patient	• Body habitus and anatomy • General status: postoperative, acute illness, chest disorders, COPD, etc. • Physiology: rate, rhythm

Related to image acquisition	• Operator skill and experience
	• Mistaking mitral regurgitation for AS
	• Pitfalls: max velocity and mean gradient
	  – Highest velocity missed due to lack of use of all windows (non-parallel intercept angle)
	  – Over- or underestimation if spectral Doppler not traced appropriately
	• Pitfalls: AVA by continuity equation acquisition
	  – Underestimation of AVA if highest VTI or velocity not recorded
	  – Difficulty measuring LVOT diameter, e.g., heavy calcification, shape of LVOT
	  – Inaccurate PW sampling – leading to over- or underestimation
	  – Subaortic obstruction leading to difficulty measuring LVOT or VTI
	  – If patient not in sinus rhythm: 8–10 quality beats needed

Related to method of assessment	• Most parameters are flow-dependent • DVI is least flow-dependent measure of AS severity • Low-dose dobutamine challenge may be needed to assess contractile reserve
Related to analysis and interpretation	• Inter- and intra-observer error • Learning curve

Assessment of max velocity and mean gradient

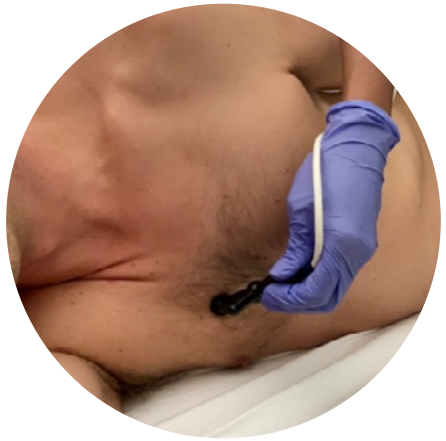
Use of multiple windows is imperative to avoid mis-evaluation of AS severity

- Use of multiple windows is required to avoid underestimation of max aortic velocity due to nonparallel intercept angle between ultrasound beam and aortic jet.[1]
- Use of non-imaging probe useful in obtaining optimal alignment.[1]

Apical

Supra sternal notch

Right sternal border



Right clavicular

Images courtesy Piedmont Atlanta Hospital

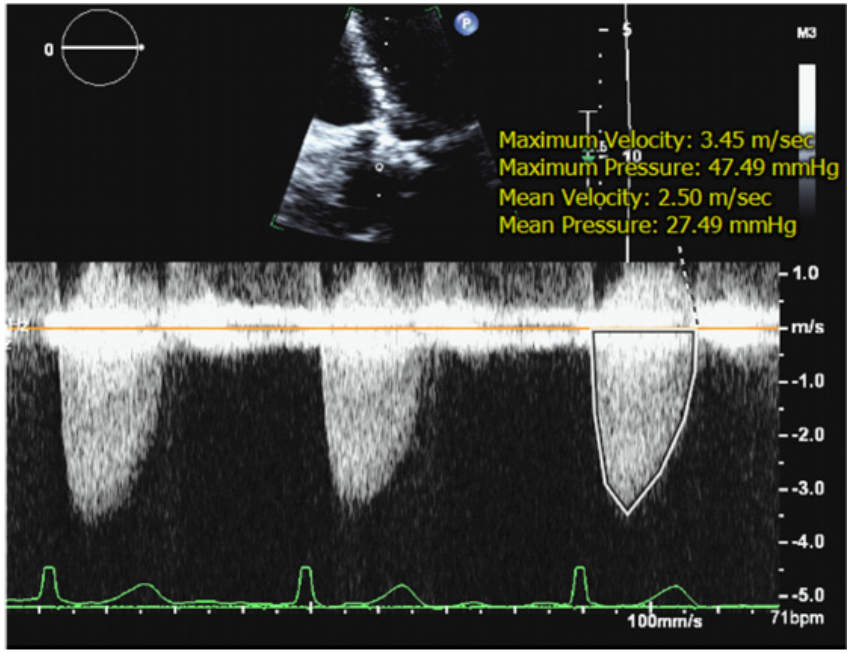
1 Thaden JJ, et al. *J Am Soc Echocardiogr.* 2015;28:780-785.

Assessment of max velocity and mean gradient

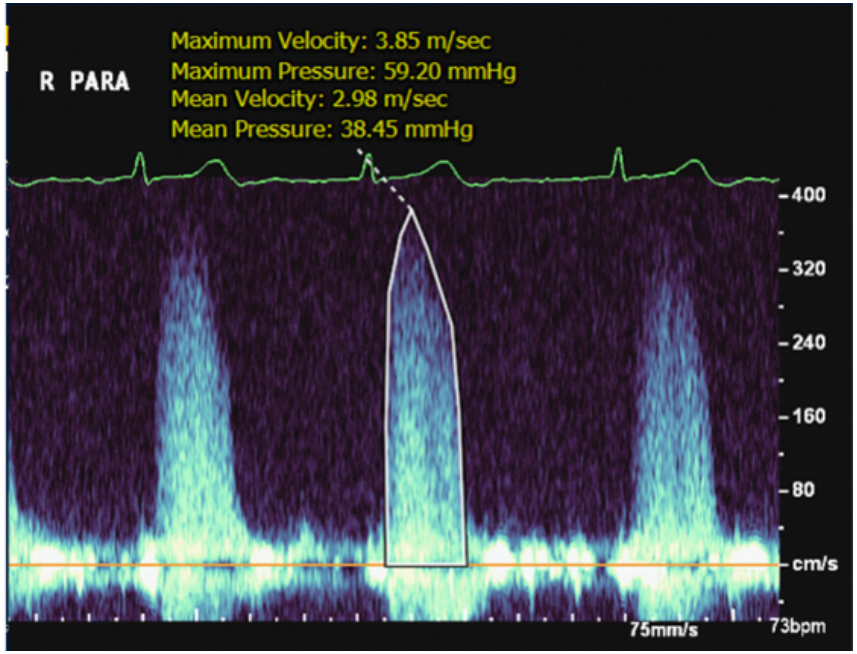
Use of multiple windows is imperative to avoid mis-evaluation of AS severity

- Vmax was located outside the apical imaging window in 61% of patients.[1]
- Neglecting the non-apical imaging windows resulted in the misclassification (underestimation) of AS severity in 23% of patients.[1]

Apical



Right parasternal

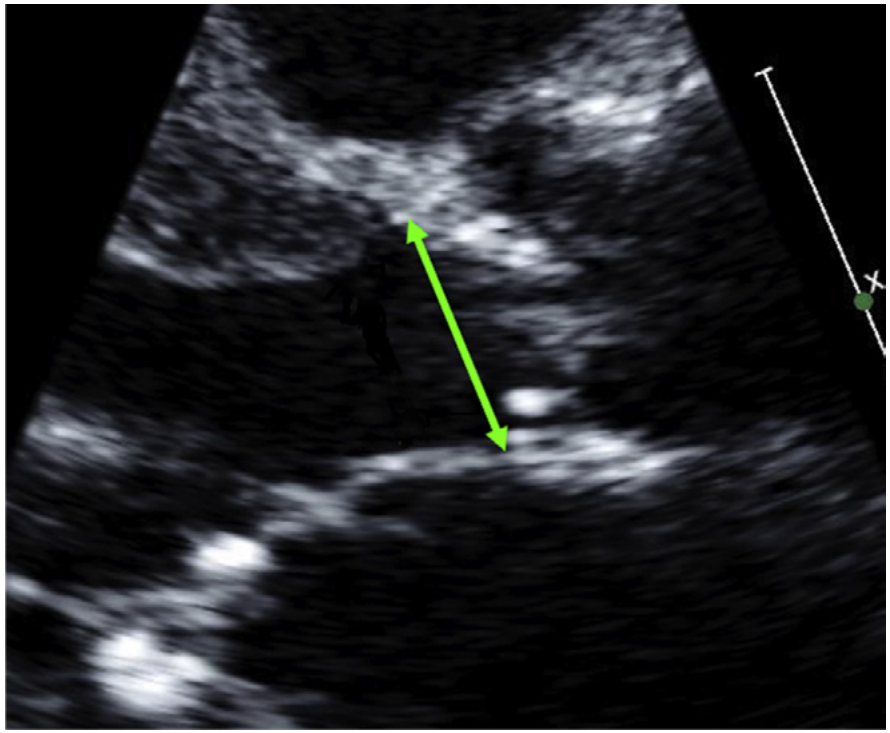


1 Thaden JJ, et al. *J Am Soc Echocardiogr.* 2015;28:780-785.

LVOT diameter

Can be the larger source of an error in the AVA continuity equation[1-7]

- LVOT diameter is measured in the parasternal long-axis view, with the optimal imaging plane through the long axis of the aorta (anterior and posterior walls of the aortic root parallel with the maximal aortic diameter).
- Measured in mid-systole at the level of the aortic annulus at the base of the aortic valve cusps with a line drawn from where the anterior aortic cusp meets the ventricular septum to where the posterior aortic cusp meets the anterior mitral leaflet perpendicular to the anterior aortic wall.

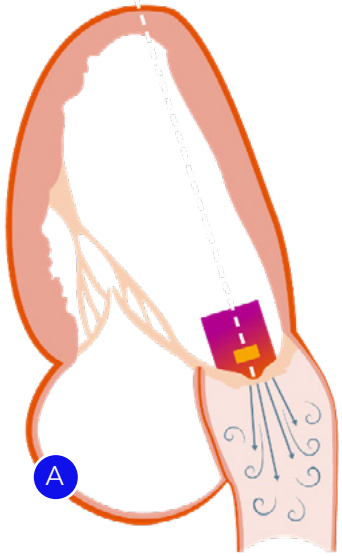


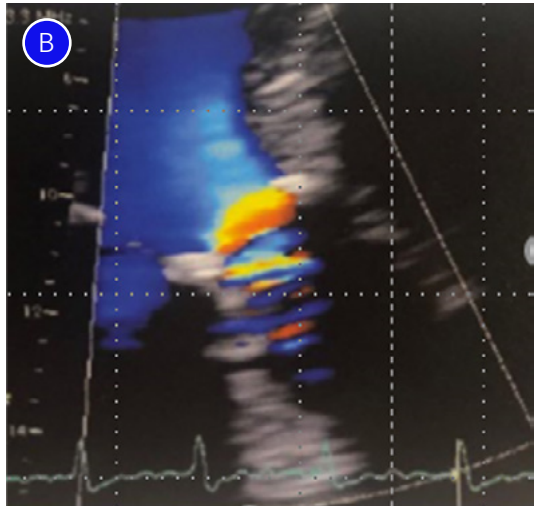
1 Bednarz JE, et al. J Am Soc Echocardiogr. 1996;9:286-294.
2 Oh JK, et al. J Am Coll Cardiol. 1988;11:1227-1234.
3 Otto CM, et al. J Am Coll Cardiol. 1986;7:509-517.
4 Pibarot P, et al. J Am Soc Echocardiogr. 2015;28:1267-1269.
5 LaBounty TM, et al. JACC Cardiovasc Imaging. 2014;7:1065-1066.
6 Hahn RT, et al. J Am Soc Echocardiogr. 2017;30:1038-1041.
7 Oh J, et al. The Echo Manual. 4th ed. Philadelphia: Wolters Kluwer; 2019.

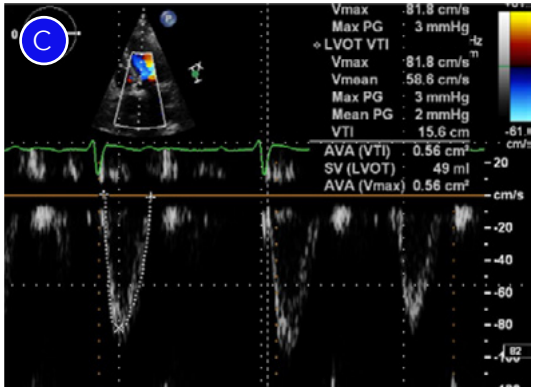
LVOT velocity

Correct sample volume placement is critical

- LVOT velocity is recorded with PW Doppler from the apical position, in either the apical long-axis view or the anteriorly angulated four-chamber view (“five-chamber view”).
- PW sample volume should be positioned just proximal to the aortic valve, with care to avoid the zone of pre-valve acceleration (usually 0.5 to 1.0 cm proximal to the cusps).
- Recommended procedure is to initially place the sample volume within the aortic valve leaflets, and then gradually move it apically until a clear spectral waveform is observed with a well-defined peak and minimal spectral broadening.
- VTI is measured by tracing the modal velocity (middle of the dense signal).





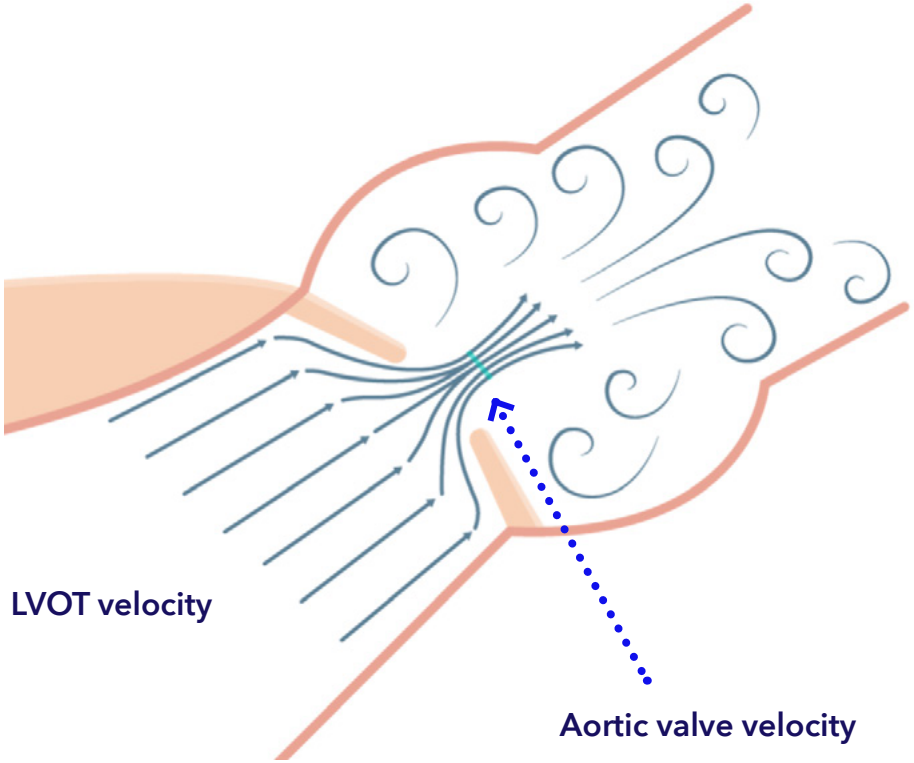


(A) Sample volume placement just proximal to zone of pre-valve acceleration
(B) Example of pre-stenotic acceleration at the aortic annulus and LVOT near the annulus. Full-screen imaging is helpful to verify positioning of sample volume before switching to Doppler mode.
(C) Correct tracing of the VTI modal velocity

Doppler velocity index (DVI)

A flow-independent measure of degree of valve obstruction

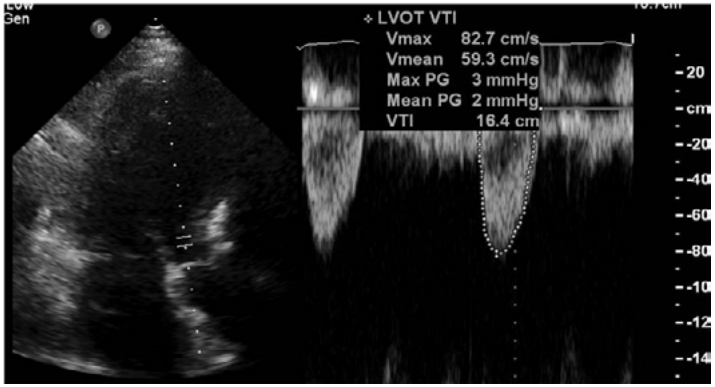
- Ratio of LVOT to aortic valve velocities
- Also known as “Dimensionless index”
- Measures degree of flow acceleration through aortic valve
- Independent of flow (useful for serial follow-up)
- DVI ≤ 0.25 consistent with severe aortic valve obstruction



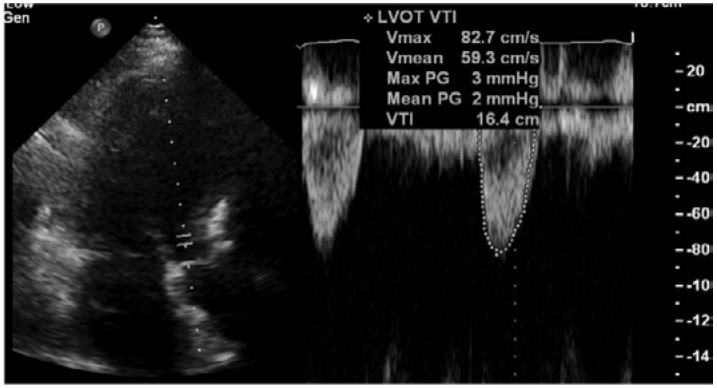
Doppler velocity index (DVI): ratio of LVOT to aortic valve velocities

Can use velocity time integral (VTI) or peak velocity

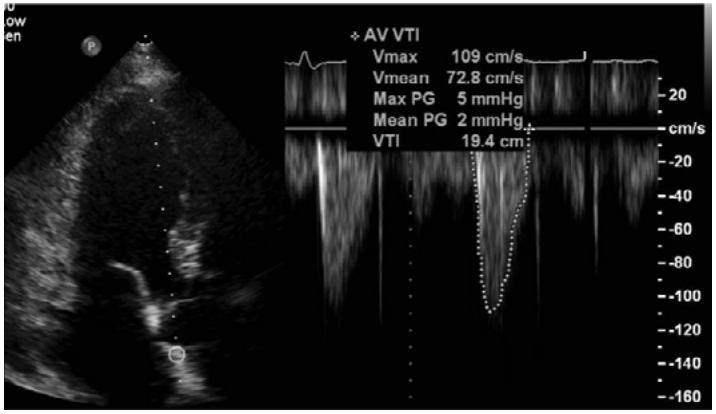
LVOT VTI: 16.4



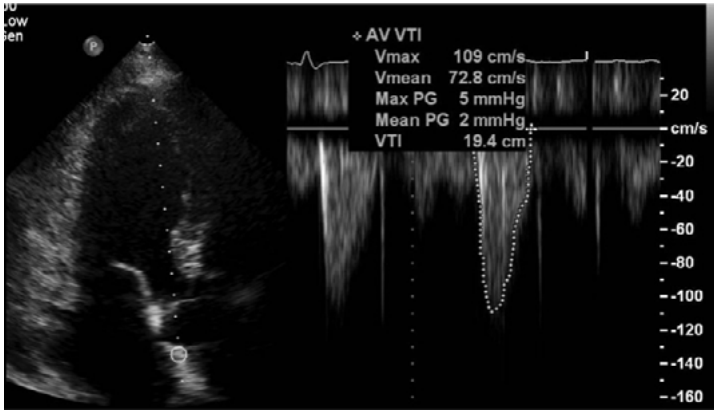
LVOT peak velocity: 82.7 cm/sec



Aortic valve VTI: 19.4



LVOT peak velocity: 109 cm/sec

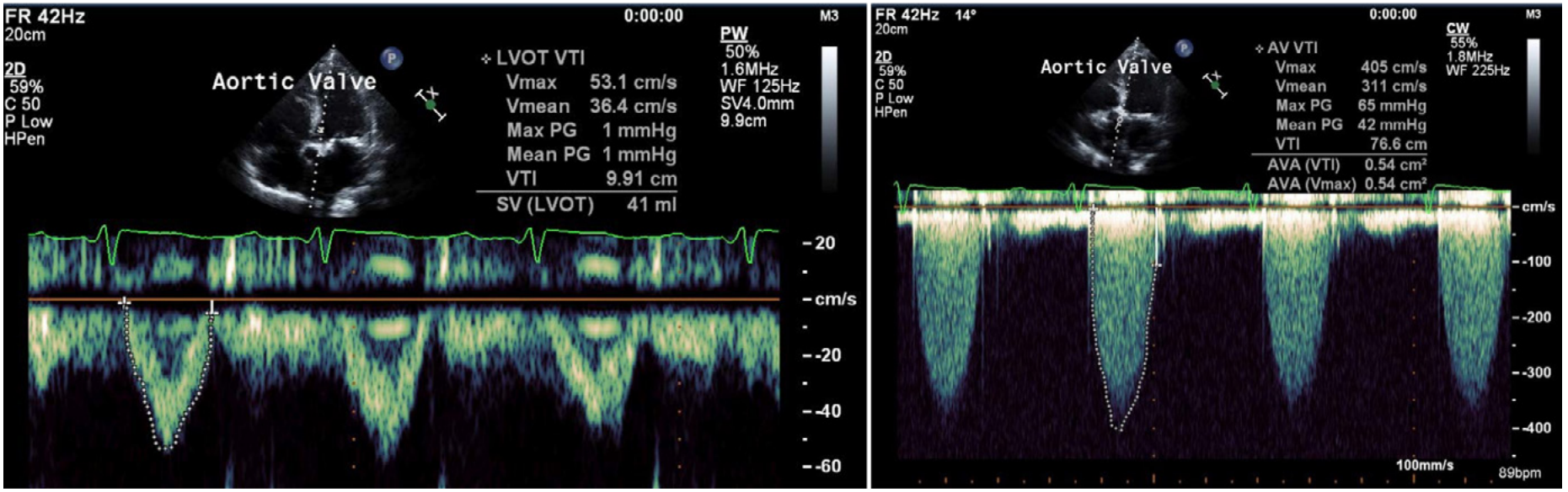


DVI (VTI) = 16.4/19.4 = 0.84

DVI (peak) = 82.7/109 = 0.76

Abnormal doppler velocity index (DVI): ratio of LVOT to aortic valve velocities

Do you use peak velocity or DVI?

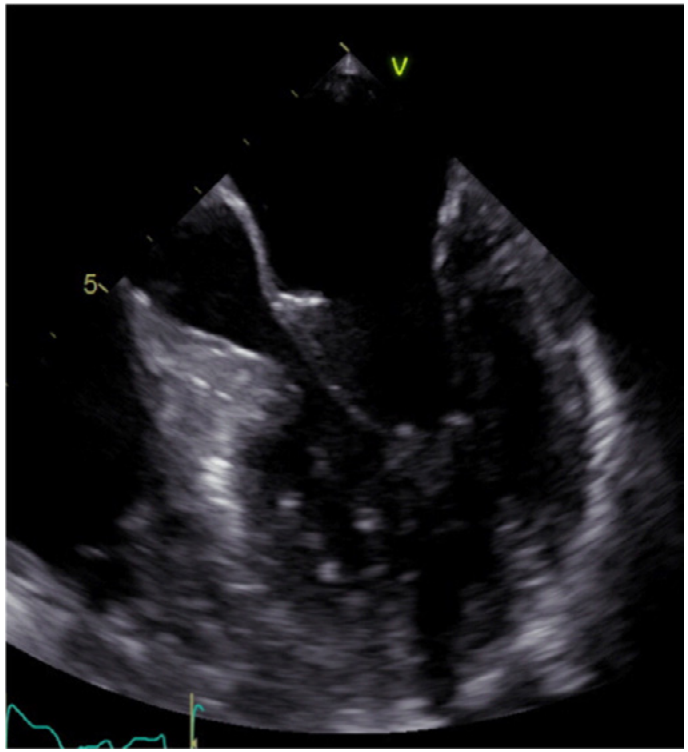


DVI (VTI) = 9.91 cm/76.6 cm = 0.13

LVOT obstruction

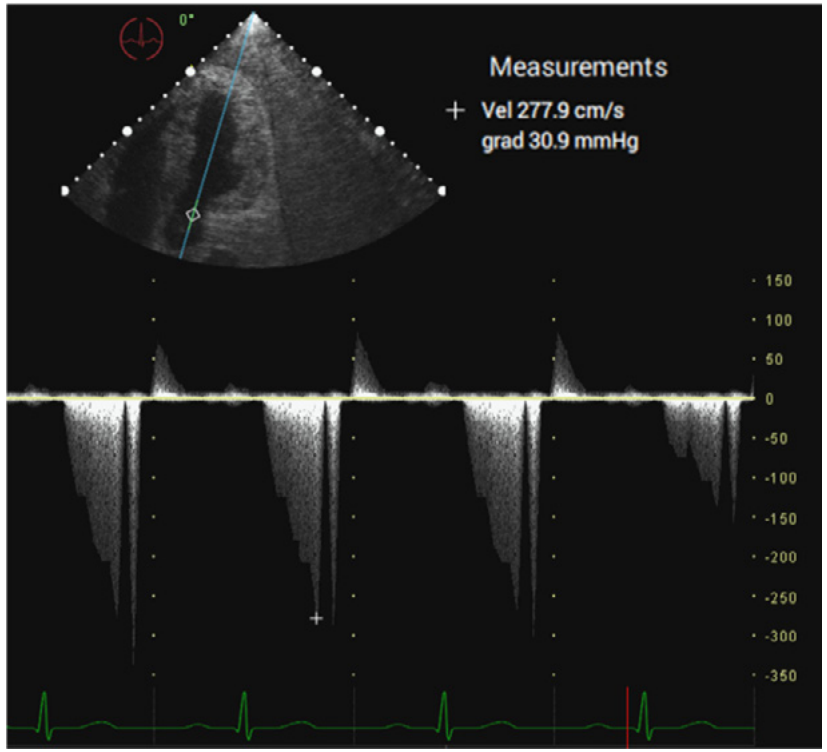
LVOT region should be carefully evaluated

The safety and effectiveness of the bioprosthesis for AVR have not been evaluated in patient populations presenting with severe basal septal hypertrophy with an outflow gradient.



TEE image

In patients with bulging basal interventricular septum (sigmoid septum) or hyperdynamic LV function, the LVOT region should be thoroughly interrogated for presence of LVOT gradient.



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