Prosthetic Valvular Disease

Hong Kong Core Cardiology Certificate Course *(Module 3)*

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Presenter Disclosure Information

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Prosthetic Valvular Disease

DISCLOSURE INFORMATION:

The following relationships exist related to this presentation: **None**

Overview

- Selection & Consideration
- Anti-coagulation and Thromboembolic Complications
- Prosthetic Valve Dysfunction and Assessment
- Summary of key points.

2017 AHA/ACC Guideline for the Management of Patients With Valvular Heart Disease (2014 Guideline with 2017 Focused Update Incorporated)

Developed in Collaboration with the American Association for Thoracic Surgery, American Society of Echocardiography, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Anesthesiologists, and Society of Thoracic Surgeons

Helping Cardiovascular Professionals
Learn. Advance. Heal.

American Heart Association

2017 ESC/EACTS Guidelines for the management of valvular heart disease

EACTS European Association for Cardio-Thoracic Surgery

ESC European Society of Cardiology

The Task Force for the Management of Valvular Heart Disease of the European Society of Cardiology (ESC) & the European Association for Cardio-Thoracic Surgery (EACTS)

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[1] Representing the European Association for Cardio-Thoracic Surgery (EACTS)

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

European Heart Journal - Cardiovascular Imaging Advance Access published May 3, 2016

European Heart Journal – Cardiovascular Imaging
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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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GUIDELINES AND STANDARDS

Guidelines for the Evaluation of Valvular Regurgitation After Percutaneous Valve Repair or Replacement

A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Angiography and Interventions, Japanese Society of Echocardiography, and Society for Cardiovascular Magnetic Resonance

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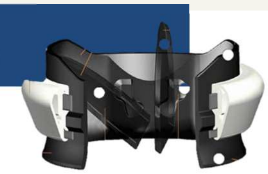
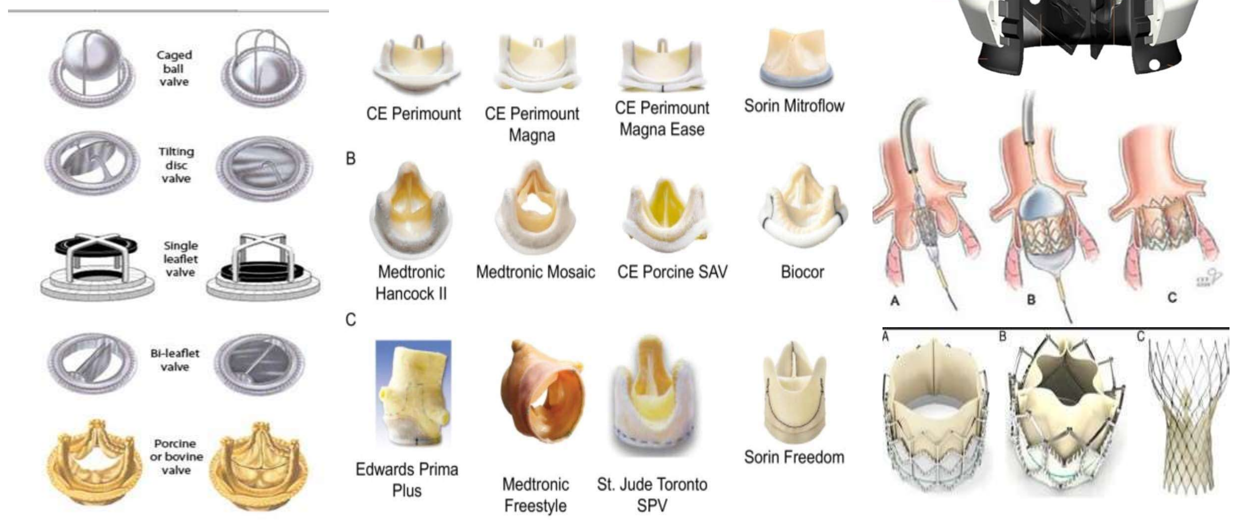
https://doi.org/10.1016/j.echo.2019.01.003

There is No Perfect Valve





" They have introduced other, new problems into clinical medicine, so that In effect , the **patient is exchanging one disease process for another**"

Factors to be Considered while Selecting a Prosthetic Heart Valve

- Age of the patient
- Comorbid conditions (Cardiac and Non-cardiac)
- Expected lifespan of the patient
- Long term outcome with the prosthetic heart valves
- Patient wishes
- Skill of the surgeon
- Women of child-bearing age

COR	LOE	2017 AHA/ACC Recommendations for Intervention of Prosthetic Valves
I	C	A bioprosthesis is recommended in patients of any age for whom anticoagulant therapy is contraindicated, cannot be managed appropriately, or is not desired.
IIa	B-NR	An aortic or mitral mechanical prosthesis is reasonable for patients aged <50 years who do not have a contraindication to anticoagulation.
IIa	B-NR	For patients aged between 50 and 70 years, it is reasonable to individualize the choice of either a mechanical or bioprosthetic valve prosthesis on the basis of individual patient factors and preferences, after full discussion of the trade-offs involved.
IIa	B	A bioprosthesis is reasonable for patients aged >70 years.
IIb	C	Replacement of the aortic valve by a pulmonary autograft (the Ross procedure), when performed by an experienced surgeon, may be considered for young patients when VKA anticoagulation is contraindicated or undesirable.

COR	LOE	2017 AHA/ACC Recommendations for Antithrombotic Therapy in PHV
I	A	Anticoagulation with a VKA and INR monitoring is recommended in patients with a mechanical prosthetic valve.
I	B	Anticoagulation with a VKA to achieve an INR of 2.5 is recommended for patients with a mechanical bileaflet or current-generation single-tilting disc AVR and no risk factors for thromboembolism.
I	B	Anticoagulation with a VKA is indicated to achieve an INR of 3.0 in patients with a mechanical AVR and additional risk factors for thromboembolic events (AF, previous thromboembolism, LV dysfunction, or hypercoagulable conditions) or an older-generation mechanical AVR (such as ball-in-cage).
I	B	Anticoagulation with a VKA is indicated to achieve an INR of 3.0 in patients with a mechanical MVR.
I	A	Aspirin 75 mg to 100 mg daily is recommended in addition to anticoagulation with a VKA in patients with a mechanical valve prosthesis.

COR	LOE	2017 AHA/ACC Recommendations for Antithrombotic Therapy in Bioprosthetic Heart Valves
IIa	B	Aspirin 75 mg to 100 mg per day is reasonable in all patients with a bioprosthetic aortic or mitral valve.
IIa	B-NR	Anticoagulation with a VKA to achieve an INR of 2.5 is reasonable for at least 3 months and for as long as 6 months after surgical bioprosthetic MVR or AVR in patients at low risk of bleeding.
IIb	B-R	A lower target INR of 1.5 to 2.0 may be reasonable in patients with mechanical On-X AVR and no thromboembolic risk factors.
IIb	B-NR	Anticoagulation with a VKA to achieve an INR of 2.5 may be reasonable for at least 3 months after TAVR in patients at low risk of bleeding.
IIb	C	Clopidogrel 75 mg daily may be reasonable for the first 6 months after TAVR in addition to lifelong aspirin 75 mg to 100 mg daily.

COR	LOE	2017 AHA/ACC Recommendations of Bridging Therapy for PHV
Although the BRIDGE (Bridging Anticoagulation in Patients who Require Temporary Interruption of Warfarin Therapy for Elective Invasive Procedure or Surgery) trial excluded MHV, this randomized trial assigned patients on chronic anticoagulation to receive low-molecular-weight heparin versus placebo for bridging before elective surgery and found no significant difference in arterial thromboembolism, but a significant increase in major bleeding (relative risk, 0.41; CI, 0.20–0.78). This study raised concerns that by bridging with overlapping anticoagulation agents can increase bleeding risk without reducing risk of thromboembolism.		
IIa	C-LD	Bridging anticoagulation therapy during the time interval when the INR is subtherapeutic preoperatively is reasonable on an individualized basis, with the risks of bleeding weighed against the benefits of thromboembolism prevention, for patients who are undergoing invasive or surgical procedures with a (1) mechanical AVR and any thromboembolic risk factor, (2) older-generation mechanical AVR, or (3) mechanical MVR.

Know the PRODUCT

- Design type & size
- Flow characteristics
- Age of valve

Know the LOOK

- Structural appearance
- Mobility & seating
- Artifacts

Know the FLOW

- Maximum & mean gradients
- Effective orifice area (EOA)
- Normal regurgitation

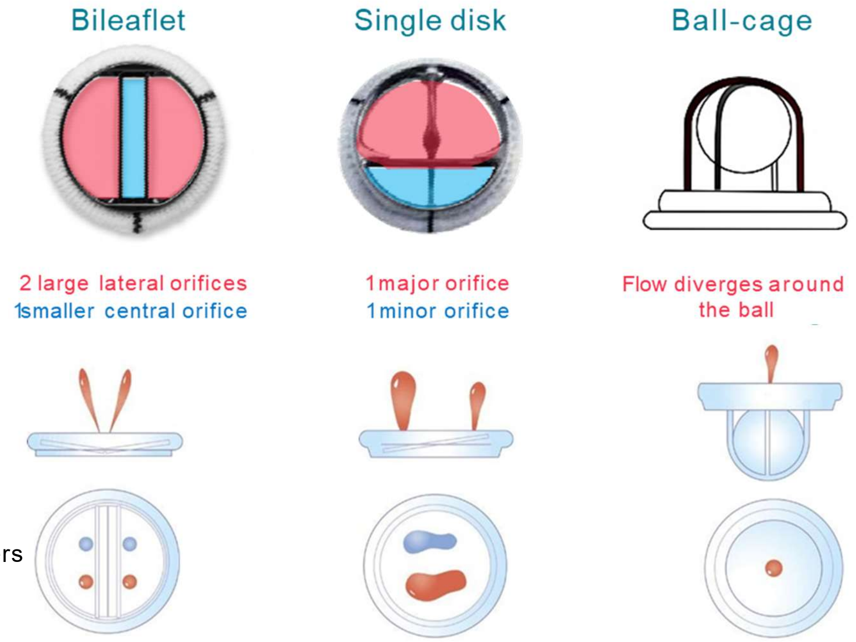
Know the PROBLEMS

- Patient-prosthesis mismatch
- Obstruction/stenosis
- Abnormal regurgitation

Basic Principles

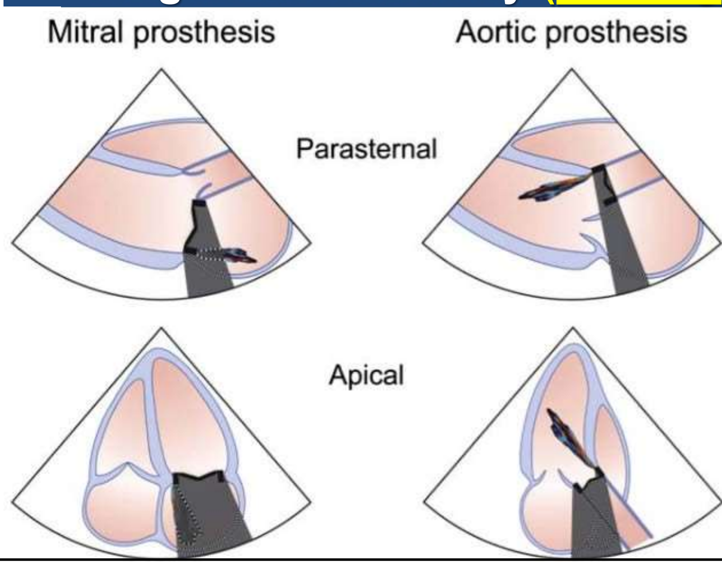
- By their design, almost all replacement valves are **obstructive** compared with normal native valves
- Most mechanic al valves and many biologic valves are associated with trivial or mild transprosthetic regurgitation **(physiologic regurgitation)**
- Because of **shielding and artifacts**, insonation of the valve especially regurgitant jets may be difficult and requires multiple angulations of the probe and the use of off-axis view

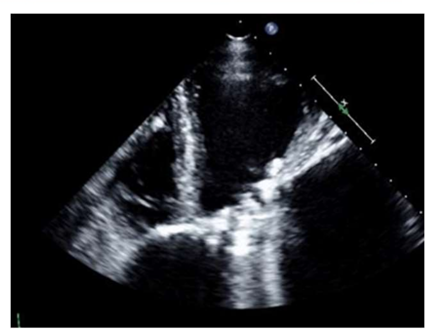
Mechanical Valve Flow Characteristics



From JB Chambers
Echo Res Pract
2016;3:R35-R43

Acoustic Shadow & Reverberation Artifacts
Decreased Resolution in Far-field with Reduced Diagnostic Accuracy (*Missing* or *Over-Diagnosis*)

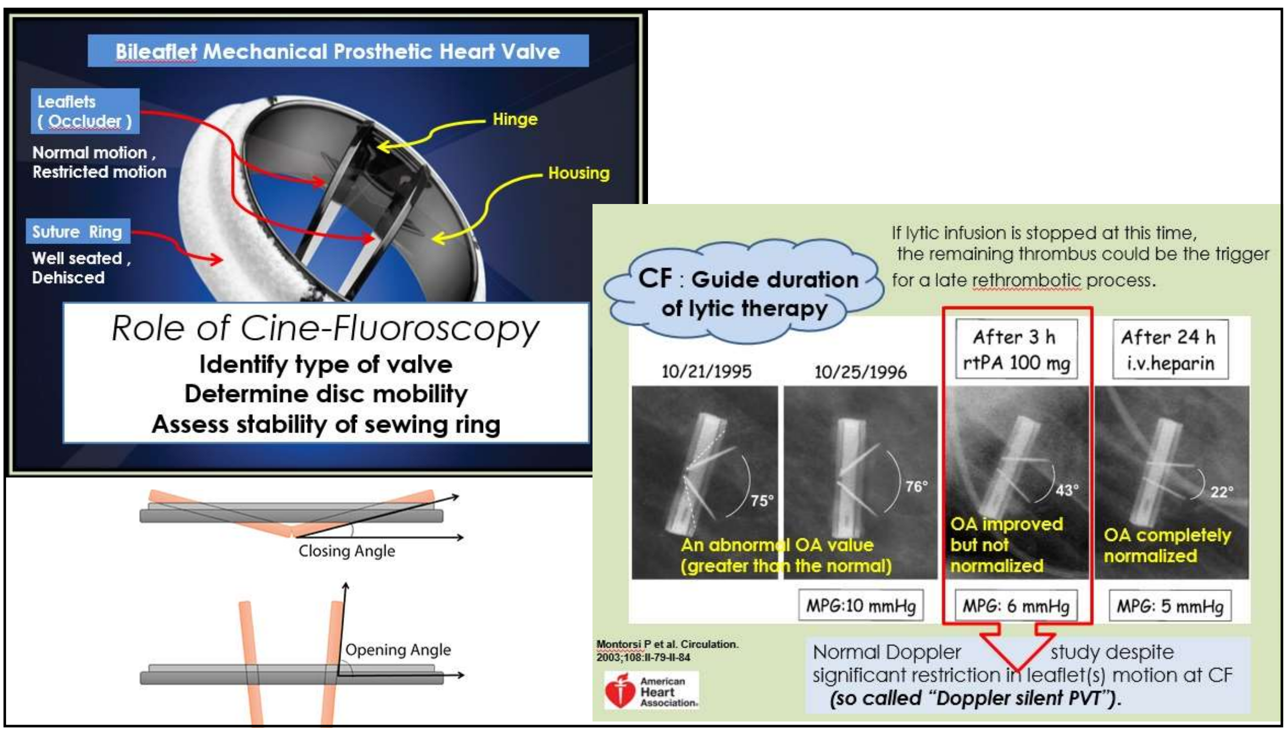




Microbubbles in St Jude MVR (Normal)

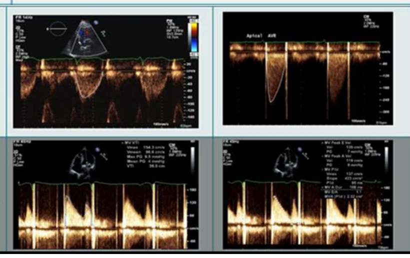
Valve Design
Bileaflet Mechanical Valves

Valve	Opening angle	Closing angle
CarboMedics	78⁰ / 78⁰	25⁰ / 25⁰
ATS Open Pivot	85⁰ / 85⁰	25⁰ / 25⁰
On-X	90⁰ / 90⁰	40⁰ / 40⁰



Know the Flow (Simplified)

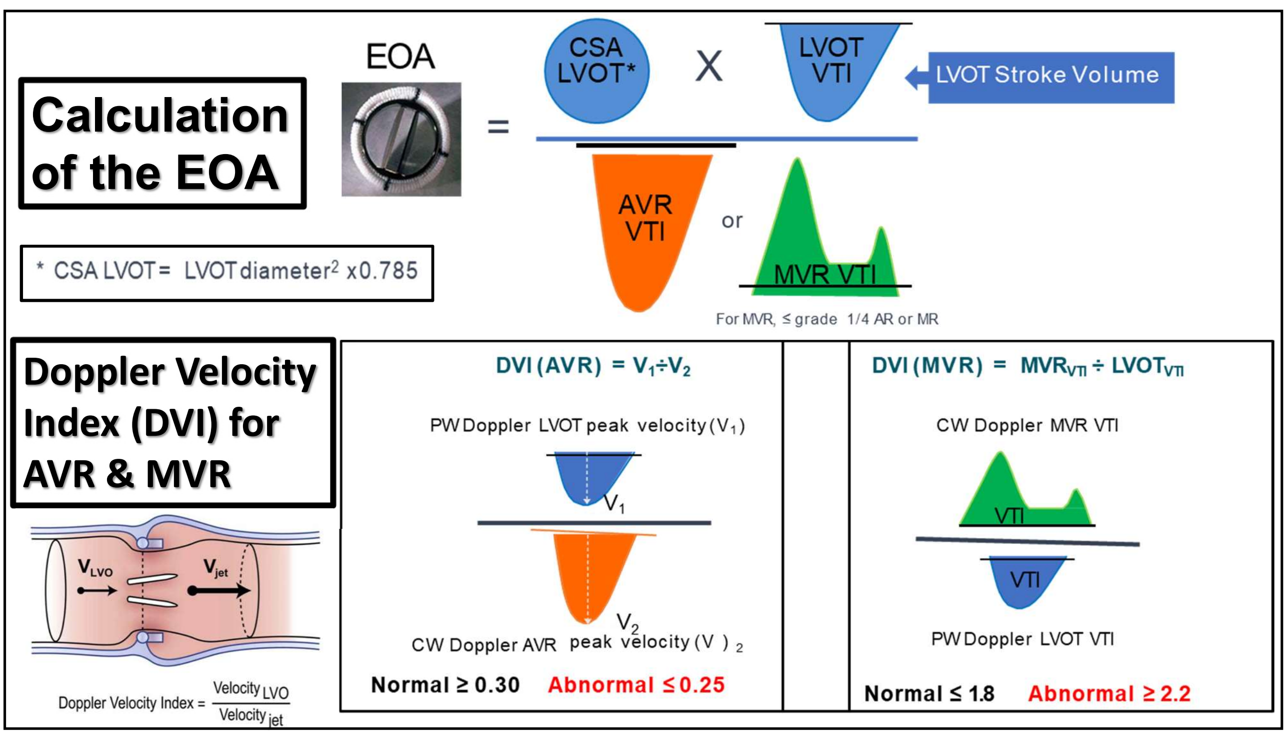
Valve	Parameter	Normal	ABNORMAL
AVR	Peak velocity Mean gradient Doppler velocity Index (DVI) Effective orifice area (EOA) Contour of the jet velocity Acceleration time (AT)	< 3 m/s < 20 mmHg ≥ 0.30 > 1.2 cm^2 Triangular, early peaking < 80 ms	**PEAK AV velocity >3 m/s and/or mean AVG ≥20 mmHg**
MVR	Peak velocity Mean gradient Doppler velocity Index (DVI) Effective orifice area (EOA) Pressure half-time (PHT)	< 1.9 m/s ≤ 5 mmHg < 2.2 ≥ 2.0 cm^2 < 130ms	**Peak mitral early diastolic velocity ≥1.9 m/s and/or mean MVG ≥6 mmHg.**



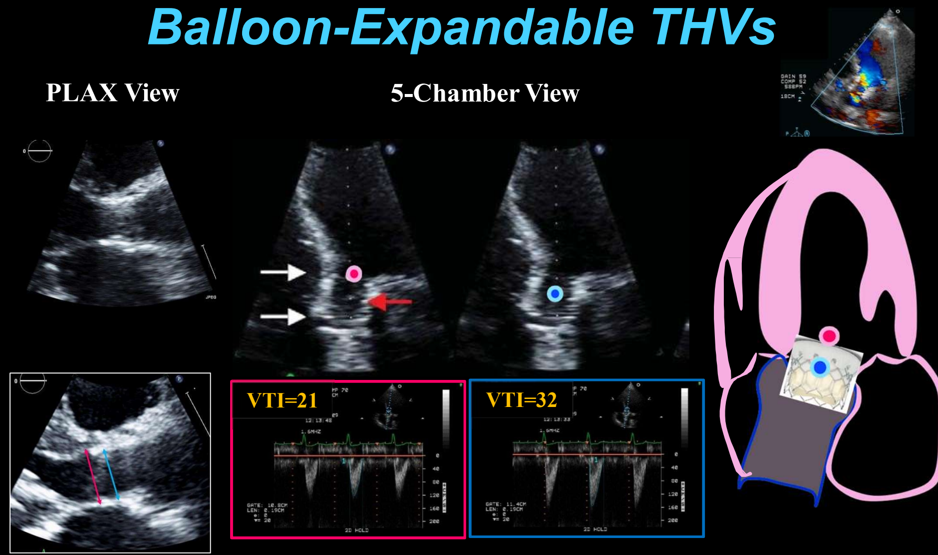
23 mm ATS AVR	• Vmax = 2.4 m/s • mPG = 13 mmHg • DVI = 0.33 • EOA = 1.5 cm^2
31 mm ATS AVR	• mPG = 4 mmHg • DVI = 1.5 • EOA = 2.8 cm^2 • PHT = 95 ms

Baseline Study Early Postop/ Post-procedure Strongly Recommended

Zoghbi WA, et al. JASE. 2009 Sep; 22(9):975-1014



LVOT Diameter and Velocity in Balloon-Expandable THVs



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

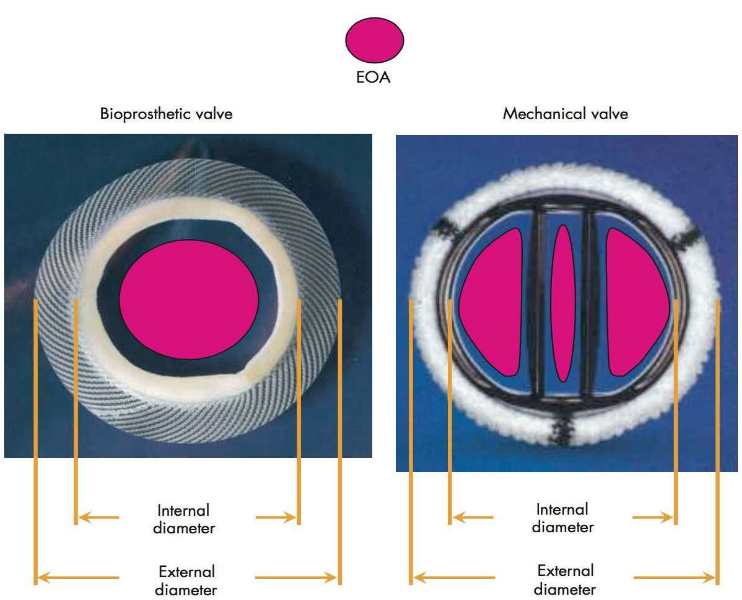
Normal Values for Implanted Aortic Valves

AORTIC VALVES	SIZE (mm)	PEAK GRADIENT (mm Hg)	MEAN GRADIENT (mm Hg)	EFFECTIVE ORIFICE AREA (cm^2)
Carpentier-Edwards Pericardial *Stented bovine pericardial*	19	32.1 ± 3.4	24.2 ± 8.6	1.2 ± 0.3
	21	25.7 ± 9.9	20.3 ± 9.1	1.5 ± 0.4
	23	21.7 ± 8.6	13.0 ± 5.3	1.8 ± 0.3
	25	16.5 ± 5.4	9.0 ± 2.3	
Carpentier-Edwards Standard *Stented porcine*	19	43.5 ± 12.7	25.6 ± 8.0	0.9 ± 0.2
	21	27.7 ± 7.6	17.3 ± 6.2	1.5 ± 0.3
	23	28.9 ± 7.5	16.1 ± 6.2	1.7 ± 0.5
	25	24.0 ± 7.1	12.9 ± 4.6	1.9 ± 0.5
	27	22.1 ± 8.2	12.1 ± 5.5	2.3 ± 0.6
	29		9.9 ± 2.9	2.8 ± 0.5
Hancock *Stented porcine*	21	18.0 ± 6.0	12.0 ± 2.0	
	23	16.0 ± 2.0	11.0 ± 2.0	
	25	15.0 ± 3.0	10.0 ± 3.0	
Hancock II *Stented porcine*	21		14.8 ± 4.1	1.3 ± 0.4
	23	34.0 ± 13.0	16.6 ± 8.5	1.3 ± 0.4
	25	22.0 ± 5.3	10.8 ± 2.8	1.6 ± 0.4
	29	16.2 ± 1.5	8.2 ± 1.7	1.6 ± 0.2
Medtronic Mosaic *Stented porcine*	21		14.2 ± 5.0	1.4 ± 0.4
	23	23.8 ± 11.0	13.7 ± 4.8	1.5 ± 0.4
	25	22.5 ± 10.0	11.7 ± 5.1	1.8 ± 0.5
	27		10.4 ± 4.3	1.9 ± 0.1
	29		11.1 ± 4.3	2.1 ± 0.2
Medtronic-Hall *Single tilting disc*	20	34.4 ± 13.1	17.1 ± 5.3	1.2 ± 0.5
	21	26.9 ± 10.5	14.1 ± 5.9	1.1 ± 0.2
	23	26.9 ± 8.9	13.5 ± 4.8	1.4 ± 0.4
	25	17.1 ± 7.0	9.5 ± 4.3	1.5 ± 0.5
	27	18.9 ± 9.7	8.7 ± 5.6	1.9 ± 0.2
St. Jude Medical Standard *Bileaflet*	19	42.0 ± 10.0	24.5 ± 5.8	1.5 ± 0.1
	21	25.7 ± 9.5	15.2 ± 5.0	1.4 ± 0.4
	23	21.8 ± 7.5	13.4 ± 5.6	1.6 ± 0.4
	25	18.9 ± 7.3	11.0 ± 5.3	1.9 ± 0.5
	27	13.7 ± 4.2	8.4 ± 3.4	2.5 ± 0.4
	29	13.5 ± 5.8	7.0 ± 1.7	2.8 ± 0.5

Normal Values for Implanted Mitral Valves

MITRAL VALVES	SIZE (mm)	GRADIENT (mm Hg)	GRADIENT (mm Hg)	PEAK VELOCITY (m/sec)	PRESSURE HALF-TIME (msec)	ORIFICE AREA (cm^2)
Carpentier-Edwards *Stented bioprosthesis*	27		6 ± 2	1.7 ± 0.3	98 ± 28	
	29		4.7 ± 2	1.76 ± 0.27	92 ± 14	
	31		4.4 ± 2	1.54 ± 0.15	92 ± 19	
	33		6 ± 3		93 ± 12	
Carpentier-Edwards Pericardial *Stented bioprosthesis*	27		3.6	1.6	100	
	29		5.25 ± 2.36	1.67 ± 0.3	110 ± 15	
	31		4.05 ± 0.83	1.53 ± 0.1	90 ± 11	
	33		1	0.8	80	
Hancock I or not specified *Stented bioprosthesis*	27	10 ± 4	5 ± 2		115 ± 20	1.3 ± 0.8
	29	7 ± 3	2.46 ± 0.79		95 ± 17	1.5 ± 0.2
	31	4 ± 0.86	4.86 ± 1.69		90 ± 12	1.6 ± 0.2
	33	3 ± 2	3.87 ± 2			1.9 ± 0.2
Hancock II *Stented bioprosthesis*	27					2.21 ± 0.14
	29					2.77 ± 0.11
	31					2.84 ± 0.1
	33					3.15 ± 0.22
Medtronic-Hall *Tilting disc*	27			1.4	78	
	29			1.57 ± 0.1	69 ± 15	
	31			1.45 ± 0.12	77 ± 17	
St. Jude Medical *Bileaflet*	23		4	1.5	160	1
	25		2.5 ± 1	1.34 ± 1.13	75 ± 4	1.35 ± 0.17
	27	11 ± 4	5 ± 1.82	1.61 ± 0.29	75 ± 10	1.67 ± 0.17
	29	10 ± 3	4.15 ± 1.8	1.57 ± 0.29	85 ± 10	1.75 ± 0.24

Valve Size is NOT equal to EOA or Geometric OA



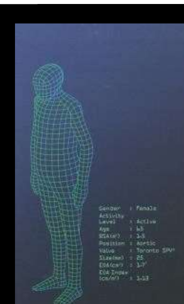
The effective orifice area(EOA) (Hemodynamic orifice) is ***NOT*** the same as the Geometric orifice area (valve opening area). The former is up to 29% smaller.

Calculating the EOA by the continuity equation presents several challenges, including accurate measurement of the LVOT diameter.

Know the Potential Problems

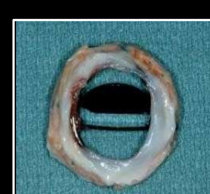
Path	Thrombosis	Pannus	Structural Degeneration	Endocarditis	PPM	Mal-deployment (TAVR)
Type of dysfunction	Obstruction	Obstruction	Stenosis / Regurgitation	Regurgitation / Shunts / stenosis	Non-structural dysfunction	Regurgitation/ Stenosis
Clinical presentation	Echo CHF Shock	Echo CHF Shock	Echo CHF Shock	Echo CHF Shock Sepsis	Echo CHF	Echo CHF Shock

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)



Pannus versus Thrombus

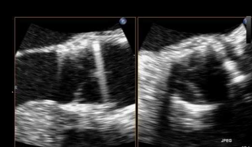
Parameters	Thrombus	Pannus
Clinical	• shorter (≈ 2 months) • Symptom duration before reoperation shorter (< 1 month) • Inadequate anticoagulation *	• Time from valve surgery to valve malfunction longer (> 12 months) • Symptom duration before reoperation • longer (≈ 10 months) • Adequate anticoagulation*
Echocardiography	• Larger • Soft tissue appearance (similar to myocardium) • Mobile • Extension of mass beyond limits of prosthetic valve ring to adjacent cardiac structures • More common in MVR than AVR	• Smaller • Echo dense appearance • Firmly fixed • Annular location (along valvular plane) • More common in AVR than MVR

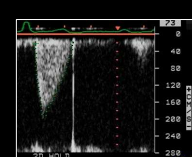
* Adequate anticoagulation defined as International Normalized Ratio (INR) ≥ 2.5 at the time of diagnosis

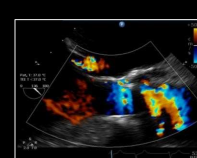
Barbetseas J, et al. *J Am Coll Cardiol.* 1998 Nov;32(5):1410-7.

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**



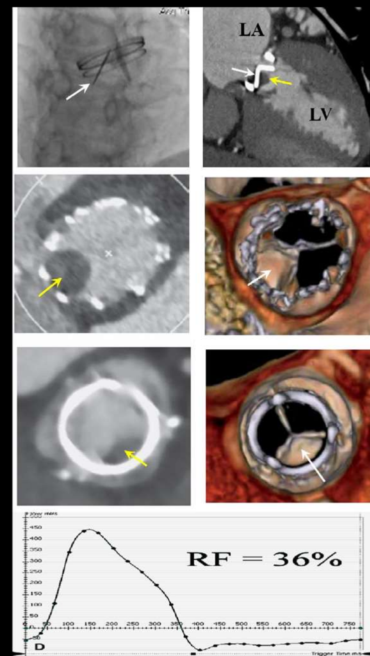




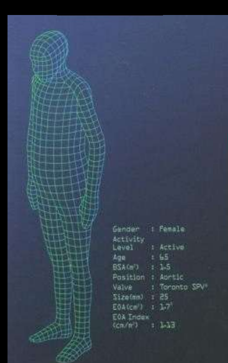
- **Functional evaluation**
  - **Transprosthetic gradients, EOA, and DVI**
  - **Localization (central vs. para) and degree of regurgitation**
- **LV/RV size and function, Pulmonary Arterial Pressure**

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

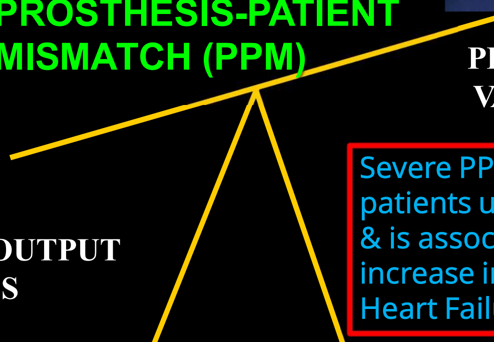


BSA



Young Physically Active patient
Depression LVEF
Low-flow, low-gradient AS
Severe LVH
Concomitant MR (Not treated at the time of AVR)

PROSTHESIS-PATIENT MISMATCH (PPM)

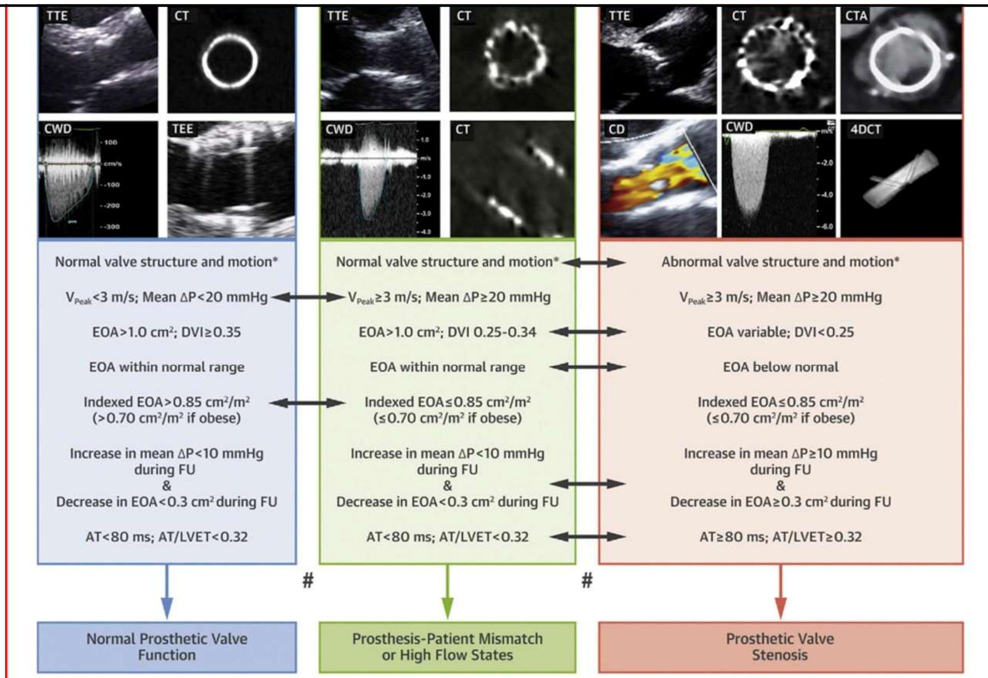


PROSTHETIC VALVE EOA

PATIENT'S CARDIAC OUTPUT REQUIREMENTS

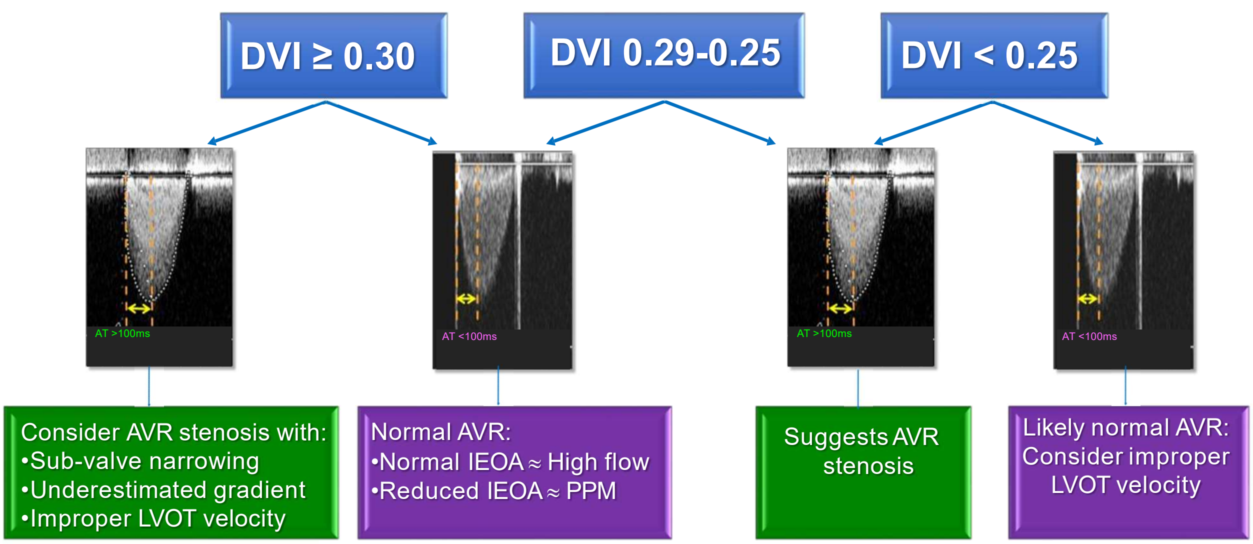
Severe PPM occurs in 2-20% of patients undergoing surgical AVR & is associated with a 1.5-2X fold increase in the Risk of Mortality & Heart Failure Re-hospitalization

PPM occurs when the EOA of the prosthesis is *TOO SMALL* in relation to patient's BODY SIZE / CARDIAC OUTPUT Requirements

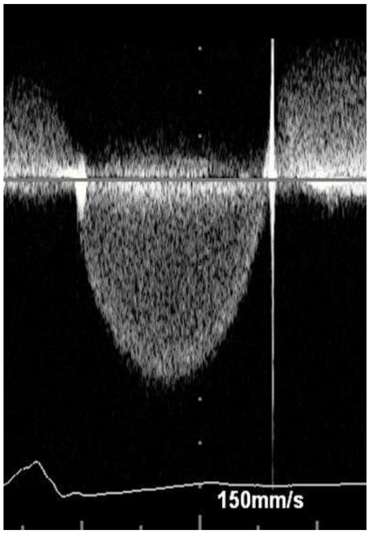


Pibarot, P. et al. J Am Coll Cardiol Img. 2019;12(1):149-62.

Value of AVR Acceleration Time (AT) for Elevated AVR Gradients



Adapted from Zoghbi WA, et al. J Am Soc Echocardiogr. 2009 Sep;22(9):975-1014



JACC: CARDIOVASCULAR IMAGING
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ORIGINAL RESEARCH

Flow Acceleration Time and Ratio of Acceleration Time to Ejection Time for Prosthetic Aortic Valve Function

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Houston, Texas; Istanbul, Turkey; Riyadh, Saudi Arabia; and Milan, Italy

Cut-off AT = 100 ms for identifying AVR stenosis:

- Sens. 86%
- Spec. 86%
- PPV 66%
- NPV 95%

Ben Zekry S, et al. JACC Cardiovasc Imaging. 2011 Nov;4(11):1161-70.

The Strategies to Prevent PPM at the time of Surgical AVR include: -

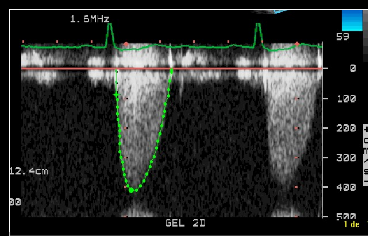
- **Implanting a Newer Generation of PHV with *<u>better hemodynamic performance & larger EOA</u>***
- **Enlarging the Aortic Root or annulus to accommodate a larger prosthetic valve; or**
- **Performing Transcatheter AVR rather than Surgical AVR.**
- **Fracture bioprosthesis stent (For valve-in-valve)**

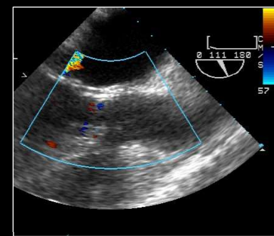
Prosthesis-Patient Mismatch after SAVR

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

↓

Reference EOA
1.0±0.4



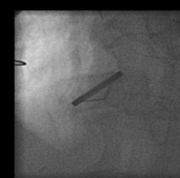


Peak / Mean Gradients= 69/40 mm Hg

↔ Measured EOA = 1.06 cm²

↓

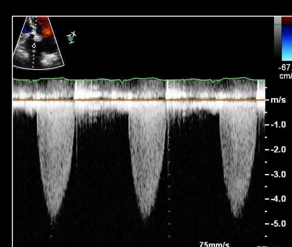
BSA = 1.95 m² ····> Measured Indexed EOA: 0.55 cm²/m²

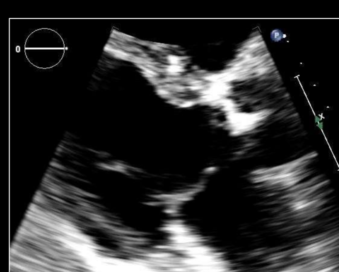


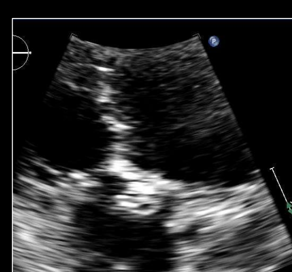
Valve Stenosis due to SVD after SAVR

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 cm²   DVI: 0.16
  (vs. 1.7 cm²   DVI: 0.42)
- AT/LVET: 0.38



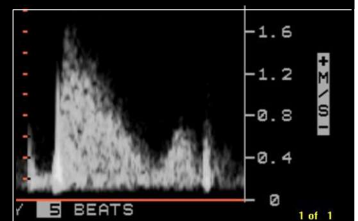




Doppler-Echo Evaluation of Mitral Prosthesis - Specifics

- **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 if delayed**

Non-Obstructed



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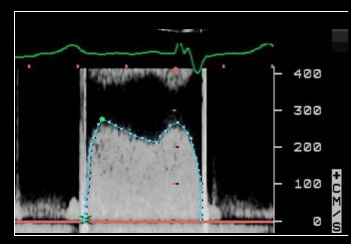
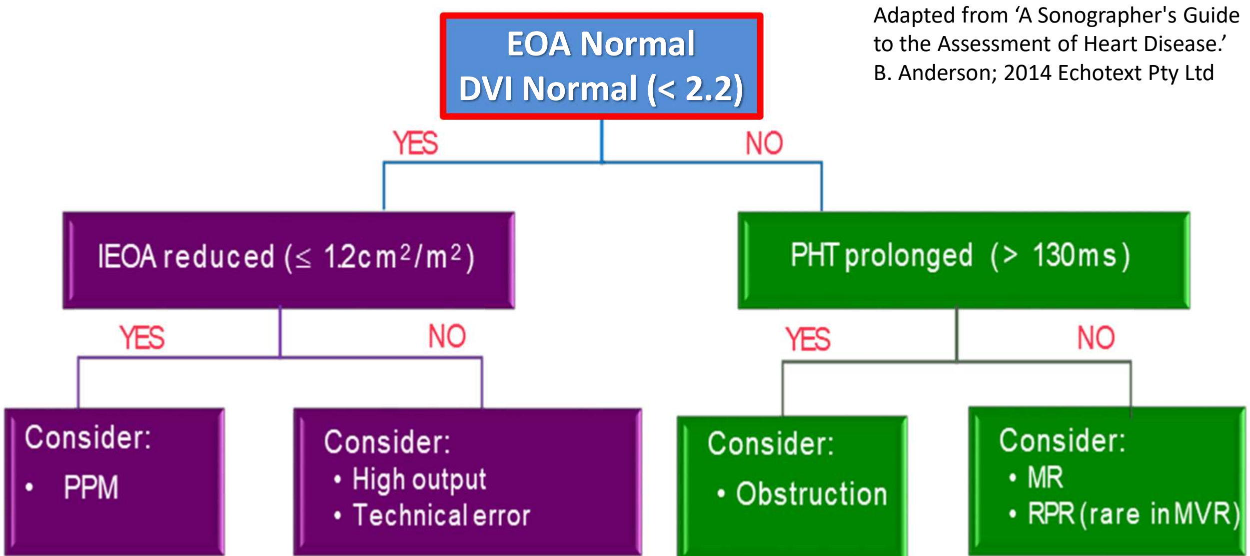


A Diagnostic Pathway for Elevated MVR Gradients

Adapted from 'A Sonographer's Guide to the Assessment of Heart Disease.' B. Anderson; 2014 Echotext Pty Ltd



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

Lancellotti EHJ CV Img 2016

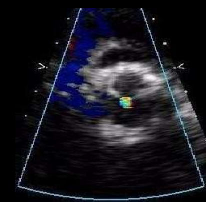
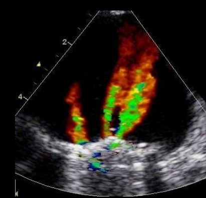
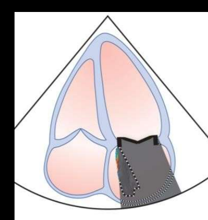
Doppler-Echo Criteria to Assess the Severity of Prosthetic Mitral Valve Stenosis

	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

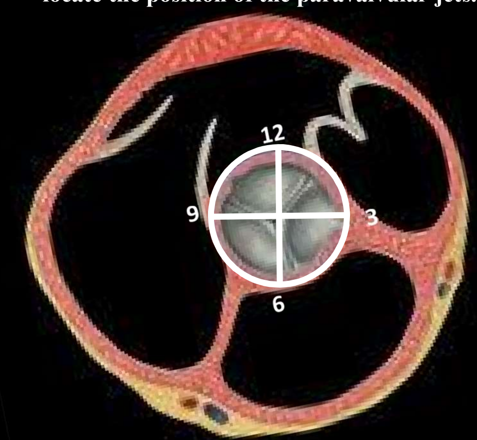
Doppler-Echo Criteria to Assess the Severity of Prosthetic Aortic Valve Regurgitation

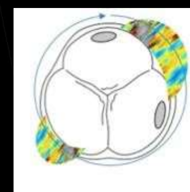
	Mild	Moderate	Severe
2D/3D TTE / TEE / Cinefluoroscopy / CT			
Valve structure / leaflet mobility	Normal	Often abnormal	Abnormal
Doppler qualitative or semi-quantitative parameters			
Vena contracta width	<3	3-6	>6
Jet width in central jets (% LVOT diameter)	≤25	26-64	≥65
Pressure half time (ms)	Slow >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

Semi-Quantitation and Location of Paravalvular Regurgitation on PSAX

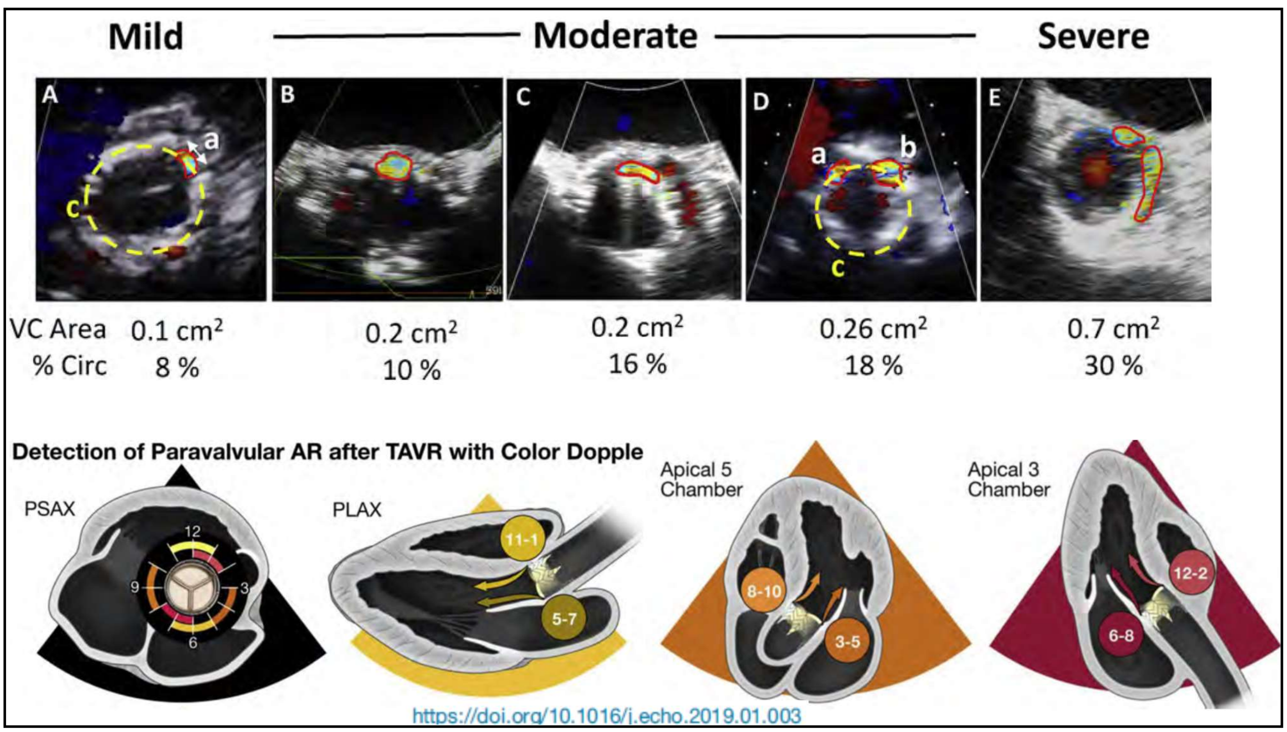
Using the TV septal leaflet insertion as 9 o'clock, locate the position of the paravalvular jets.



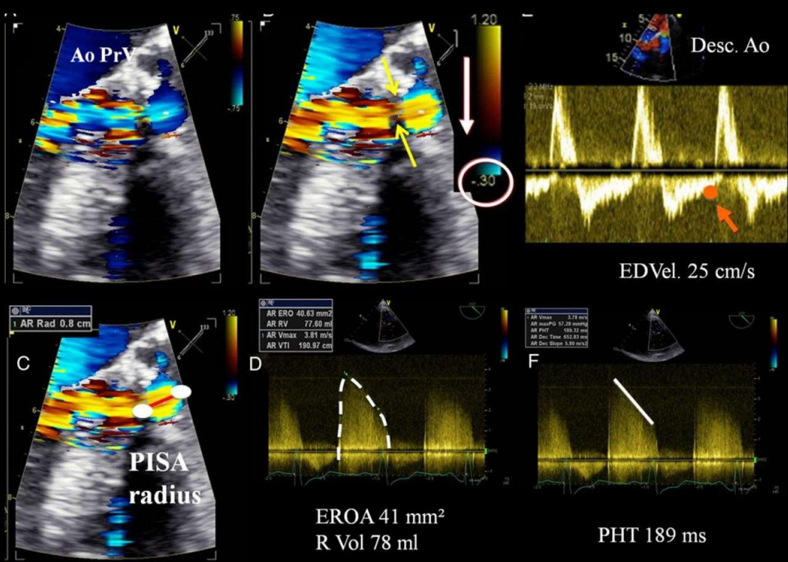


12 min + 6 min = 18 min
CE: (18/60)×100= 30%

Moderate-to-Severe PVR



Doppler-Echo Assessment of Prosthetic Aortic Valve Regurgitation



Specific Criteria for Severe AR

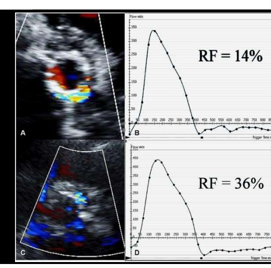
- VC width > 0.6 cm
- VCA ≥ 0.30 cm^2
- Circumferential VC extent ≥ 30%
- Large flow convergence
- PHT < 200 ms
- Prominent holodiastolic flow reversal in the descending aorta

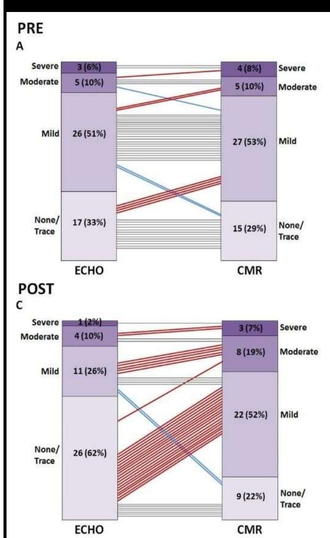
≥4 Above Criteria Definitely Severe

Zoghbi WA JASE 2019
Lancellotti EHJ CV Img 2016

Assessment of PVR by CMR

Ribeiro et al. Heart 2016



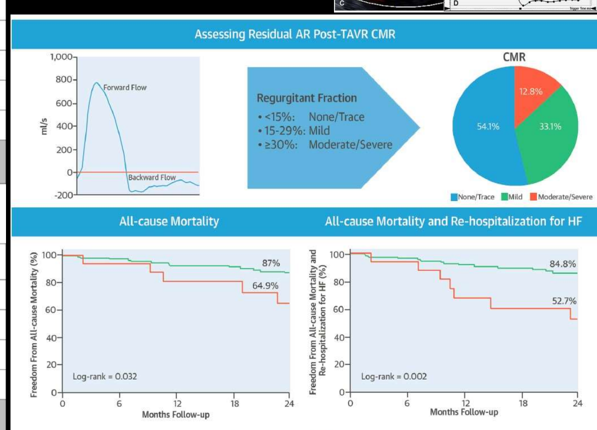


B

CMR \ ECHO	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)

D

CMR \ ECHO	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)

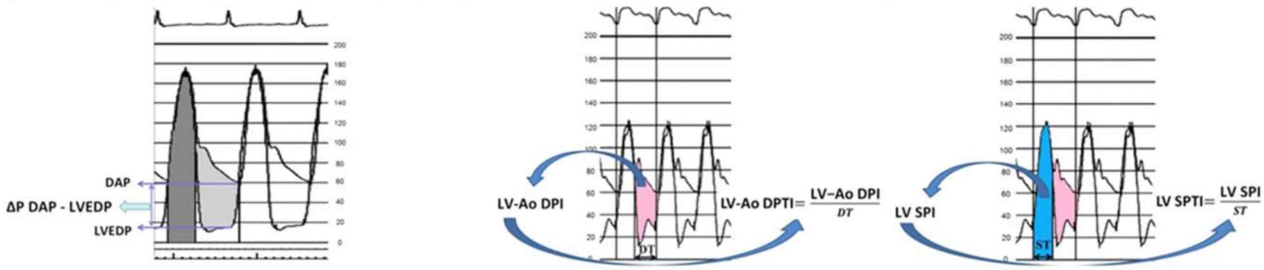


Ribeiro, H.B. et al. J Am Coll Cardiol. 2016;68(6):577-85.

Table 2 Invasive hemodynamic indexes for assessing severity of AR immediately After TAVR

Author	Index	Formula	Cutoff for significance
Sinning *et al.*[52]	AR index	([DBP– LVEDP] ÷ SBP) x 100	AR index <25 predicted higher mortality
Sinning *et al.*[54]	ARI ratio	Ratio of post-procedural to pre-procedural AR index	ARI ratio <0.60 improved 1-year mortality prediction of post TAVR AR Index <25
Jilaihawi *et al.*[53]	CHAI score	([DBP – LVEDP] ÷ HR) x 80	<25 (denoting ≥ moderate PVR), predicted higher mortality
Bugan *et al.*[55]	TIAR index	(LV-Ao diastolic pressure time integral)/(LV systolic pressure time integral) x 100	TIAR index <80 was associated with a sensitivity of 86% and a specificity of 83% for ≥mild AR.

AR, Aortic regurgitation; *ARI*, AR index; *CHAI*, composite heart-rate-adjusted hemodynamic-echocardiographic aortic insufficiency; *DBP*, diastolic blood pressure; *HR*, heart rate; *LVEDP*, left ventricular end-diastolic pressure, *SBP*, systolic blood pressure; *TIAR*, Time-integrated aortic regurgitation. https://doi.org/10.1016/j.echo.2019.01.003



$$\text{AR Index} = \frac{\Delta\text{P DAP} - \text{LVEDP}}{\text{SBP}} \text{ X } 100$$

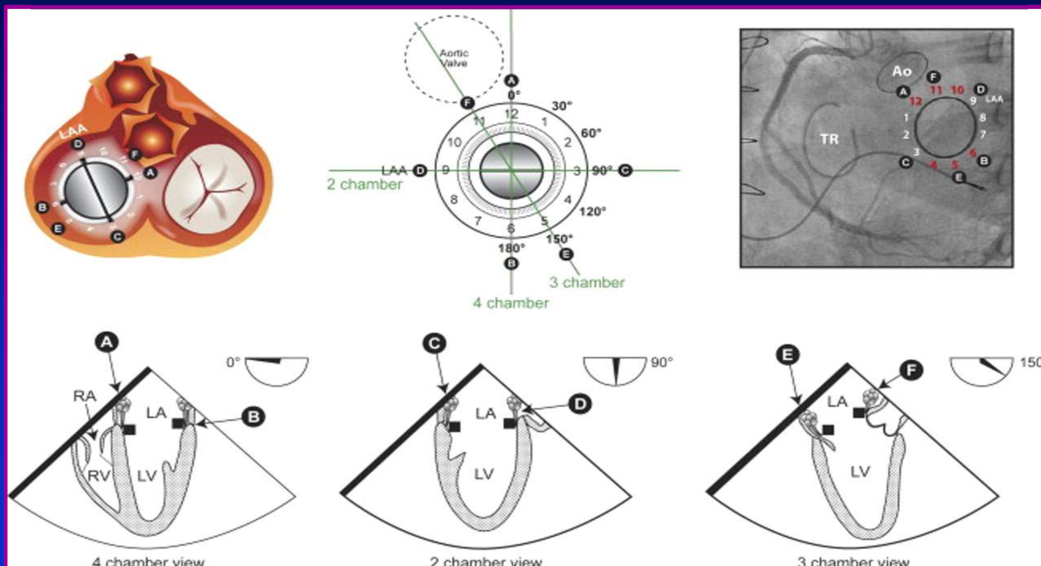
$$\text{TIAR Index} = \frac{\text{LV}-\text{Ao DPTI}}{\text{LV SPTI}} \text{ X } 100$$

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 MRjet	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

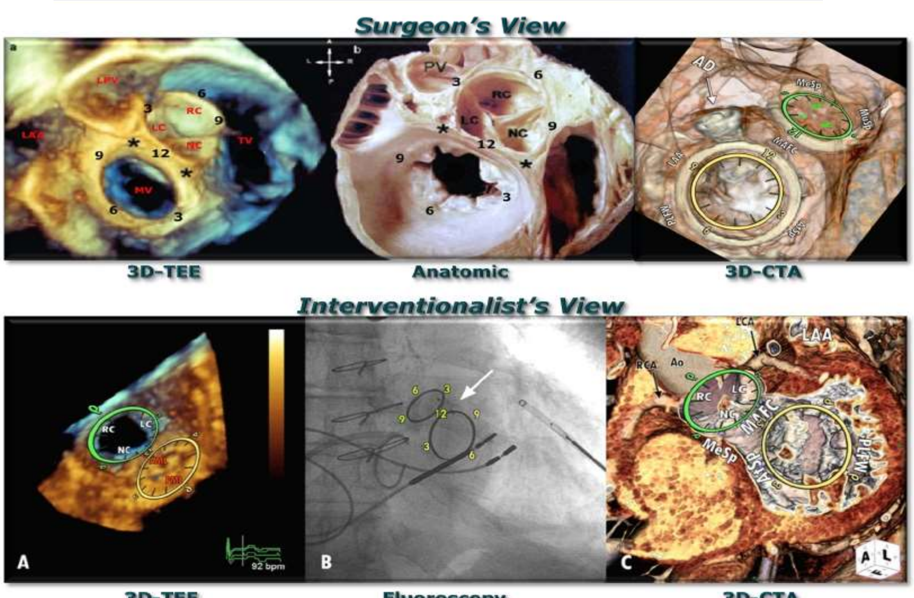
Zoghbi JASE 2009
Lancellotti EHJ CV Img 2016

Peri-prosthetic Leak Localization

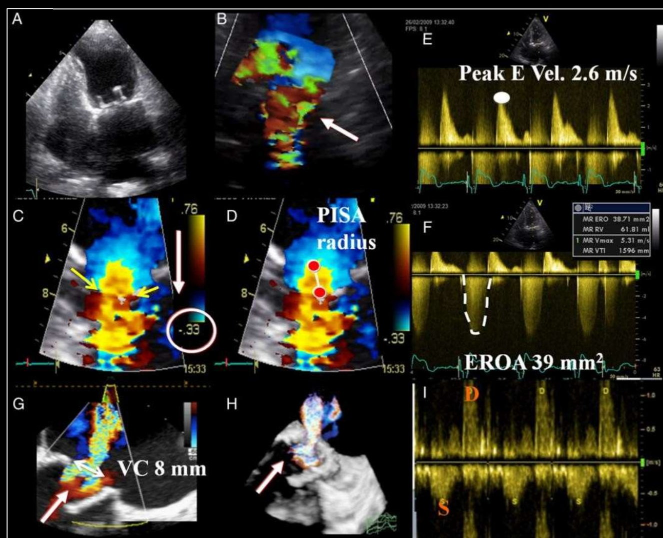


Mahjoub, H. et al. J Am Coll Cardiol Intv 2011;4:107-114

Imaging & Nomenclature



Doppler-Echo Assessment of Prosthetic Mitral Valve Regurgitation



Specific Criteria for Severe MR
- Abnormal device morphology/flail leaflet
- VCW ≥ 0.7 cm or ≥ 2 moderate jets
- VCA ≥ 0.4 cm^2 or ≥ 2 moderate jets
- Large flow convergence
- Central large jet > 50% of LA area
- Pulmonary vein systolic flow reversal

≥4 Above Criteria Definitely Severe

Zoghbi WA JASE 2019
Lancellotti EHJ CV Img 2016

Conclusions

- Patients between aged 50-70 can now opt for either biological or mechanical PHV.
- Bridging AC therapy is reasonable in older mechanical AVR, AVR with 1 thrombo-embolic risk factor (RF) & mechanical MVR.
- INR 2.5 for metallic AVR and 3.0 for metallic AVR with ≥1 RF.
- INR 3.0 for metallic MVR
- Know your PHV: Products, Look, Flow, potential Problems.
- Multi-modality imaging with multi-parameter integrative approach is required for problematic metallic PHVs. Record BP, HR, BMI
- PPM – Indexed EOA (↓) & DVI (>0.25 for AVR; <2.2 for MVR)
- Indexed EOA is the only parameter shown to have any correlation with post-op gradients &/or outcomes in PPM.