GUIDELINES AND STANDARDS

Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound

A Report From the American Society of Echocardiography's Guidelines and Standards Committee and the Task Force on Prosthetic Valves, Developed in Conjunction With the American College of Cardiology Cardiovascular Imaging Committee, Cardiac Imaging Committee of the American Heart Association, the European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography and the Canadian Society of Echocardiography, Endorsed by the American College of Cardiology Foundation, American Heart Association, European Association of Echocardiography, a registered branch of the European Society of Cardiology, the Japanese Society of Echocardiography, and Canadian Society of Echocardiography

Aortic Valve

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Prosthetic Aortic Valve Function and Stenosis

- Imaging Considerations
- Doppler Parameters of Prosthetic Aortic Valve Function
  - Velocity and Gradients
  - EOA
  - DVI
- Diagnosis of Prosthetic Aortic Valve Stenosis

Imaging considerations

- Sewing ring
- The valve or occluder mechanism
  - Ball or disc
    - Often indistinctly imaged
  - Normal tissue valves
    - Thin with an unrestricted motion.
- Surrounding area

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Velocity and Gradients

- Normal prosthetic valves
  - Resemble those of mild native aortic stenosis
    - Maximal velocity usually >2 m/s
    - Triangular shape of the velocity
    - Maximal velocity in early systole

Velocity and Gradients

- With increasing stenosis of the valve
- Higher velocity and gradient
  - Longer duration of ejection
  - More delayed peaking of the velocity during systole

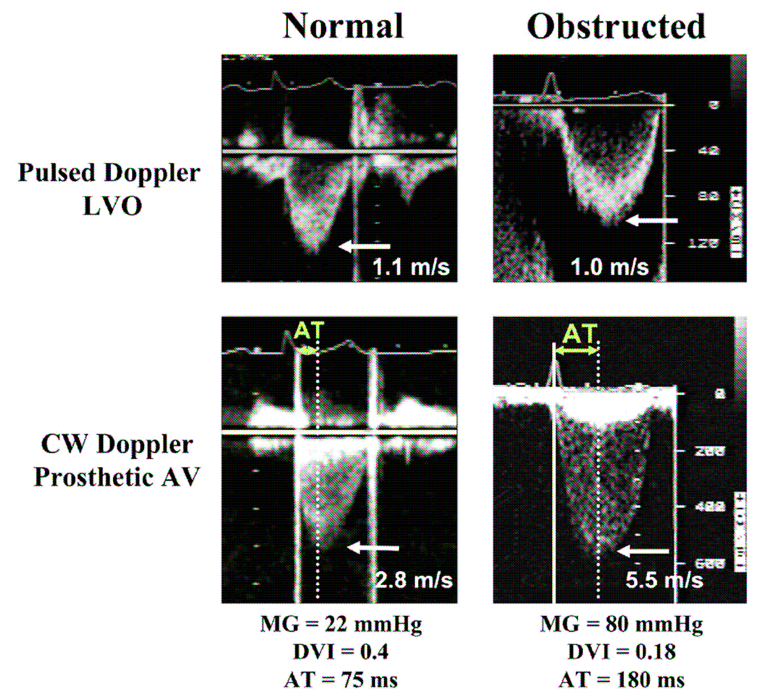

Figure 7 Doppler recordings of a normal and obstructed prosthetic valve in the aortic position. With obstruction, the velocity of the jet is increased along with changes in the contour of the jet velocity to that of a parabolic, late peaking profile. The ET as well as the AT is increased. AT (in milliseconds) is measured as the duration from the onset of aortic ejection *(solid line)* to the maximal jet velocity *(dotted line)*. Mean gradient (MG) is increased and the DVI is decreased with prosthetic obstruction.

Velocity and Gradients

- High gradient = Stenosis ?

➔ Not necessary

  - Small size
  - Increased stroke volume
  - PPM
  - Valve obstruction

Velocity and Gradients

- Mildly elevated gradient ≠ Significant stenosis ?

➔ Not necessary

– severe LV dysfunction

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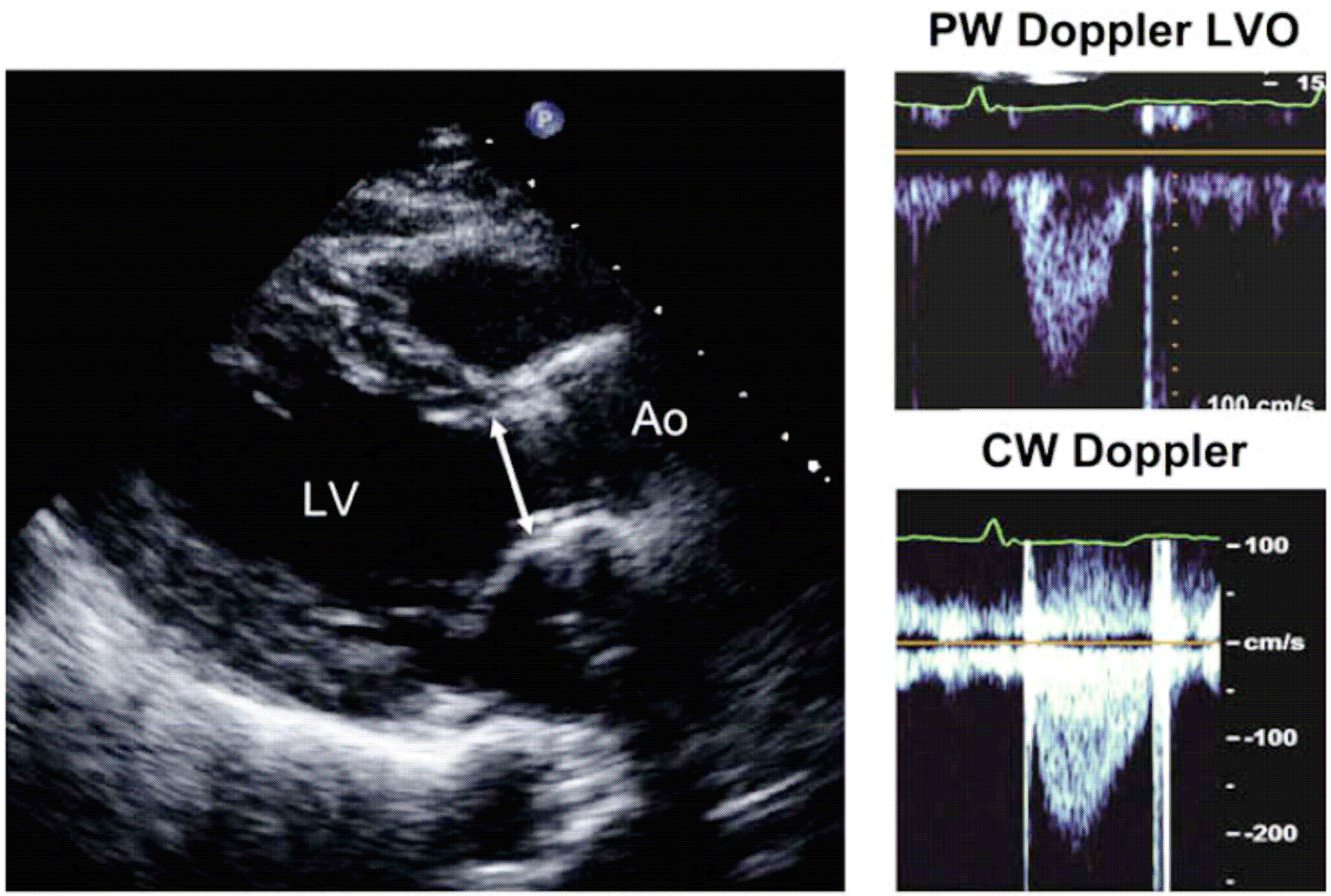
EOA (Effective Orifice Area)

$$EOA_{PrAV} = (CSA_{LVO} \times VTI_{LVO})/VTI_{prAV},$$

- VTI_{LVO}
  - PW at 0.5 to 1 cm below the sewing ring
- VTI_{prAV}
  - CW

EOA (Effective Orifice Area)

- Dependent on the size of the inserted valve
- A comparison with a baseline postoperative study is helpful.
- The largest source of variability is measurement of the LVO tract
  - When this diameter is difficult to obtain, another site for flow measurement may be used
  - TEE
    - an excellent opportunity for an LVO measurement



$$\text{Effective Orifice Area} = \frac{CSA_{LVO} \times VTI_{LVO}}{VTI_{JET}}$$

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DVI (Doppler Velocity Index)

$$EOA_{PrAV} = (CSA_{LVO} \times VTI_{LVO})/VTI_{prAV,}$$

$$DVI = V_{LVO}/V_{PrAV}.$$

- The ratio of the respective peak velocities
- Much less dependent on valve size
- When the CSA_{LVO} cannot be obtained or valve size is not known
- A $DVI < 0.25$ is highly suggestive of significant valve obstruction

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Diagnosis of Prosthetic Aortic Valve Stenosis

- High velocity alone is not proof of intrinsic prosthetic obstruction and may be secondary to high flow or PPM
- High gradients may not be manifest in patients with prosthesis dysfunction and low cardiac output state
- Doppler recorded gradients may be spuriously elevated in bileaflet mechanical prosthesis because of pressure recovery at the valvular level

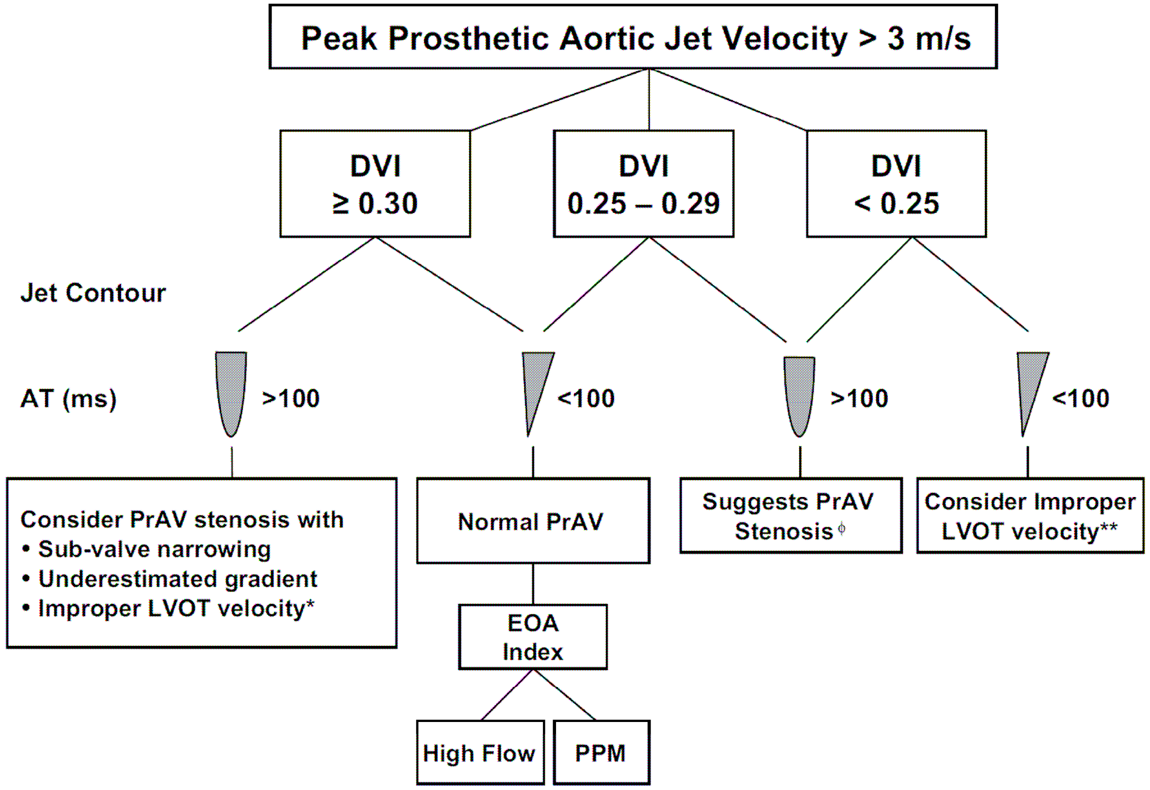
Diagnosis of Prosthetic Aortic Valve Stenosis

Table 5 Doppler parameters of prosthetic aortic valve function in mechanical and stented biologic valves*

Parameter	Normal	Possible stenosis	Suggests significant stenosis
Peak velocity (m/s)†	<3	3-4	>4
Mean gradient (mm Hg)†	<20	20-35	>35
DVI	≥0.30	0.29-0.25	<0.25
EOA (cm^2)	>1.2	1.2-0.8	<0.8
Contour of the jet velocity through the PrAV	Triangular, early peaking	Triangular to intermediate	Rounded, symmetrical contour
AT (ms)	<80	80-100	>100

PrAV, Prosthetic aortic valve.
*In conditions of normal or near normal stroke volume (50-70 mL) through the aortic valve.
†These parameters are more affected by flow, including concomitant AR.

Diagnosis of Prosthetic Aortic Valve Stenosis



igure 10 Algorithm for evaluation of elevated peak prosthetic aortic jet velocity incorporating DVI, jet contour, and AT. *PW Doppler ample too close to the valve (particularly when jet velocity by CW Doppler is ≥4 m/s). **PW Doppler sample too far (apical) from the alve (particularly when jet velocity is 3-3.9 m/s). φStenosis further substantiated by EOA derivation compared with reference values if alve type and size are known. Fluoroscopy and TEE are helpful for further assessment, particularly in bileaflet valves. *AVR*, Aortic alve replacement.

Prosthetic Aortic Valve Regurgitation

- Imaging Considerations
- Doppler Evaluation of Severity of Prosthetic AR
- Role of TEE in Prosthetic AR
- An Integrative Approach in Evaluating Prosthetic AR.

Imaging Considerations

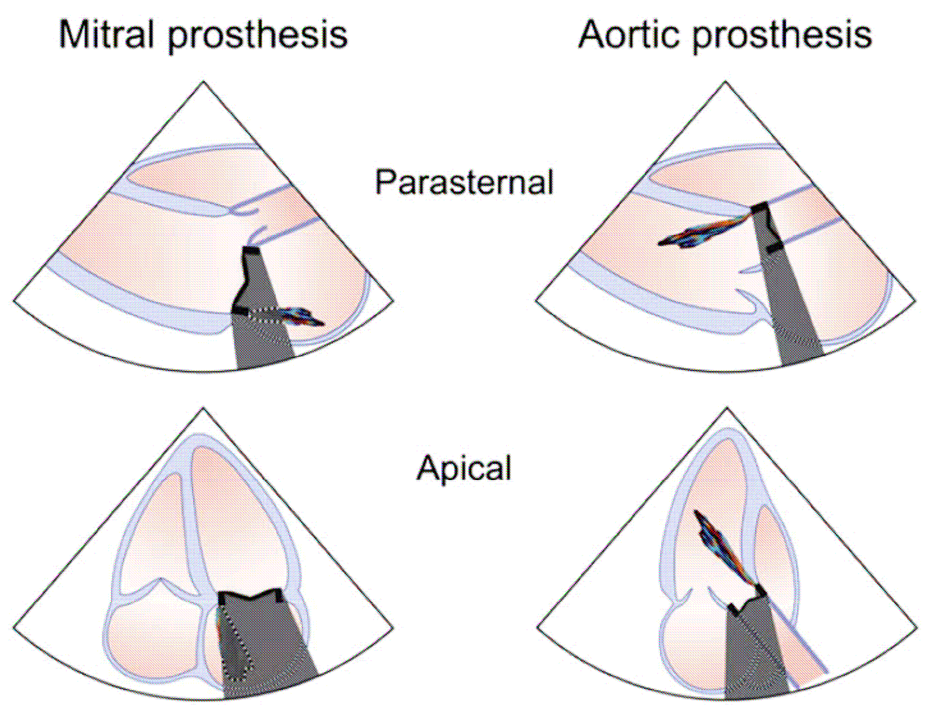


Figure 4 Effect of mechanical prosthetic valve position and echocardiographic imaging view on shadowing and masking of a regurgitation jet by Doppler. A higher effect from transthoracic imaging is seen on prostheses in the mitral position compared to the aortic position.

Imaging Considerations

- TTE is useful to identify the presence of both paravalvular and intravalvular prosthetic AR
- Optimal views for the detection of regurgitant jets include
  - Parasternal long-axis
  - Short-axis views
  - Apical long-axis view
  - 5-chamber view

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Doppler Evaluation of Severity of Prosthetic AR

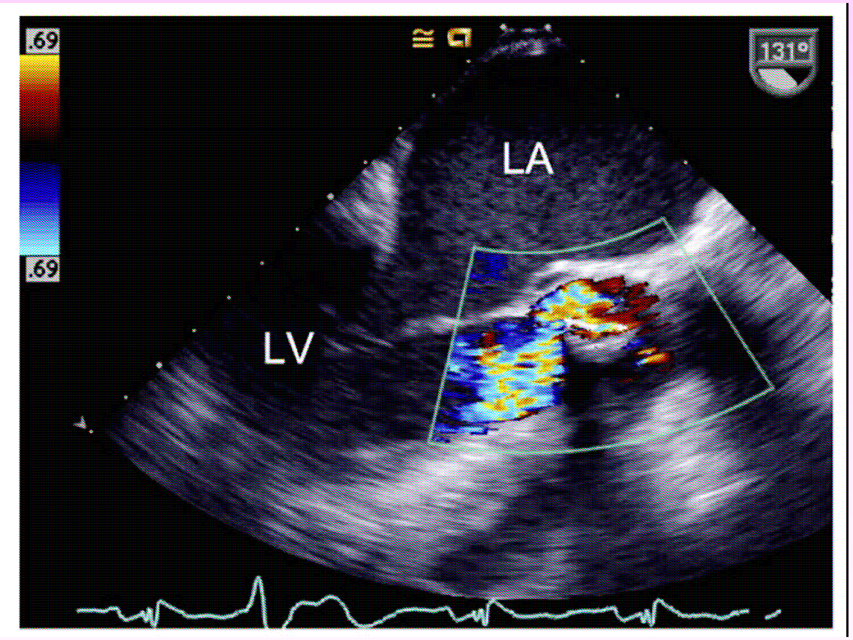
- Color Doppler
- Spectral Doppler
- Role of TEE in Prosthetic AR

Color Doppler

- Evaluation of the components of the color AR jet
  - Flowconvergence
  - Vena contracta
  - Extent in the LVOand left ventricle
- Its origin, and its direction Is necessary for an accurate evaluation
- Normal “physiologic” jets will usually be low in momentum, as shown by homogeneous color jets that are small in extent

Color Doppler

- The ratios of jet diameter/LVO diameter from parasternal long-axis imaging and jet area/LVO area from parasternal short-axis imaging of the LVO just below the prosthesis, as parameters of AR severity, are best applied in central jets



- AR jets may often be eccentric

Color Doppler

- In contrast to native valves, the width of the vena contracta, as a parameter of AR severity, may be difficult to accurately measure in the long axis in the presence of a prosthesis
- Careful imaging of the neck of the jet in a short-axis view, at the level of the prosthesis sewing ring
  - <10% of the sewing ring suggests mild
  - 10% to 20% suggests moderate
  - >20% suggests severe

Spectral Doppler

- The pressure half-time is useful
  - <200 ms, suggesting severe regurgitation
  - >500 ms, consistent with mild regurgitation.
  - However, intermediate ranges of pressure half-time (200-500 ms) may reflect other hemodynamic variables such as LV compliance and are less specific

Spectral Doppler

- The presence of holodiastolic flow reversal in the descending thoracic aorta is indicative of at least moderate AR
- Severe AR is suspected when the VTI of the reverse flow approximates that of the forward flow

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Role of TEE in Prosthetic AR

- To better identify technically difficult site in TTE
- Delineate the mechanism of regurgitation and associated complications such as
  - Endocarditis
  - Abscess formation
  - Masses, or thrombus that Interfere with disc function

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An Integrative Approach in Evaluating Prosthetic AR

Table 6 Parameters for evaluation of the severity of prosthetic aortic valve regurgitation

	Parameter	Mild	Moderate	Severe
1	Valve structure and motion			
	Mechanical or bioprosthetic	Usually normal	Abnormal†	Abnormal†
	Structural parameters			
	LV size	Normal‡	Normal or mildly dilated‡	Dilated‡
	Doppler parameters (qualitative or semiquantitative)			
	Jet width in central jets (% LVO diameter): color*	Narrow (≤25%)	Intermediate (26%-64%)	Large (≥65%)
	Jet density: CW Doppler	Incomplete or faint	Dense	Dense
	Jet deceleration rate (PHT, ms): CW Doppler§	Slow (>500)	Variable (200-500)	Steep (<200)
	LVO flow vs pulmonary flow: PW Doppler	Slightly increased	Intermediate	Greatly increased
	Diastolic flow reversal in the descending aorta: PW Doppler	Absent or brief early diastolic	Intermediate	Prominent, holodiastolic
2	Doppler parameters (quantitative)			
	Regurgitant volume (mL/beat)	<30	30-59	>60
	Regurgitant fraction (%)	<30	30-50	>50

Concordance

Contradictory ➔ Physiological or Technical reasons?

➔Rely on most accurate component with best quality

Thanks