Important Notes:

The cut-offs used for determining the various degrees of severity vary between laboratories. Therefore, students should check with their clinical supervisors regarding the cut-offs that are used in their laboratory.

Students are encouraged to read the reference articles for more detailed information about measurement techniques, etc.

For prosthetic valves, normal values for various types and sizes of prosthetic valves can be found in the following references:

- Zoghbi WA et al. Recommendations for Evaluation of Prosthetic Valves with Echocardiography and Doppler Ultrasound. J Am Soc Echocardiogr 2009; 22:975-1014
- Rosenhek R, Binder T, Maurer G, Baumgartner H. Normal Values for Doppler Echocardiographic Assessment of Heart Valve Prostheses. J Am Soc Echocardiogr 2003; 16: 1116-1127.

This file has been composed by Bonita Anderson, Clinical Fellow, Queensland University of Technology

References can be found at the end of this document

Last Update: August 2020

Aortic Dimensions (Normal Adult)
*2SDs from the mean is abnormal

	Men		Women	
	Absolute Values (cm)	Indexed Values (cm/m^2)	Absolute Values (cm)	Indexed Values (cm/m^2)
Aortic annulus#, *	2.6 ± 0.3	1.3 ± 0.1	2.3 ± 0.2	1.3 ± 0.1
Sinus of Valsalva *	3.4 ± 0.3	1.7 ± 0.2	3.0 ± 0.3	1.8 ± 0.2
Sinotubular junction *	2.9 ± 0.3	1.5 ± 0.2	2.6 ± 0.3	1.5 ± 0.2
Proximal ascending aorta *	3.0 ± 0.4	1.5 ± 0.2	2.7 ± 0.4	1.6 ± 0.3
Aortic arch (just proximal to brachiocephalic artery)	2.2-3.6 (range)		2.2-3.6 (range)	
Descending aorta (opposite ligamentum arteriosum)	2.0-3.0 (range)		2.0-3.0 (range)	

Aortic annulus measurement performed during **mid systole** via **inner edge to inner edge** method from a zoomed parasternal long axis view

All other aortic measurements performed at **end diastole** via **leading edge to leading edge** method

Note: can only consider these values for determining if normal or dilated when measurements are performed at end diastole via leading edge to leading edge method

* Measurements exceeding ± 1.96 SDs (i.e., the 95% confidence interval) should be classified as abnormal; therefore + 2 standard deviations (SD) above the mean ≈ dilated

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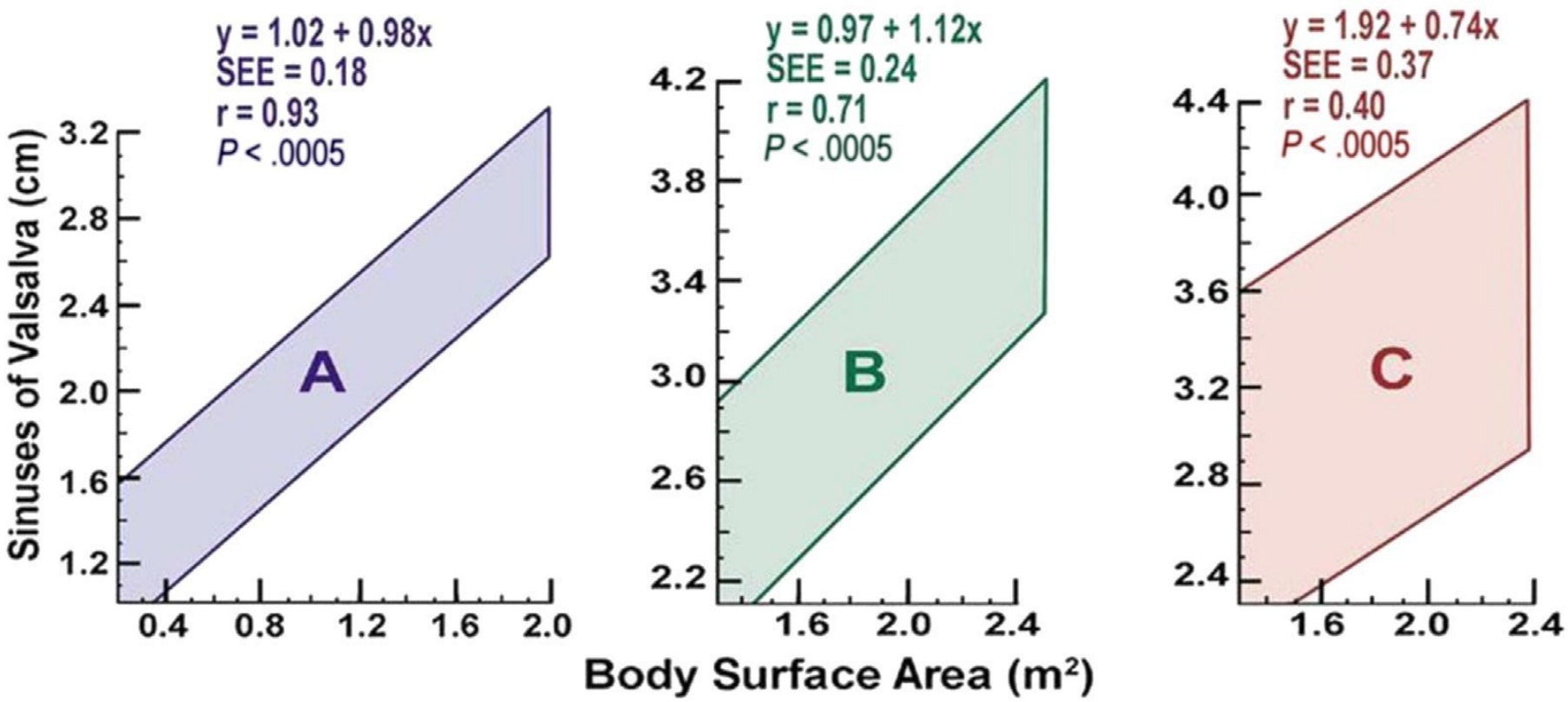
Identifying Aortic Root Dilatation



The 95% confidence intervals for aortic root diameter at sinuses of Valsalva on the basis of BSA in children and adolescents (A), adults aged 20 to 39 years (B), and adults aged >40 years (C).

Aortic root dilatation at the sinuses of Valsalva is defined as an aortic root diameter above the upper limit of the 95% confidence interval of the distribution.

Last Update: August 2020

Left Atrial Volumes				
ILAV (mL/m^2) Preferred method = Biplane disk summation (method of disks)	**Normal**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**
	16-34	35-41	42-48	> 48

Right Atrial Volumes		
	Men	**Women**
RAV (ml/m^2) (normal range; mean ± SD)	≤ 39 mL/m^2 (25 +/- 7)	≤ 33 mL/m^2 (21 +/- 6)
Abnormal: Dilated *	>39 mL/m^2 (25 + 14)	>33 mL/m^2 (21 + 12)

* Measurements exceeding ± 1.96 SDs (i.e., the 95% confidence interval) should be classified as abnormal; therefore + 2 standard deviations (SD) above the mean ≈ dilated

Last Update: August 2020

Left Ventricular Dimensions

	Men				Women			
Linear method	**Normal**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**	**Normal**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**
ILVEDD (cm/m^2)	2.2-3.0	3.1-3.3	3.4-3.6	> 3.6	2.3-3.1	3.2-3.4	3.5-3.7	> 3.7
ILVESD (cm/m^2)	1.3-2.1	2.2-2.3	2.4-2.5	> 2.5	1.3-2.1	2.2-2.3	2.4-2.6	> 2.6

Left Ventricular Mass

	Men				Women			
	Normal	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**	**Normal**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**
IVS (cm)	0.6-1.0	1.1-1.3	1.4-1.6	> 1.6	0.6-0.9	1.0-1.2	1.3-1.5	> 1.5
PW (cm)	0.6-1.0	1.1-1.3	1.4-1.6	> 1.6	0.6-0.9	1.0-1.2	1.3-1.5	> 1.5
Linear ILVM (g/m^2)	49-115	116-131	132-148	> 148	43-95	96-108	109-121	> 121
2D ILVM (g/m^2)	50-102	103-116	117-130	> 130	44-88	89-100	101-112	> 112

Last Update: August 2020

Left Ventricular Volumes

	Men				Women			
Simpson's Biplane	**Normal**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**	**Normal**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**
ILVEDV (mL/m^2)	34-74	75-89	90-100	> 100	29-61	62-70	71-80	> 80
ILVESV (ml/m^2)	11-31	32-38	39-45	> 45	8-24	25-32	33-40	>40

3D (Upper limit normal)	Men		Women	
	ILVEDV (mL/m^2)	ILVESV (ml/m^2)	ILVEDV (mL/m^2)	ILVESV (ml/m^2)
	79	32	71	28

NB: The partition values for females have been questioned as being too small; so consider with respect to other measurements and visual impressions

Left Ventricular Ejection Fraction *

Men				Women			
Normal	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**	**Normal**	**Mildly abnormal**	**Moderately abnormal**	**Severely abnormal**
52-72	41-51	30-40	< 30	54-74	41-53	30-40	< 30

* **NB:** patients with significant MR: EF < 60% is abnormal

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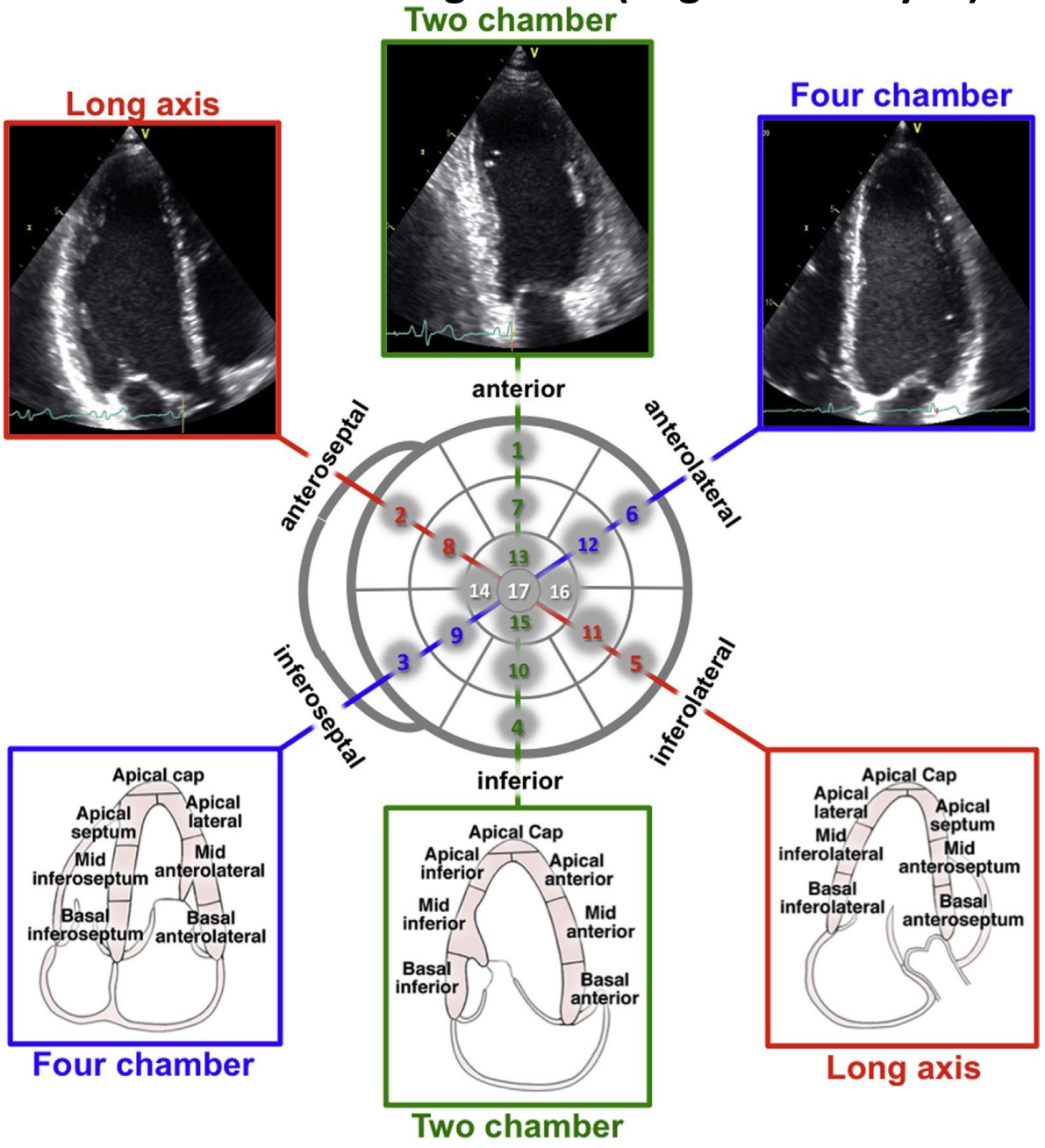
Left Ventricular Segmental (Regional Analysis)



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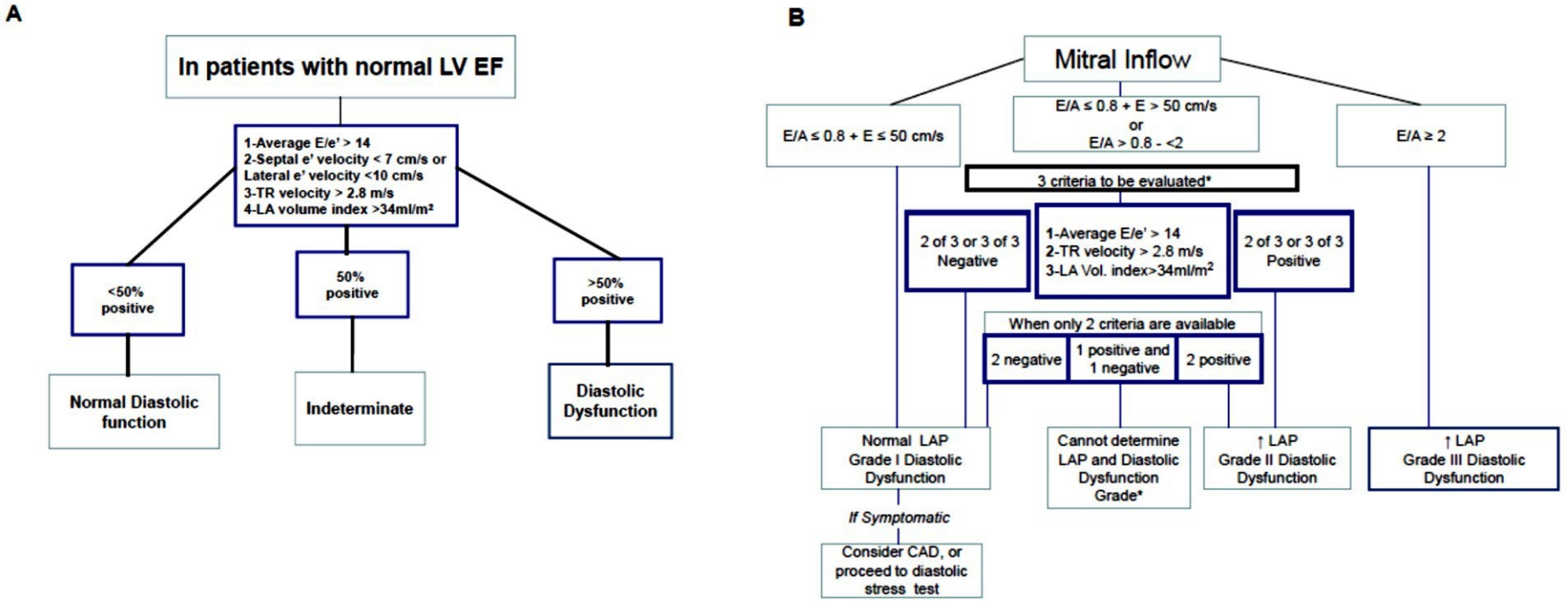
LV Diastolic Function



* LAP indeterminate if only 1 of 3 parameters available. Pulmonary vein S/D ratio <1 applicable to conclude elevated LAP in patients with depressed LV EF)

(A) Algorithm for diagnosis of LV diastolic dysfunction in subjects with normal LVEF. (B) Algorithm for estimation of LV filling pressures and grading LV diastolic function in patients with depressed LVEFs and patients with myocardial disease and normal LVEF after consideration of clinical and other 2D data.

Using these algorithms: consider (A) first: if normal – proceed no further; if Indeterminate or diastolic dysfunction – proceed to B.

Identifying Increased LVFP (> 15 mmHg) in Special Populations		
AF [43, 94-99]	IVRT	≤ 65 ms
	E/Vp ratio	≥ 1.4
	Septal E/e'	≥11
Sinus tachycardia [41,44]	Mitral inflow	predominant early LV filling + EFs <50%
	IVRT	**≤ 70 ms - specific (79%)**
	Pul vein SFF	**≤ 40% - specific (88%)**
	Average E/e'	**>14 (highest specificity but low sensitivity)**
	Post-ectopic	- consider profile post-ectopic beats
HCM [100-106]	Average E/e'	>14
	Ar-A	≥ 30 ms
	TR velocity	>2.8 m/s
	ILAV	>34 mL/m^2
Mitral stenosis[110]	**IVRT**	**<60 ms - high specificity**
	IVRT/TE-e'	<4.2
	Mitral A	>1.5 m/s
MR [110-112]	Ar-A	≥ 30 ms
	IVRT	**<60 ms - high specificity**
	IVRT/TE-e'	<5.6 (and normal EFs)
	Average E/e'	>14 (with depressed EFs)

Continued over……

Identifying Increased LVFP (> 15 mmHg) in Special Populations		
Restrictive CM [13,107-109]	DT	<140 ms
	Mitral E/A	>2.5
	IVRT	**<50 ms - high specificity**
	Average E/e'	>14
Noncardiac PHT [32]	Lateral E/e'	<8 (noncardiac aetiology for PHT)
	Lateral E/e'	> 13 (cardiac aetiology for increased PAP)

A comprehensive approach is recommended in all of the above settings, which includes estimation of PASP using peak velocity of TR jet (>2.8 m/s) and LA maximum volume index (>34 mL/m^2). Conclusions should not be based on single measurements. Specificity comments refer to predicting filling pressures > 15 mmHg. Note that the role of LA maximum volume index to draw inferences on LAP is limited in athletes, patients with AF, and/or those with mitral valve disease.

For references – see Nagueh SF, et al. Recommendations for the Evaluation of Left Ventricular Diastolic Function by Echocardiography: An Update from the American Society of Echocardiography and the European Association of Cardiovascular Imaging. J Am Soc Echocardiogr. 2016 Apr;29(4):277-314.

Right Ventricular Size

RV focused normal range (mean ± SD)	**Basal RV (mm)**	**Mid RV (mm)**	**RV Length (mm)**
	25-41 (33 ± 4)	19-35 (27 ± 4)	59-83 (71 ± 6)
RVOT normal range (mean ± SD)	**PLAX (mm)**	**Proximal (mm)**	**Distal (mm)**
	20-30 (25 ± 2.5)	21-35 (28 ± 3.5)	17-27 (22 ± 2.5)
RV wall thickness (subcostal) normal range (mean ± SD)		1-5 mm (3 ± 1 mm)	

2D normal range (mean ± SD)	**Men**		**Women**	
	IRVEDA (cm^2/m^2)	IRVESA (cm^2/m^2)	IRVEDA (cm^2/m^2)	IRVESA (cm^2/m^2)
	5-12.6 (8.8 ± 1.9)	3-15 (9 ± 3)	4.5-11.5 (8.0 ± 1.75)	1.6 – 6.4 (4.0 ± 1.2)

* Measurements exceeding ± 1.96 SDs (i.e., the 95% confidence interval) should be classified as abnormal; therefore + 2 standard deviations (SD) above the mean ≈dilated or thickened (in case of RV wall thickness)

IRVEDA = indexed RV end-diastolic area; IRVESA = indexed RV end-systolic area

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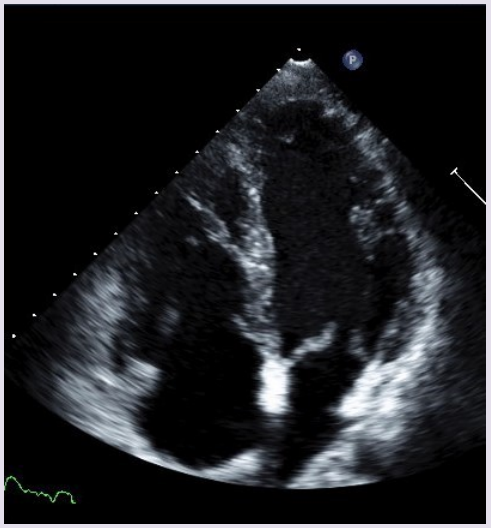
Right Ventricular Size (Qualitative)

Normal RV Size:

RV area or mid-cavity diameter should be smaller than that of the LV; apex is formed by the left ventricle

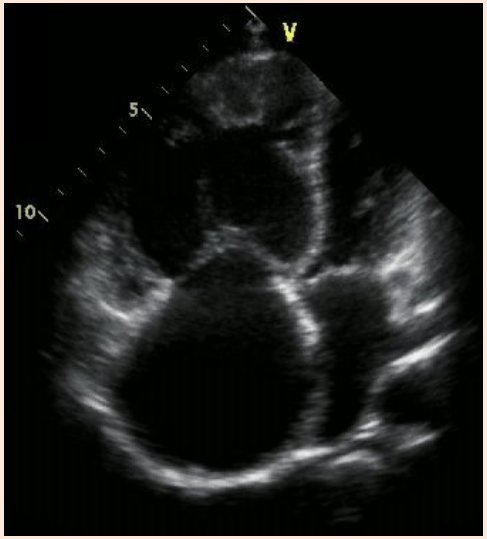


Mildly dilated RV:

RV cavity area appears increased (> 2/3 of LV but still smaller than LV) and apex still formed by LV

Moderate RV dilatation:

RV cavity area is similar to that of the LV and RV may share the apex of the heart



Severe RV dilatation:

RV cavity area exceeds that of the LV and the RV forms the apex

Right Ventricular Systolic Function

	Normal	Abnormal
RVFAC (%)	≥ 35 (49 ± 7)	< 35
TAPSE (mm)	≥ 17 (24 ± 3.5)	< 17
Pulsed DTI S' (cm/s)	≥ 9.5 (14.1 ± 2.3)	< 9.5
3D RVEF (%)	≥ 45 (58 ± 6.5)	< 45

	Normal	Abnormal
MPI (PW)	≤ 0.43 (0.26 ± 0.085)	> 0.43
MPI (DTI)	≤ 0.54 (0.38 ± 0.08)	> 0.54
RV free wall strain (%)	-29 ± 4.5	Less negative than -20

* Measurements exceeding ± 1.96 SDs (i.e., the 95% confidence interval) should be classified as abnormal

Limited data; values may vary depending on vendor and software version

Last Update: August 2020

Right Ventricular Diastolic Function			
Normal	E/A	1.4 ± 0.3	(range 0.8-2.0; abnormal < 0.8 or > 2.0)
	DT	180 ± 31	(range 119-242; abnormal < 119 or > 242)
	E/e’	4.0 ± 1.0	(abnormal > 6.0)
	e'	14.0 ± 3.1	(abnormal < 7.8)
Impaired relaxation	Tricuspid E/A ratio < 0.8		
Pseudonormal	Tricuspid E/A ratio 0.8 – 2.1 + E/e’ ratio > 6 or Hepatic vein = diastolic predominance		
Restrictive	Tricuspid E/A ration > 2.1 + deceleration time < 120 ms		

Note: RV diastolic function is influenced by the systolic and diastolic function of the left heart. Therefore, need to report systemic blood pressure also

Right Atrial Pressure Estimation				
	Normal RAP **3 mmHg**	**Intermediate** **8 mmHg**		**High RAP** **15 mmHg**
IVC diameter	≤ 2.1 cm	≤ 2.1 cm	> 2.1 cm	> 2.1 cm
Collapse with sniff	> 50%	< 50%	> 50%	< 50%
2^0 indices ↑ RAP				• Restrictive filling (right heart) • Tricuspid E/e' > 6 • SSF ratio < 55%

Note:

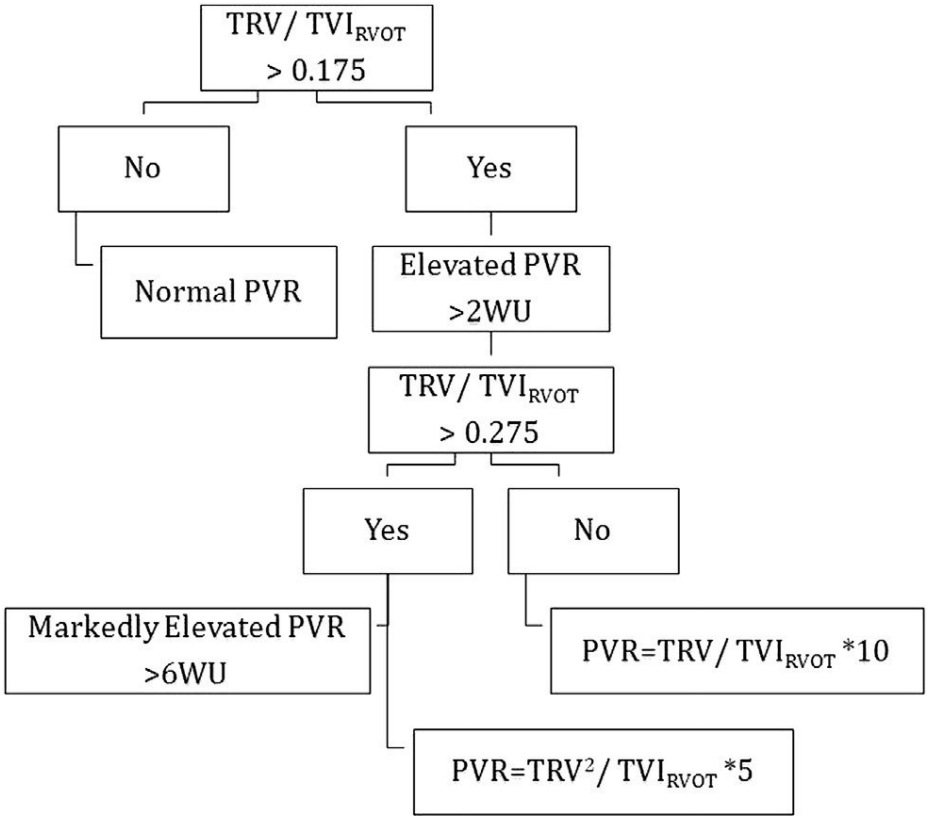
- In normal young athletes, IVC may be dilated in the presence of normal RA pressure
- IVC is commonly dilated and may not collapse in patients on ventilators, so should not be used to estimate RA pressure

Pulmonary Haemodynamics/Hypertension

Pulmonary Vascular Resistance *	
Normal	< 1.2 WU
Elevated	> 3 WU

Pulmonary Hypertension	
Mild	40-54 mmHg
Moderate	55-64 mmHg
Severe	≥ 65 mmHg

* **Note:** The estimation of PVR is not adequately established to be recommended for routine use



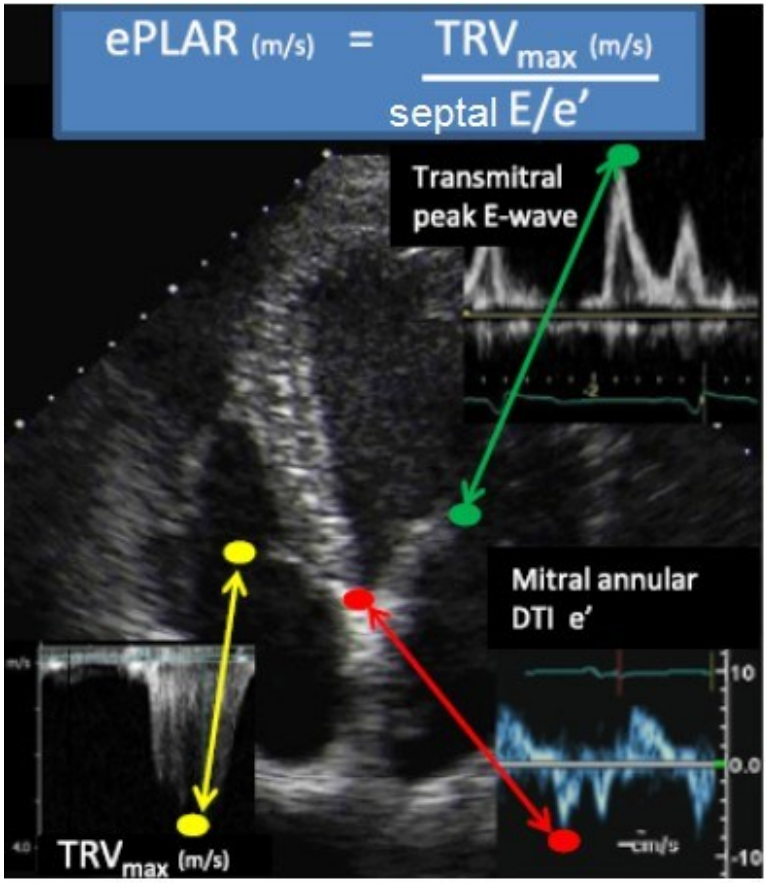
Algorithm for noninvasive estimation of PVR

TRV = TR velocity (m/s)

TVI_{RVOT} = VTI of the RVOT via PW (cm)

From: Abbas AE, et al. Noninvasive assessment of pulmonary vascular resistance by Doppler echocardiography. J Am Soc Echocardiogr. 2013 Oct;26(10):1170-7

Differentiation between Pre-capillary & Post-capillary Pulmonary Hypertension



PHT due to LH Disease:

- TR velocity ↑
- E/e' ↑
- ePLAR < 0.25 m/s

PHT due to pulmonary disease:

- TR velocity ↑
- E/e' low or normal
- ePLAR > 0.3 m/s

ePLAR = echocardiographic Pulmonary to Left Atrial Ratio
Scalia GM, et al. Int J Cardiol. 2016 Jun 1;212:379-86

Last Update: August 2020

Aortic Stenosis			
	Mild Stenosis	**Moderate Stenosis**	**Severe Stenosis**
Peak velocity (m/s)	2.6 – 2.9	3.0 – 4.0	> 4.0
Mean gradient (mmHg) • **AHA/ACC guidelines**	< 20	20 – 40	> 40
• **ESC Guidelines**	< 30	30 - 50	> 50
AS via AVA (cm^2)	> 1.5	1.5 – 1.0	< 1.0
AVA Indexed (cm^2/m^2)	> 0.85	0.85 – 0.6	< 0.6
DSI	> 0.5	0.50 - 0.25	< 0.25

Indexing of obese patients should be avoided as it will generally overestimate the severity of the aortic stenosis

Integrated, stepwise approach to grading aortic stenosis severity

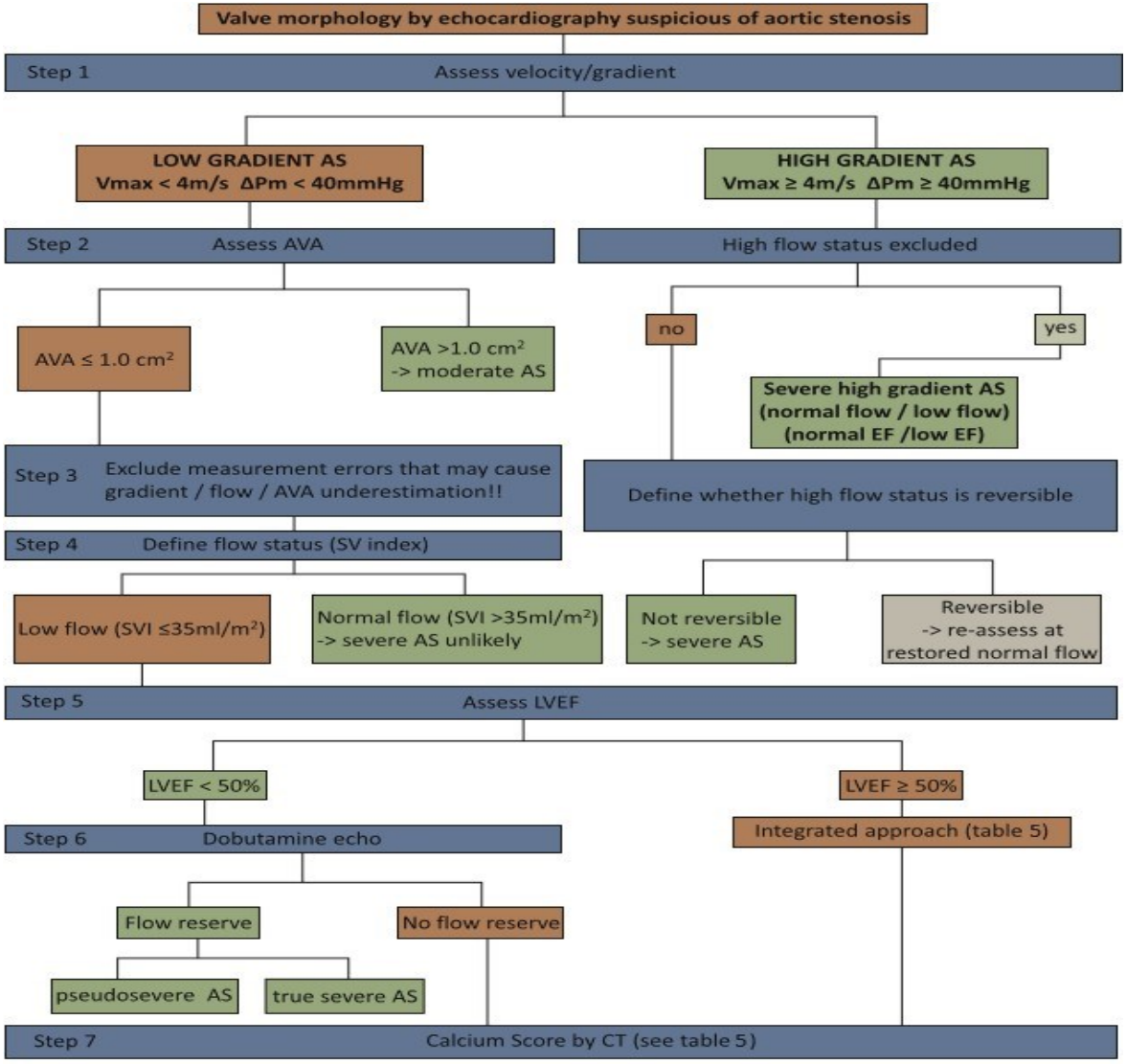


Figure 8 Integrated, stepwise approach to grading AS severity.

From: Baumgartner H et al. Recommendations on the Echocardiographic Assessment of Aortic Valve Stenosis: A Focused Updated from the European Association of Cardiovascular Imaging and the American Society of Echocardiography. J Am Soc Echocardiogr 2017; 30: 372-392

Last Update: August 2020

Mitral Stenosis			
	Mild Stenosis	**Moderate Stenosis**	**Severe Stenosis**
Mean Gradient (mmHg) *	< 5	5 - 10	> 10
MVA (cm^2)	> 1.5	1.0 – 1.5	< 1.0
RVSP (mmHg)	< 30	30 - 50	> 50

* At heart rates between 60 and 80 bpm and in sinus rhythm.

Mitral Valve Scoring - Wilkins				(Wilkins, GT. et al.: *Br Heart J 60: 299,1988)*
Grade	**Mobility**	**Subvalvular Thickening**	**Thickening**	**Calcification**
1	Highly mobile valve with only leaflet tips restricted	Minimal thickening just below mitral leaflets	Leaflets near normal in thickness (4-5 mm)	A single area of increased echo brightness
2	Leaflet mild & base portions normal mobility	Thickening of chordal structures extending up to 1/3 of chordal length	mid-leaflets normal, considerable thickening of margins (5-8 mm)	Scattered areas of brightness confined to leaflet margins
3	Valve continues to move forward in diastole, mainly from base	Thickening extending to distal 1/3 of the chords	Thickening extending through entire leaflet (5-8 mm)	Brightness extending into the mid-portion of leaflets
4	No or minimal forward movement of the leaflets in diastole	Extensive thickening and shortening of all chordal structures extending down to papillary muscles	Considerable thickening of all leaflet tissue (>8-10 mm)	Extensive brightness throughout much of the leaflet tissue

Score ≤ 8 pts most likely to have a good result; Score > 8 pts less likely to have good results

Last Update: August 2020

Mitral Valve Scoring - Padial

(Padial LR et al.: *Am J Cardiol. 83:1210-3, 1999)*

Grade	Leaflet Thickening Each valve scored separately	Commissural Calcification	Subvalvular Thickening
1	Leaflet near normal (4-5 mm) or with only a thick segment	Fibrosis and/or calcium in only one commissure	Minimal thickening of chordal structures just below the valve
2	Leaflet fibrotic and/or calcified evenly; no thin areas	Both commissures mildly affected	Thickening of chordae extending up to 1/3 of chordal length
3	Leaflet fibrotic and/or calcified with uneven distribution; thinner segments are mildly thickened (5-8 mm)	Calcium in both commissures, one markedly affected	Thickening of the distal 1/3 of the chordae
4	Leaflet fibrotic and/or calcified with uneven distribution; thinner segments near normal (4-5 mm)	Calcium in both commissures, both markedly affected	Extensive thickening and shortening of all chordae extending down to the papillary muscle

Score ≥ 10 pts likely to develop severe MR

Tricuspid Stenosis			
	Mild Stenosis	**Moderate Stenosis**	**Severe Stenosis**
Mean Gradient (mmHg)	< 2	2 - 4	≥ 5
TVA (cm^2)	-	-	≤ 1.0

Pulmonary Stenosis			
	Mild Stenosis	**Moderate Stenosis**	**Severe Stenosis**
Peak velocity (m/s)	< 3	3 - 4	> 4
Maximum pressure gradient (mmHg)	< 36	36 – 64	> 64

Estimation of PASP when PS/RVOT Obstruction	
Mild-moderate obstruction	PASP (mmHg) = RVSP – **mean** PV gradient
Critical obstruction (rounded PS signal)	PASP (mmHg) = RVSP – **maximum** PV gradient

Mitral Regurgitation (Qualitative Parameters)

	Mild (1/4)	Moderate (2-3/4)	Severe (4/4)
Spectral Doppler Signs			
Transmitral inflow PW #	A wave dominant	Variable	E wave dominant (> 1.2 m/s)
Pulmonary venous PW ^	**Systolic dominance** (may be blunted in LV dysfunction or AF)	Normal or systolic blunting	Minimal to no systolic flow/ **systolic flow reversal**
Intensity of MR CW signal	Faint/partial/parabolic	Dense but partial or parabolic	Holosystolic/dense/**triangular**
MR Jet Contour CW	Parabolic	Usually parabolic	Early peaking or triangular
Colour Doppler Signs			
Jet area ratio (%) **	**Small, central, narrow, often brief**	Variable	Large central jet (>50% of LA) or eccentric wall-impinging jet of variable size
VC-W (cm)	< 0.30	0.30-0.69	≥ 0.7 (>0.8 for biplane)Φ
Flow convergence δ	**Not visible, transient or small**	Intermediate in size and duration	**Large throughout systole**

BOLDED qualitative and semiquantitative signs are considered specific for their MR grade.

Most valid in patients >50 years old and is influenced by other causes of elevated LA pressure

* Influenced by many other factors (LV diastolic function, atrial fibrillation, LA pressure)

^ Unless other reasons of systolic blunting (e.g. atrial fibrillation, elevated LA pressure).

** Using a Nyquist limit of 50–70 cm/s

Φ For average between apical two- and four-chamber views

Last Update: August 2020

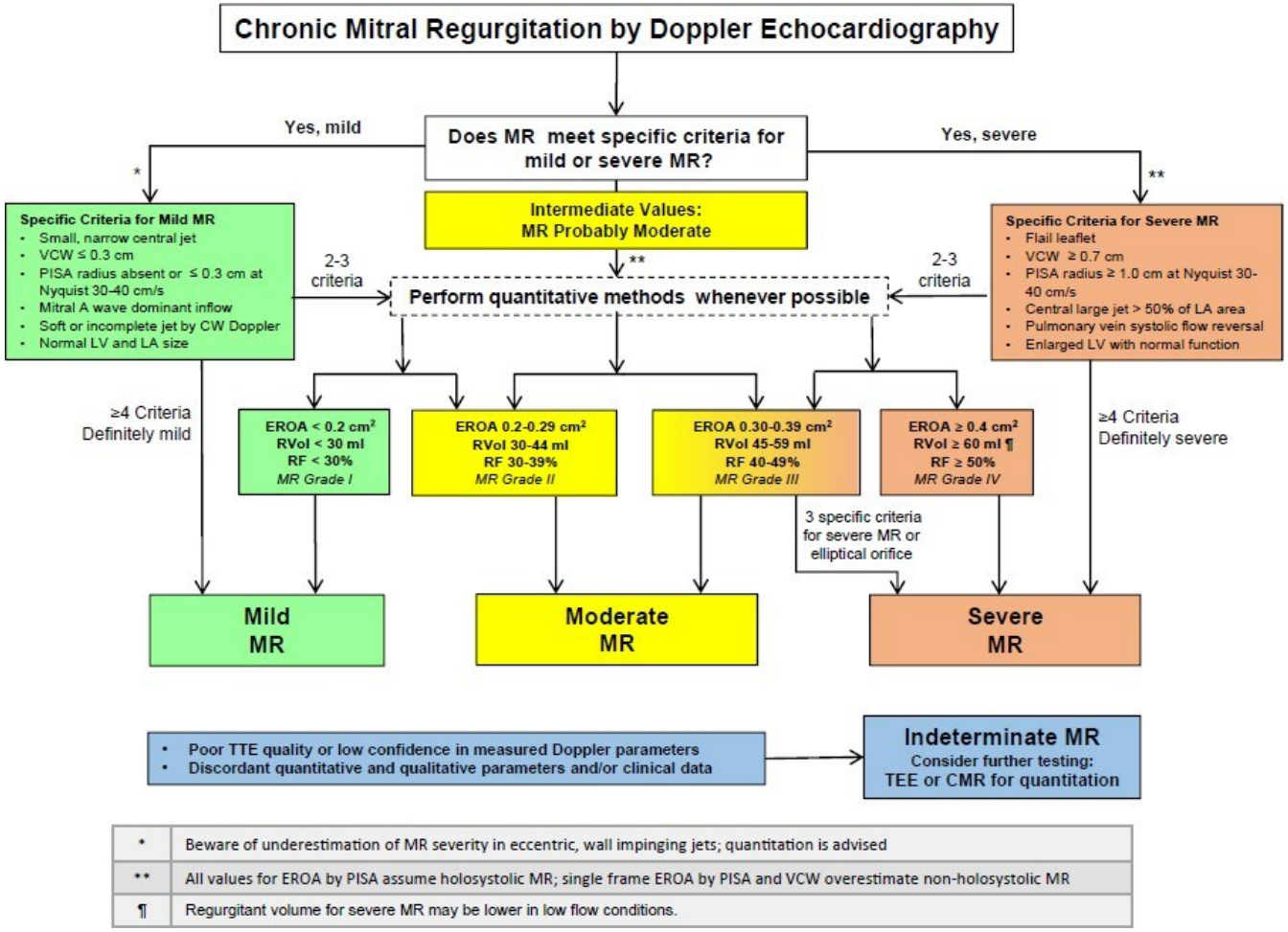
δ Small flow convergence is usually <0.3 cm, and large is ≥ 1 cm at a Nyquist limit of 30-40 cm/sec

Mitral Regurgitation (Quantitative Parameters)				
†, ‡	Mild Grade 1/4	Moderate		Severe Grade 4/4
		Grade 2/4	Grade 3/4	
RVol (mL)	< 30	30 - 44	45 – 59 **	≥ 60
RF (%)	< 30	30 – 39	40 – 49	≥ 50
EROA, 2D PISA (cm^2)	< 0.20	0.20 – 0.29	0.30 – 0.39	≥ 0.40 (may be lower in secondary MR with elliptical ROA)

†† Discrepancies among EROA, RF, and RVol may arise in the setting of low or high flow states.

‡‡ Quantitative parameters can help subclassify the moderate regurgitation group.

** LV and LA can be within the ‘‘normal’’ range for patients with acute severe MR or with chronic severe MR who have small body size, particularly women, or with small LV size preceding the occurrence of MR.



Algorithm for the integration of multiple parameters of MR severity. Good-quality echocardiographic imaging and complete data acquisition are assumed. If imaging is technically difficult, consider TEE or CMR. MR severity may be indeterminate due to poor image quality, technical issues with data, internal inconsistency among echo findings, or discordance with clinical findings.

From: Zoghbi WA, et al. Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation: A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance. J Am Soc Echocardiogr. 2017 April (in Press)

Last Update: August 2020

Carpentier Functional Classification for MR		
Carpentier Classification	**Leaflet Motion**	**Anatomical Lesion**
Type I	Normal	Annular dilatation Leaflet perforation Cleft leaflet
Type II **(prolapse)**	Increased	Chordal rupture Chordal elongation Papillary muscle rupture Papillary muscle elongation
Type IIIa **(rheumatic type)**	Restricted during systole & diastole	Leaflet thickening/retraction Leaflet calcification Chordal fusion Commissural fusion
Type IIIb **(ischaemic type)**	Restricted during systole only	Papillary muscle displacement or leaflet tethering Ventricular dilatation Chordal thickening/shortening

Aortic Regurgitation (Qualitative Parameters)

	Mild (1/4)	Moderate (2-3/4)	Severe (4/4)
Spectral Doppler Signs			
Intensity of AR CW signal	**Incomplete or faint**	Dense	Dense
Flow reversal – Desc aorta	**Brief, early diastolic**	Intermediate	**Prominent Pan-diastolic**
Flow reversal – Abdo aorta	-	-	Pan-diastolic
AR pressure half-time (ms) #	Slow, > 500	500 – 200	**Steep, < 200**
Colour Doppler Signs **			
Jet width of LVOT	**Small in central jets**	Intermediate	**Large in central jets**; variable in eccentric jets
Jet width/LVOT width, central jets (%) ‡‡	< 25	25-45 46-64	≥ 65
Jet CSA/LVOT CSA, central jets (%) ‡‡	< 5	5-20 21-59	≥ 60
VC-W (cm)	< 0.30	0.3 – 0.6	> 0.6
Flow convergence	**None or very small**	Intermediate	**Large**

BOLDED qualitative and semiquantitative signs are considered specific for their AR grade.

** Color Doppler usually performed at a Nyquist limit of 50-70 cm/sec.

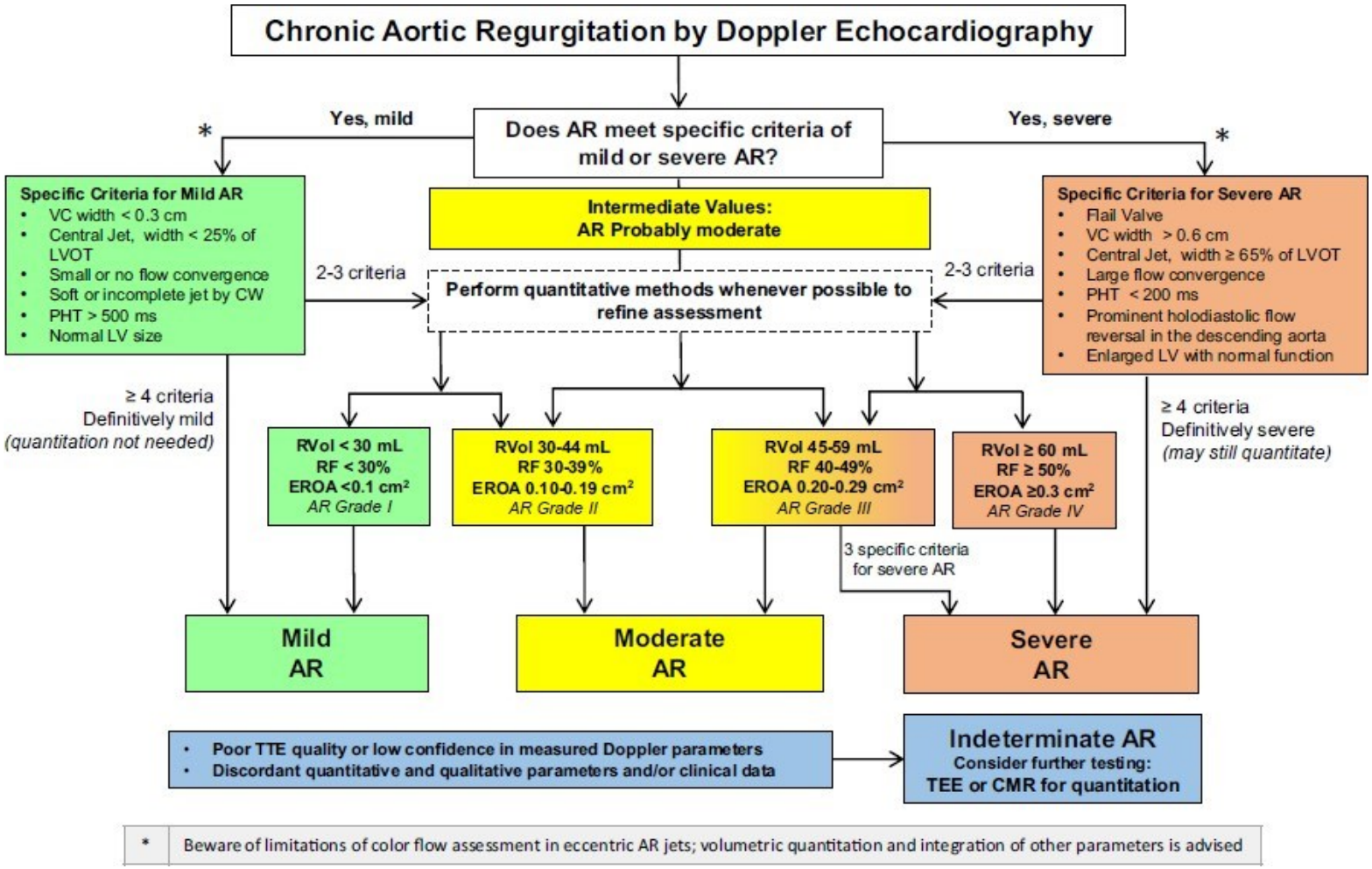
PHT is shortened with increasing LV diastolic pressure and may be lengthened in chronic adaptation to severe AR.

‡‡ Semi-quantitative parameters can help subclassify the moderate regurgitation group.

Last Update: August 2020

Aortic Regurgitation (Quantitative Parameters)				
‡‡	Mild Grade 1/4	Moderate		Severe Grade 4/4
		Grade 2/4	Grade 3/4	
RVol (mL)	< 30	30 - 44	45 – 59	≥ 60
RF (%)	< 30	30 – 39	40 – 49	≥ 50
EROA (cm^2)	< 0.10	0.10 – 0.19	0.20 – 0.29	≥ 0.30

‡‡ Quantitative parameters can help subclassify the moderate regurgitation group.



Algorithm for the integration of multiple parameters of AR severity. Good-quality echocardiographic imaging and complete data acquisition are assumed. If imaging is technically difficult, consider TEE or CMR. AR severity may be indeterminate due to poor image quality, technical issues with data, internal inconsistency among echo findings, or discordance with clinical findings. PHT, Pressure half-time.

From: Zoghbi WA, et al. Recommendations for Noninvasive Evaluation of Native Valvular Regurgitation: A Report from the American Society of Echocardiography Developed in Collaboration with the Society for Cardiovascular Magnetic Resonance. J Am Soc Echocardiogr. 2017 April (in Press)

Last Update: August 2020

Pulmonary Regurgitation (Qualitative Parameters)			
	Mild	**Moderate**	**Severe**
Spectral Doppler Signs			
Intensity & contour of PR CW signal	Soft	Dense	Dense; early termination of diastolic flow
Deceleration time of PR signal Φ	-	-	Short, < 260 ms
PR pressure half-time (ms) Φ	-	-	< 100 ms *
PR Index ‡, Φ	-	-	< 0.77
Flow reversal – MPA or branch PAs	-	-	Prominent
Pulmonic systolic flow (VTI) compared to systemic flow (LVOT VTI) by PW	Slightly increased	Intermediate	Greatly increased
Colour Flow Doppler Indicators			
Jet size *	Thin (usually <10 mm in length) with a narrow origin	Intermediate	Broad origin; variable depth of penetration
PR jet width/pulmonary annulus ratio	-	-	> 0.7 #
Pulmonary Regurgitation (Quantitative Parameters)			
RF (%) **	< 20	20 - 40	> 40

Φ not specific for severe PR and have to be integrated with other findings in evaluating PR severity

* Not reliable in the presence of high RV end diastolic pressure

‡ Defined as the duration of the PR signal divided by the total duration of diastole, with this cutoff identifying a CMR-derived PR fraction > 25%.

* At a Nyquist limit of 50-70 cm/sec.

Identifies a CMR-derived PR fraction ≥40%

** RF data primarily derived from CMR with limited application with echocardiography

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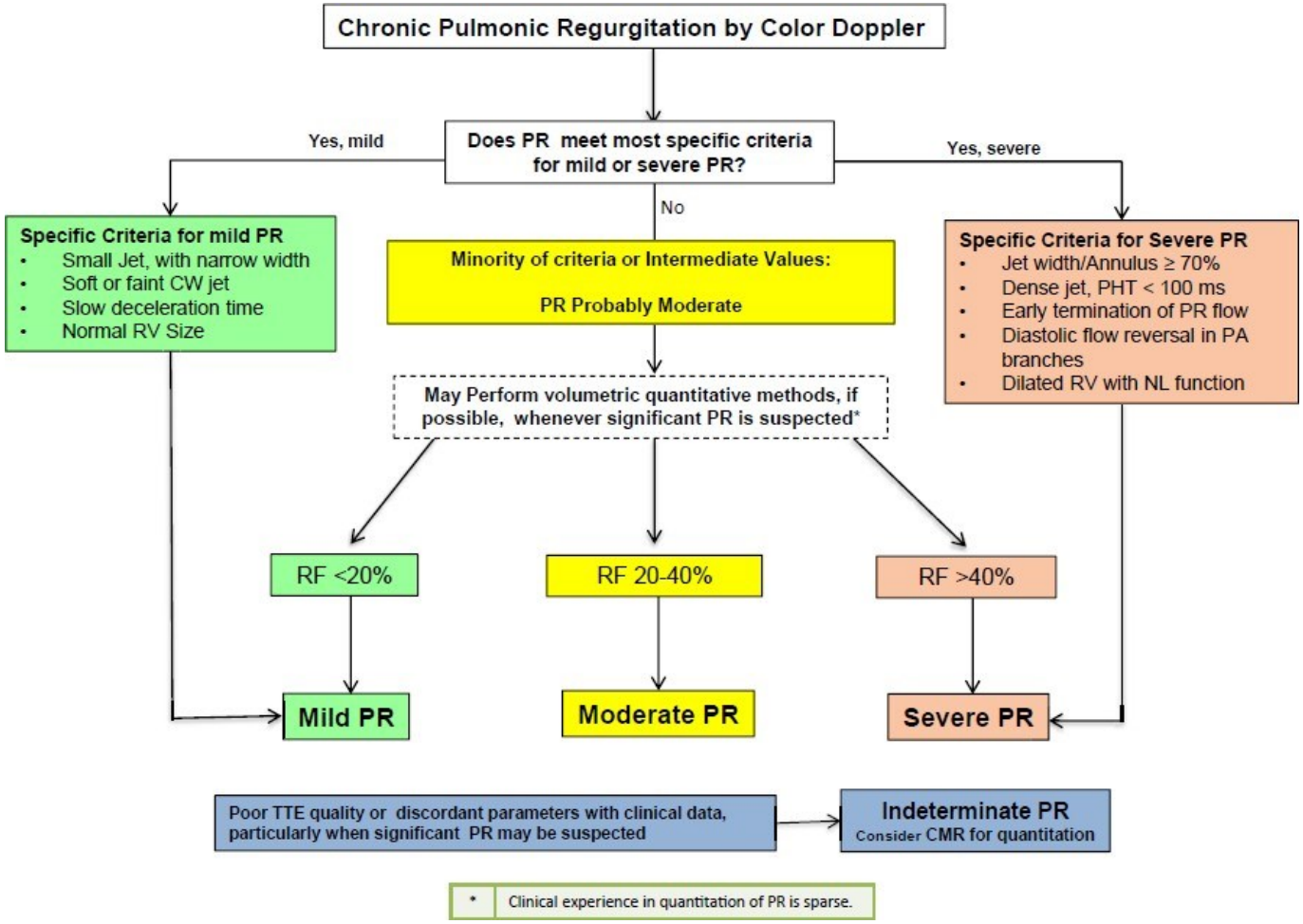

Algorithm for the integration of multiple parameters of PR severity. Good-quality echocardiographic imaging and complete data acquisition are assumed. If imaging is technically difficult, consider CMR or TEE. PR severity may be indeterminate due to poor image quality, technical issues with data, internal inconsistency among echo findings, or discordance with clinical findings. PHT, Pressure half-time

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Last Update: August 2020

Tricuspid Regurgitation (Qualitative Parameters)			
	Mild	**Moderate**	**Severe**
Spectral Doppler Signs			
Tricuspid inflow #	**A-wave dominant**	Variable	E velocity > 1.0 cm/sec
Intensity of TR CW signal	**Faint/partial/**parabolic	Dense, parabolic or triangular	Dense, often triangular
Contour	Parabolic	Usually parabolic	Early peaking (V cut-off)
Hepatic venous flow #	Systolic dominance	Systolic blunting	**Systolic flow reversal**
Colour Flow Doppler Indicators			
Jet area (cm^2) †	Not defined	Not defined	**> 10**
Vena contracta width (cm) †	< 0.3	0.3 – 0.69	**≥ 0.7**
Flow convergence radius (cm) ††	≤ 0.5	0.6 – 0.9	**> 0.9**

BOLDED qualitative and semiquantitative signs are considered specific for their TR grade.

† With Nyquist limit >50-70 cm/sec

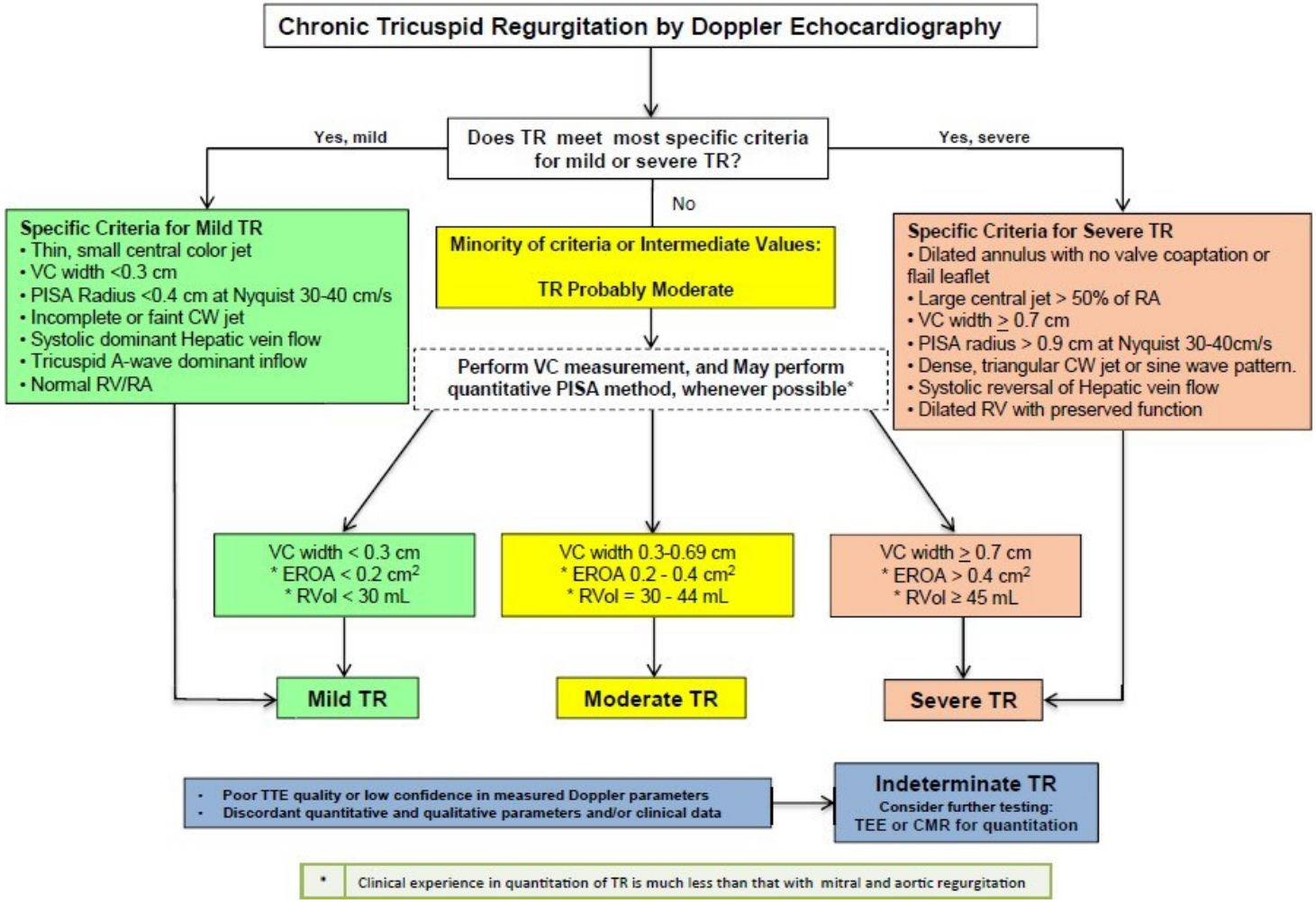
†† With baseline Nyquist limit shift of 28 cm/sec

Signs are nonspecific and are influenced by many other factors (RV diastolic function, atrial fibrillation, RA pressure)

Tricuspid Regurgitation (Quantitative Parameters)			
	Mild	**Moderate**	**Severe**
EROA, 2D PISA (cm^2)	< 0.20	0.20 – 0.39 **	≥ 0.40
RVol (2D PISA) (mL)	< 30	30 – 44 **	≥ 45

** There are little data to support further separation of these values

Last Update: August 2020



Algorithm for the integration of multiple parameters of TR severity. Good-quality echocardiographic imaging and complete data acquisition are assumed. If imaging is technically difficult, consider TEE or CMR. TR severity may be indeterminate due to poor image quality, technical issues with data, internal inconsistency among echo findings, or discordance with clinical findings

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Last Update: August 2020

Doppler Parameters of Prosthetic Aortic Valve Function in Mechanical and Stented Biologic Valves *			
Parameter	**Normal**	**Possible Stenosis**	**Suggestive of significant stenosis**
Peak velocity (m/s) †	< 3	3 – 4	> 4
Mean gradient (mmHg) †	< 20	20 - 35	> 35
DPI	≥ 0.30	0.29- 0.25	< 0.25
EOA (cm^2)	> 1.2	1.2 – 0.8	< 0.8
Contour of jet through AVR	Triangular, early peaking	Triangular to intermediate	Rounded, symmetrical contour
Acceleration time (ms)	< 80	80 – 100	> 100

*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.

Patient-Prosthesis Mismatch			
	"Normal"	**Moderate**	**Severe**
AVR (Indexed EOA cm^2/m^2)	> 0.85	0.85 – 0.65	< 0.65

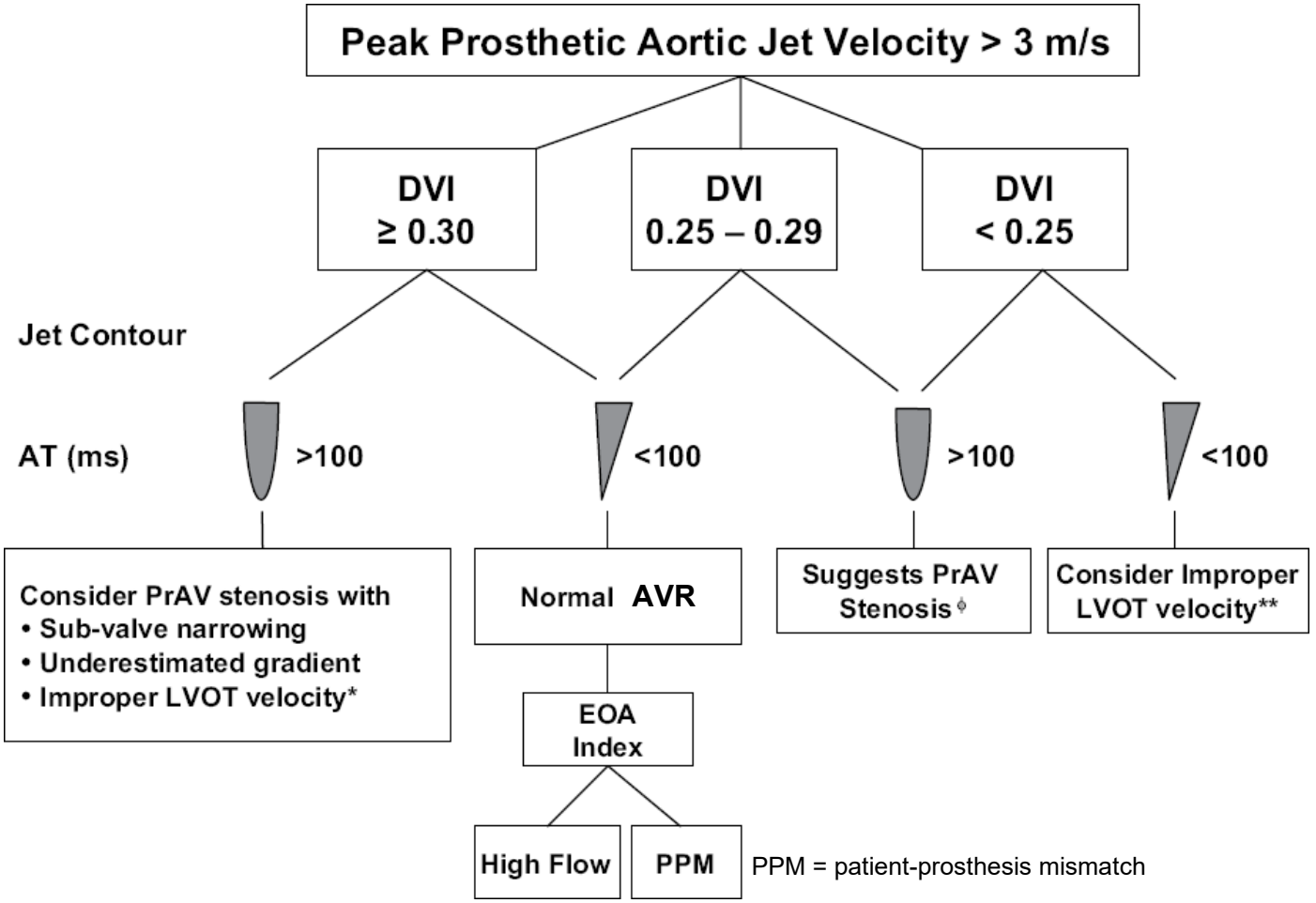
Last Update: August 2020

Interpretation of elevated AVR Gradients

Doppler parameter	P-P Mismatch	Obstruction	Valve Geometry*	High output state
Valve Gradients	Elevated	Elevated	Elevated	Elevated
DPI (DVI)	Normal	Reduced	Reduced	Normal
EOA	Normal	Reduced	Reduced	Normal
EOA index	Reduced	Reduced	Reduced	Normal
Δ in EOA/DPI cf with baseline	No	Yes	No	No
Abnormal Leaflet motion	No	Yes	No	No

* Most commonly seen in 19mm and 21mm bileaflet prostheses

Last Update: August 2020



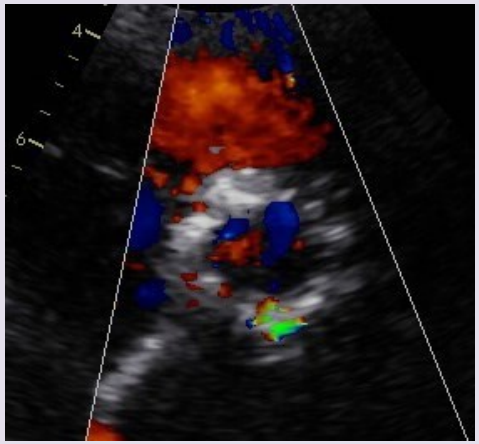
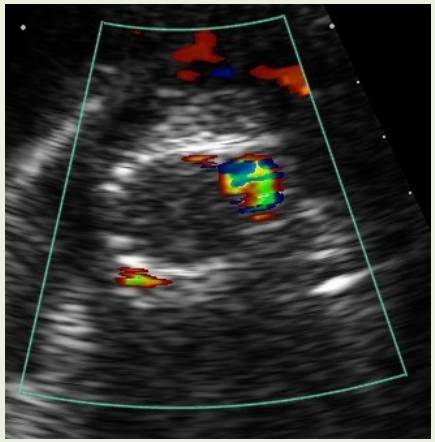
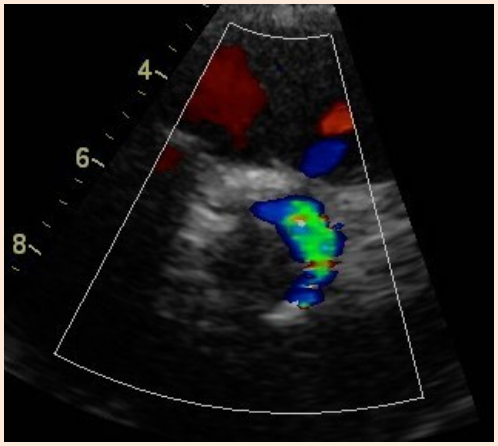
Algorithm for evaluation of elevated peak prosthetic aortic jet velocity incorporating DVI (or DPI), jet contour, and acceleration time (AT).

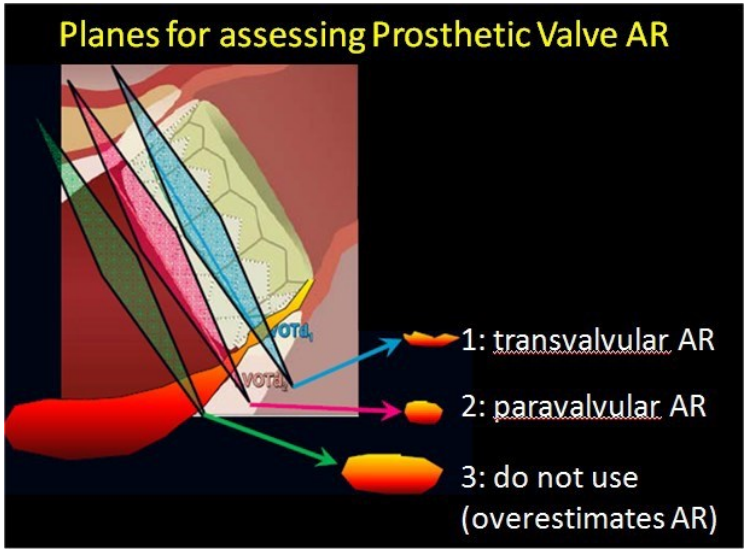
*PW Doppler sample too close to the valve (particularly when jet velocity by CW Doppler is ≥ 4 m/s).

**PW Doppler sample too far (apical) from the valve (particularly when jet velocity is 3-3.9 m/s).

ϕ Stenosis further substantiated by EOA derivation compared with reference values if valve type and size are known. Fluoroscopy and TEE are helpful for further assessment, particularly in bileaflet valves.

Semiquantification of Paravalvular AR*

Mild	Moderate	Severe
(<10% of circumference; or < '6 mins' of 'clock face')	(10-20% of circumference; or '6-12 mins' of 'clock face')	(>20% of circumference; or > '12 mins' of 'clock face')
		



Paravalvular AR is best assessed from a zoomed PSAX view of the AVR
If more than 1 jet, sum of all jets is considered.

* The best plane to assess paravalvular AR is generally just below the native annulus (or at the apical end of the stent for a TAVI) – position 2 on opposite diagram.

For transvalvular AR, the best plane is at the level of native valve but just below prosthetic valve cups – position 1 on opposite diagram.

Reference: Personal correspondence with Dr Philippe Pibarot; Chair, Canada Research Chair in Valvular Heart Diseases, 1/12/2012

Last Update: August 2020

Doppler Parameters of Prosthetic Mitral Valve Function			
Parameter	**Normal**	**Possible Stenosis ‡**	**Suggestive of significant stenosis * ‡**
Peak velocity (m/s) † §	< 1.9	1.9 – 2.5	> 2.5
Mean gradient (mmHg) † §	≤ 5	6 – 10	> 10
MVR Index † §	< 2.2	2.2 – 2.5	> 2.5
EOA (cm^2)	≥ 2.0	2 - 1	< 1
P1/2T (ms)	< 130	130 – 200	> 200

*Best specificity for normality or abnormality is seen if the majority of the parameters listed are normal or abnormal, respectively.

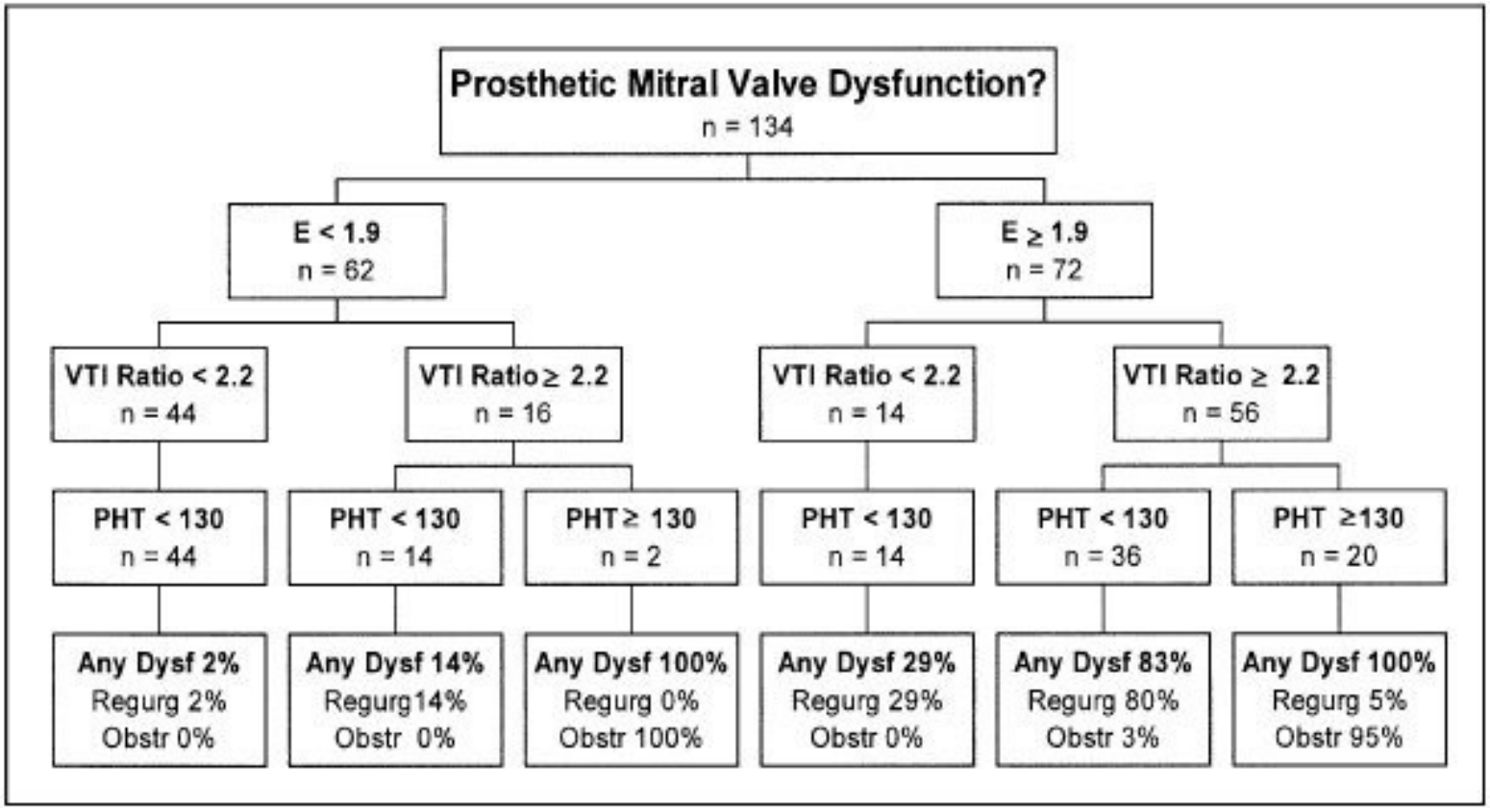
†Slightly higher cut-off values than shown may be seen in some bioprosthetic valves.

‡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.

Last Update: August 2020

Decision Tree for Detecting MVR Dysfunction



Outcome of the 134 patients according to the most important transthoracic Doppler variables associated with prosthetic mitral valve dysfunction: peak early velocity (E) of mitral inflow, the VTI ratio (VTIpmv/VTIlvo) and PHT. The end of each branch of the tree depicts the conditional probability for the presence of significant prosthetic mitral valve dysfunction (regurgitation or stenosis). In 4 patients, VTIlvo could not be determined; PHT could also not be determined in 1 of these patients. Dysf = dysfunction; Obstr = obstruction; Regurg = regurgitation.

From: Valerian Fernandes, et al: Am J Cardiol 2002;89:704–710

Last Update: August 2020

Doppler Parameters of Prosthetic Tricuspid Valve Function	
Parameter	**Suggestive of significant stenosis ***
Peak velocity (m/s) †	> 1.7
Mean gradient (mmHg) †	≥ 6
P1/2 t (ms)	≥ 230
EOA (cm^2) and TVR Index	No data currently available for TVR

*Because of respiratory variation, average ≥ 5 cycles.

† May be increased also with valvular regurgitation.

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