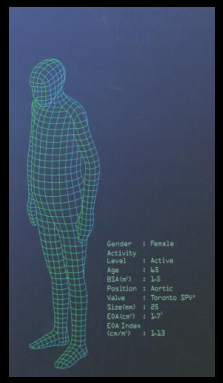
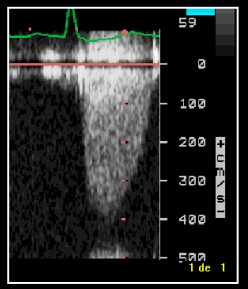
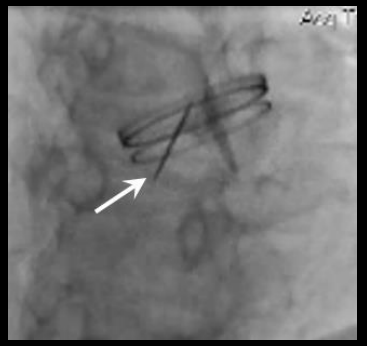
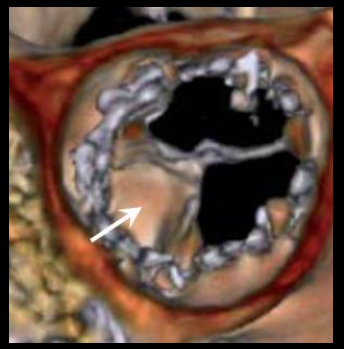


ASE/EACVI Guidelines: Basic Assessment of Normal Prosthetic Valve Function

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DE QUÉBEC

Université
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Disclosure: Philippe Pibarot

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- **Edwards Lifesciences: Echo CoreLab for PARTNER 2–SAPIEN 3, PARTNER 3, TAVR-UNLOAD, EARLY-TAVR trials**
- **V-Wave Ltd: Echo CoreLab for FIM Study**
- **Cardiac Phoenix: Echo CoreLab for BACE FIM Study**

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Off label Use: None

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

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Zoghbi et al. J Am Soc Echocardiogr, 22:975-1014, 2009

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14975

REVIEW

Recommendations for the imaging assessment of prosthetic heart valves: a report from the European Association of Cardiovascular Imaging endorsed by the Chinese Society of Echocardiography, the Inter-American Society of Echocardiography, and the Brazilian Department of Cardiovascular Imaging†

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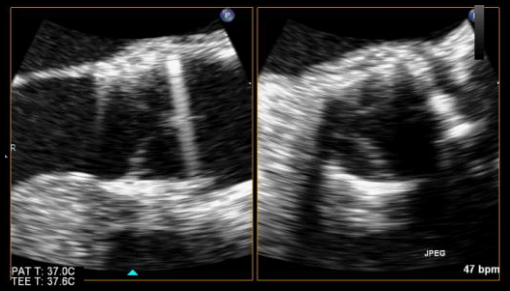
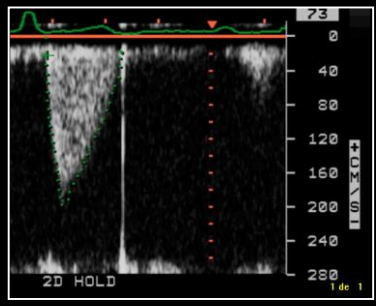
Doppler-Echo Evaluation of Prosthetic Valves

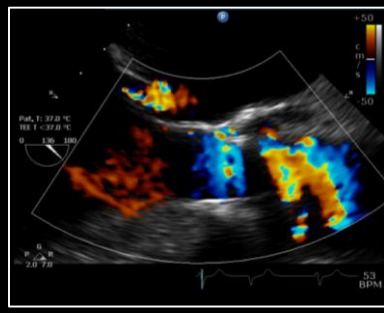
- **Doppler-echocardiography is the primary imaging modality to evaluate prosthetic valve function**

- **Structural evaluation (TTE and TEE)**
  - **Valve position and shape**
  - **Leaflet morphology and mobility**
  - **Paravalvular region**



- **Functional evaluation**
  - **Transprosthetic gradients, EOA, and DVI**
  - **Localization (central vs. para) and degree of regurgitation**

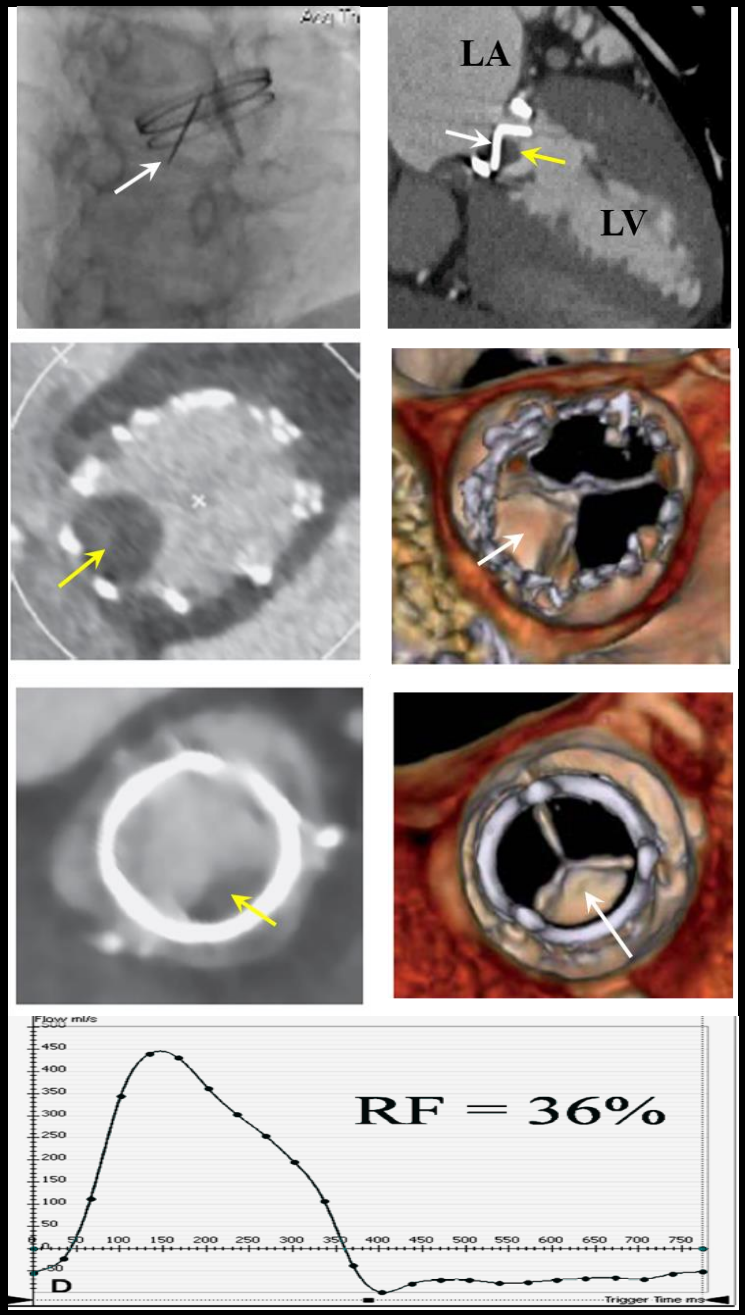




- **LV/RV size and function, Pulmonary Arterial Pressure**

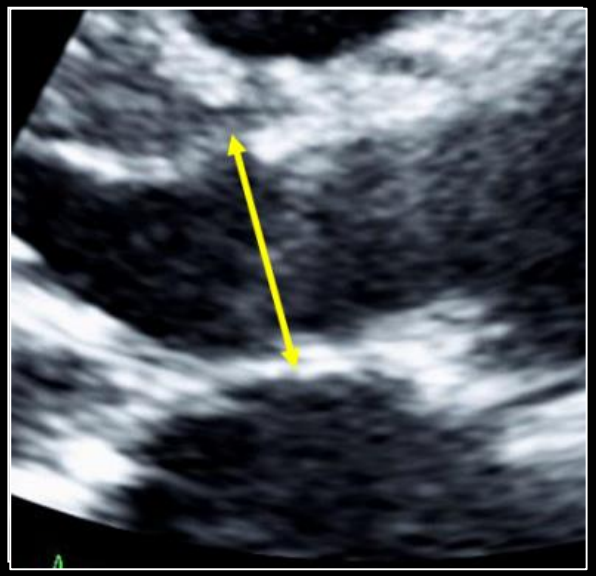
Non-Echo Imaging Modalities

- **Not performed routinely for the evaluation of PHVs**
- **Can provide incremental information on valve integrity and valvular / paravalvular pathology**
- **Cinefluoroscopy: leaflet mobility of mechanical PHVs**
- **Cardiac CT: leaflet thickening / calcification, thrombus vs. pannus**
- **CMR: quantitation of AR and MR**
- **Nuclear imaging: PHVs endocarditis**

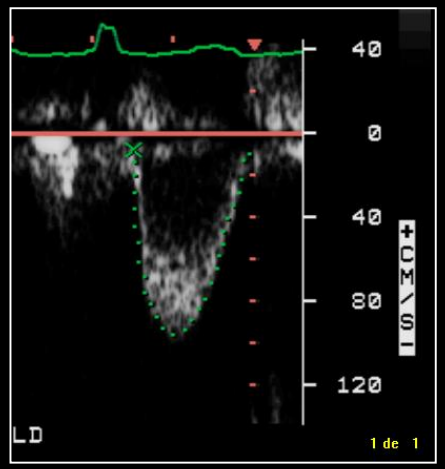


Measurement of Prosthetic Aortic Valve EOA

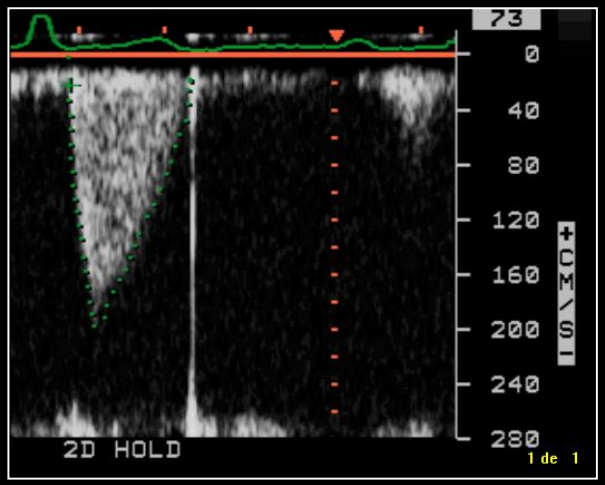
LVOT Diameter



PW Doppler LVOT



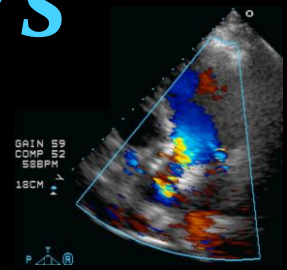
CW Doppler Prosthetic Aortic Valve Flow



$$\text{Effective orifice area} = \frac{CSA_{LVOT} \times VTI_{LVOT}}{VTI_{PrAv}}$$

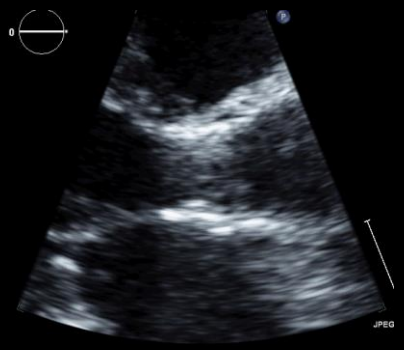
$$\text{Doppler Velocity Index} = \frac{VTI_{LVOT}}{VTI_{PrAv}}$$

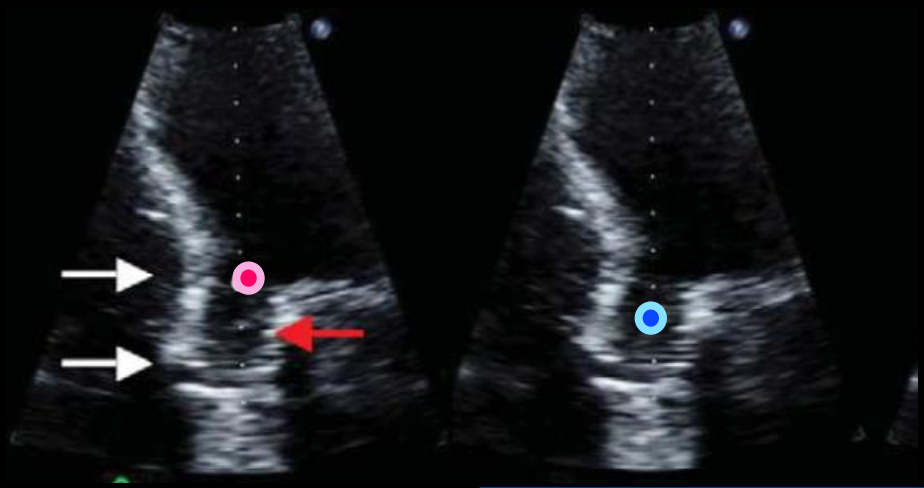
LVOT Diameter and Velocity in Balloon-Expandable THVs

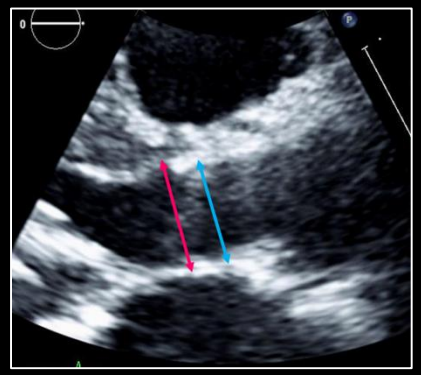


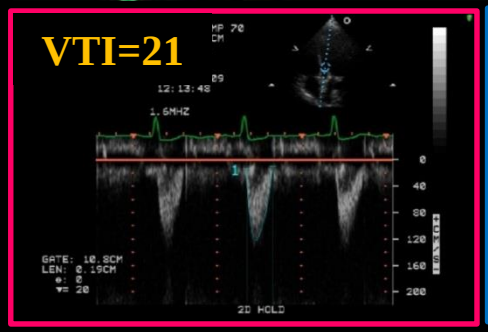
PLAX View

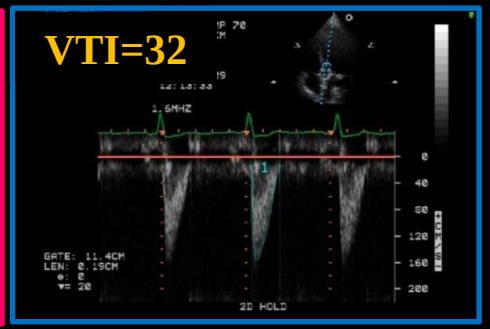
5-Chamber View





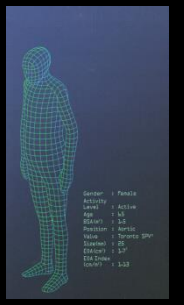






Shames et al. JASE 2012
Clavel et al. JACC Img;4:1053–62, 2011

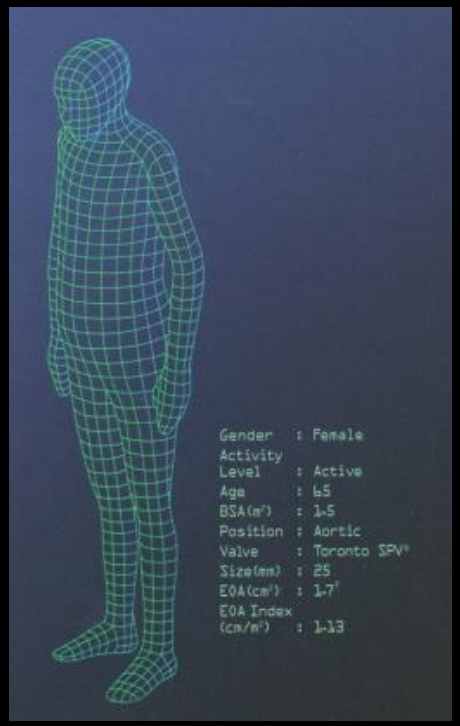
Etiology of High Doppler Gradients in Prosthetic Heart Valves



- **Prosthesis-patient mismatch i.e. too small a prosthesis in too large a patient**

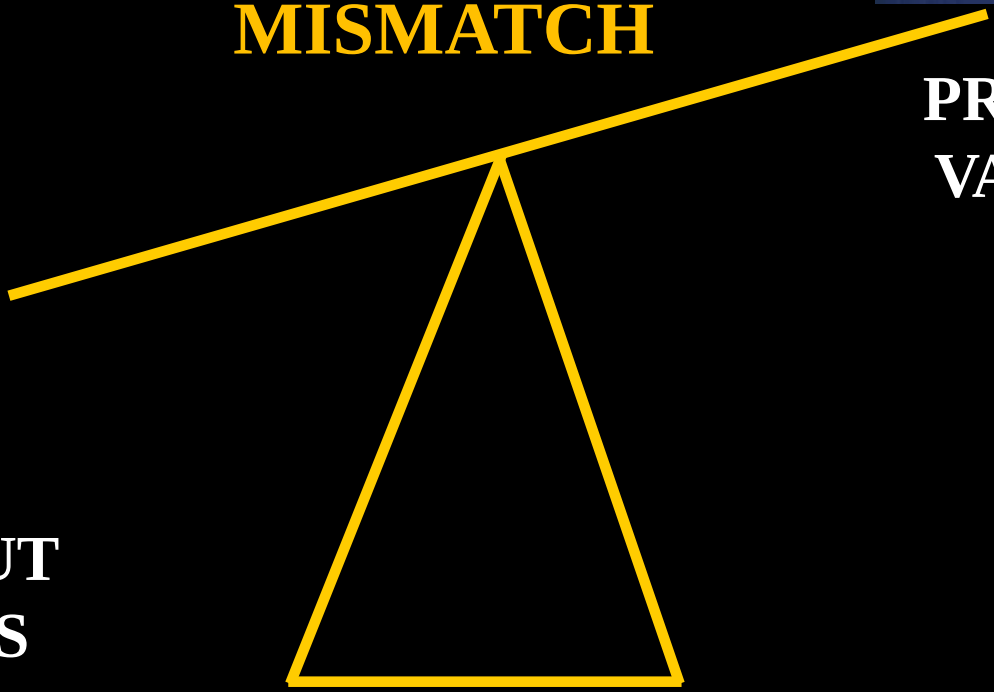
- **Prosthesis dysfunction due to an acute (e.g. thrombus) , subacute (e.g. endocarditis) or chronic process (e.g. pannus, calcific degeneration in bioprosthesis)**

BSA



PATIENT'S CARDIAC OUTPUT REQUIREMENTS

PROSTHESIS-PATIENT MISMATCH



PROSTHETIC VALVE EOA

PPM occurs when the EOA of the prosthesis is too small in relation to patient's body size / cardiac output requirements

Criteria for Definition of Aortic Prosthesis-Patient Mismatch

PPM definition: **prosthesis functioning normally but too small for patient's body size**

Normal EOA but small indexed EOA

	None/Mild	Moderate	Severe
Valve structure and motion	**Usually normal**	**Usually normal**	**Usually normal**
Difference (Normal reference EOA – Measured EOA) (cm^2)	**<0.30**	**>0.30**	**>0.30**
Indexed EOA (cm^2/m^2)	**>0.85**	**0.85-0.65**	**<0.65**
Indexed EOA (cm^2/m^2) in obese patients (BMI ≥30 kg/m^2)	**>0.70**	**0.70-0.55**	**<0.55**

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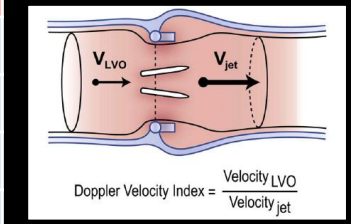
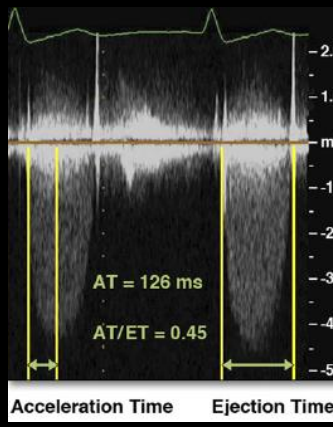
Doppler-Echo Criteria to Assess the Severity of Prosthetic Aortic Valve Stenosis

	Normal	Possible Stenosis	Significant Stenosis
2D/3D TTE/TEE / Cinefluoroscopy / CT			
Valve structure / leaflet mobility	Normal	Often abnormal	Abnormal
Doppler quantitative parameters			
Peak velocity (m/s)	<3	3-4	≥4
Mean gradient (mmHg)	<20	20-35	≥35
Doppler velocity index	≥0.35	0.25-0.35	<0.25
Effective orifice area (cm^2)	>1.1	0.8-1.1	<0.8
Difference (Normal EOA - Measured EOA)	<0.30	0.30-0.59	>0.60
Doppler semi-quantitative parameters			
Acceleration time (ms)	<80	80-100	>100
Acceleration time / LV ejection time	<0.32	0.32-0.37	>0.37
Changes in echo parameters during FU			
Increase in mean gradient (mmHg) + concomitant decrease in EOA	<10	10-19	≥20

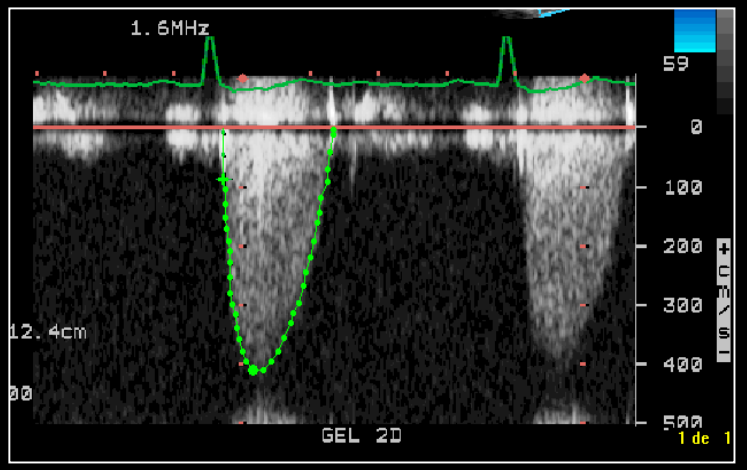


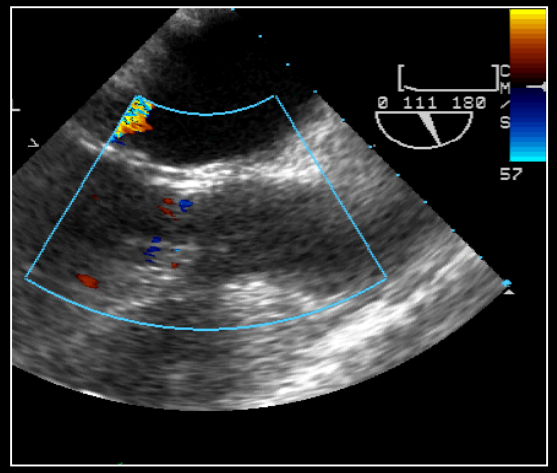


Zoghbi JASE 2009. Lancellotti EHJ CV Img 2016

Prosthesis-Patient Mismatch after SAVR

68 y.o. patient, NYHA 3
3 Years post AVR
Carbomedic # 19 mm





Peak / Mean Gradients= 69/40 mm Hg

Reference EOA
1.0±0.4

Measured EOA = 1.06 cm^2

BSA = 1.95 m^2

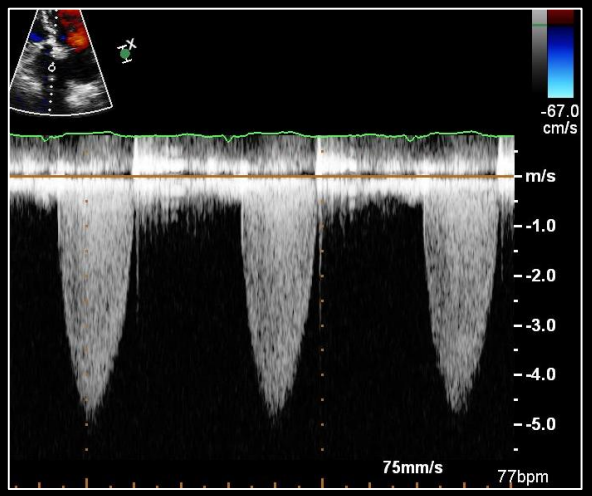
Measured Indexed EOA: 0.55 cm^2/m^2

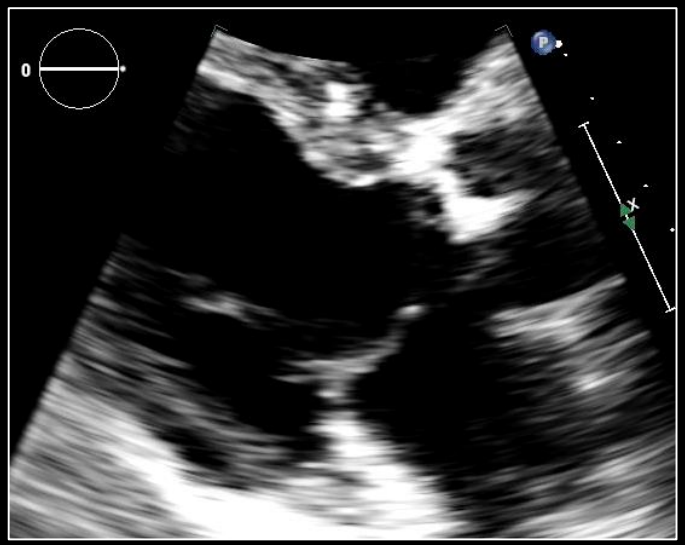
Valve Stenosis due to SVD after SAVR

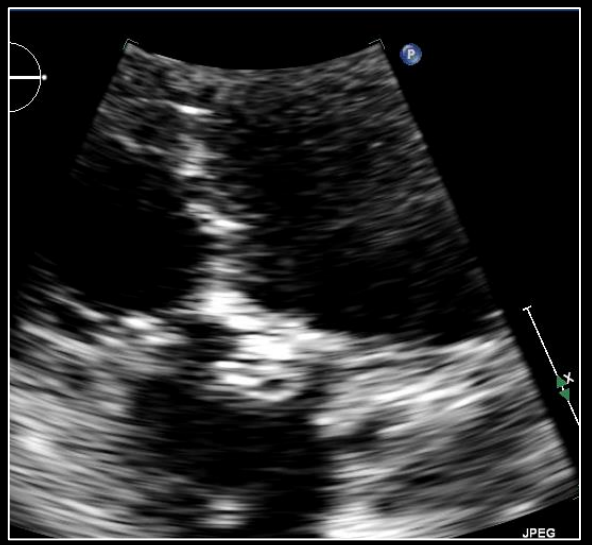
Case: 78 y.o. man, 13 year post SAVR with CEP # 23 mm

Echo 13 years post SAVR:

- Gradients: 93/57 mmHg
  (vs. 30/18 at discharge)
- EOA: 0.7 cm^2 DVI: 0.16
  (vs. 1.7 cm^2 DVI: 0.42)
- AT/LVET: 0.38







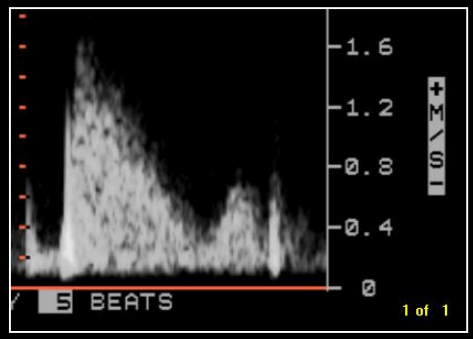
Doppler-Echo Evaluation of Mitral Prosthesis - Specifics

- **EOA calculated using continuity equation as follows :**
  $EOA = SV_{lvot} / VTI_{mvp}$
  (Not valid if significant aortic or mitral regurgitation)

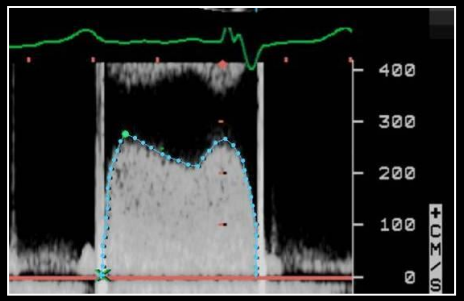
- **Doppler Velocity Index: VTI_{mvp} / VTI_{lvot}**

- **Pressure half-time not valid to calculate EOA (grossly overestimates) but may be useful for serial comparisons or if delayed**

Non-Obstructed



Obstructed



Criteria for Definition of Mitral Prosthesis-Patient Mismatch

PPM is defined as: normal EOA but small indexed EOA

	None/Mild	Moderate	Severe
Valve structure and motion	**Usually normal**	**Usually normal**	**Usually normal**
Difference (Normal reference EOA – Measured EOA) (cm^2)	**<0.30**	**>0.30**	**>0.30**
Indexed EOA (cm^2/m^2)	**>1.2**	**0.9-1.2**	**<0.90**
Indexed EOA (cm^2/m^2) in obese patients (BMI ≥30 kg/m^2)	**>1.0**	**1.0-0.75**	**<0.75**

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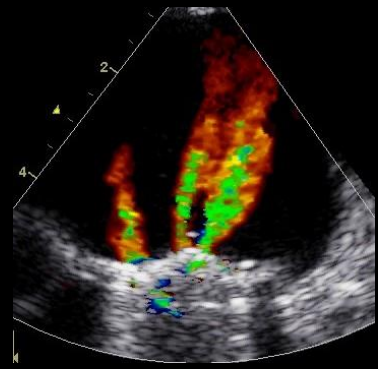
Doppler-Echo Criteria to Assess the Severity of Prosthetic Mitral Valve Stenosis

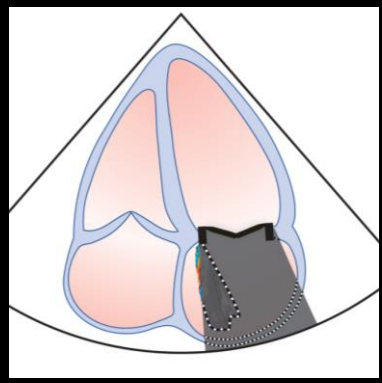
	Normal	Possible Stenosis	Significant Stenosis
2D/3D TTE / TEE / Cinefluoroscopy / CT			
Valve structure / leaflet mobility	Normal	Often abnormal	Abnormal
Doppler quantitative parameters			
Peak velocity (m/s)	<1.9	1.9-2.5	≥2.5
Mean gradient (mmHg)	≤5	6-10	≥10
Doppler velocity index	<2.2	2.2-2.5	>2.5
Effective orifice area (cm^2)	≥2	1-2	<1
Difference (Normal EOA - Measured EOA)	<0.30	0.30-0.60	>0.60
Doppler semi-quantitative parameters			
Pressure half time (ms)	<130	130-200	>200
Changes in echo parameters during FU			
Increase in mean gradient (mmHg) + concomitant decrease in EOA	<5	5-9	≥10

Lancellotti et al.
EHJ CV Img 2016

Doppler-Echo Evaluation of Prosthetic Valve Regurgitation

- **Mild regurgitations, central or paravalvular are frequent, sometimes transient and rarely progressive**
- **Mechanical prostheses usually show small regurgitation due to normal closing volume**
- **Mitral regurgitation may be underestimated by TTE due to acoustic shadowing**
- **If significant regurgitation suspected, look for underlying pathology and proceed to TEE**



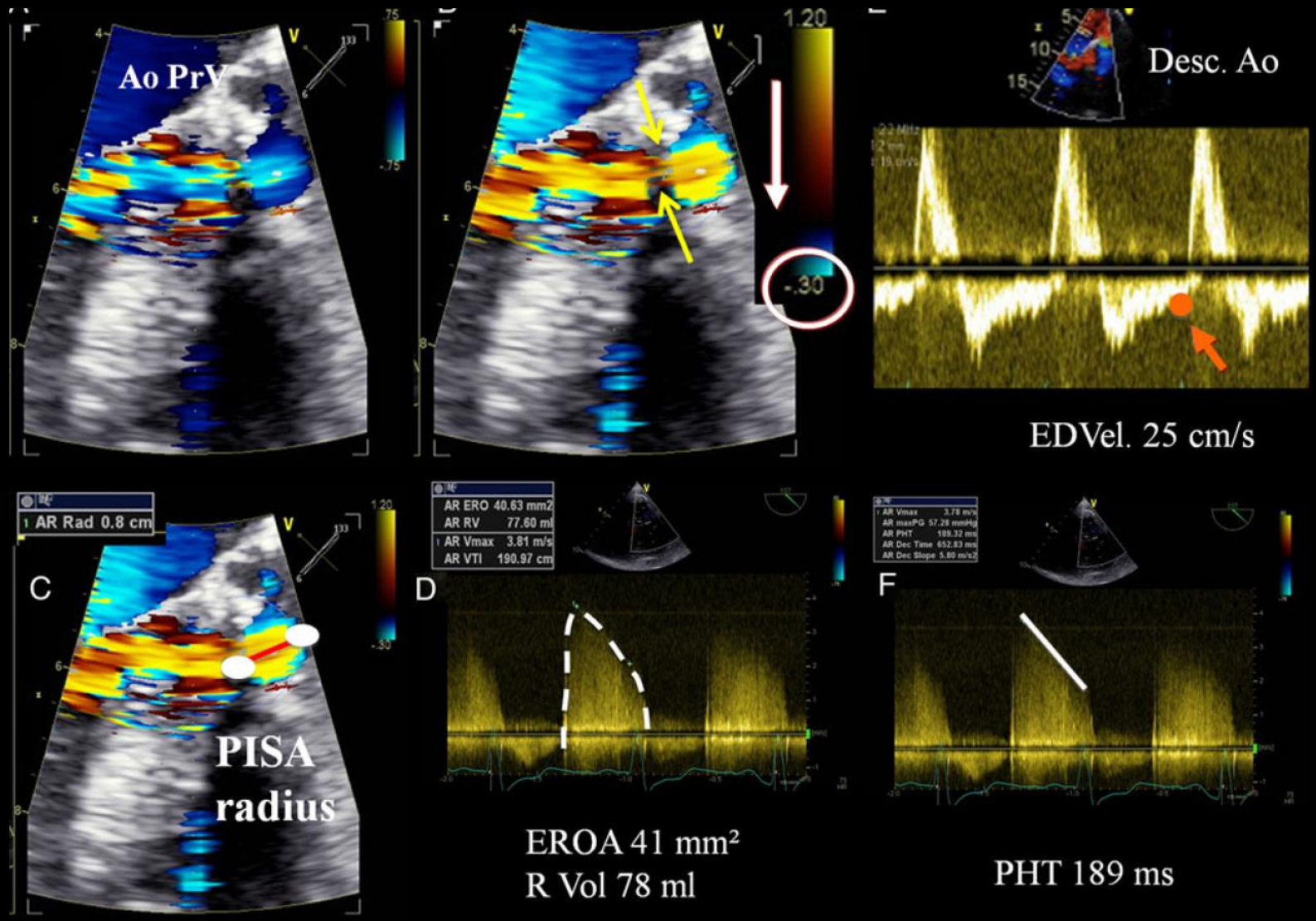


Doppler-Echo Criteria to Assess the Severity of Prosthetic Aortic Valve Regurgitation

	Mild	Moderate	Severe
2D/3D TTE / TEE / Cinefluoroscopy / CT			
Valve structure / leaflet mobility	Normal	Often abnormal	Abnormal
Doppler qualitative or semi-quantitative parameters			
Vena contracta width	<3	3-6	>6
Jet width in central jets (% LVOT diameter)	≤25	26-64	≥65
Pressure half time (ms)	Slow >500	200-500	Steep <200
Diastolic flow reversal in descending aorta	Absent- brief	Intermediate	Holodiastolic
Circumferential extent (paravalvular) (%)	<10	10-29	≥30
Doppler / CMR quantitative parameters			
Regurgitant volume (ml)	<30	30-59	≥60
Regurgitant fraction (%)	<30	30-49	≥50

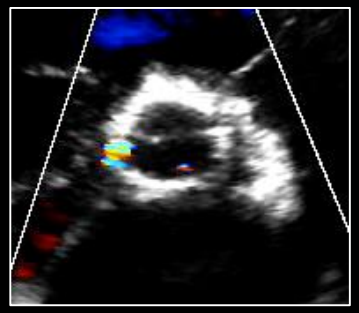
Zoghbi JASE 2009
Lancellotti EHJ CV Img 2016

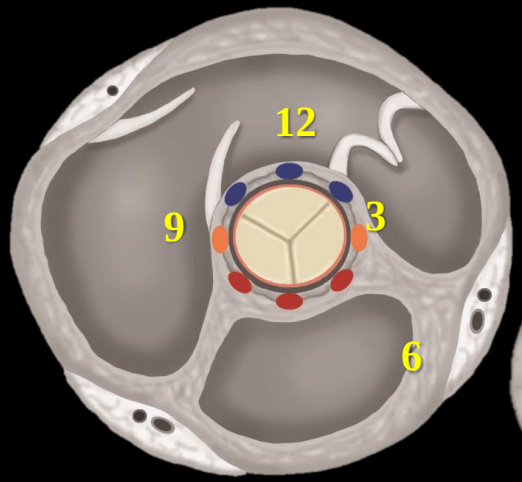
Doppler-Echo Assessment of Prosthetic Aortic Valve Regurgitation

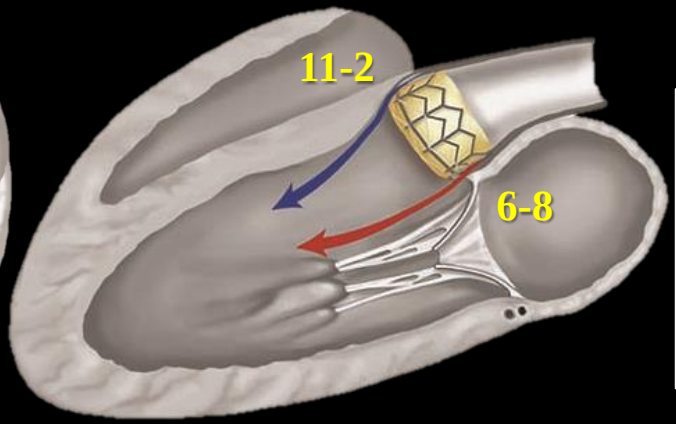


Assessment of PVR by Echo: Multi-window Imaging is Key!

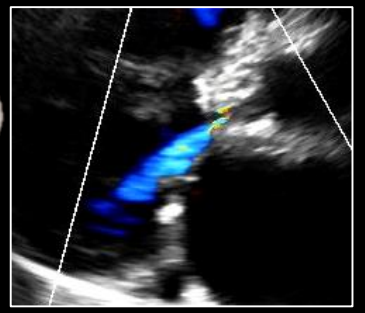
PSAX

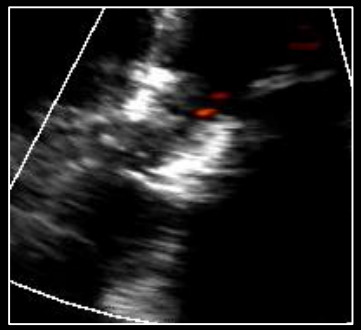




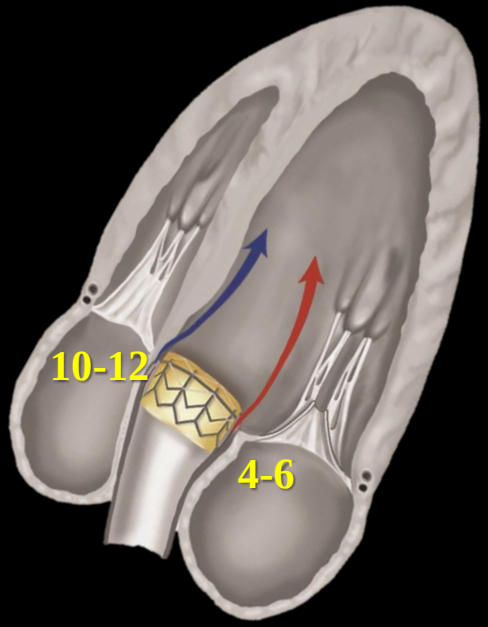


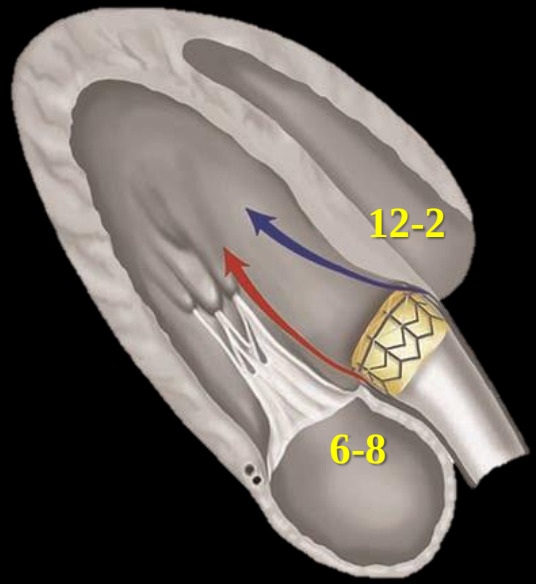
PLAX

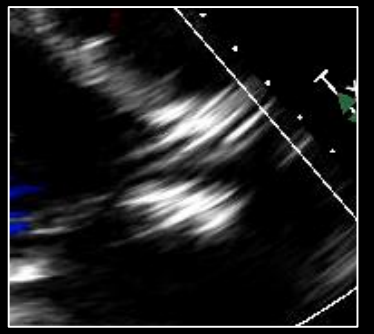




Ap-5Ch

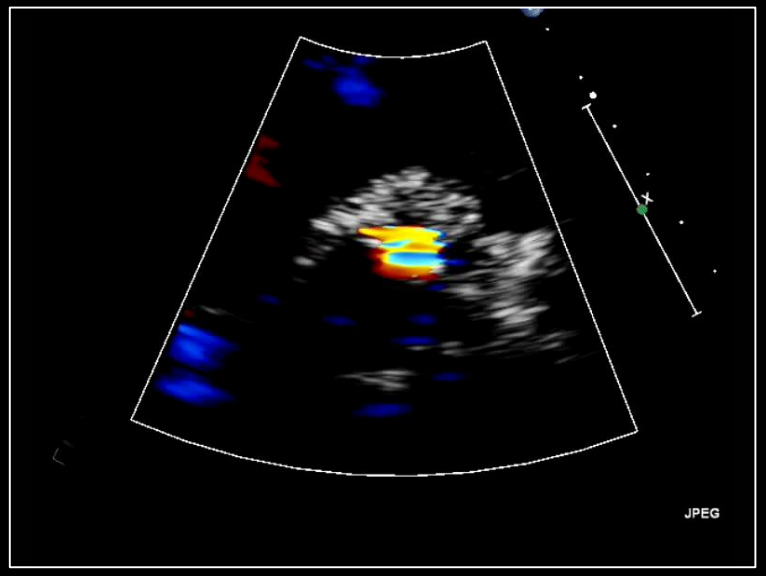


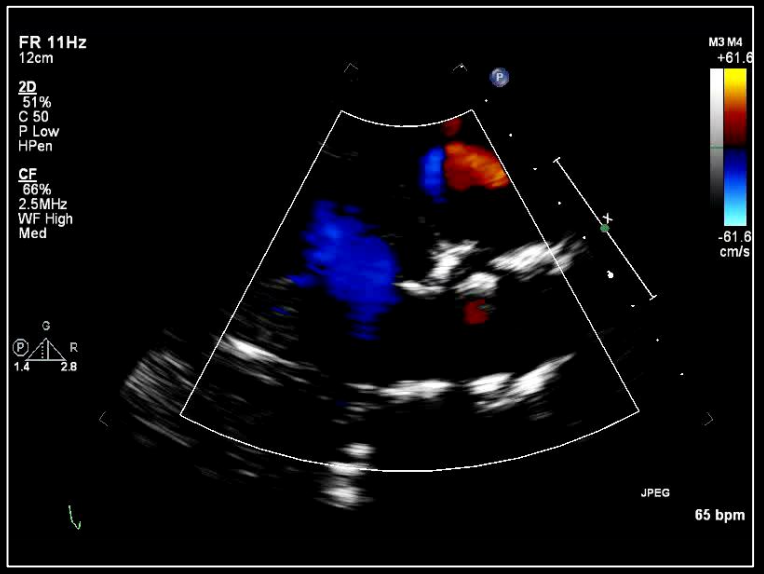


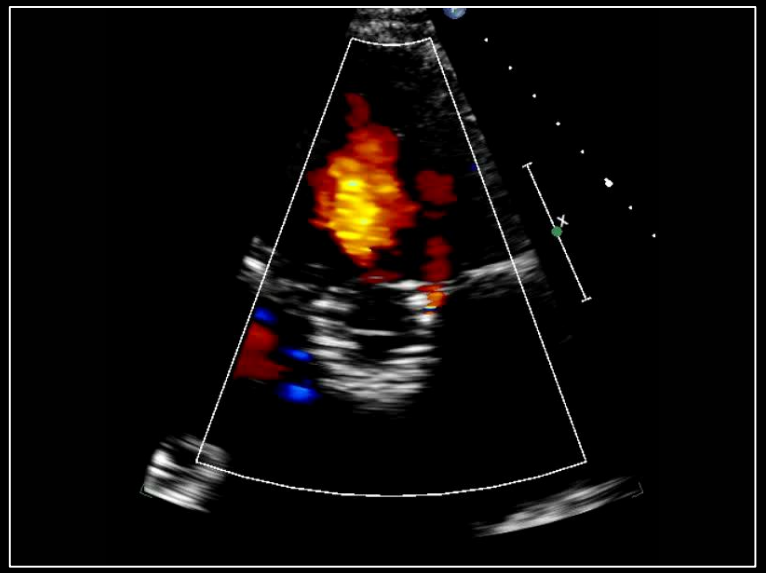


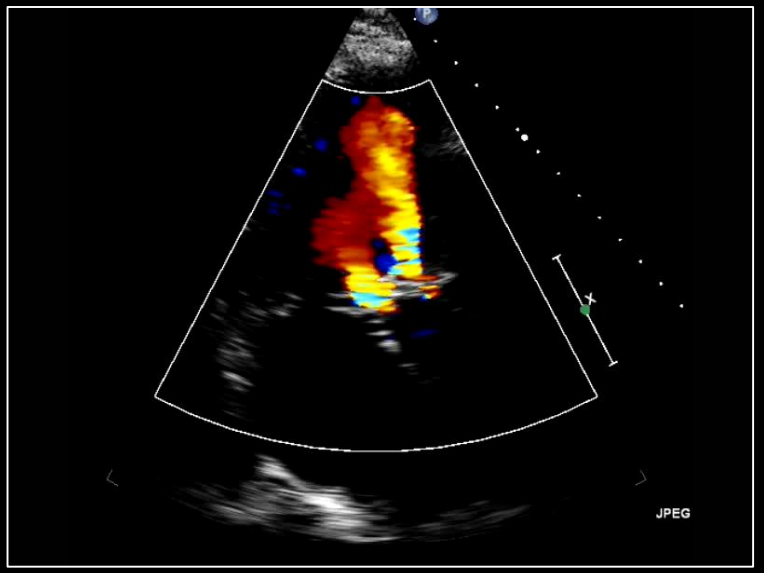
Ap-3Ch

Moderate-to-Severe PVR



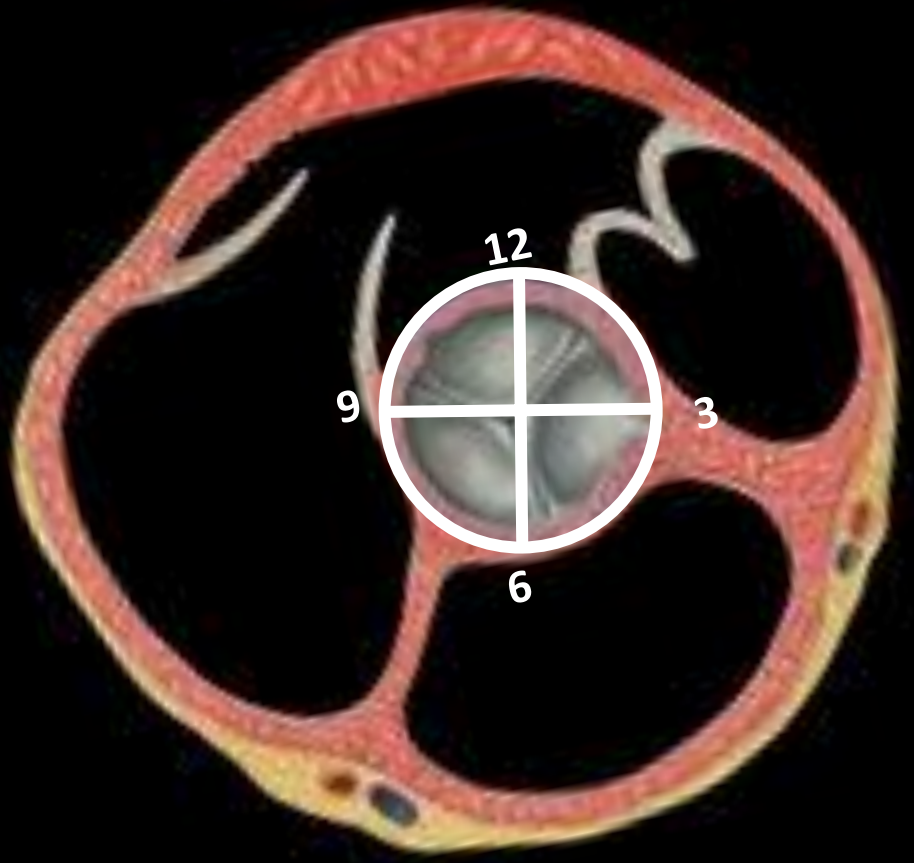


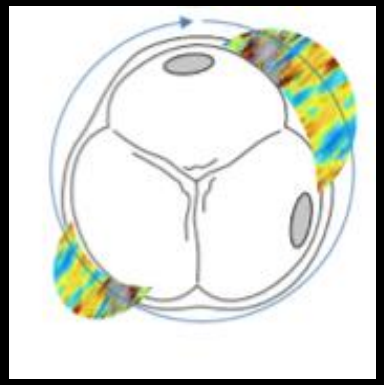




Semi-Quantitation and Location of Paravalvular Regurgitation on PSAX

Using the TV septal leaflet insertion as 9 o'clock, locate the position of the paravalvular jets.





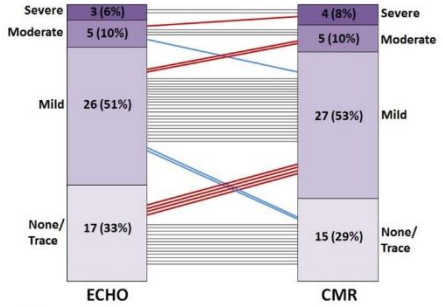
12 min + 6 min = 18 min
CE: (18/60)×100= 30%

Moderate-to-Severe PVR

Assessment of PVR by CMR

PRE

A

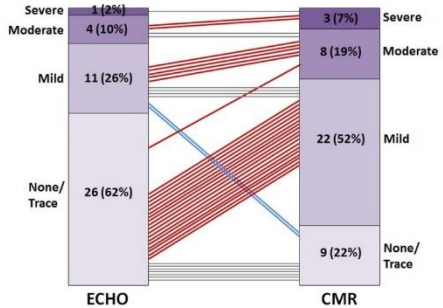


B

ECHO / CMR	None/ Trace	Mild	Moderate	Severe	Total
None/ Trace	13 (76)	2 (8)	-	-	15
Mild	4 (24)	22 (84)	1 (20)	-	27
Moderate	-	2 (8)	3 (60)	-	5
Severe	-	-	1 (20)	2 (100)	3
Total	17	26	5	2	40/50 (80)

POST

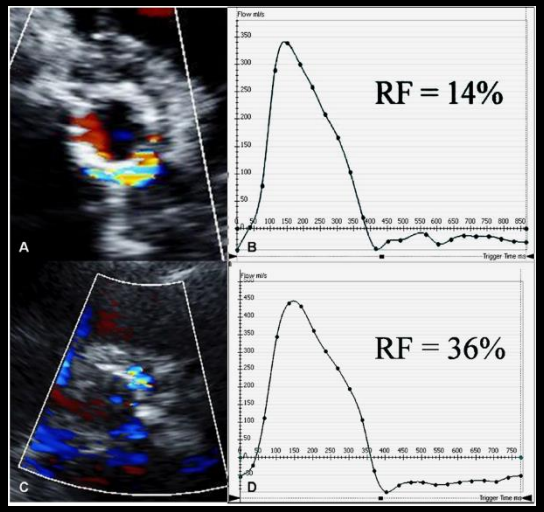
C

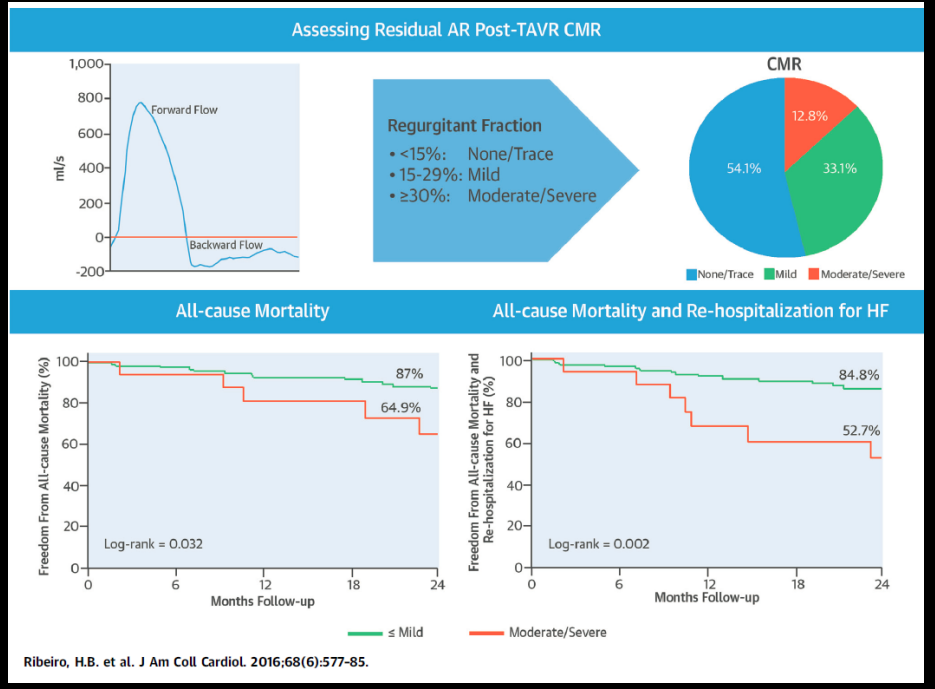


D

ECHO / CMR	None/ Trace	Mild	Moderate	Severe	Total
None/ Trace	7 (27)	2 (18)	-	-	9
Mild	18 (69)	4 (36)	-	-	22
Moderate	1 (4)	5 (46)	2 (50)	-	8
Severe	-	-	2 (50)	1 (100)	3
Total	26	11	4	1	14/42 (33)

Ribeiro et al. Heart 2016





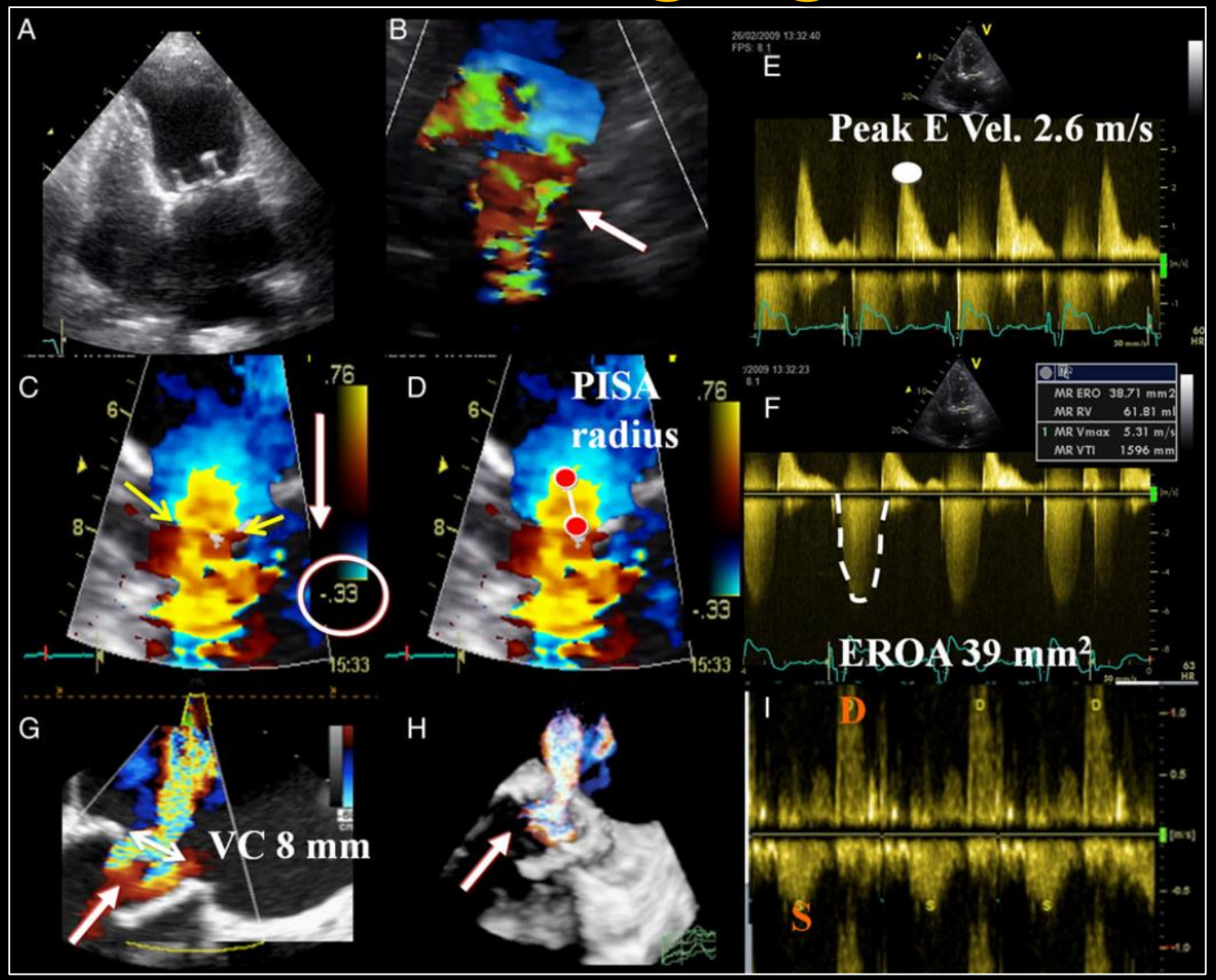
Ribeiro, H.B. et al. J Am Coll Cardiol. 2016;68(6):577-85.

Doppler-Echo Criteria to Assess the Severity of Prosthetic Mitral Valve Regurgitation

	Mild	Moderate	Severe
2D/3D TTE / TEE / Cinefluoroscopy / CT			
Valve structure / leaflet mobility	Normal	Often abnormal	Abnormal
Doppler qualitative or semi-quantitative parameters			
Vena contracta width	<3	3-6	>6
Mitral E Velocity	Variable	Variable	≥65
Doppler velocity index	<2.2	2.2-2.5	>2.5
CW Doppler signal of MR jet	Faint Parabolic	Dense Parabolic	Dense Triangular
Circumferential extent (paravalvular) (%)	<10	10-29	≥30
Doppler quantitative parameters			
Regurgitant volume (ml)	<30	30-59	≥60
Regurgitant fraction (%)	<30	30-49	≥50

Zoghbi JASE 2009
Lancellotti EHJ CV Img 2016

Doppler-Echo Assessment of Prosthetic Mitral Valve Regurgitation



Lancellotti EHJ CV Img 2016

Conclusions

- **Doppler-echo is the first line imaging modality to assess PHV function.**
- **Multiple-views and multiple planes imaging is key to ensure complete visualization of the valvular and paravalvular region.**
- **Multi-parameter integrative approach is needed for grading prosthetic valve dysfunction**
- **Other imaging modalities such as 3D TEE, cinefluoroscopy, CT, and CMR can provide some additional information for the assessment of aortic valve morphology, function, and related complications.**

Differential Diagnosis Aortic Prostheses

PPM

- High Gradient
- No change in gradient during FU
- EOA ~ normal (±0.3)
- Small indexed EOA (<0.85)
- Normal/Intermediate DVI
- Variable AT/LVET
- Normal leaflet morphology / mobility

Stenosis

- High Gradient
- Increase in gradient during FU (>10 mmHg)
- EOA << normal (Δ>0.3)
- Small indexed EOA (<0.85)
- Small DVI (<0.35)
- High AT/LVET (>0.37)
- Abnormal leaflet morphology / mobility

Winter in Canada

Summer in Canada