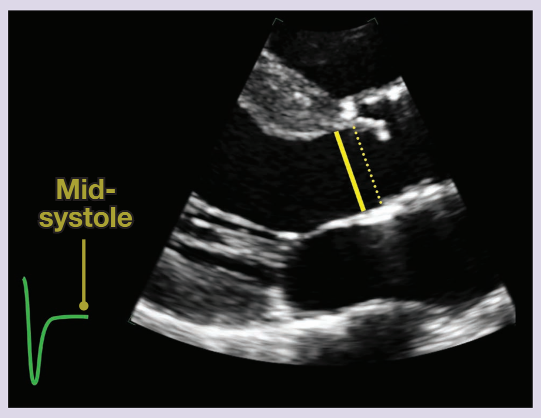
Echocardiographic Assessment of Valve Stenosis

ASE American Society of Echocardiography

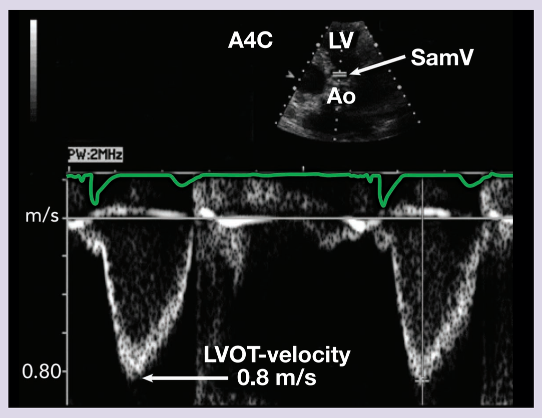
Aortic Stenosis

LVOT Diameter



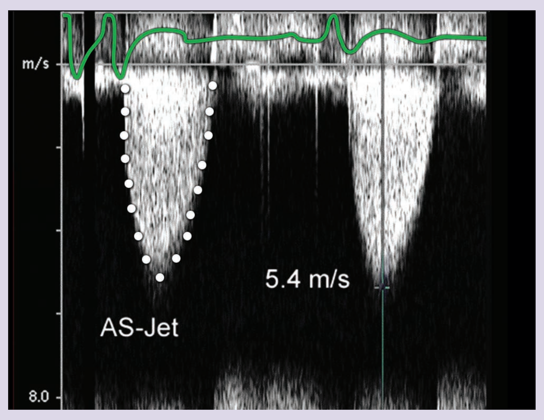
- Parasternal long-axis view
- Zoom mode
- Measure 5 mm to 10 mm from aortic annulus (solid yellow line)
- Mid-systole

LVOT Doppler



- Pulsed-wave Doppler
- Apical long-axis or 5-chamber view
- Sample volume positioned at the same location as the measure of LVOT diameter
- Obtain a laminar LVOT flow profile
- Optimize baseline, scale, sweep speed
- VTI traced from modal velocity

AS Jet Velocity



- CW Doppler
- Multiple acoustic window (apical, suprasternal, right parasternal)
- Optimize signal by adjusting gain, baseline, scale, wall filter and sweep speed
- VTI traced from outer edge of dense signal curve
- Measure peak velocity and mean gradient
- Advantage: direct measurement
- Limitation: flow dependent, angle dependent

Recommendations for Grading of AS Severity

	Mild	Moderate	Severe
Peak velocity (m/s)	2.6 - 2.9	3.0 - 4.0	≥ 4.0
Mean gradient (mmHg)	< 20	20 - 40	≥ 40
AVA (cm^2)	> 1.5	1.0 - 1.5	< 1.0
Indexed AVA (cm^2/m^2)	> 0.85	0.60 - 0.85	< 0.6
Velocity ratio	> 0.50	0.25 - 0.50	< 0.25

Continuity equation valve area (cm^2)

$$AVA = \frac{CSA_{LVOT} \times VTI_{LVOT}}{VTI_{AV}}$$

Advantages: Measures effective orifice area, relatively flow independent

Disadvantage: Measurement error more likely

Integrated and Stepwise Approach to Grading Aortic Stenosis

1 Assess Velocity/Gradient

- LOW GRADIENT AS: Vmax < 4 m/s ΔPm < 40 mmHg
  - **2 Assess AVA**
    - AVA < 1.0 cm²
    - AVA ≥ 1.0 cm² = moderate AS
  - **3 Exclude Measurement Errors**
  - **4 Define Flow Status**
    - Low flow (SVi < 35 ml/m²)
    - Normal flow (SVi ≥ 35 ml/m²) -> severe AS unlikely
- HIGH GRADIENT AS: Vmax ≥ 4 m/s ΔPm ≥ 40 mmHg
  - High Flow Status Excluded
    - Yes → Severe high gradient AS
    - No → Not reversible -> severe AS
    - No → Reversible -> re-assess at restored normal flow

5 Assess LVEF

- LVEF abnormal < 50%
- LVEF preserved ≥ 50%

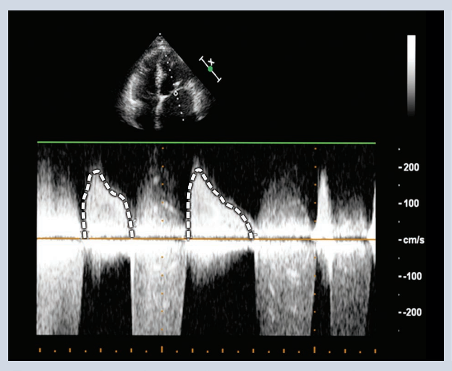
6 Dobutamine Echo

- Flow Reserve
  - Pseudo-severe AS
  - True severe AS
- No flow reserve

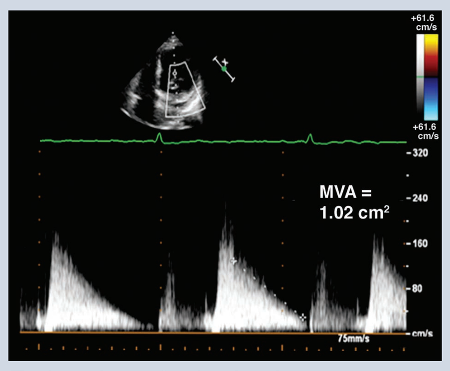
7 Consider

- Clinical criteria
- Qualitative imaging data: LVH, strain
- Quantitative imaging data: CT calcium score

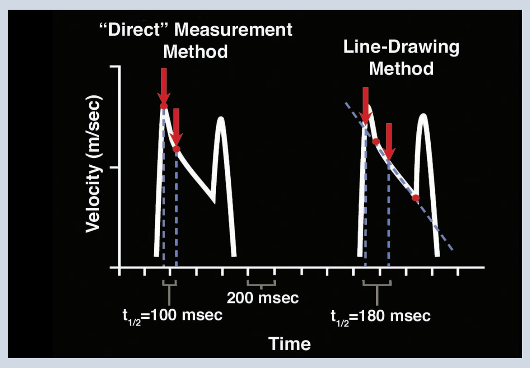
Mitral Stenosis



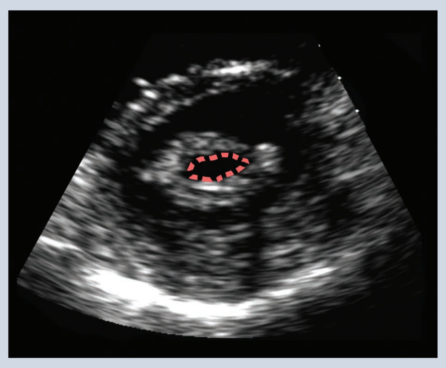
Determination of mean mitral gradient from Doppler diastolic mitral flow in a patient with severe mitral stenosis in atrial fibrillation. (average A and B)



Estimation of mitral valve area using the pressure half-time method.



Determination of the T½ with a bimodal, non-linear slope of the E-wave. The deceleration slope should not be traced from the early part (left), but using the extrapolation of the linear mid-portion of the mitral velocity profile (right).

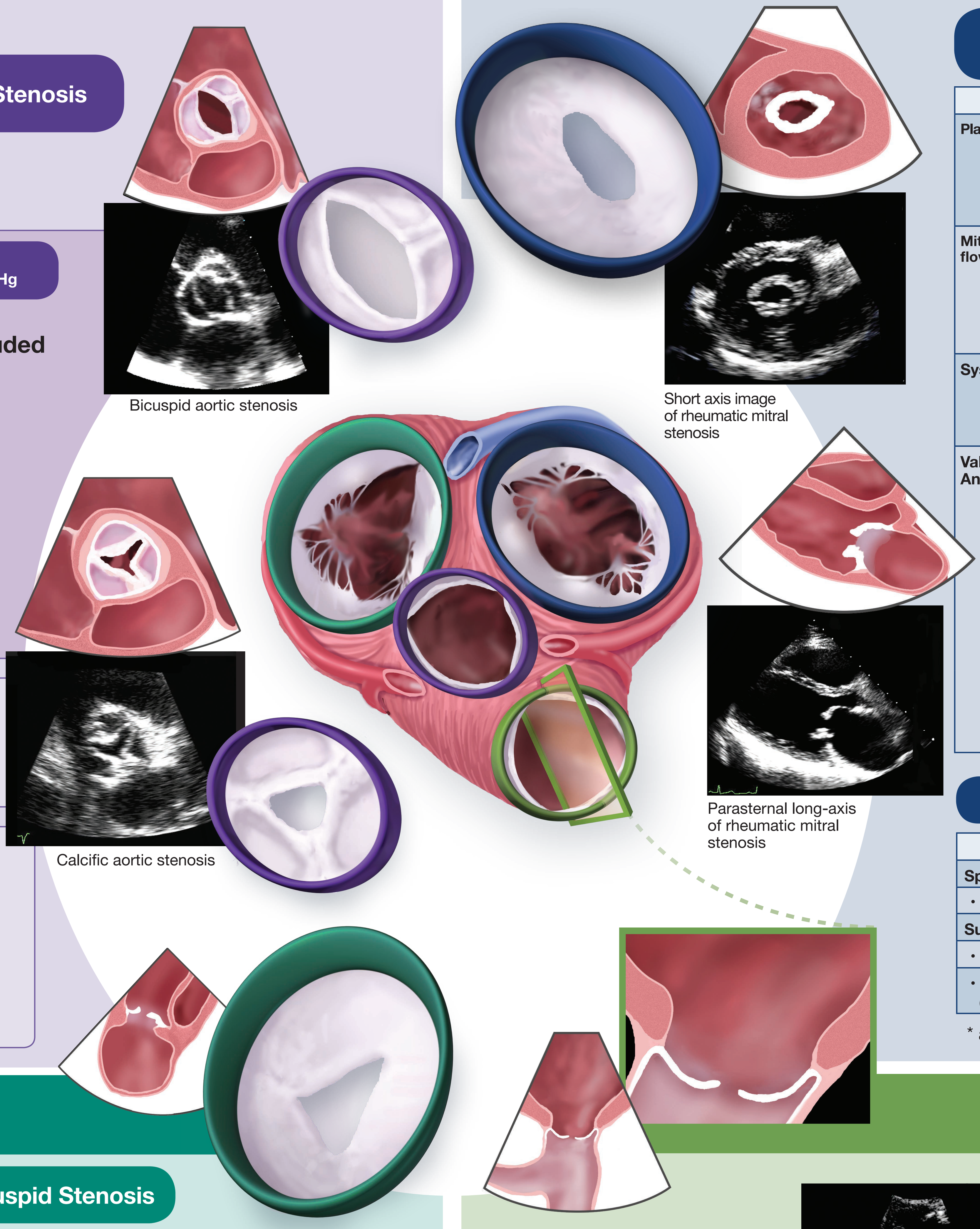


Planimetry of the mitral orifice. Transthoracic echocardiography, parasternal short-axis view.

Approaches to Evaluation of Mitral Stenosis

Measurement	Units	Formula / Method	Concept	Advantages	Disadvantages
Valve area					
• Planimetry by 2D echo	cm²	Tracing mitral orifice using 2D echo	Direct measurement of anatomic MVA	• Accuracy • Independence from other factors	• Experience required • Not always feasible (poor acoustic window, severe valve calcification)
• Pressure half-time	cm²	$\frac{220}{T_{1/2}}$	Rate of decrease of transmitral flow is inversely proportional to MVA	Easy to obtain	Dependence on other factors (AR, LA compliance, LV diastolic function)
Mean gradient	mmHg	$\Delta P_{Mitral} = \sum 4v^2_{Mitral}/N$	Pressure gradient calculated from velocity using the Bernoulli equation	Easy to obtain	Dependent on heart rate and flow conditions
Systolic pulmonary artery pressure	mmHg	$sPAP = 4v^2_{Tricuspid} + RA_{Pressure}$	Addition of RA pressure and maximum gradient between RV and RA	Obtained in most patients with MS	• Arbitrary estimation of RA pressure • No estimation of pulmonary vascular resistance

AR: aortic regurgitation, **CSA**: cross-sectional area, **DFT**: diastolic filling time, **LA**: left atrium, **LV**: left ventricle, **LVOT**: left ventricular outflow tract, **MR**: mitral regurgitation, **MS**: mitral stenosis, **MVA**: mitral valve area, **MVres**: mitral valve resistance, **ΔP**: gradient, **sPAP**: systolic pulmonary artery pressure, **r**: the radius of the convergence hemisphere, **RA**: right atrium, **RV**: right ventricle, **$T_{1/2}$**: pressure half-time, **V**=velocity, **VTI**: velocity time integral.



Bicuspid aortic stenosis

Short axis image of rheumatic mitral stenosis

Calcific aortic stenosis

Parasternal long-axis of rheumatic mitral stenosis

Data Recording and Measurement in Routine Use for Mitral Stenosis Quantitation

	Formula/method	Advantages
Planimetry	• Determine the smallest orifice by scanning from apex to base • Positioning of measurement plan can be oriented by 3D echo • Lowest gain setting to visualize the whole mitral orifice	• Contour of the inner mitral orifice • Include commissures when opened • In mid-diastole (use cine-loop) • Average measurements if atrial fibrillation
Mitral flow	• Continuous-wave Doppler • Apical windows often suitable (optimize intercept angle) • Adjust gain setting to obtain well-defined flow contour	• Mean gradient from the traced contour of the diastolic mitral flow • Pressure half-time from the descending slope of the E-wave (mid-systole slope if not linear) • Average measurements if atrial fibrillation
Systolic	• Continuous-wave Doppler • Multiple acoustic windows to optimize intercept angle	• Maximum velocity of tricuspid regurgitant flow • Estimation of right atrial pressure according to inferior vena cava diameter
Valve Anatomy	• Parasternal short-axis view	• Valve thickness (maximum and heterogeneity) • Commissural fusion • Extension and location of localized bright zones (fibrous nodules or calcification)
	• Parasternal long-axis view	• Valve thickness • Extension of calcification • Valve pliability • Subvalvular apparatus (chordal thickening, fusion, or shortening)
	• Apical 2-chamber view	• Subvalvular apparatus (chordal thickening, fusion, or shortening) • Detail each component and summarize in a score

Classification of Mitral Stenosis Severity

	Mild	Moderate	Severe
Specific findings			
• Valve area (cm²)	> 1.5	1.0 - 1.5	< 1.0
Supportive findings			
• Mean gradient (mmHg)*	< 5	5-10	> 10
• Pulmonary artery pressure (mmHg)	< 30	30-50	> 50

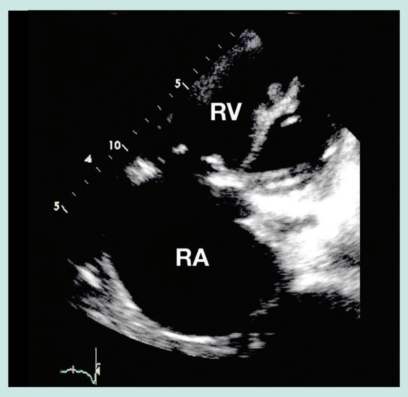
* at heart rates between 60 to 80 beats per minute and in sinus rhythm

Tricuspid Stenosis

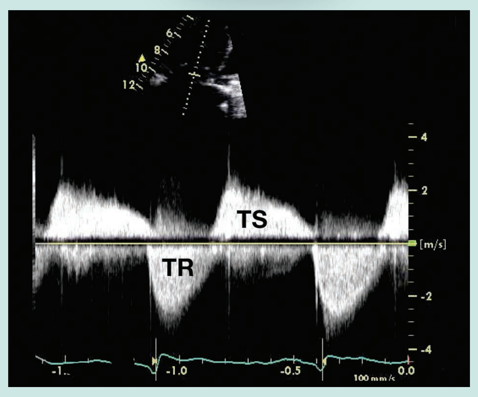
Findings Indicative of Hemodynamically Significant Tricuspid Stenosis

Specific Findings	
• Mean pressure gradient	≥ 5 mmHg
• Inflow time velocity integral	> 60 cm
• T½	≥ 190 ms
• Valve area by continuity equation*	≤ 1 cm²*
Supportive Findings	
• Enlarged right atrium ≥ moderate	
• Dilated inferior vena cava	

*Stroke volume derived from left or right ventricular outflow. In the presence of more than mild tricuspid regurgitation, the derived valve area will be underestimated. Nevertheless a value ≤ 1 cm² implies a significant hemodynamic burden imposed by the combined lesion.



Stenotic triscuspid valve obtained in a modified apical 4-chamber view during diastole.

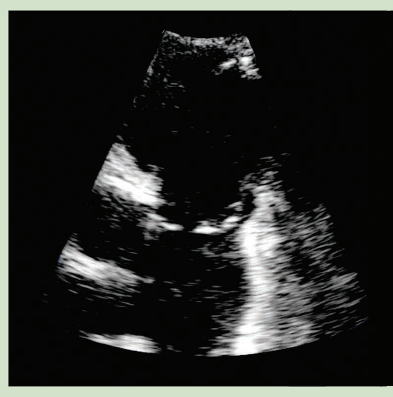


The peak velocity, diastolic time-velocity integral, mean gradient, and pressure half-time by continuous-wave Doppler.

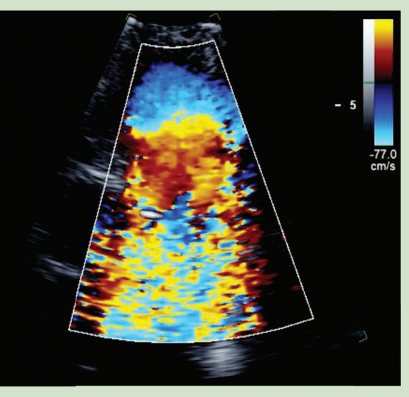
Pulmonic Stenosis

Grading of Pulmonary Stenosis

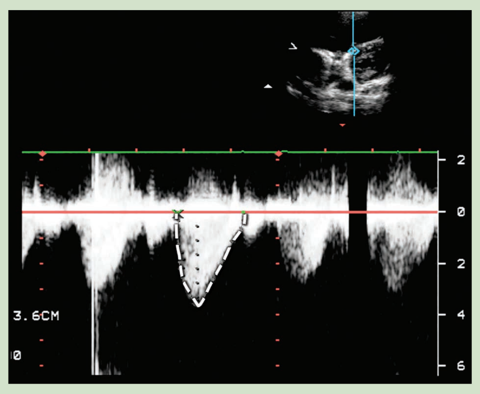
	Mild	Moderate	Severe
Peak Velocity (m/s)	< 3	3-4	>4
Peak Gradient (mmHg)	< 36	36 to 60	>60



Doming of the pulmonary leaflets in systole noted in valvular pulmonary stenosis.



Aliasing of velocities at the level of the pulmonary valve in pulmonary stenosis.



Continuous-wave Doppler across the pulmonary valve showing increased velocities.

Adapted from:

- Echocardiographic Assessment of Valve Stenosis: EAE/ASE Recommendations for Clinical Practice. Eur J Echocardiogr and J Am Soc Echocardiogr 2009.
- 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. J Am Soc Echocardiogr 2017.

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