SIÊU ÂM TIM ĐÁNH GIÁ VAN NHÂN TẠO

(Echocardiography for evaluation Prosthetic valves)

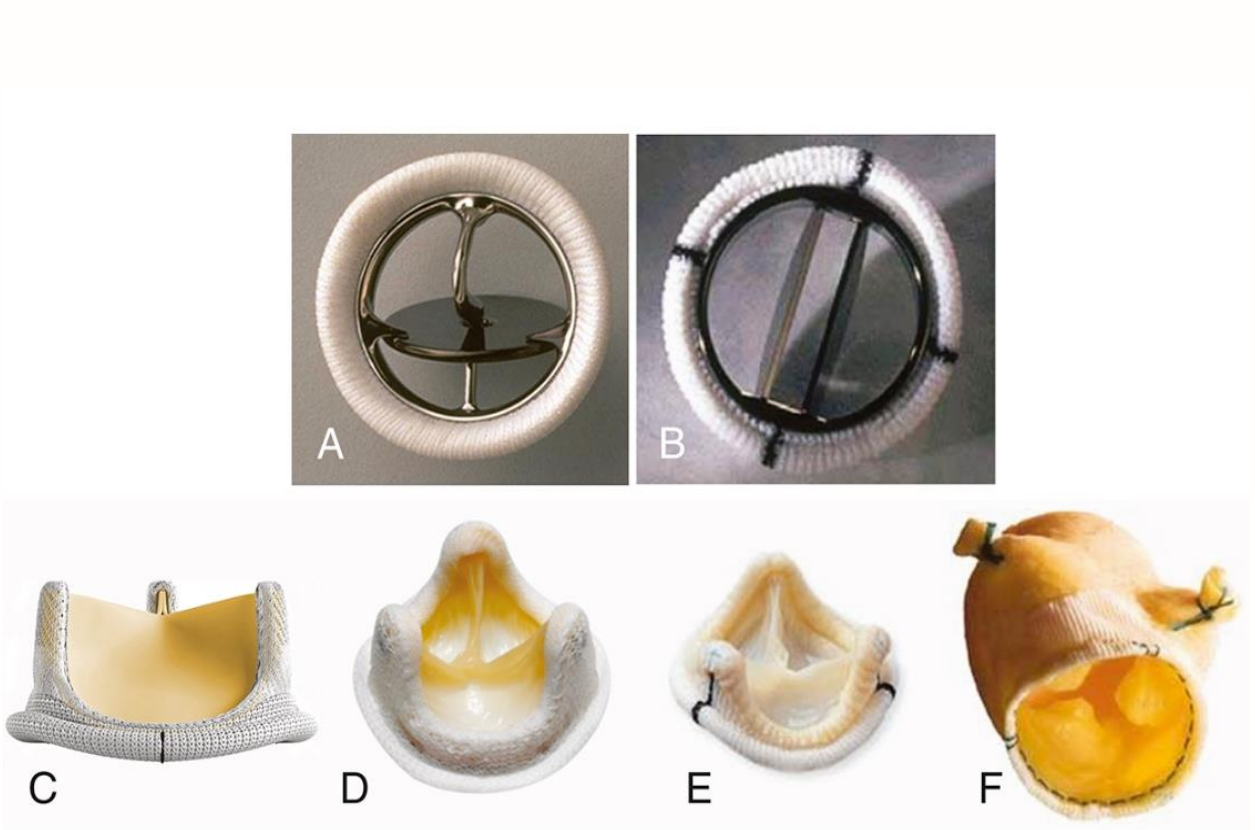
Bs Huỳnh Thanh Kiều

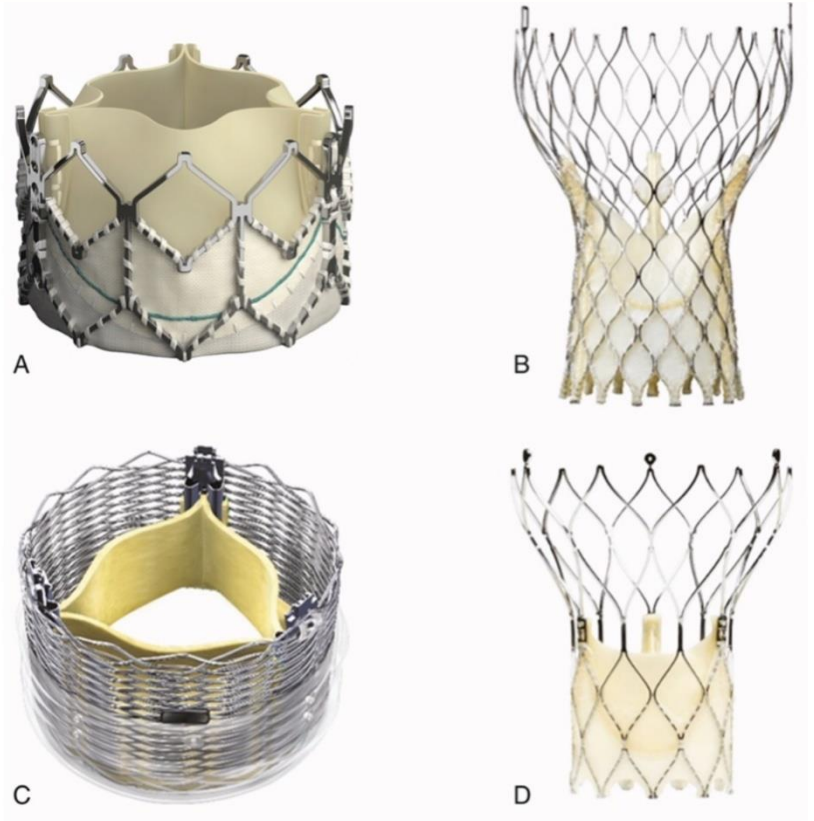
Bv tim Tâm Đức

Prosthetic valves

- Mechanical valves
  - Ball – cage
  - Tilting- disc
  - Bi-leaflet
- Biologic valves
  - Animal tissue (xenograft): stented and unstented
  - Human tissue (homograft and autograft)
- Transcatheter valves: biologic valves delivered through the catheter

Prosthetic valves





Mahjoub H, et al. Echocardiographic Recognition and Quantitation of Prosthetic Valve Dysfunction. In: The Practical of Clinical Echocardiography, 5th ed, 2017. Elvsevier. Chap 24.

Parameters in the evaluation of prosthetic valve function

Clinical information	- Type of valve and size - Date of surgery - Blood pressure and heart rate - Height, weight and BSA - Symptoms and signs
Imaging of the valve	- Motion of leaflets or occlude - Calcification on the leaflets or abnormal echo densities - Valve sewing ring integrity and motion
Doppler parameters	- Peak velocity and gradient - Mean pressure gradient - VTI, DVI, PHT, EOA - Severity of regurgitation†
Others data	- LV and RV size, function, and hypertrophy - LA and right atrial size - Concomitant valvular disease - Pulmonary artery pressure
Previous postoperative studies, when available	- Comparison of above parameters

Zoghbi WA, et al. Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound. JASE Sep 2009. Doi:10.1016

Timing of Echocardiography

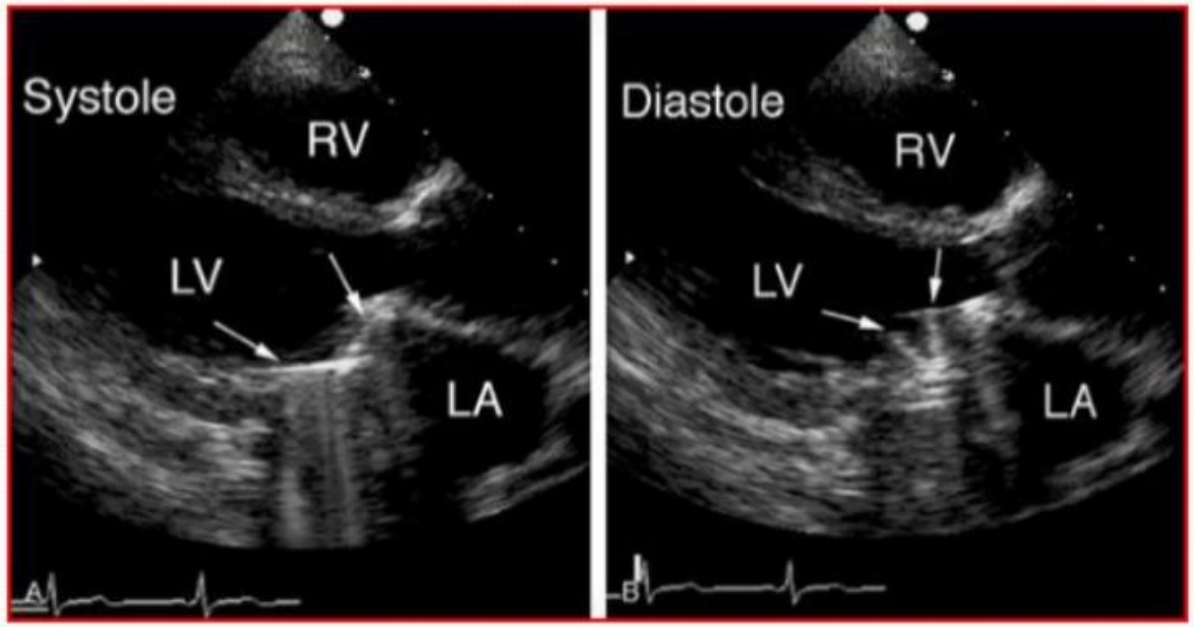
- 4-8 weeks after valve implantation (baseline study)

- 6 months and yearly TTE

- Change in symptoms and signs suggesting valve dysfunction

Mahjoub H, et al. Echocardiographic Recognition and Quantitation of Prosthetic Valve Dysfunction. In: The Practical of Clinical Echocardiography, 5th ed, 2017. Elvsevier. Chap 24.

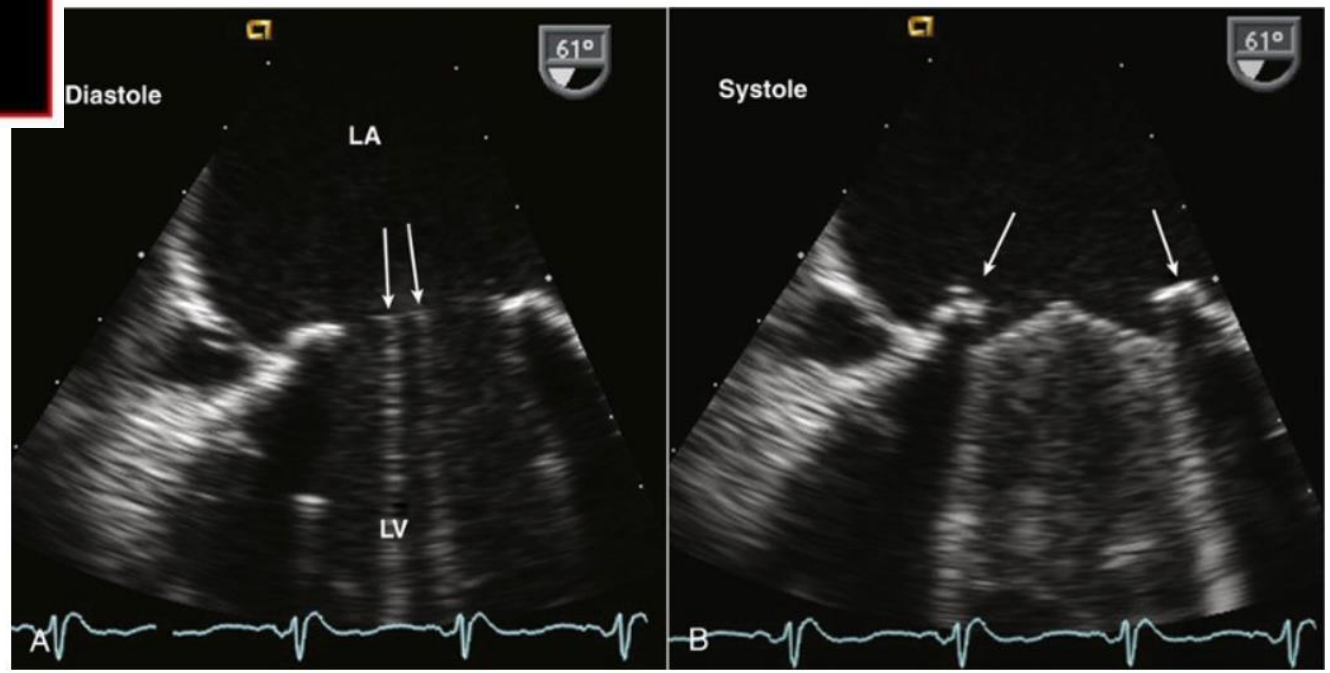
TTE vs TEE



Transthoracic Echocardiography

Prosthetic valve evaluation:

- Transthoracic Echocardiography (TTE)
- Transeosophageal Echocardiography (TEE)
- Cinefluoroscopy
- MSCT
- Cardiac Catheterization



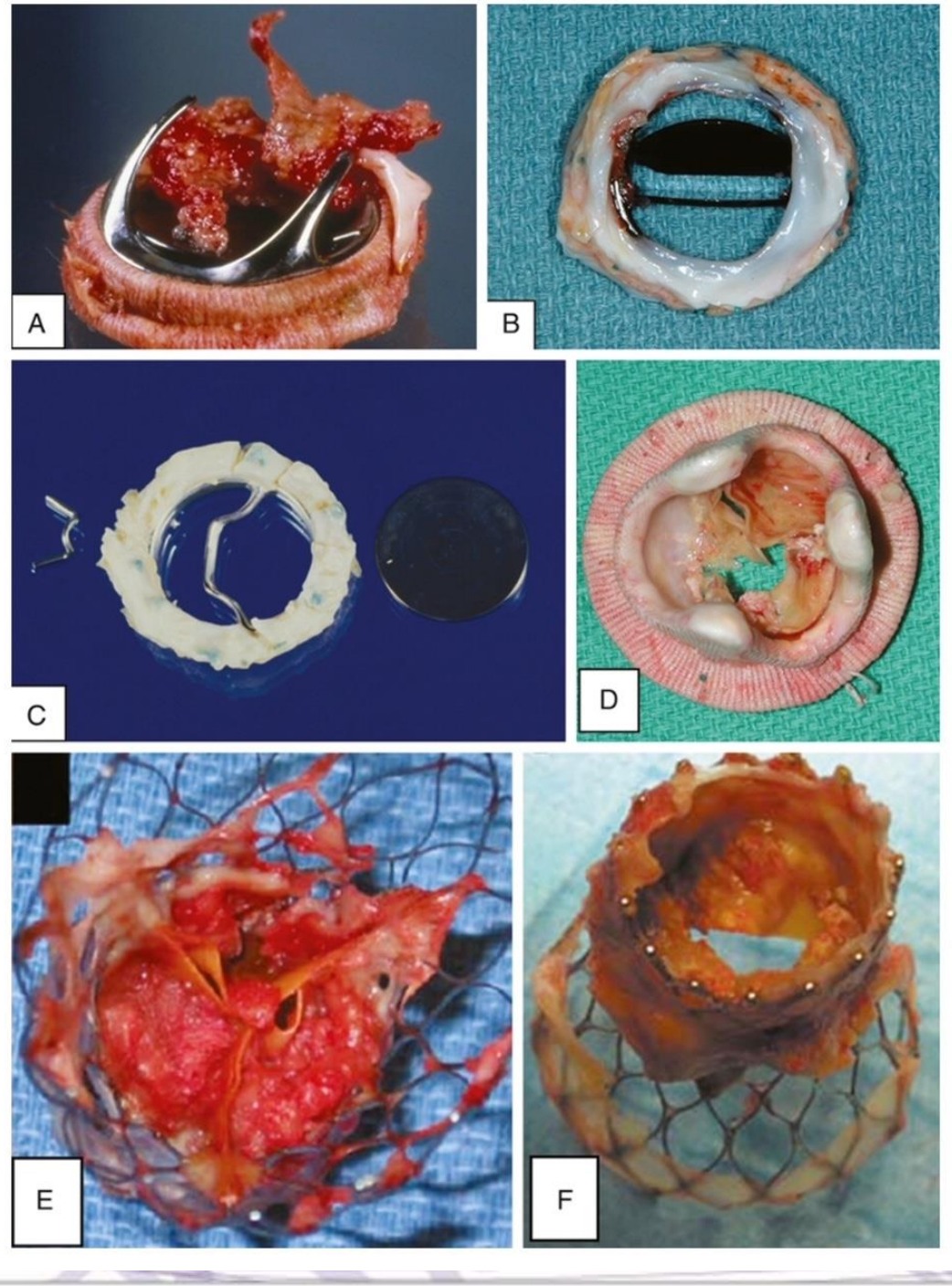
Transeosophageal Echocardiography

Complications of prosthetic valves

Early stage	- Valvular dysfunction (related to technique or early infection) - Thromboembolism - Paravalvular leak - Endocarditis
Late stage	- Thromboembolism - Pannus - Valve degeneration (stenosis and/or regurgitation) - Endocarditis - Hemolysis

Zoghbi WA, et al. Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound. JASE Sep 2009. Doi:10.1016

Prosthetic valves explanted for severe dysfunction



Mahjoub H, et al. Echocardiographic Recognition and Quantitation of Prosthetic Valve Dysfunction. In: The Practical of Clinical Echocardiography, 5th ed, 2017. Elvsevier. Chap 24.

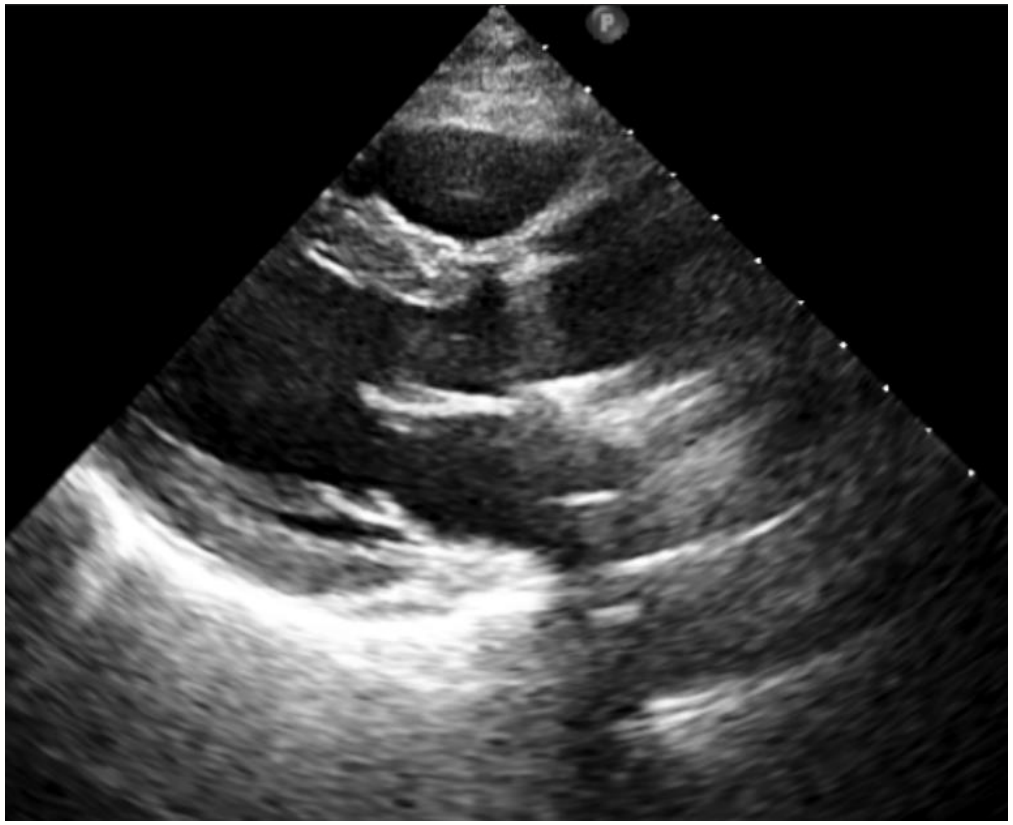
Aortic Prosthetic valves

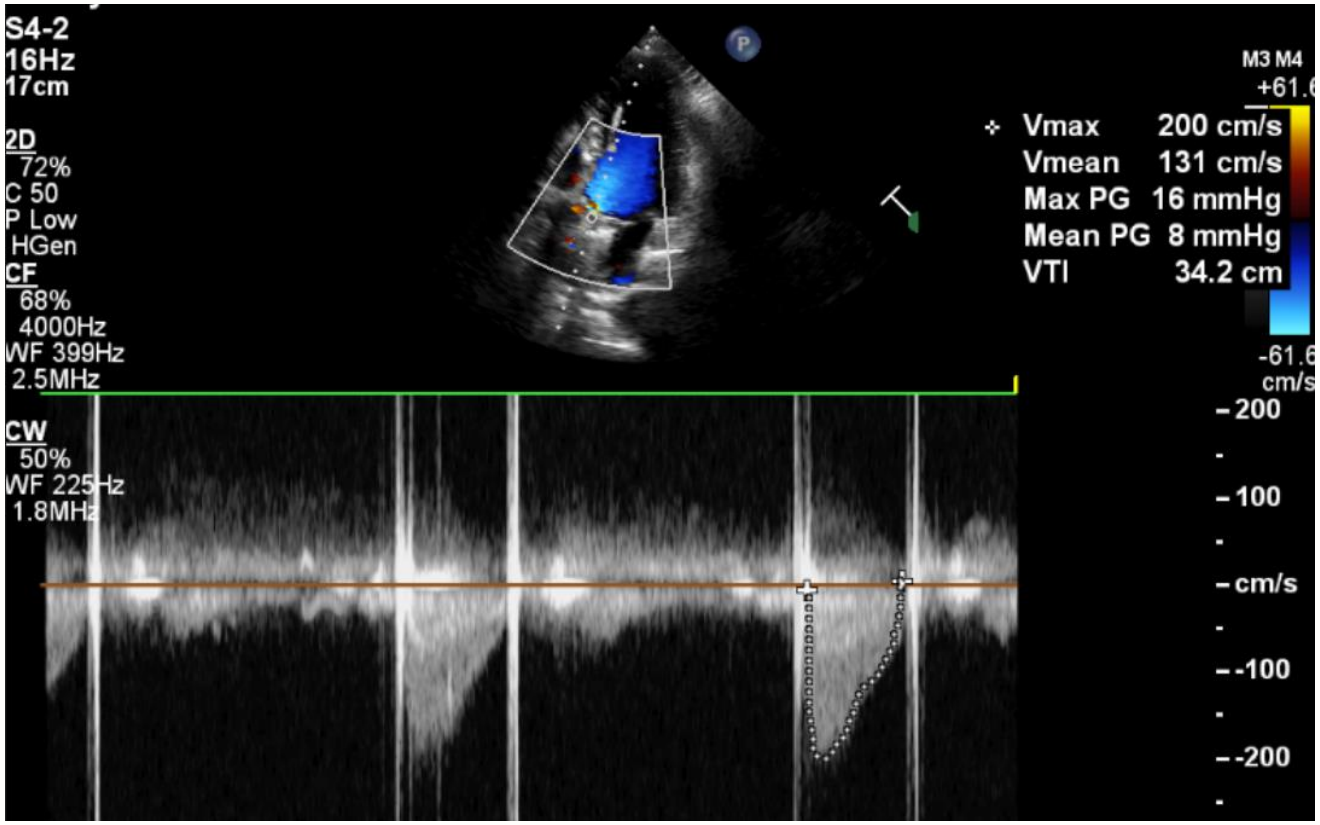
Evaluation of prosthetic aortic valves

Imaging findings	- Sewing ring - Valve or occluder mechanism - Surrounding area
Doppler Parameters	- Peak velocity/gradient - Mean gradient - Contour of the jet velocity, AT - DVI - PHT - EOA - Presence, location, and severity of regurgitation
Others data	- LV size, function, and hypertrophy

Zoghbi WA, et al. Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound. JASE Sep 2009. Doi:10.1016

Aortic valve image





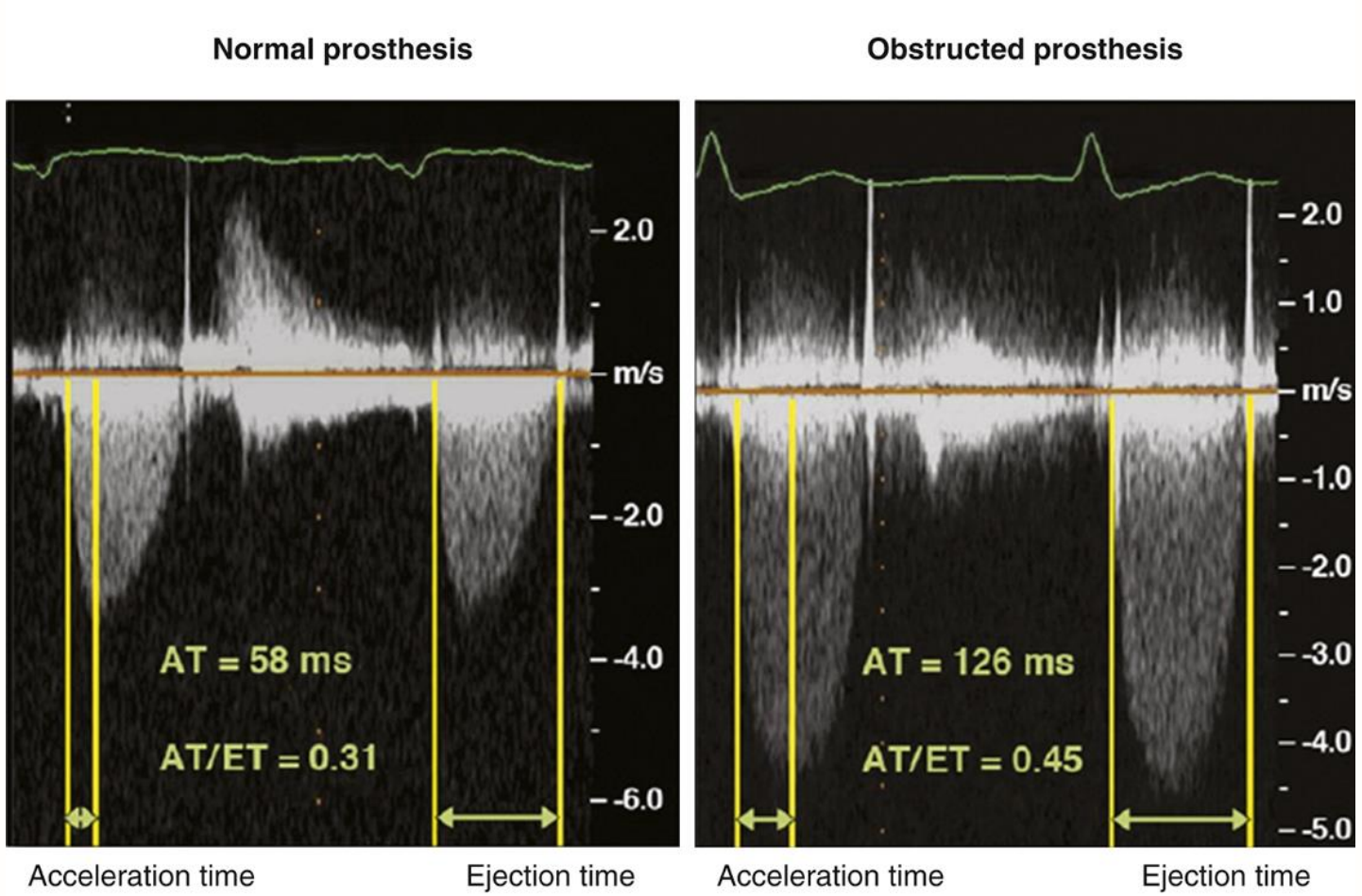
Bn thay van ĐMC cơ học:

Vmax= 2 m/s

Mean gradient= 8 mmHg

AT= 35 ms

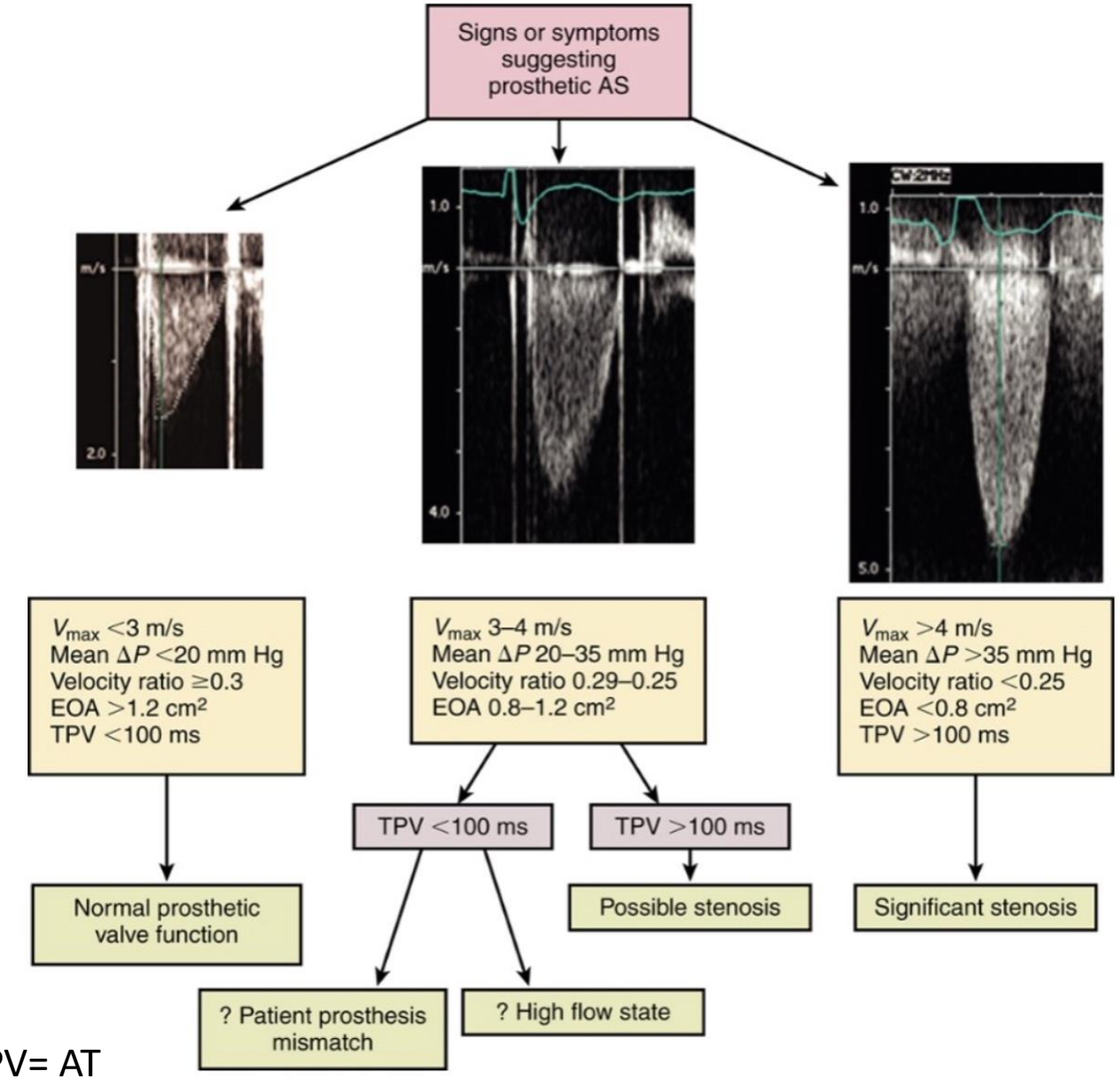
Doppler recordings of a normal and obstructed prosthetic valve in the aortic position



MG = 24 mmHg
DVI = 0.4
AT = 58 ms
AT/LVET = 0.31

MG = 47 mmHg
DVI = 0.2
AT = 126 ms
AT/LVET = 0.45

Algorithm for evaluation of prosthetic aortic stenosis



TPV= AT

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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.

V > 4 m/s
Mean gradient > 35 mmHg
DVI < 0.25
EOA < 0.8 cm2
AT > 100 ms

↓

Significant Stenosis

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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

PHT, Pressure half-time.

*Parameter applicable to central jets and is less accurate in eccentric jets; Nyquist limit of 50 to 60 cm/s.

†Abnormal mechanical valves, for example, immobile occluder (valvular regurgitation), dehiscence or rocking (paravalvular regurgitation); abnormal biologic valves, for example, leaflet thickening or prolapse (valvular), dehiscence or rocking (paravalvular regurgitation).

‡Applies to chronic, late postoperative AR in the absence of other etiologies.

§Influenced by LV compliance.

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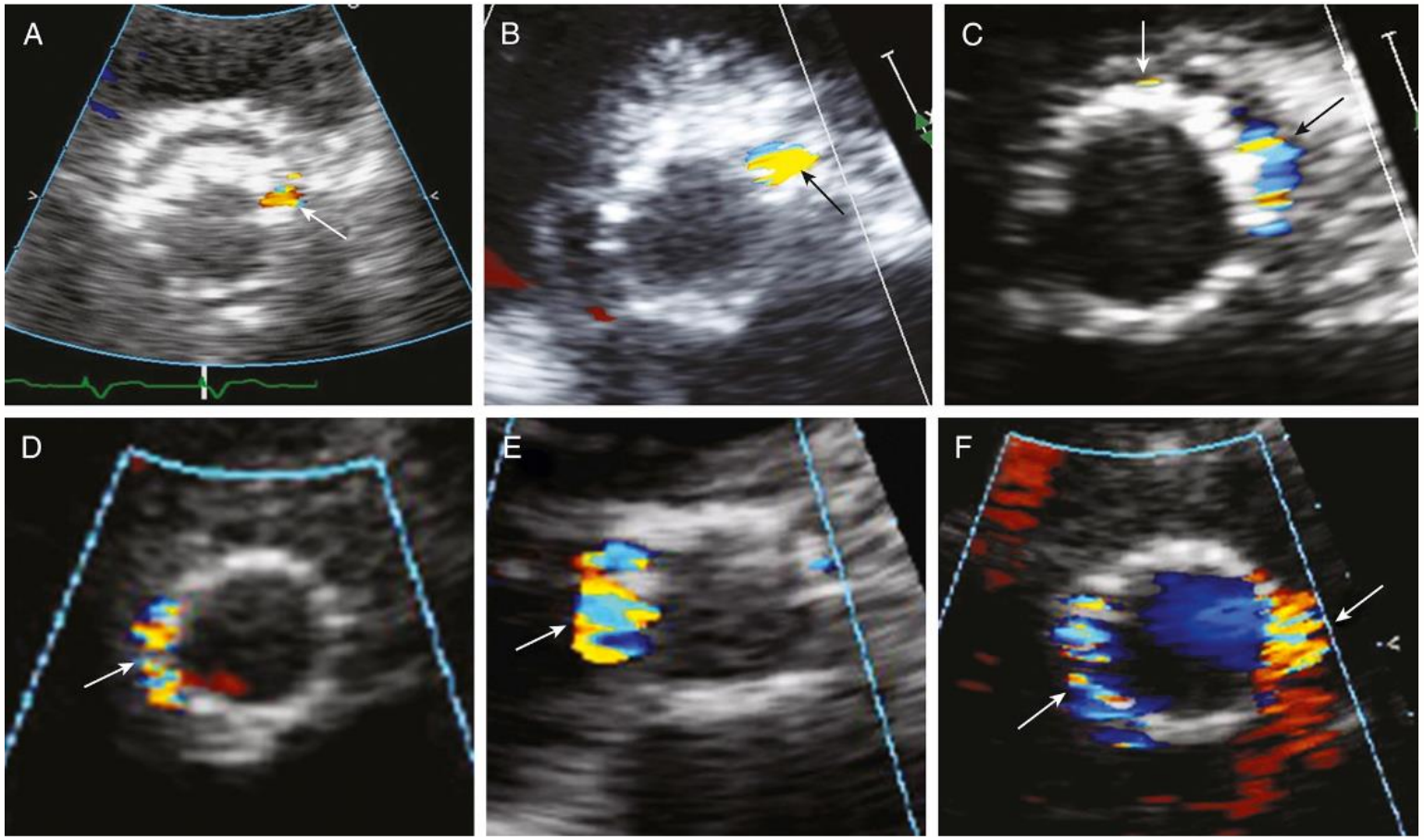
Aortic prosthetic valve regurgitation

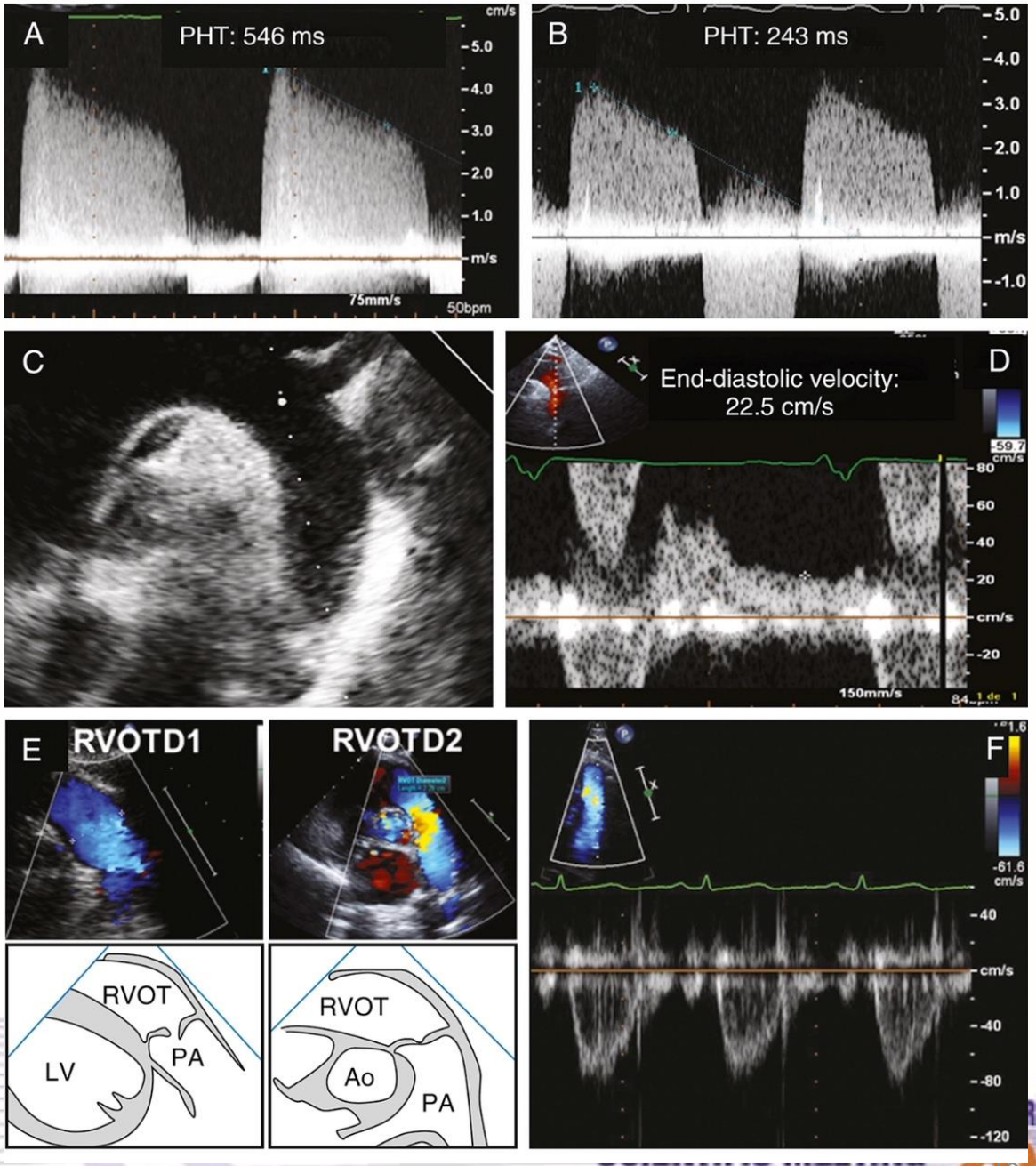
- Color Doppler: (Intra or paravalvular regurgitation)
  - Flow convergence
  - VC
  - Extention (radiation) to LV
- Doppler parameters:
  - Jet area/ Prosthetic sewing area (short axis):
    - < 10%: mild
    - > 20%: severe
  - PHT
    - < 200 ms → severe AR
    - > 500 ms → mild
  - Holodiastolic flow reversal/Descending aorta
  - RV (Regurgitant volume):
    - < 30 Ll: mild
    - > 60 mL: severe AR
  - RF (Regurgitant fraction):
    - < 30%: mild
    - > 50%: severe AR

Jet area/ Prosthetic sewing area (short axis)

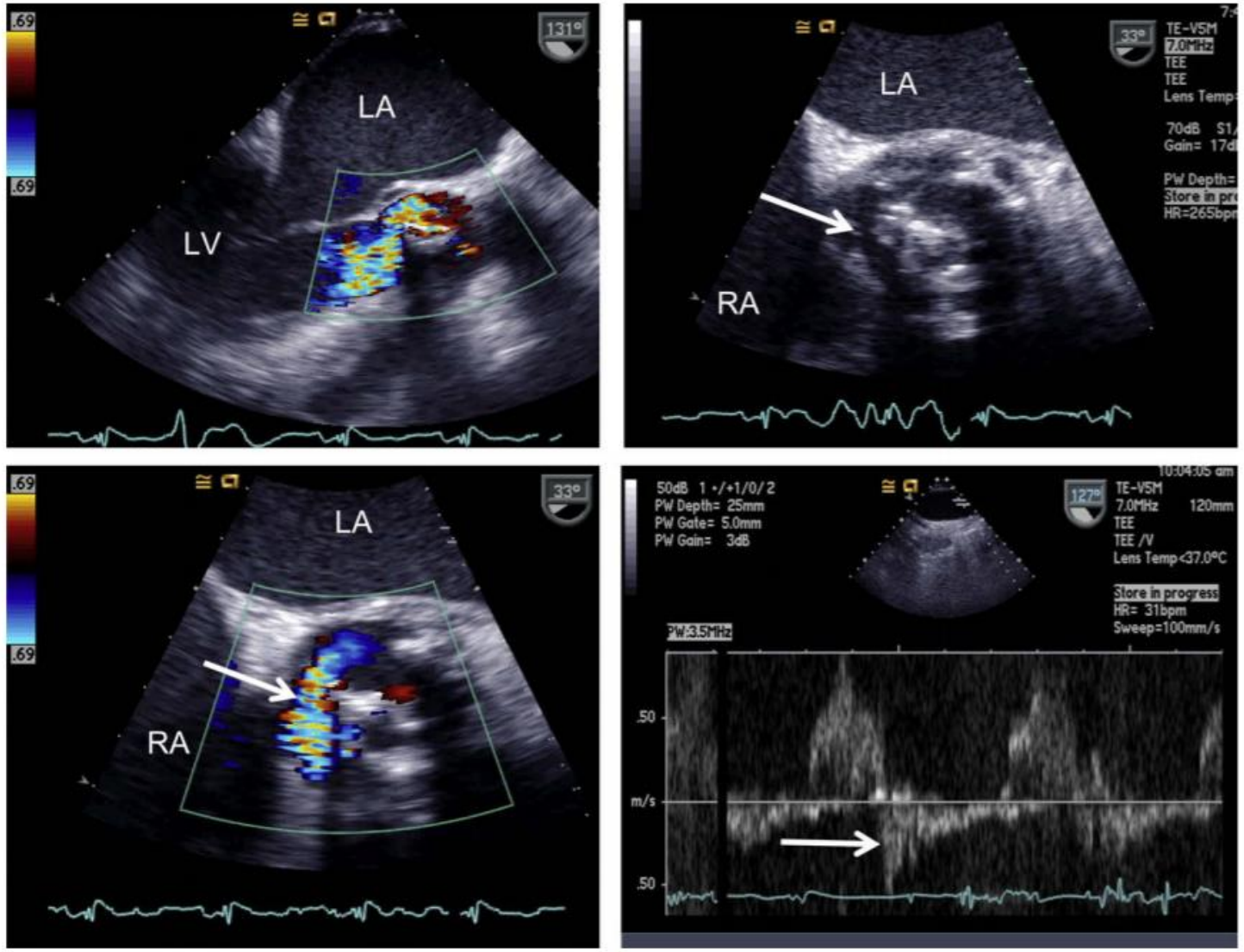


MC cạnh ức trục ngang: diện tích dòng hở/diện tích vòng van ĐMC

Doppler parameters: PHT and Holodiastolic flow reversal/Descending aorta



Transesophageal images of a patient with perivalvular significant AR



Zoghbi WA, et al. Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound. JASE Sep 2009. Doi:10.1016

Mitral prosthetic valves

Mitral ProstheticValve Function and Stenosis

Imaging findings	
Parasternal view	- Sewing ring - Leaflet excursion
Apical view	Leaflet excursion - Valve motion - Thrombus - Pannus - Vegetation: limited - Paravalvular leak

Mitral ProstheticValve Function and Stenosis

Doppler parameters	
	- Peak early velocity (E wave) - Mean pressure gradient - PHT - DVI and EOA (as needed) - Heart rate
Others data	
	- LV, RV size and function - LA, RA size - PASP

Mitral ProstheticValve Function and Stenosis

	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

PHT, Pressure half-time; *PrMV*, prosthetic mitral valve.
*Best specificity for normality or abnormality is seen if the majority of the parameters listed are normal or abnormal, respectively.
†Slightly higher cutoff values than shown may be seen in some bioprosthetic valves.
‡Values of the parameters should prompt a closer evaluation of valve function and/or other considerations such as increased flow, increased heart rate, or PPM.
§These parameters are also abnormal in the presence of significant prosthetic MR.

Significant Stenosis

V ≥ 2.5 m/s

Mean gradient > 10 mmHG

VTI PrV/LVO > 2.5

EOA < 1.0 cm2

PHT > 200 ms

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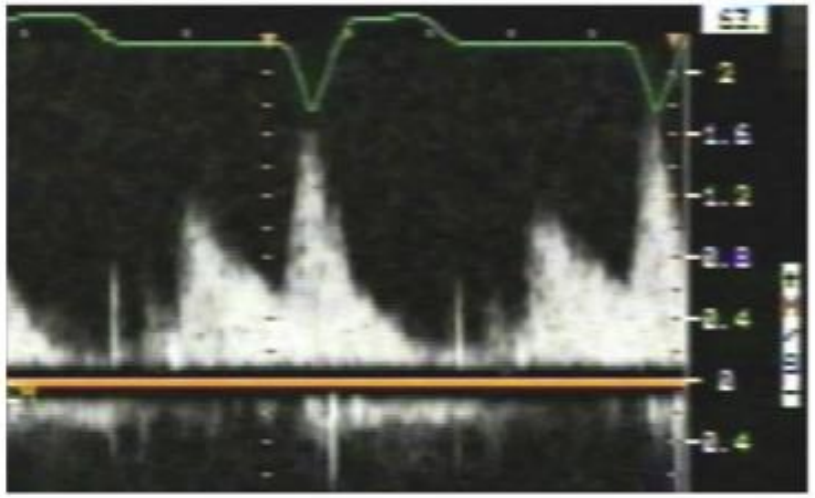
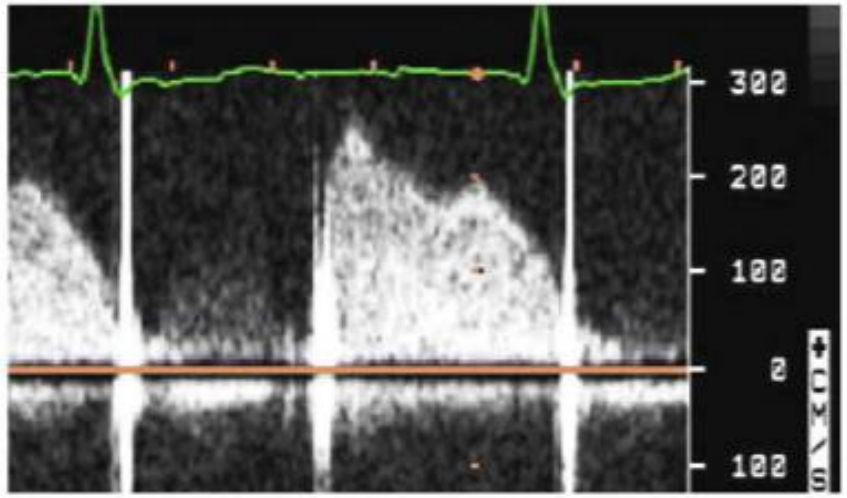
Doppler patterns in a normal and an obstructed mitral prosthetic valve

Normal



Peak E = 1.1 m/s
Mean G = 4 mmHg
PHT = 123 ms

Obstructed



Peak E = 2.5 m/s
Mean G = 15 mmHg
PHT = 170 ms

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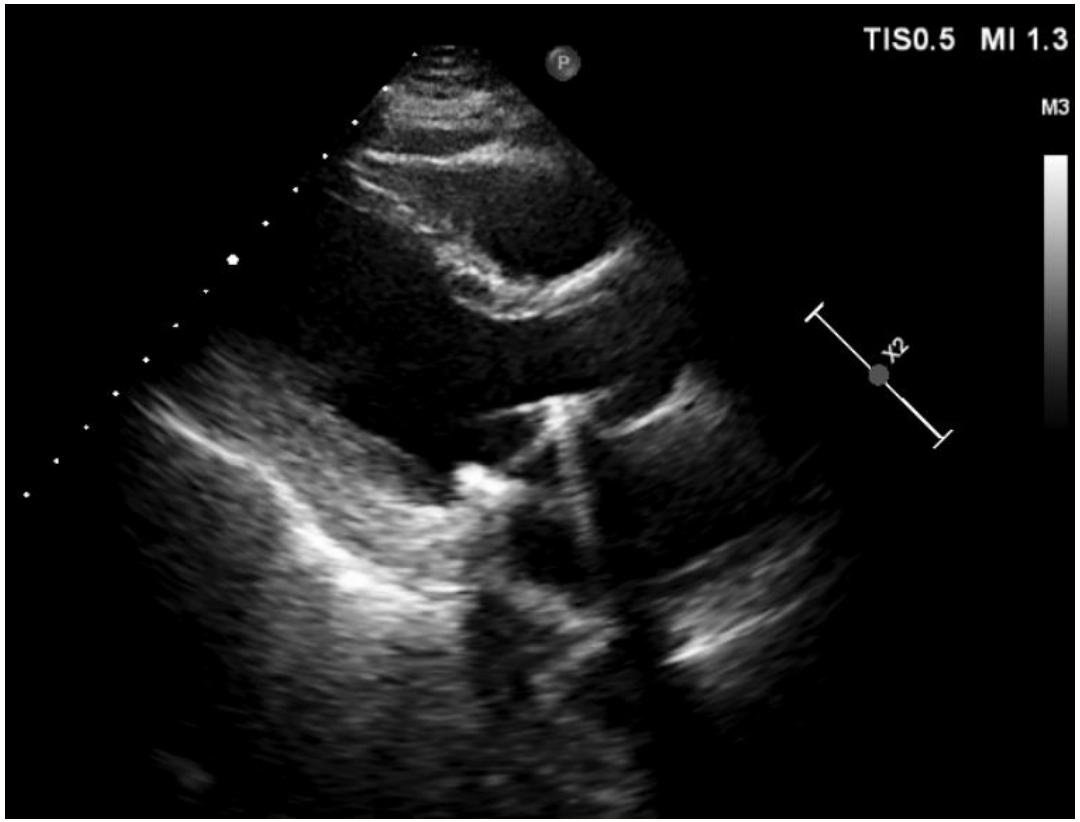
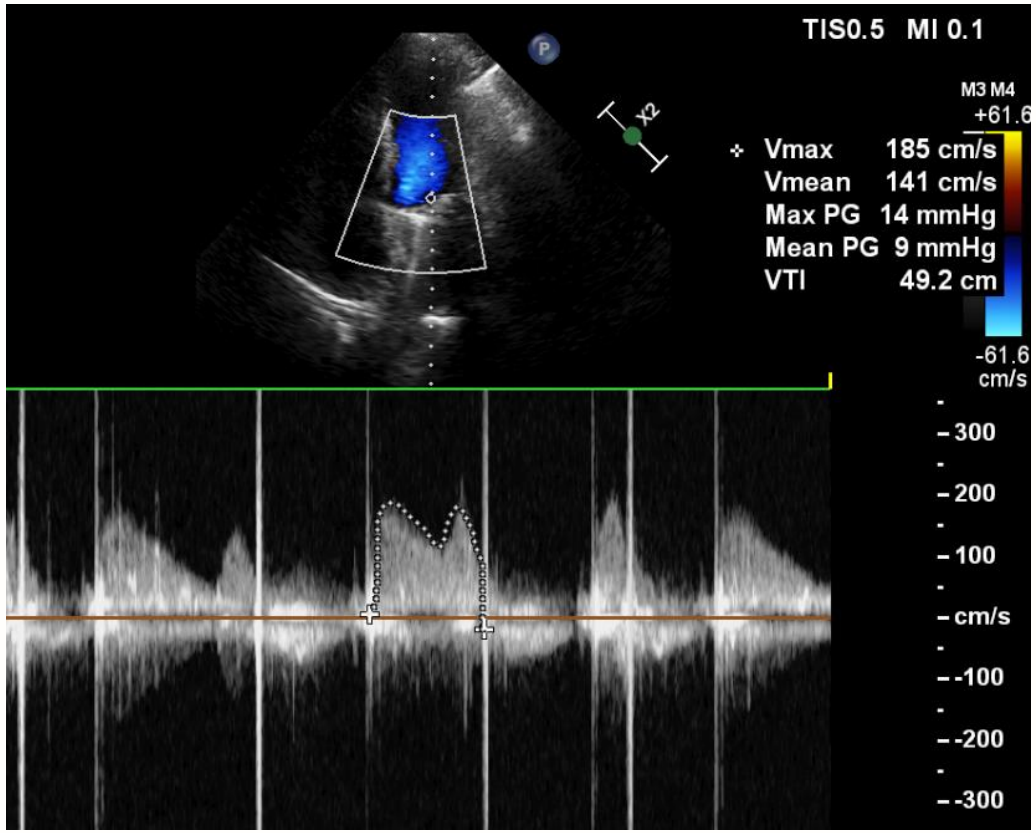
Ca lâm sàng





Bn nam, 50 tuổi, mổ thay van 2 lá 5/2015. Khám 10/2015: kẹt 1 đĩa van 2 lá cơ học

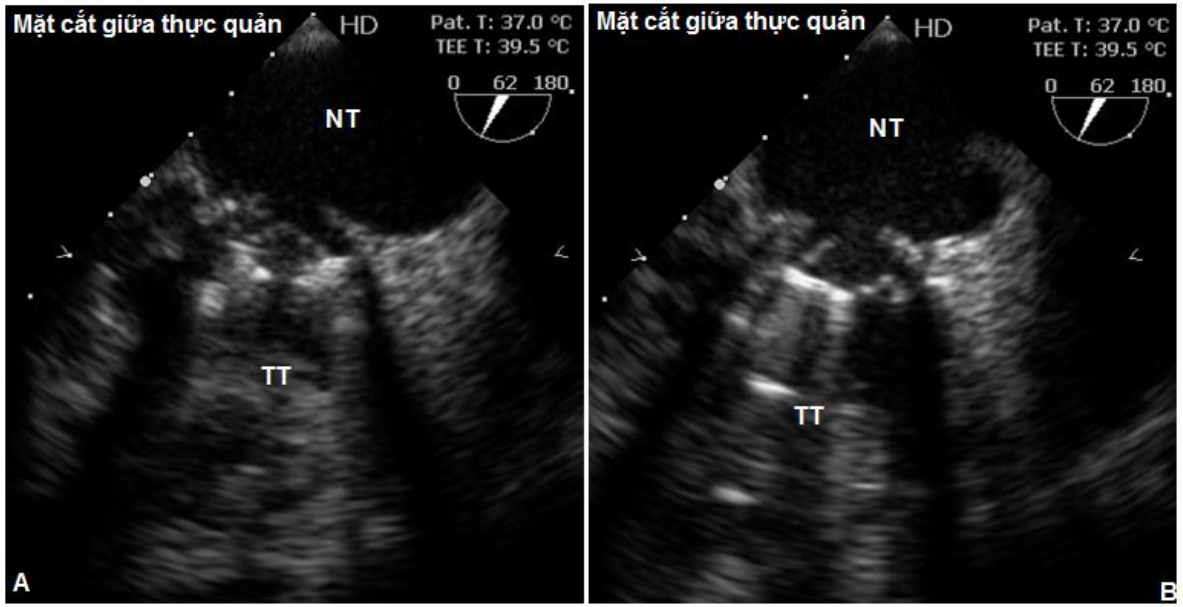
E velocity: 1.85 m/sec

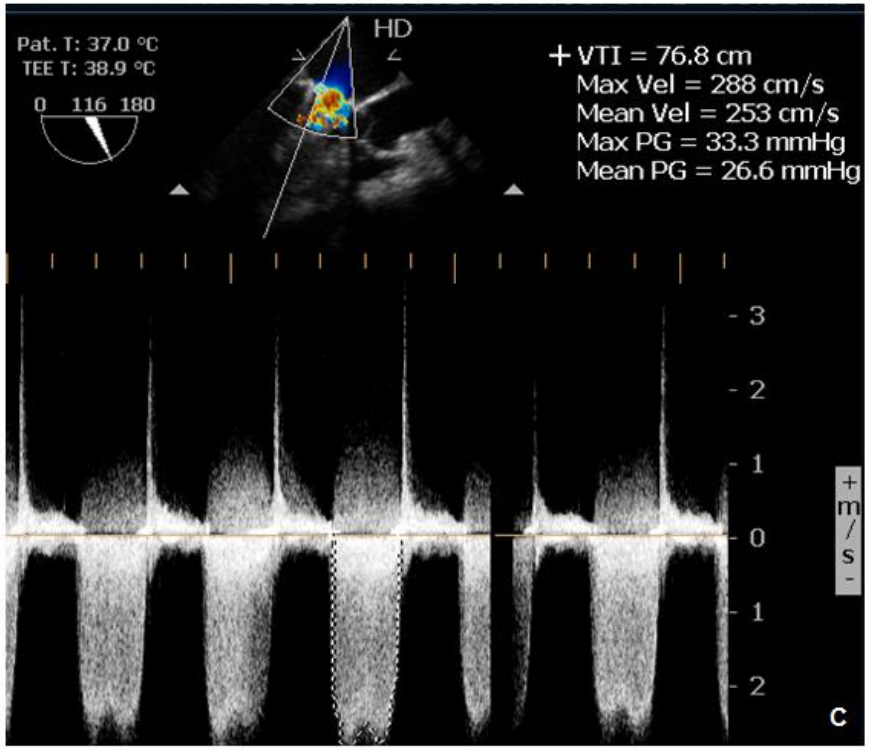
Mean gradient: 9 mmhg

PHT: 180 ms

PAPs= 50 mmHg

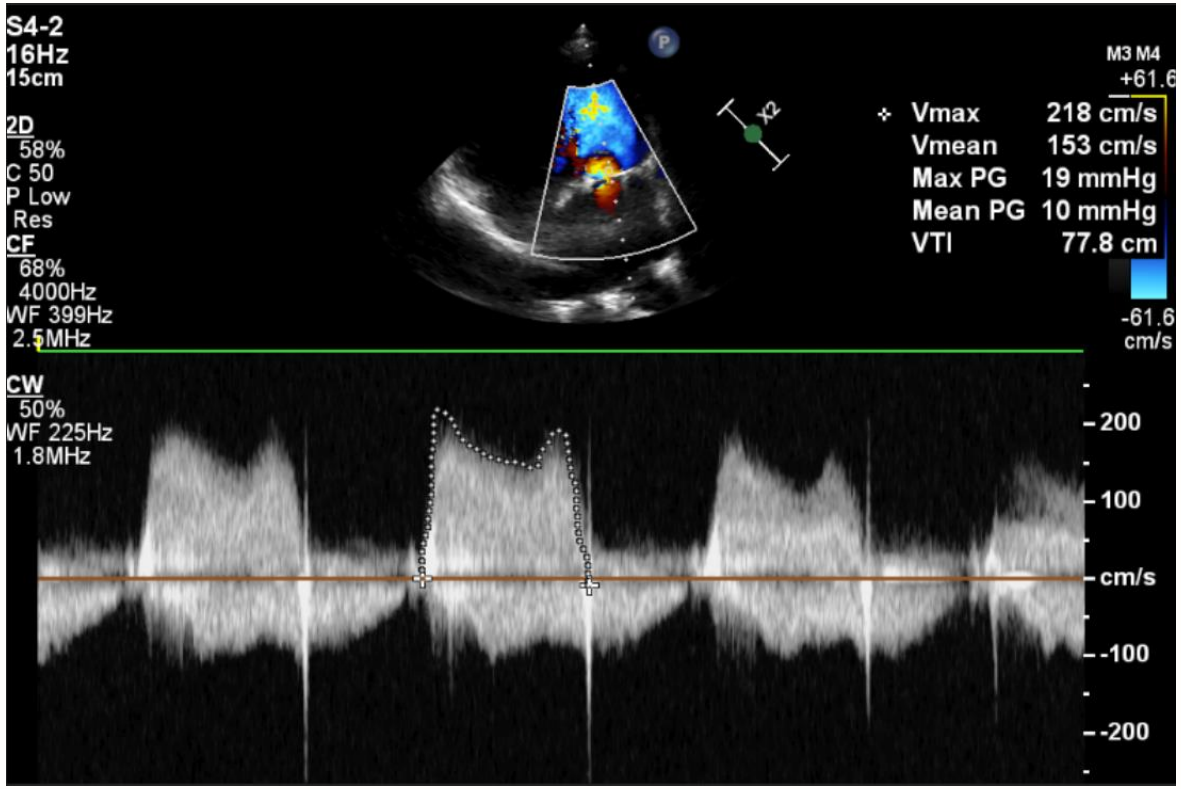
Ca lâm sàng





Siêu âm tim qua thực quản với mặt cắt giữa thực quản. Kẹt van hai lá cơ học. Bệnh nhân nữ, 44 tuổi. A, Van hai lá đóng, huyết khối ở vòng van. B, một lá van không mở, một lá mở 60º. C, chênh áp tối đa qua van hai lá 33mmHg.

Ca lâm sàng



BN nam, 54 tuổi, mổ thay van 2 lá sinh học 1997: thoái hóa van 2 lá sinh học

Vmax= 2.2 m/s; mean gradient= 10 mmHg; PHT= 198 ms

Transthoracic echocardiographic findings suggestive of significant prosthetic MR

Finding	Sensitivity	Specificity	Comments
Peak mitral velocity ≥1.9 m/s*	90%	89%	Also consider high flow, PPM
$VTI_{PrMV}/VTI_{LVO} \geq 2.5$*	89%	91%	Measurement errors increase in atrial fibrillation due to difficulty in matching cardiac cycles; also consider PPM
Mean gradient ≥ 5 mmHg*	90%	70%	At physiologic heart rates; also consider high flow, PPM
Maximal TR jet velocity > 3 m/s*	80%	71%	Consider residual postoperative pulmonary hypertension or other causes
LV stroke volume derived by 2D or 3D imaging is >30% higher than systemic stroke volume by Doppler	Moderate sensitivity	Specific	Validation lacking; significant MR is suspected when LV function is normal or hyperdynamic and VTI_{LVO} is <16 cm
Systolic flow convergence seen in the left ventricle toward the prosthesis	Low sensitivity	Specific	Validation lacking; technically challenging to detect readily

PrMV, Prosthetic mitral valve.
*Data from Olmos et al.[148] When both peak velocity and VTI ratio are elevated with a normal pressure half-time, specificity is close to 100%.

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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

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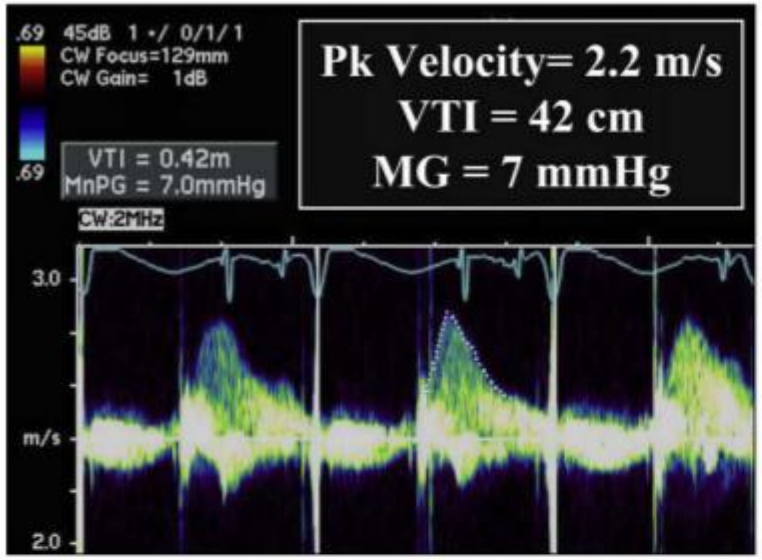
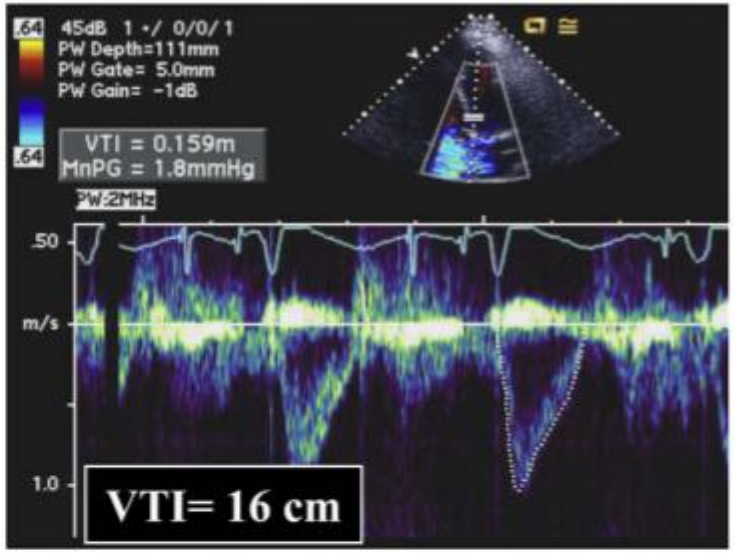
Transthoracic Doppler echocardiographic clues for significant mechanical MR

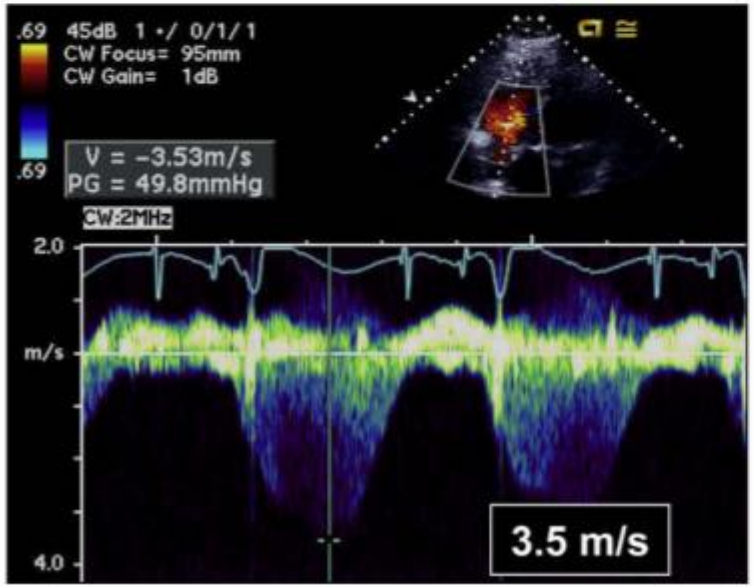
Prosthetic MV Jet



LVOT flow



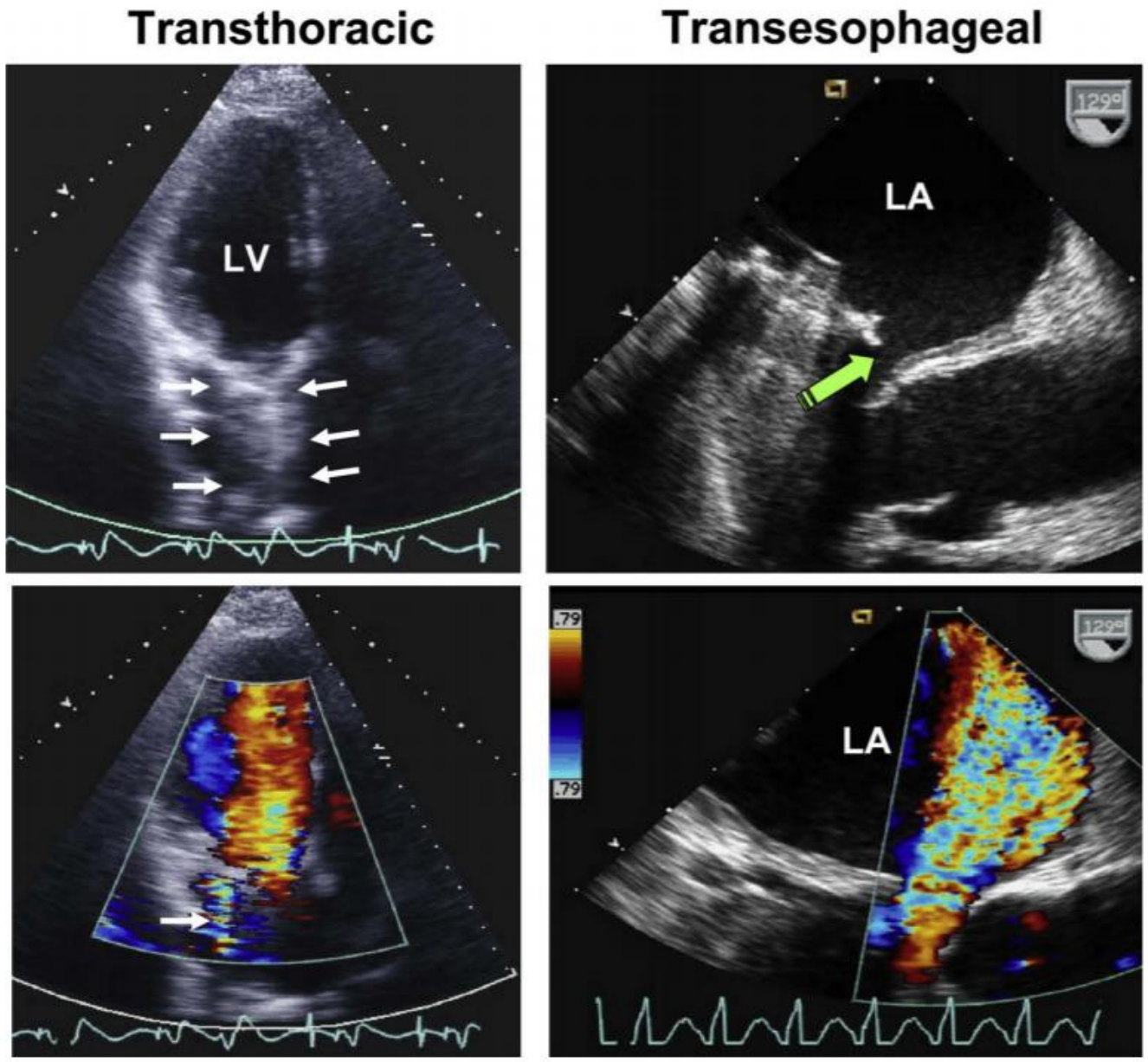
TR Jet velocity



$$\frac{VTI_{PrMV}}{VTI_{LVO}} = \frac{42}{16} = 2.6$$

Zoghbi WA, et al. Recommendations for Evaluation of Prosthetic Valves With Echocardiography and Doppler Ultrasound. JASE Sep 2009. Doi:10.1016

Transthoracic versus transesophageal echocardiographic and Doppler images in a patient with severe paravalvular MR



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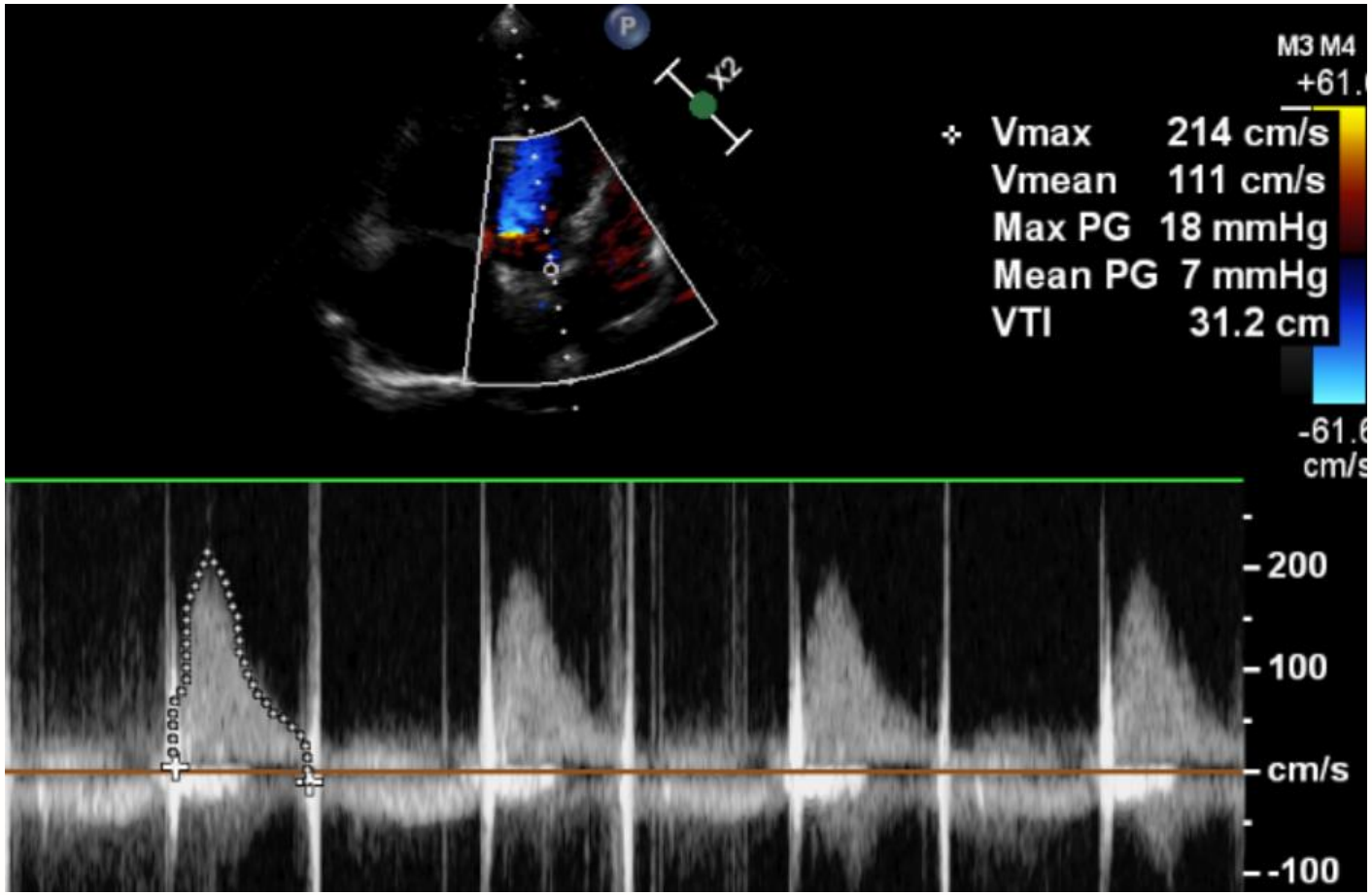
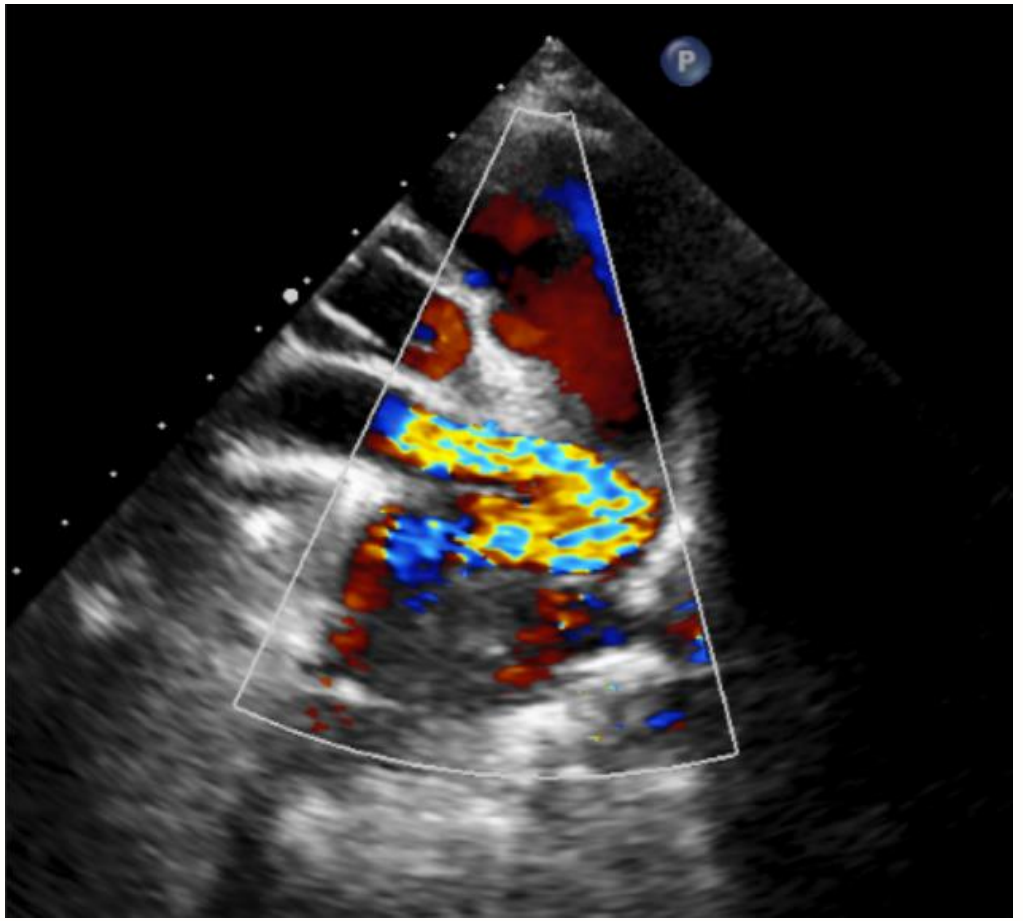
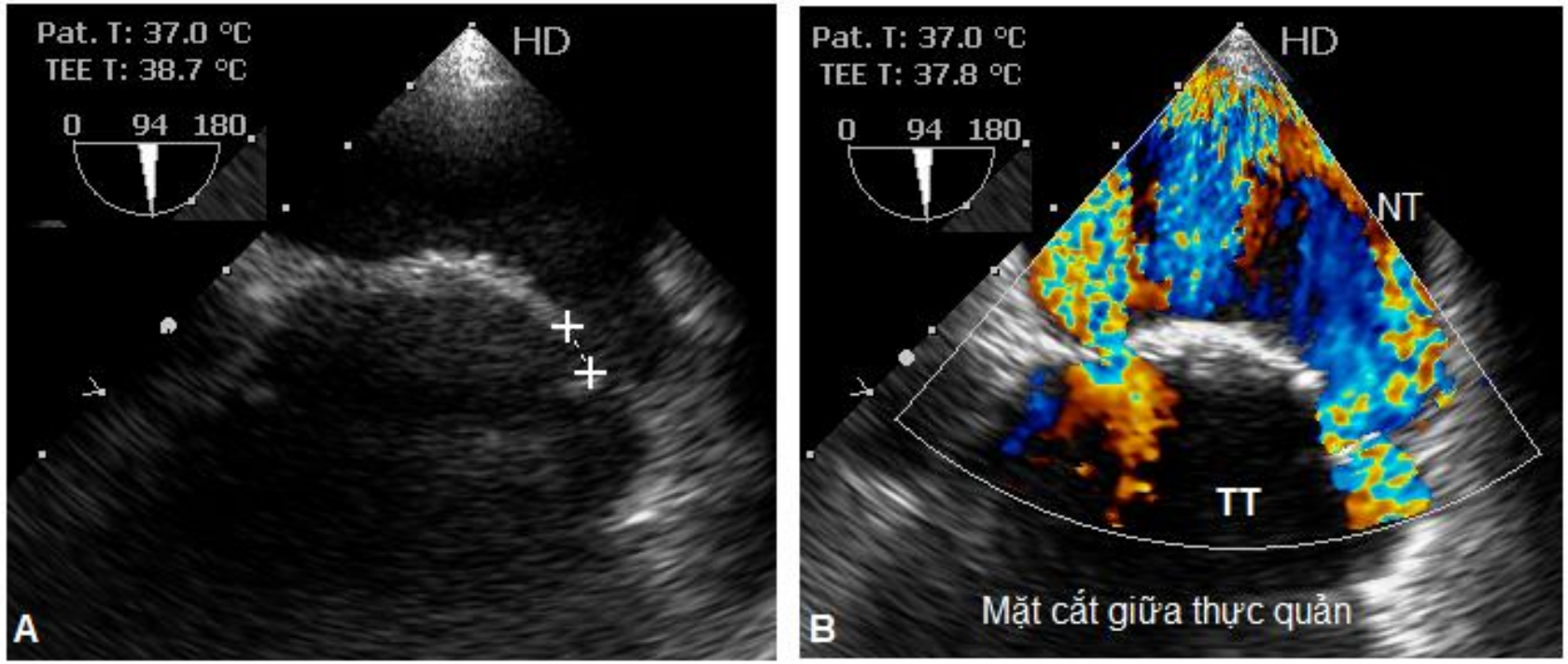
Ca lâm sàng



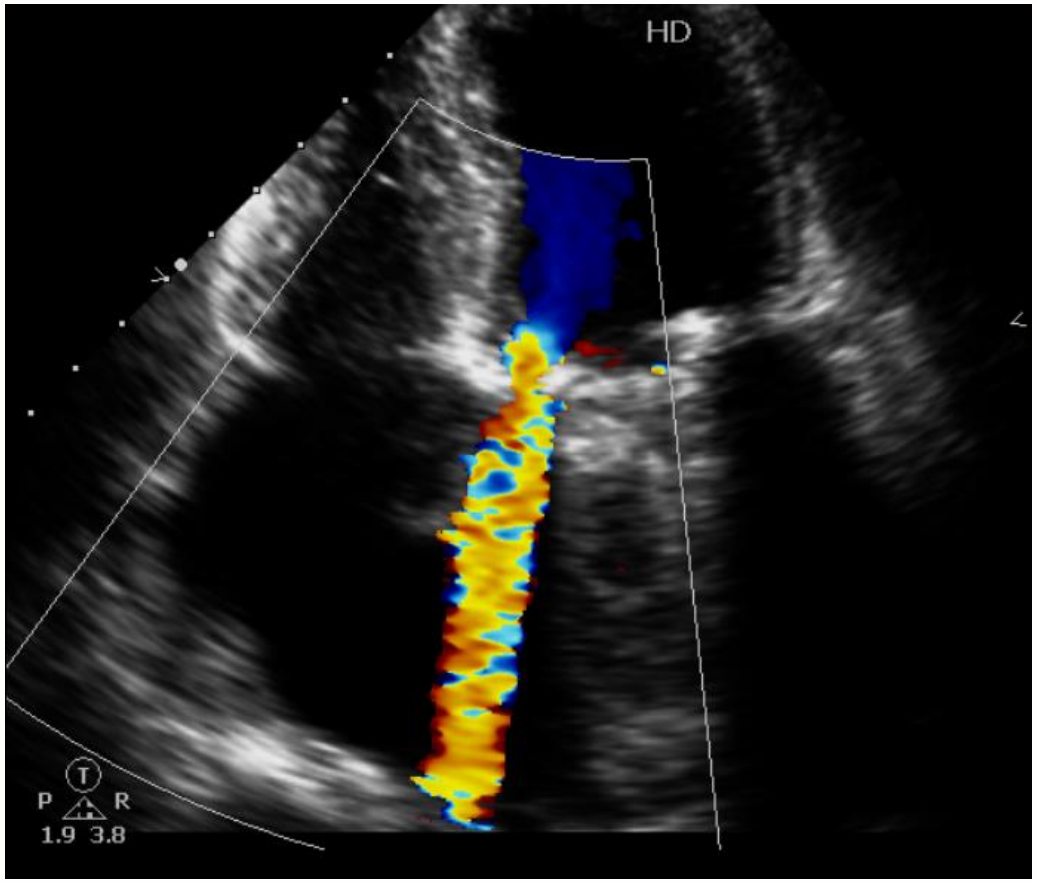


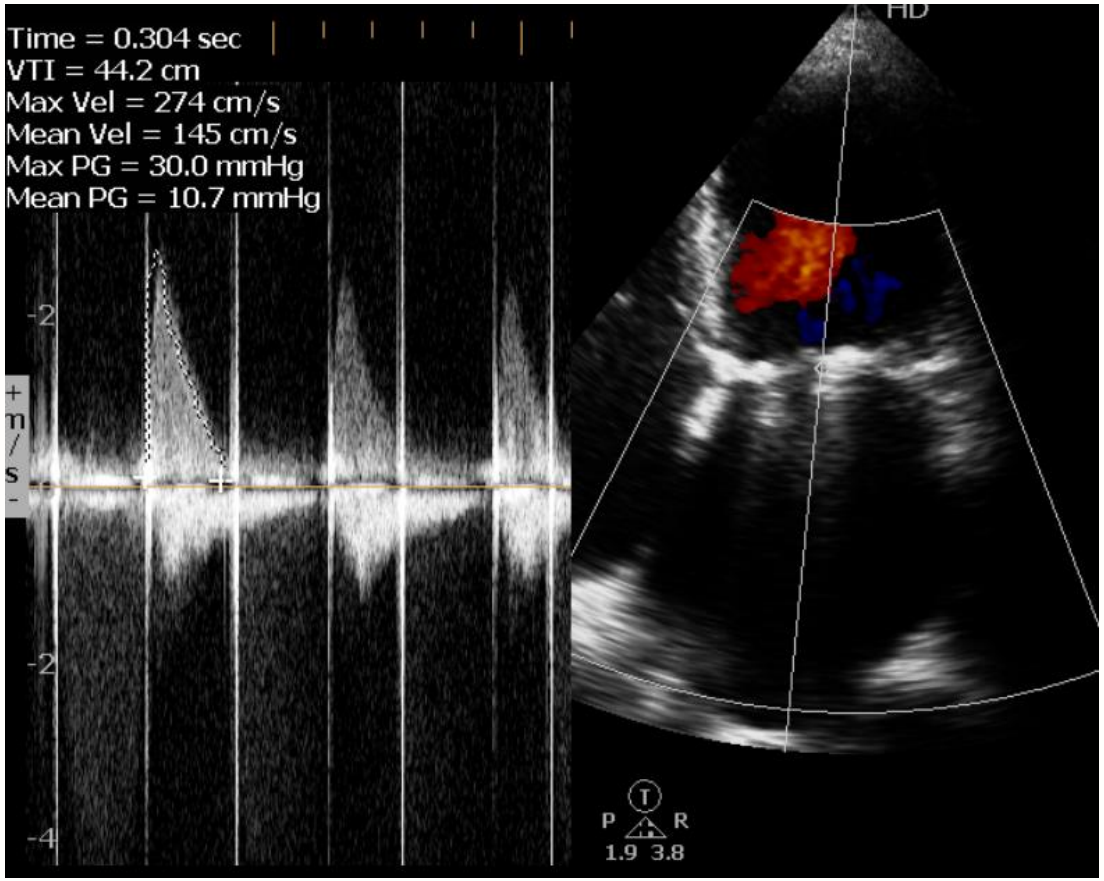
BN nữ, 43 tuổi, mổ thay van 2 lá cơ học 2012, Chẩn đoán VNTMNT gây hở cạnh van (2016)
Vmax= 2.1 m/s; Mean gradient= 7 mmHg
VC= 4.5 mm; EROA = 0.3 cm^2

Ca lâm sàng



Siêu âm tim qua thực quản với mặt cắt giữa thực quản:Sút van hai lá sinh học do VNTMNT. Bệnh nhân nữ 29 tuổi. A, van hai lá sút (+). B, hai dòng hở cạnh van do van bị sút.





BN nữ, 74 tuổi, nhập viện vì thiếu máu. Chẩn đoán: Hở cạnh van 2 lá mức độ trung bình/ Thay van 2 lá cơ học (2007) – Thiếu máu tán huyết do dòng hở cạnh van.

Kết luận

- Siêu âm tim có vai trò quan trọng đánh giá chức năng van cơ học: siêu âm qua thành ngực và siêu âm qua thực quản.
- Làm thường quy: sau can thiệp, định kỳ và khi có triệu chứng
- Cần phối hợp: lâm sàng (thời gian mổ, loại van, kích thước van), hình ảnh 2D, Doppler màu và các thông số Doppler đo đạc được và so sánh với những kết quả trước đó.
- Phương tiện khác hỗ trợ: soi van, MSCT, MRI