From ASE guidelines. Zoghbi et al 2009 (http://asecho.org/guidelines/guidelines-standards/)

Prosthetic Aortic Valve

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

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

Parameter	Mild	Moderate	Severe
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
Doppler parameters (quantitative)			
Regurgitant volume (mL/beat)	<30	30-59	>60
Regurgitant fraction (%)	<30	30-50	>50

Prosthetic Mitral Valve

Table 8 Doppler parameters of prosthetic mitral valve function

	Normal*	Possible stenosis‡	Suggests significant stenosis* ‡
Peak velocity (m/s)† §	<1.9	1.9-2.5	≥2.5
Mean gradient (mm Hg)† §	≤5	6-10	>10
VTI_{PrMV}/VTI_{LVO} † §	<2.2	2.2-2.5	>2.5
EOA (cm^2)	≥2.0	1-2	<1
PHT (ms)	<130	130-200	>200

Table 9 TTE findings suggestive of significant prosthetic MR (with normal PHT)

- Peak mitral velocity ≥ 1.9 m/s
- VTI (MV)/VTI (LVOT) ≥ 2.5
- Mean gradient ≥ 5 mm of Hg
- Maximal TR jet velocity > 3 m/s
- LV stroke volume (by 2D/3D) > 30 % higher than stroke volume derived by Doppler
- Systolic flow convergence towards prosthesis

Table 10 Echocardiographic and Doppler criteria for severity of prosthetic MR using findings from TTE and TEE

Parameter	Mild	Moderate	Severe
Structural parameters			
LV size	Normal*	Normal or dilated	Usually dilated‡
Prosthetic valve‖	Usually normal	Abnormal¶	Abnormal¶
Doppler parameters			
Color flow jet area‖ #	Small, central jet (usually <4 cm^2 or <20% of LA area)	Variable	Large central jet (usually >8 cm^2 or >40% of LA area) or variable size wall-impinging jet swirling in left atrium
Flow convergence**	None or minimal	Intermediate	Large
Jet density: CW Doppler‖	Incomplete or faint	Dense	Dense
Jet contour: CW Doppler‖	Parabolic	Usually parabolic	Early peaking, triangular
Pulmonary venous flow‖	Systolic dominance§	Systolic blunting§	Systolic flow reversal†
Quantitative parameters††			
VC width (cm)‖	<0.3	0.3-0.59	≥0.6
R vol (mL/beat)	<30	30-59	≥60
RF (%)	<30	30-49	≥50
EROA (cm^2)	<0.20	0.20-0.49	≥0.50

Prosthetic Pulmonary Valve

Table 12 Findings suspicious for prosthetic pulmonary valve stenosis

Cusp or leaflet thickening or immobility
Narrowing of forward color map
Peak velocity through the prosthesis >3 m/s or >2 m/s through a homograft*
Increase in peak velocity on serial studies†
Impaired RV function or elevated RV systolic pressure

Table 13 Evaluation of severity of prosthetic pulmonary valve regurgitation

Parameter	Mild	Moderate	Severe
Valve structure	Usually normal	Abnormal or valve dehiscence	Abnormal or valve dehiscence
RV size	Normal*	Normal or dilated	Dilated‡
Jet size by color Doppler (central jets)‖	Thin with a narrow origin; jet width ≤25% of pulmonary annulus	Intermediate; jet width 26%-50% of pulmonary annulus	Usually large, with a wide origin; jet width >50% of pulmonary annulus; may be brief in duration
Jet density by CW Doppler	Incomplete or faint	Dense	Dense
Jet deceleration rate by CW Doppler	Slow deceleration	Variable deceleration	Steep deceleration§, early termination of diastolic flow
Pulmonary systolic flow vs systemic flow by PW Doppler†	Slightly increased	Intermediate	Greatly increased
Diastolic flow reversal in the pulmonary artery	None	Present	Present

Prosthetic Tricuspid Valve

Table 15 Doppler parameters of prosthetic tricuspid valve function

	Consider valve stenosis*
Peak velocity†	>1.7 m/s
Mean gradient†	≥6 mm Hg
Pressure half-time	≥230 ms
EOA and VTI_{PrTV}/VTI_{LVO}	No data yet available for tricuspid prostheses

Table 16 Echocardiographic and Doppler parameters used in grading severity of prosthetic tricuspid valve regurgitation

Parameter	Mild	Moderate	Severe
Valve structure	Usually normal	Abnormal or valve dehiscence	Abnormal or valve dehiscence
Jet area by color Doppler, central jets only (cm^2)	<5	5-10	>10
VC width (cm)*	Not defined	Not defined, but <0.7	>0.7
Jet density and contour by CW Doppler	Incomplete or faint, parabolic	Dense, variable contour	Dense with early peaking
Doppler systolic hepatic flow	Normal or blunted	Blunted	Holosystolic reversal
Right atrium, right ventricle, IVC	Normal†	Dilated	Markedly dilated

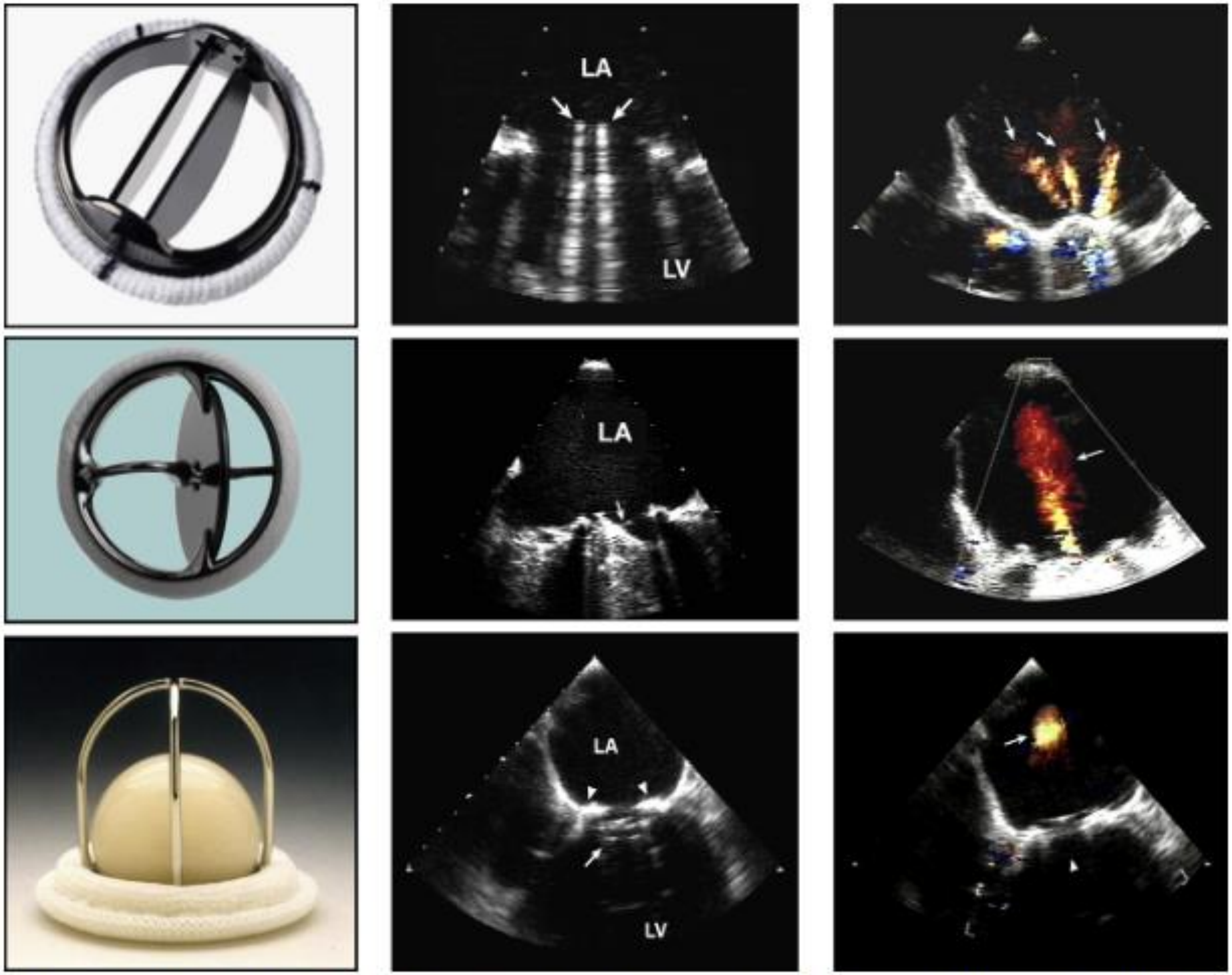

Figure 1 Examples of bileaflet, single-leaflet, and caged-ball mechanical valves and their transesophageal echocardiographic characteristics taken in the mitral position in diastole *(middle)* and in systole *(right)*. The *arrows* in diastole point to the occluder mechanism of the valve and in systole to the characteristic physiologic regurgitation observed with each valve. Videos 1 to 6 show the motion and color flow patterns seen with these valves. View video clips online.

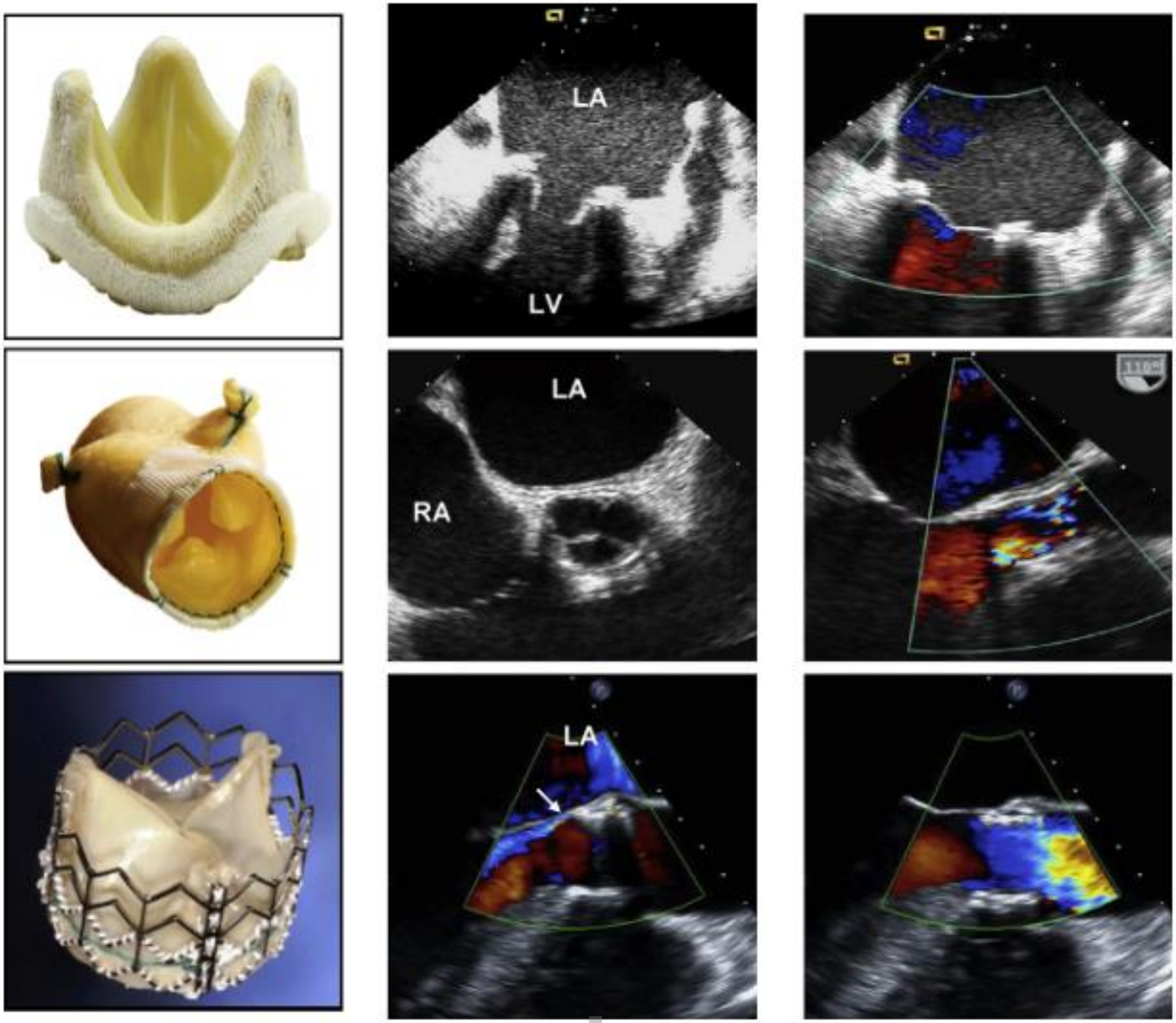

Figure 2 Examples of stented, stentless, and percutaneous biologic valves and their echocardiographic features in diastole *(middle)* and in systole *(right)* as seen by TEE. The stentless valve is inserted by the root inclusion technique. Mild perivalvular AR in the percutaneous valve is shown by *arrow*. The percutaneous biologic valve is currently for investigational use only. Videos 7 to 10 show the valve motion and color Doppler flow pattern of these valves. View video clips online.

Table 1 Types of prosthetic heart valves

Biologic
Stented
Porcine xenograft
Pericardial xenograft
Stentless
Porcine xenograft
Pericardial xenograft
Homograft (allograft)
Autograft
Percutaneous
Mechanical
Bileaflet
Single tilting disc
Caged-ball

velocity of the jet in meters per second. In patients with aortic prostheses and high cardiac output or narrow LV outflow (LVO), the velocity proximal to the prosthesis may be elevated and therefore not negligible (proximal velocity > 1.5 m/s). In these situations, estimation of the pressure gradient is more accurately determined by considering the velocity proximal to the prosthesis as $P = 4(V_2^2 - V_1^2)$. Pressure gradients derived with the simplified Bernoulli equation have correlated well with hemodynamically measured gradients. In bileaflet prostheses and caged-ball valves, however, overestimation of the gradient may occur, particularly with smaller valves and high cardiac output (see below).[18-21]

b. EOA. The EOA of a prosthesis by the continuity equation is a better index of valve function than gradient alone. This is calculated as

$$\text{EOA} = \text{stroke volume}/\text{VTI}_{PrV},$$

where VTI_{PrV} is the velocity-time integral through the prosthesis determined by CW Doppler. Stroke volume is usually derived as cross-sectional area just proximal to the prosthesis (in aortic or pulmo-

Table 2 Essential parameters in the comprehensive evaluation of prosthetic valve function

	Parameter
Clinical information	Date of valve replacement Type and size of the prosthetic valve Height, weight, body surface area Symptoms and related clinical findings Blood pressure and heart rate
Imaging of the valve	Motion of leaflets or occluder Presence of calcification on the leaflets or abnormal echo densities on the various components of the prosthesis Valve sewing ring integrity and motion
Doppler echocardiography of the valve	Contour of the jet velocity signal Peak velocity and gradient Mean pressure gradient VTI of the jet DVI Pressure half-time in MV and TV. EOA* Presence, location, and severity of regurgitation†
Other echocardiographic data	LV and RV size, function, and hypertrophy LA and right atrial size Concomitant valvular disease Estimation of pulmonary artery pressure
Previous postoperative studies, when available	Comparison of above parameters is particularly helpful in suspected prosthetic valvular dysfunction