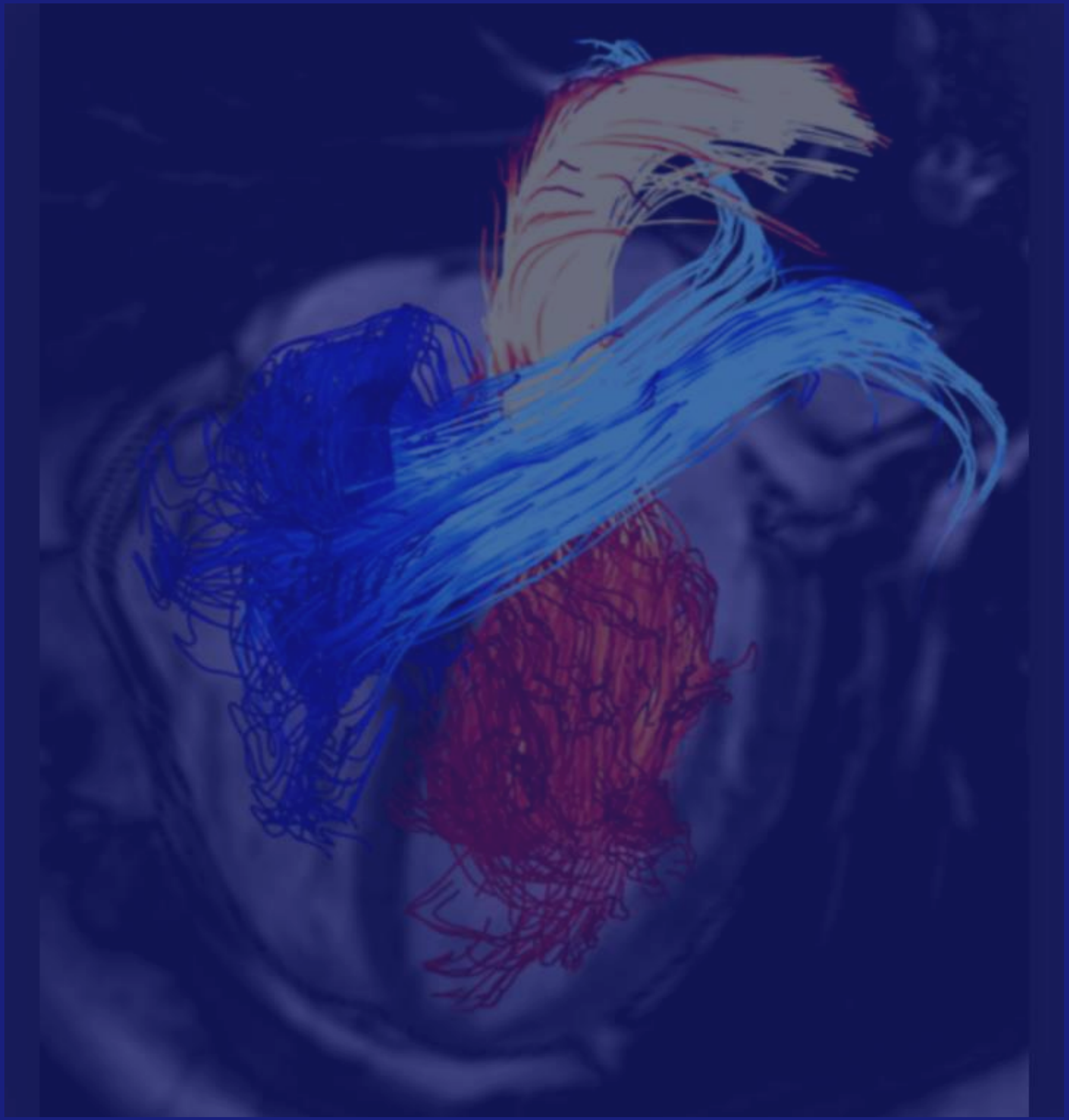
Valve Evaluation: Stenosis & Regurgitation



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STENOSIS: Aortic

Mitral

REGURGITATION: Aortic

MItral

VALVE STENOSIS

Complete echocardiographic evaluation of the patient with valvular stenosis includes:

Imaging of the valve to define the cause of the stenosis
Quantitation of the stenosis severity
Evaluation of coexisting valvular lesion
Assessment of the left ventricular (LV) systolic function
The response to the chronic pressure overload of other upstream cardiac chambers and the pulmonary vascular bed

Aortic Stenosis

Evaluation of valve morphology

Determine aetiology

How many cusps are there?

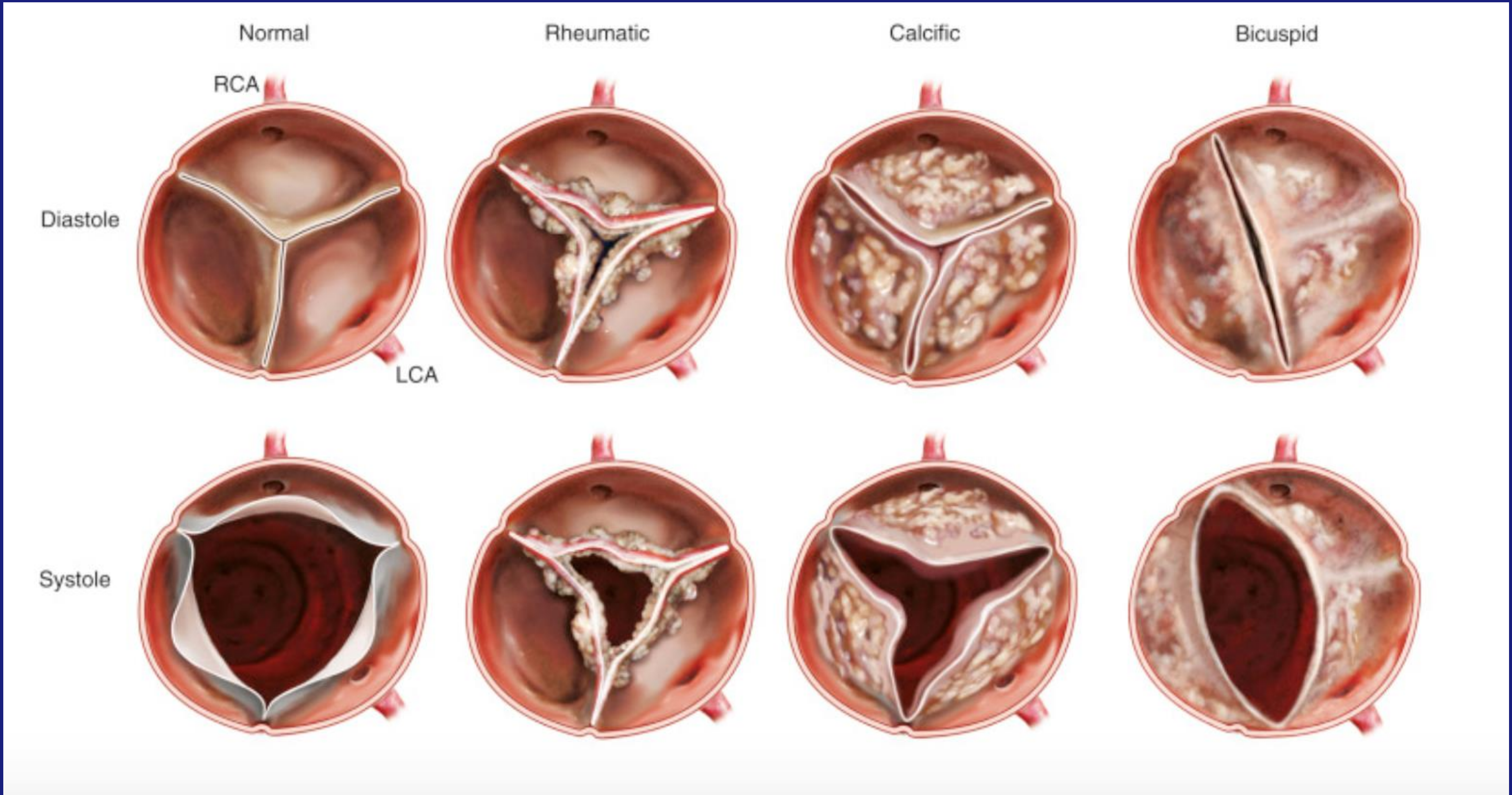
Degree of calcification?

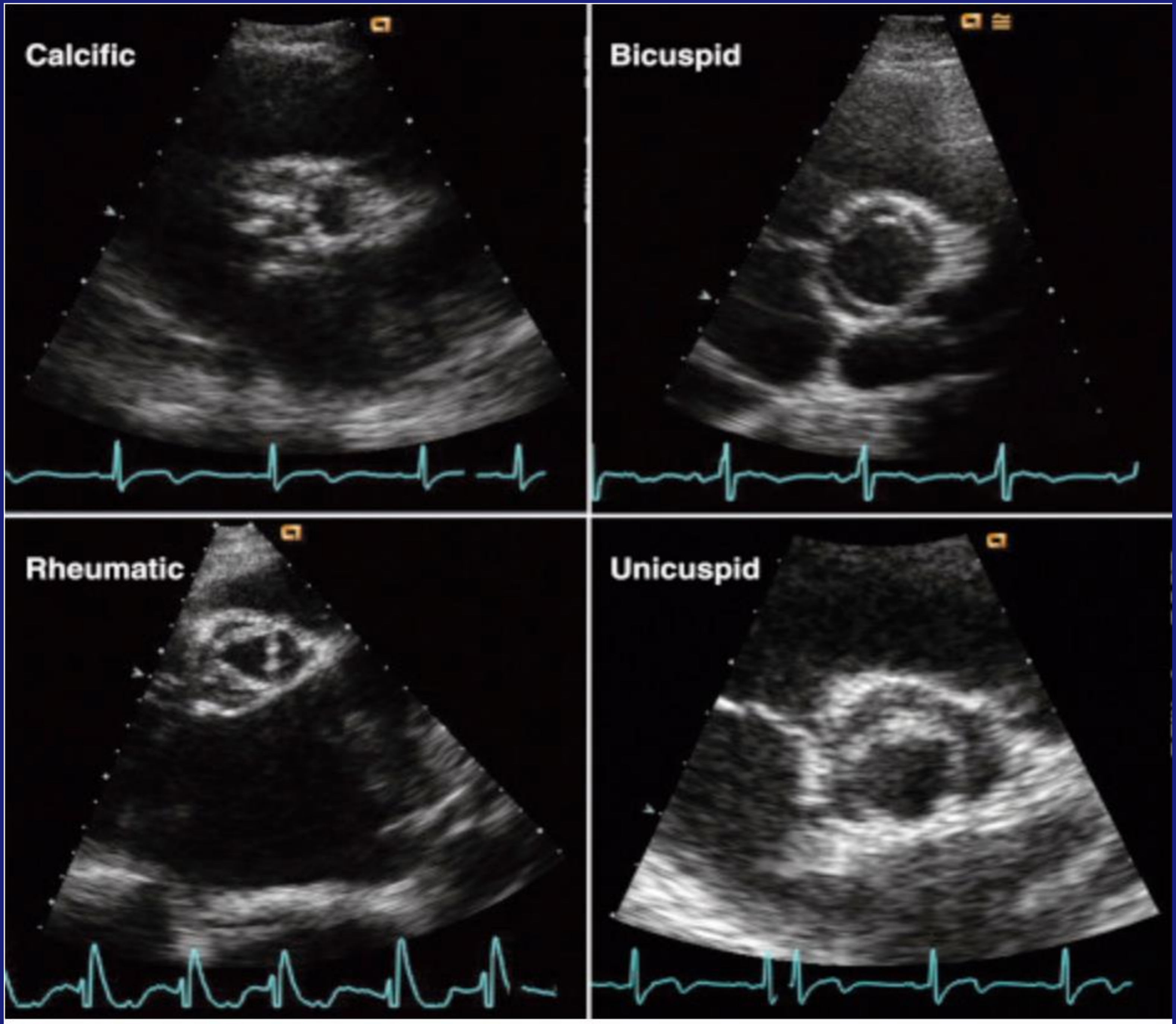
Is stenosis at valve level, or pre-valve or post-valve

Valvular Stenosis

Valvular Aortic Stenosis

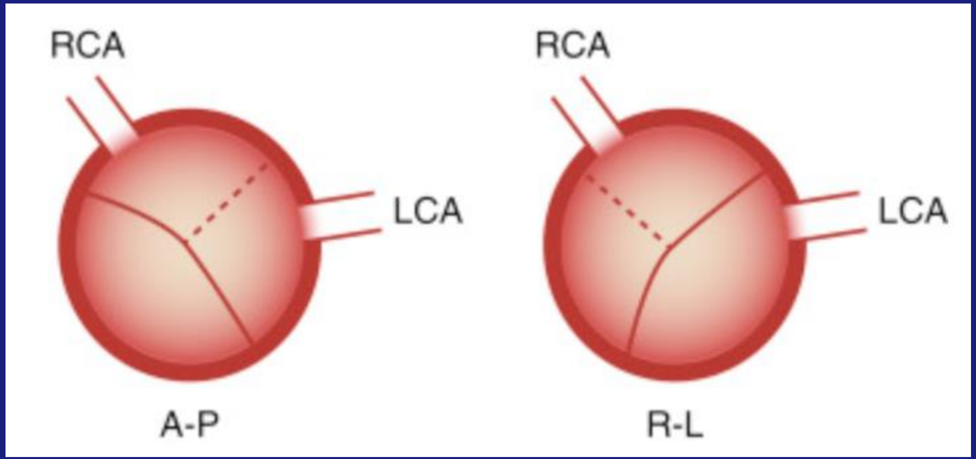
- Age-related etiology
  - <30: Congenital (unicuspid, bicuspid)
  - 40-60: Calcified bicuspid
  - 40-60: Rheumatic
  - >70: Senile degenerative
- Most common cause
  - **Senile degenerative**

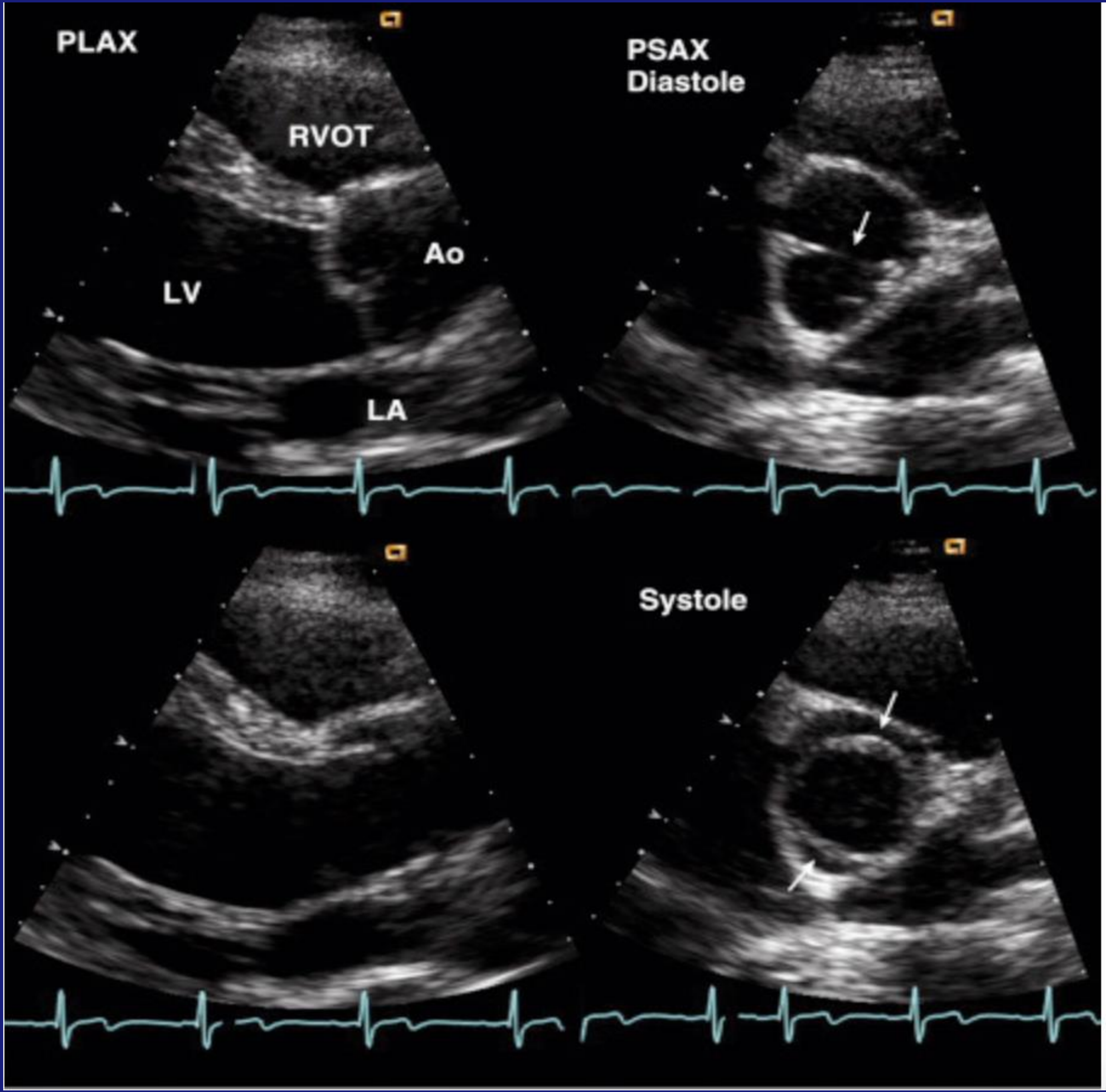

Normal
Rheumatic
Calcific
Bicuspid
RCA
Diastole
LCA
Systole


Calcific
Bicuspid
Rheumatic
Unicuspid

Determination of bicuspid valve

In Systole





AORTIC STENOSIS

2D Assessment:

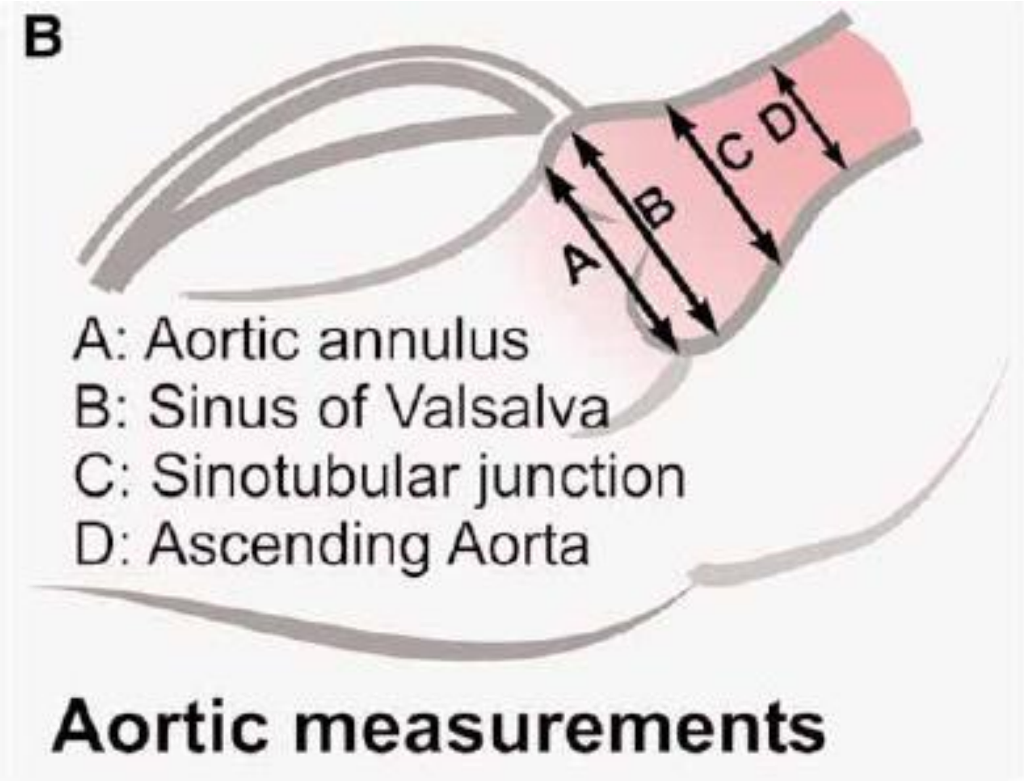
Leaflet motion
Visual estimates must correlate with the measures of severity.
Eccentric closure, doming or prolapse of the valve in the PLX view suggest the presence of bicuspid valve.

Aortic root dimension: LVOT, annulus, sinus of valsalva, sinotubular junction, ascending aorta.

LV dimension

LVH and LV mass

LVEF and SV(index)



Aortic dimensions Aortic diameters are proportional to body size and generally increase with aging	
Parasternal long axis view measurements	**Range (cm)**
Aortic annular diameter	1.4–2.6
Sinus of Valsalva	2.1–3.5
Sinotubular junction	1.7–3.4
Ascending aorta	2.1–3.4

Cardiac Ultrasound Laboratory, Massachusetts General Hospita

Measure of Severity

- Aortic Jet Velocity
- Mean Gradient
- Aortic Valve Area
- Index Aortic Valve Area
- Velocity Ratio

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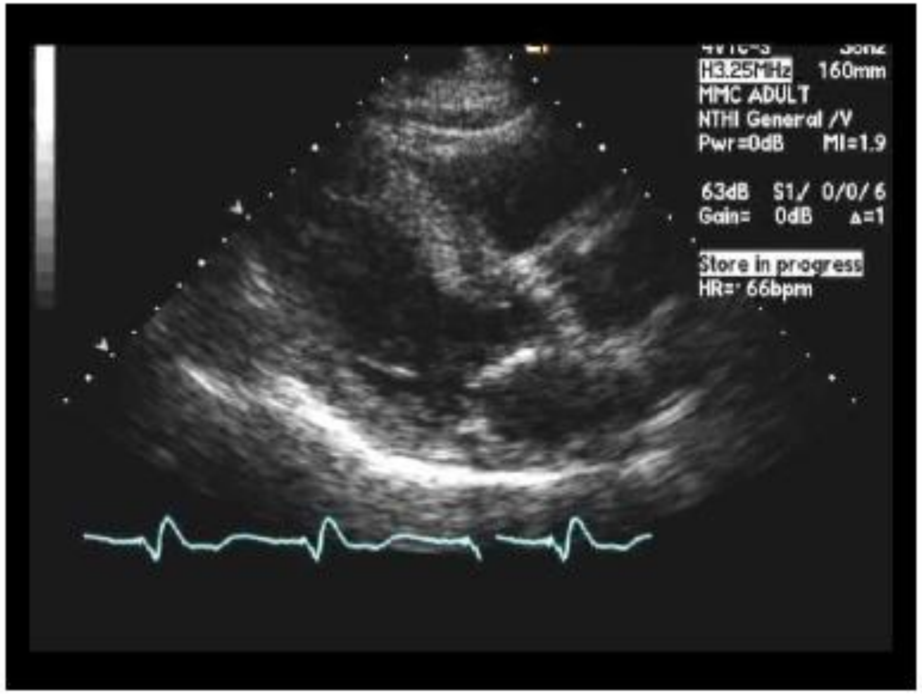
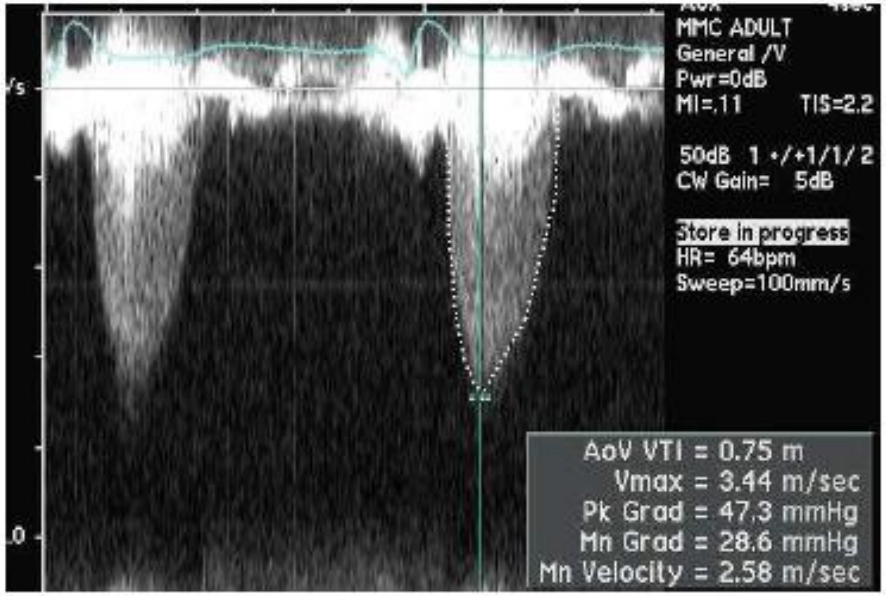
Valvular Aortic Stenosis

Calcified immobile aortic valve
Left ventricular hypertrophy
Early to mid peaking high velocity





Bicuspid Aortic Valve – Associated Problems

Bicuspid aortic valve

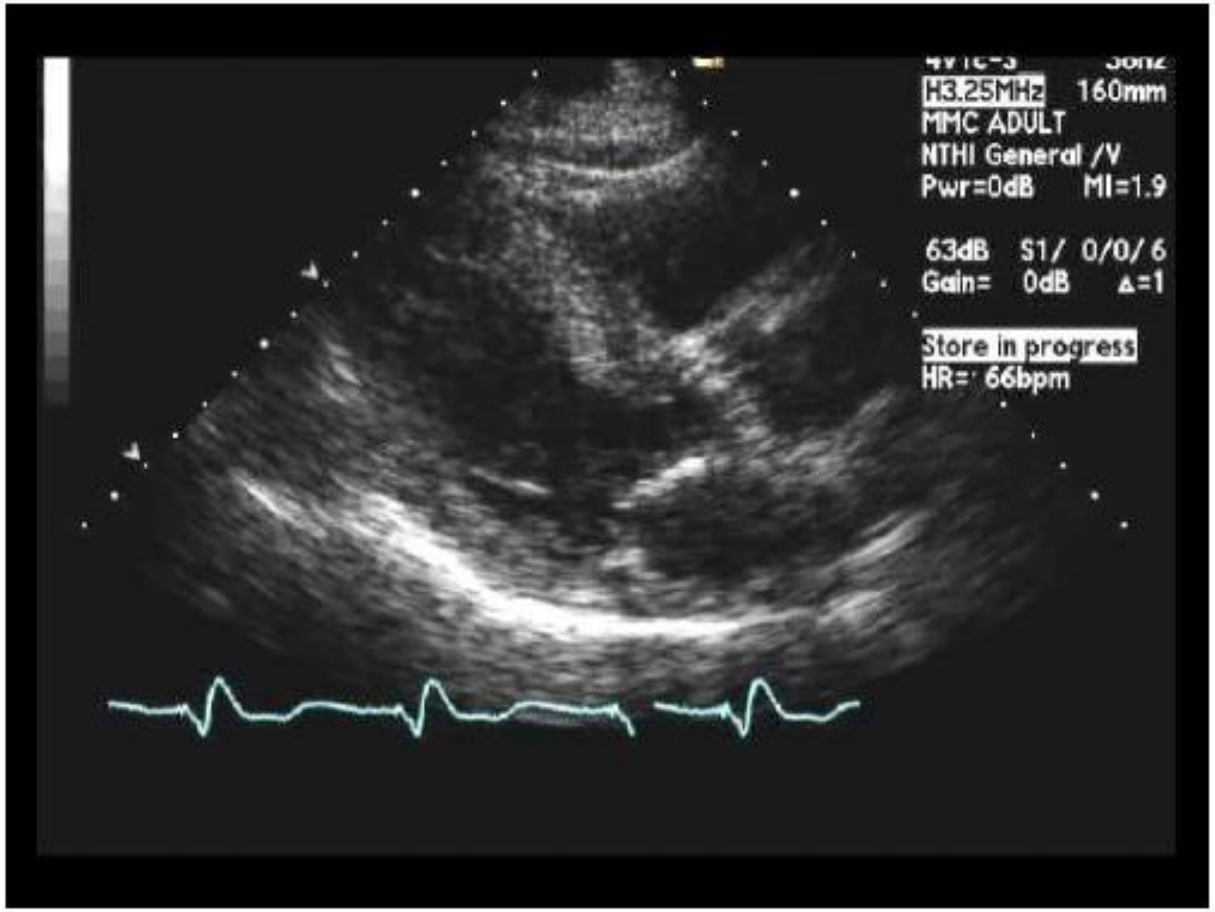
Aortic medial changes

Aortic Stenosis: Role of Echo

- Diagnosis
- Eval for TAVR
- Severity

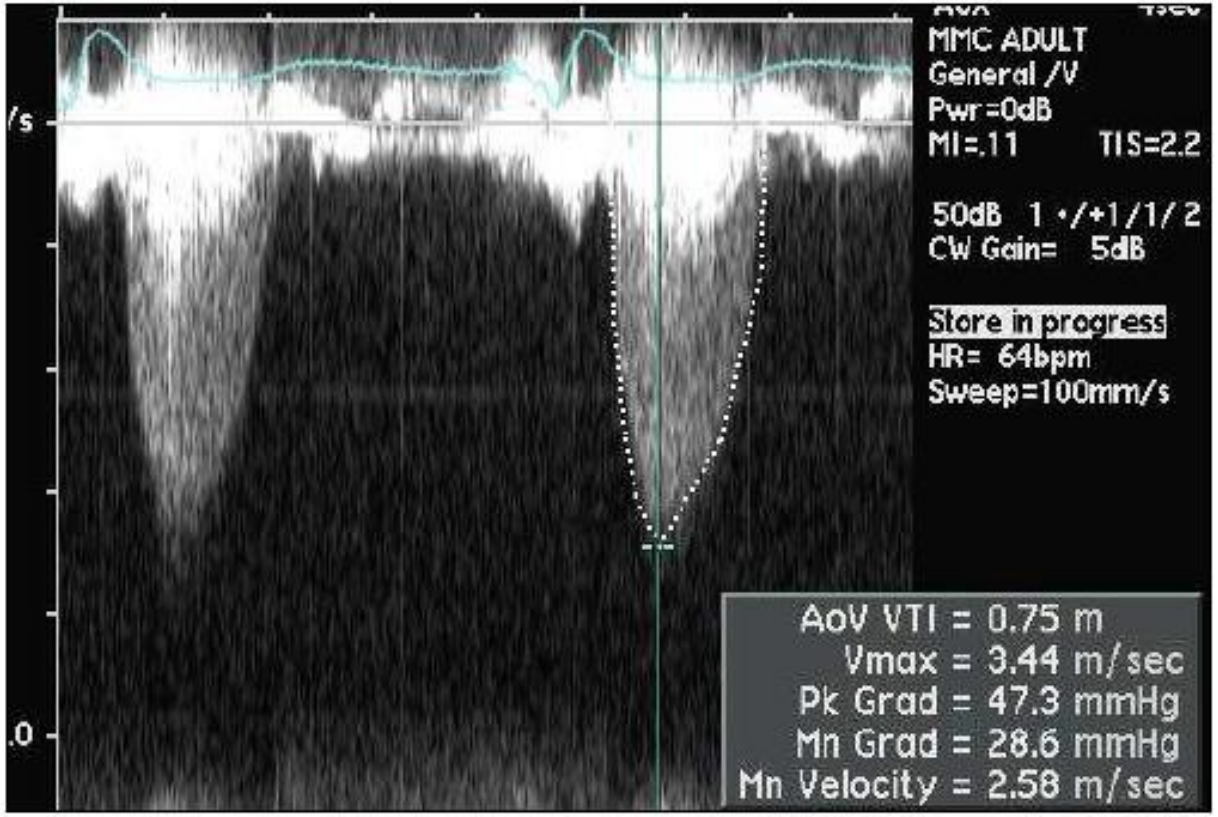
Aortic Stenosis: Severity

2-DE: Cannot tell severity of AS
Need hemodynamics from Doppler



Aortic Stenosis: Severity

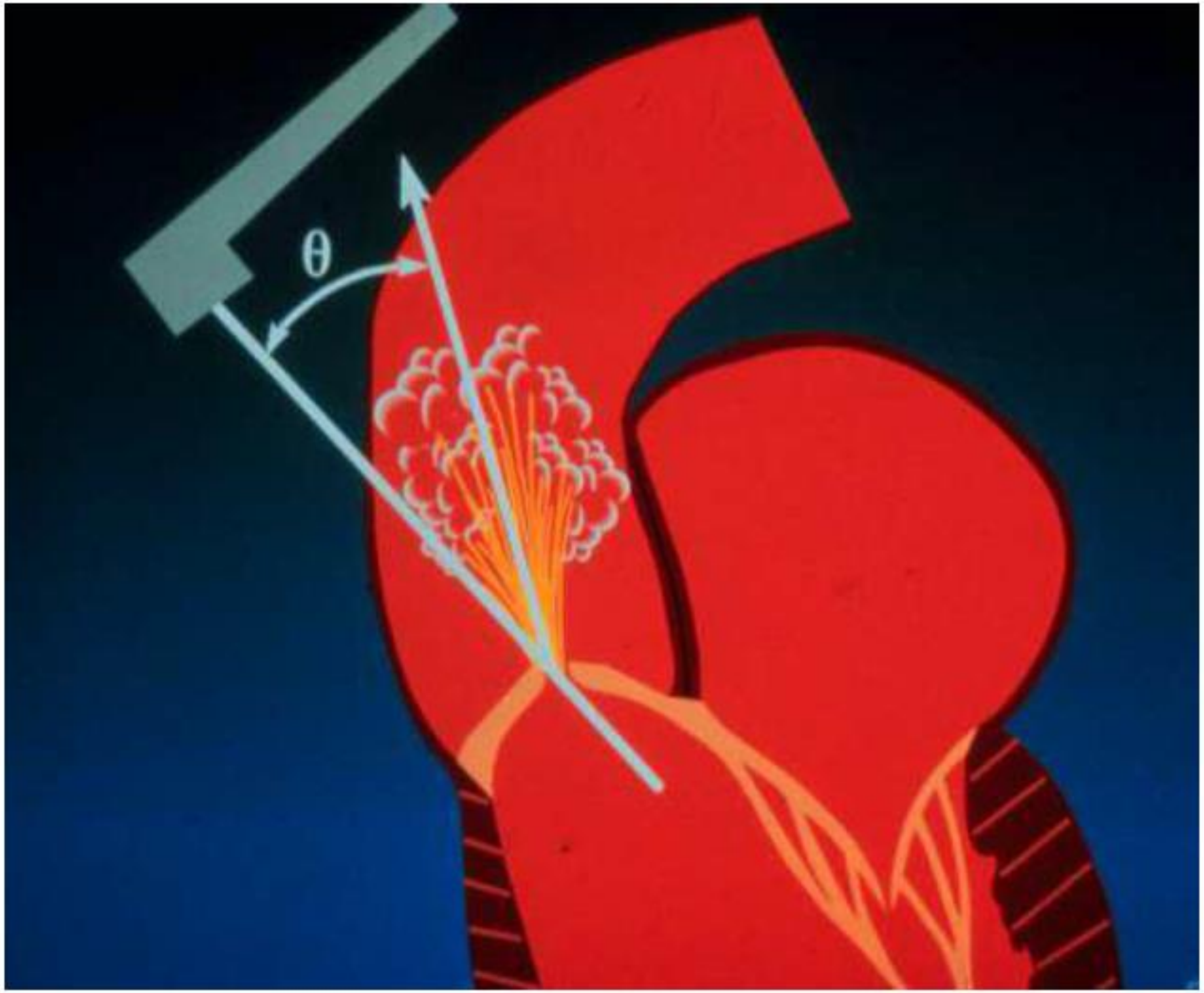
2-DE: Cannot tell severity of AS
Need hemodynamics from Doppler



Peak velocity
Mean gradient
Aortic valve area

Severity of Aortic Stenosis

	Peak Velocity	Mean Gradient
Severe	>4 m/s	>40 mm Hg
Very Severe	>5 m/s	>60 mm Hg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Aortic Stenosis
Doppler Echocardiography

Mean aortic valve gradient

- Can underestimate gradient
  - Not parallel to jet
- Cannot overestimate gradient
  - Unless Hb <8 or subvalvular stenosis
  - Gradient >40 = severe

Valvular Stenosis
Doppler Echocardiography

- Aortic valve area
  - Gradient is flow dependent
  - Use if gradient <40 mm Hg
- Continuity equation
  - $$AVA = \frac{\text{LVO velocity} \times \text{LVO area}}{\text{AVA velocity}}$$

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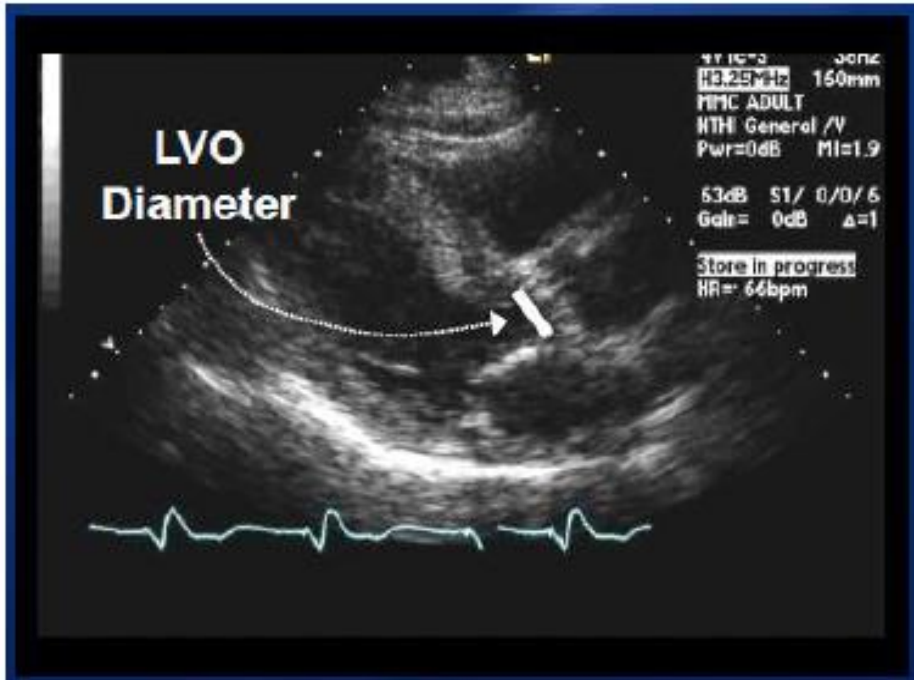
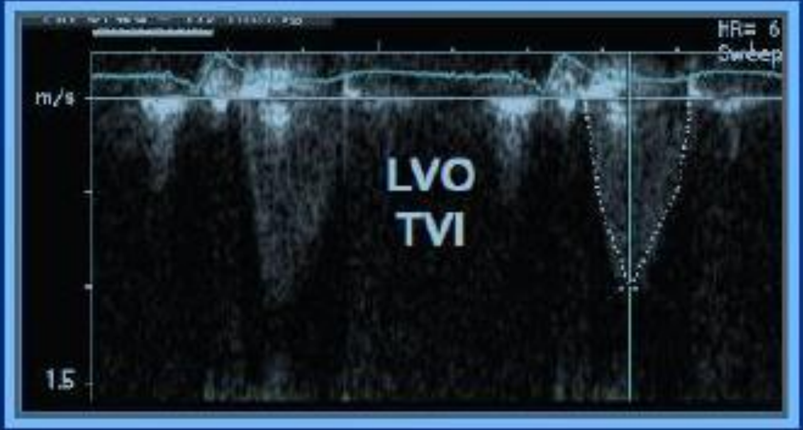
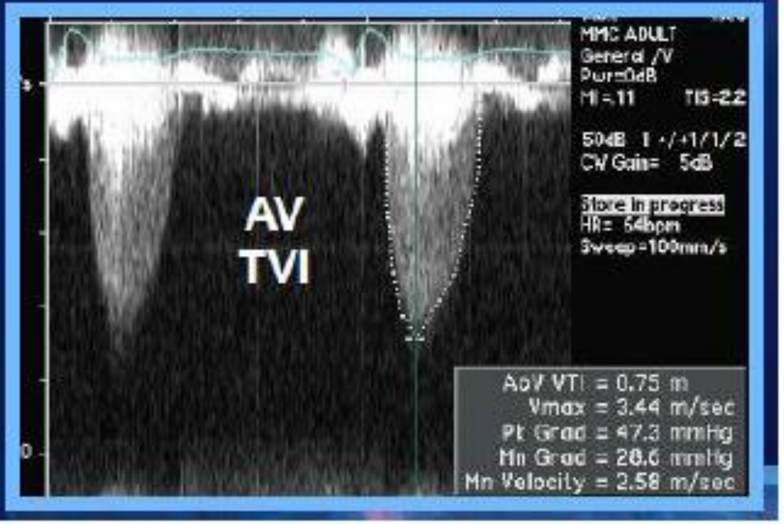




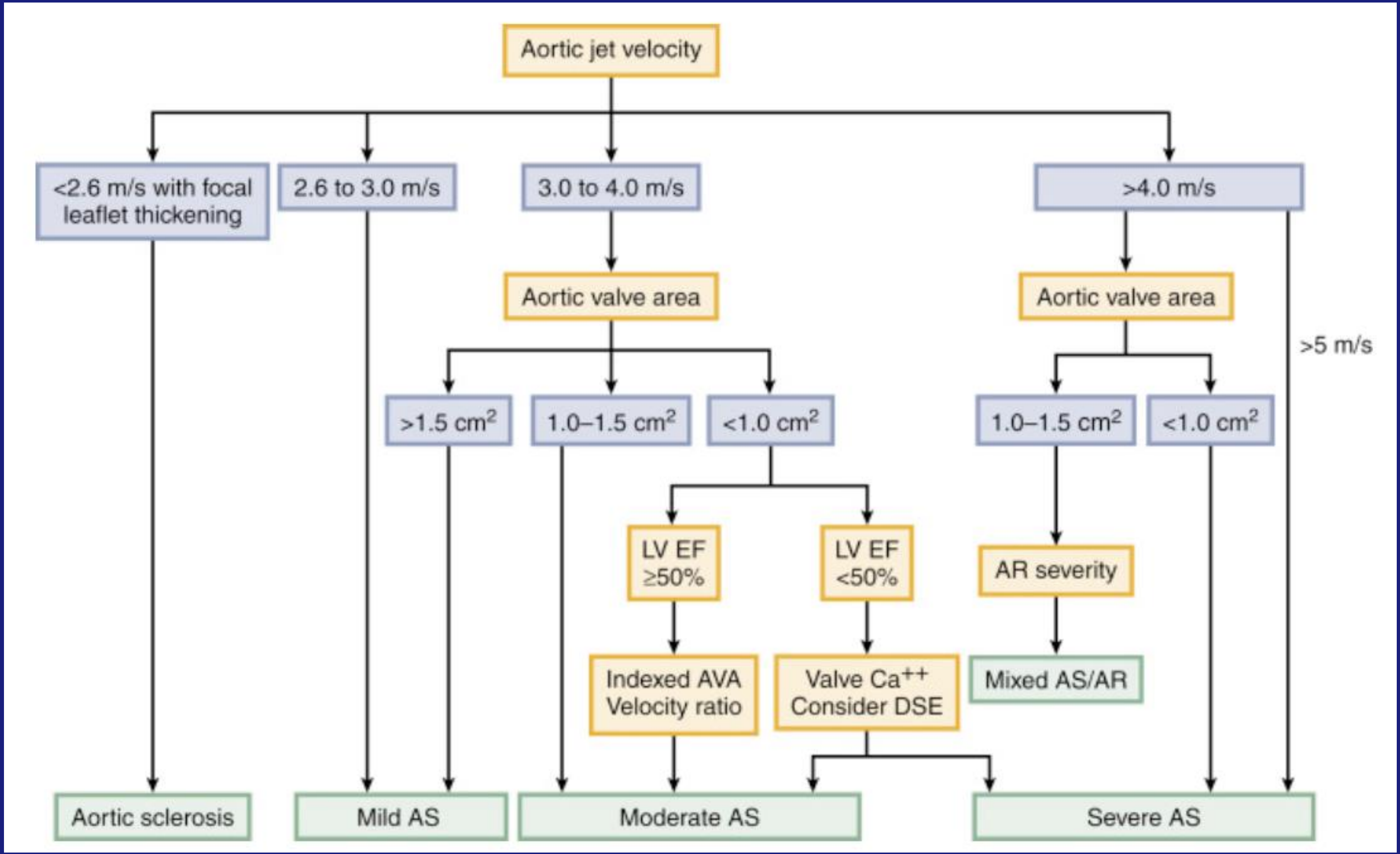
AVA
Continuity Equation

$$AVA = \frac{\text{LVO area} \times \text{LVOTVI}}{\text{AV TVI}}$$

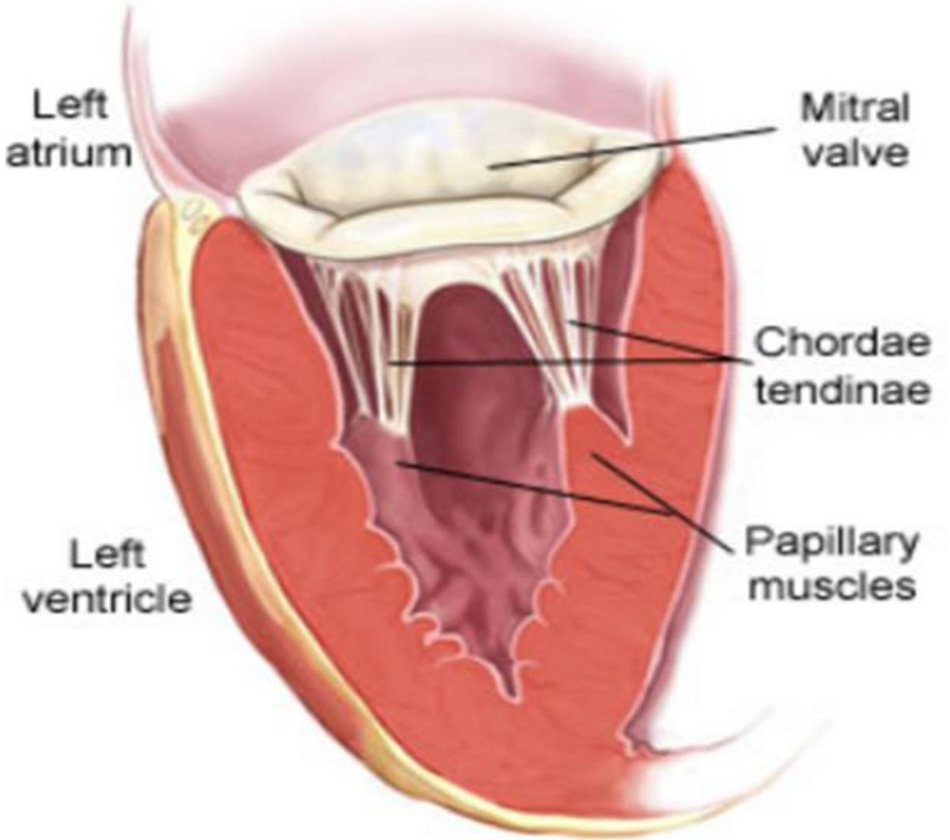


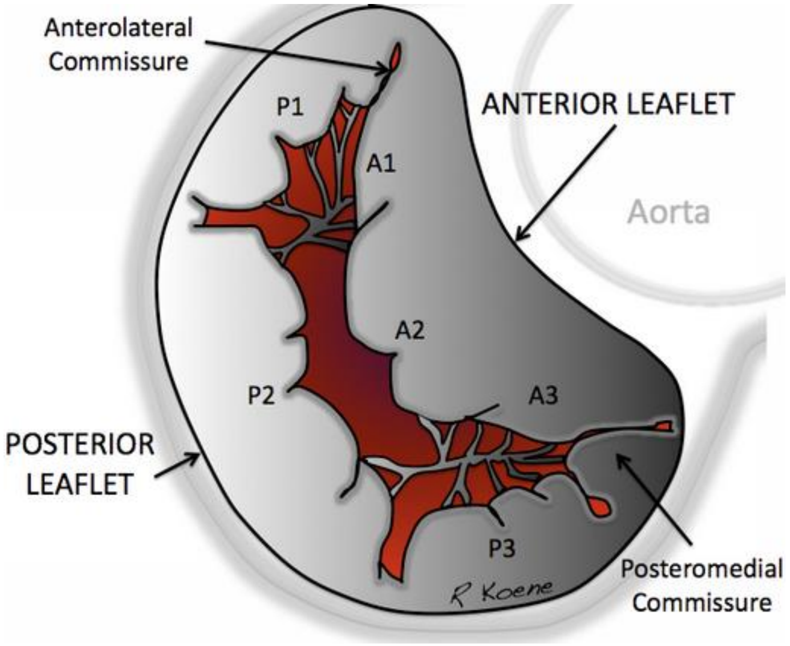
	Aortic Sclerosis	Mild	Moderate	Severe
Aortic jet velocity	<2.5	2.6-2.9	3.0-4.0	>4.0
Mean gradient		<20 (30)	20-40 (30-50)	>40 (50)
AVA		>1.5	1.0-1.5	<1.0
Indexed AVA		>0.85	0.60-0.80	<0.6
Velocity ratio		>0.5	0.25-0.50	<0.25

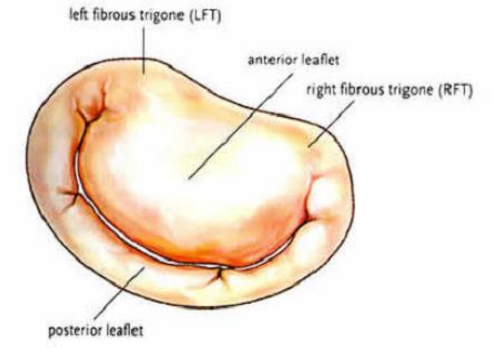
	LEFT VENTRICULAR FUNCTION (EJECTION FRACTION)	PEAK AORTIC JET VELOCITY (m/s)	MEAN GRADIENT (mm Hg)	AORTIC VALVE AREA (cm^2)
"Classic" aortic stenosis:				
Mild	Normal	2.5-3.0	<25	>1.5
Moderate	Normal	3.0-4.0	25-50	1.0-1.5
Severe	Normal	≥4.0	≥40	≤1.0
Very severe	Normal	≥5.0 (≥5.5)	≥60	<0.9
Severe aortic stenosis despite reduced LV EF	Reduced	≥4.0	≥40	≤1.0
Low-flow, low-gradient aortic stenosis	Reduced	≤4.0	≤40	≤1.0
"Paradoxical" low-flow, low-gradient aortic stenosis	Normal *	≤4.0	≤40	≤1.0


Aortic jet velocity
<2.6 m/s with focal leaflet thickening
2.6 to 3.0 m/s
3.0 to 4.0 m/s
>4.0 m/s
Aortic valve area
Aortic valve area
>5 m/s
>1.5 cm²
1.0–1.5 cm²
<1.0 cm²
1.0–1.5 cm²
<1.0 cm²
LV EF ≥50%
LV EF <50%
AR severity
Indexed AVA Velocity ratio
Valve Ca++ Consider DSE
Mixed AS/AR
Aortic sclerosis
Mild AS
Moderate AS
Severe AS

Mitral Valve Structure







Causes of MS

- Rheumatic
- Degenerative
- Congenital MS
- Other: Systemic lupus , Infiltrative disease, Carcinoid heart disease , Drug-induced.

Anatomical Features

- **Rheumatic**

  Commissural fusion

  Leaflet thickening

  Chordal shortening and fusion

  Superimposed calcification.

- **Degenerative**

  Annular calcification.

  Rarely leaflet thickening & calcification at base.

- **Congenital**

    Subvalvular apparatus abnormalities.

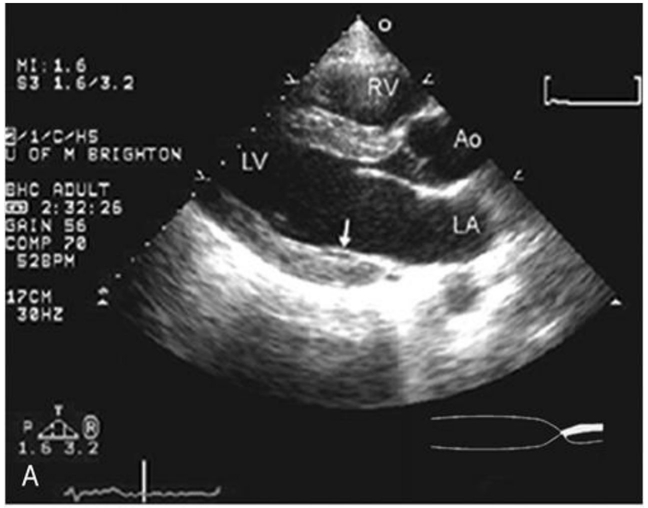
- **Systemic lupus , Carcinoid & Drug induced**

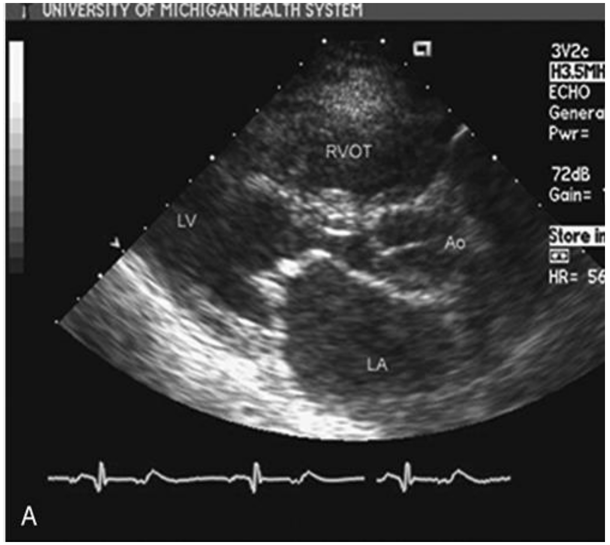
    Leaflet thickening & restriction are common here.

    Commissures are rarely fused.

2D ECHO

- Normally anterior & posterior leaflets open with maximal excursion at leaflet tips.
- In rheumatic MS there will be doming motion of AML with restriction of motion at tips – **Hockey Stick** appearance.
- Convert mitral apparatus from tubular channel to a funnel-shaped orifice.





2D ECHO

- **Commissural fusion**

  Assessed in PSAX view

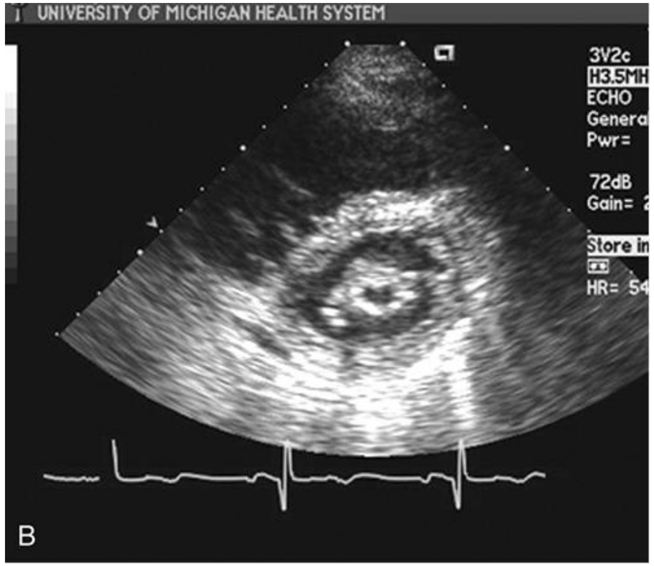
  Rheumatic etiology

  Complete fusion - severe MS.

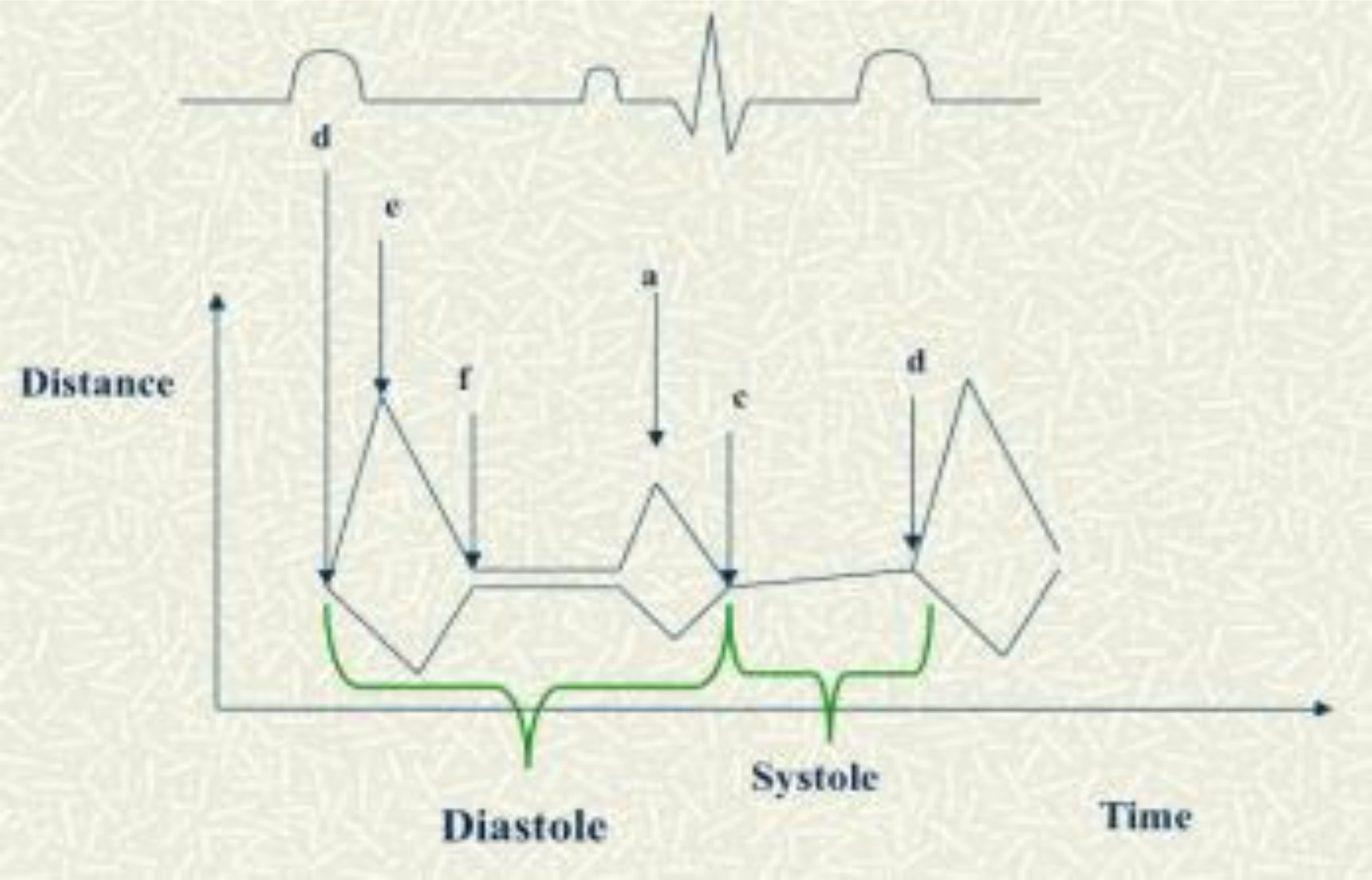
- **Leaflet thickening**

  Asssessed in PLAX

- **Chordal thickening & fusion** in PLAX , Apical 4 Chamber views



M mode of mitral leaflets

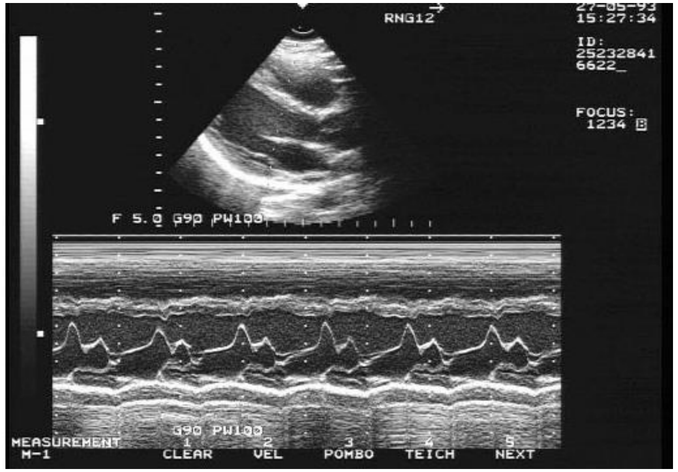


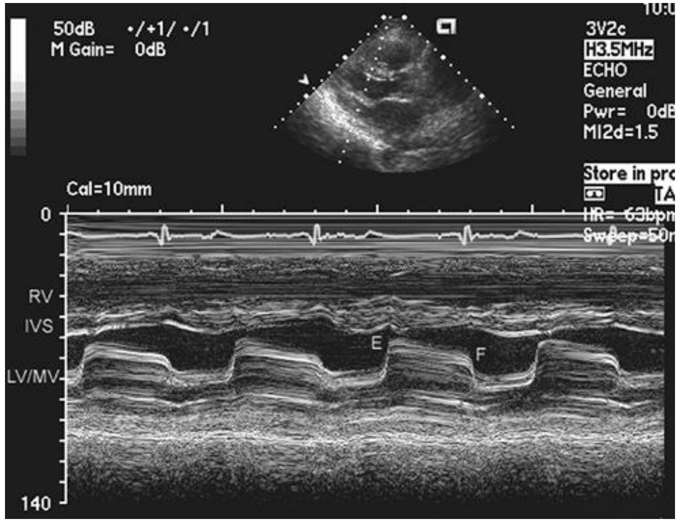
M Mode ECHO

- Increased echogenicity of leaflets.
- Decreased excursion & reduced separation of anterior and posterior leaflets.
- Reduced diastolic E-F slope of mitral closure

  Normal EF slope is > 60mm/sec

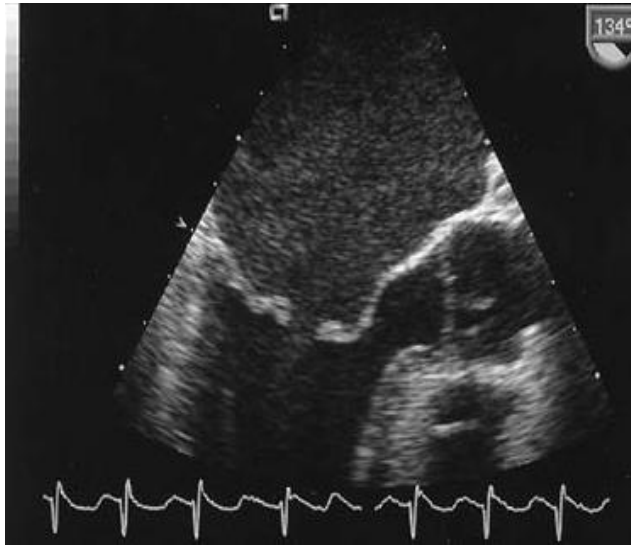
  If < 10 mm/sec indicate severe MS





TEE

- Gives higher resolution view of mitral apparatus
- Better to assess LAA thrombus
- Midesophageal views assist in evaluating   extent of disease.
- Transgastric long-axis imaging plane provides best information about extent of subvalvular involvement.



Assessment of Mitral Stenosis Severity

Level 1 Recommendations:

Pressure gradient.

MVA Planimetry.

Pressure half-time.

Level 2 Recommendations:

Continuity equation.

Proximal isovelocity surface area (PISA).

Stress echocardiography.

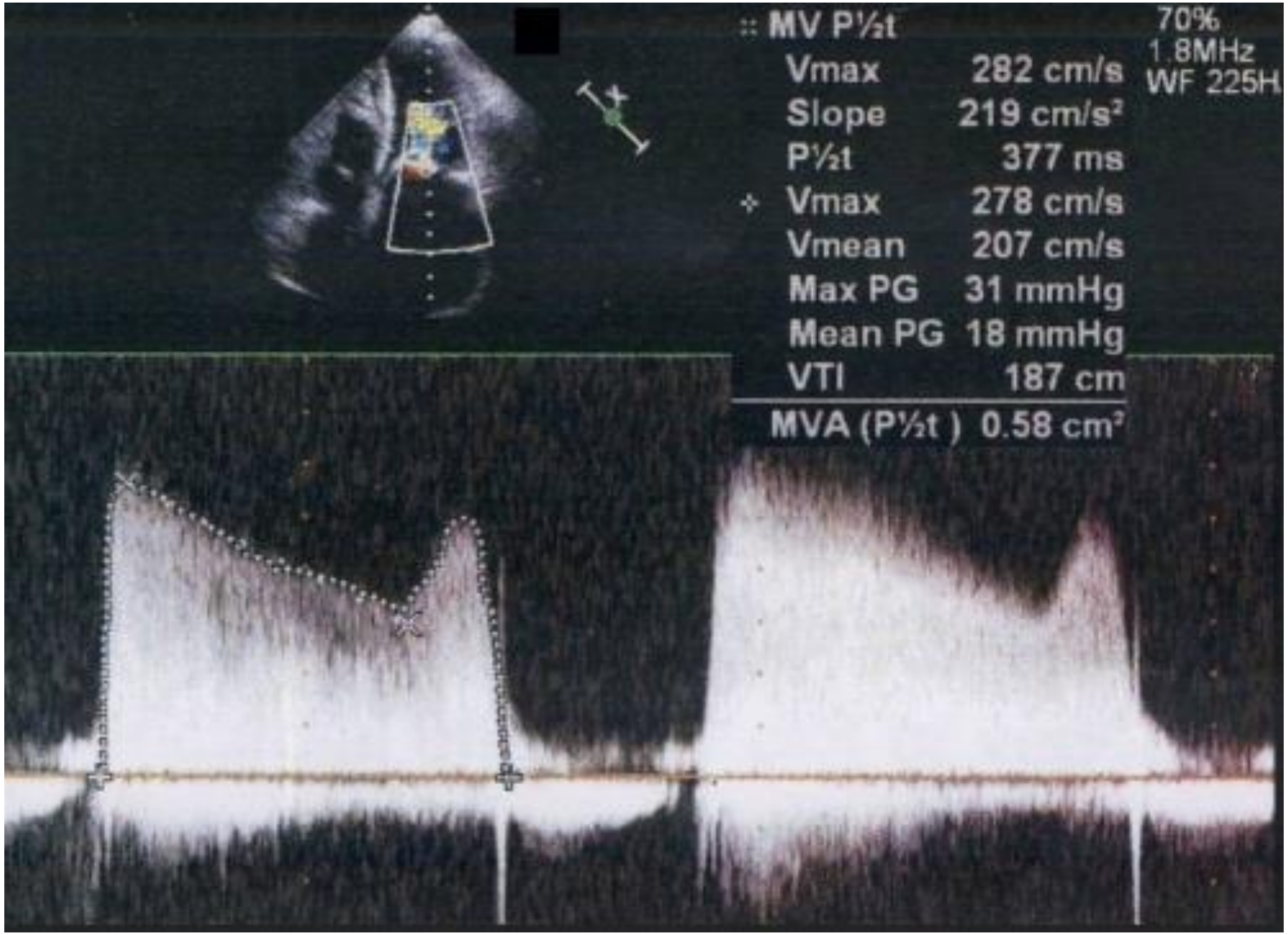
EAE/ASE RECOMMENDATIONS

Pressure gradient

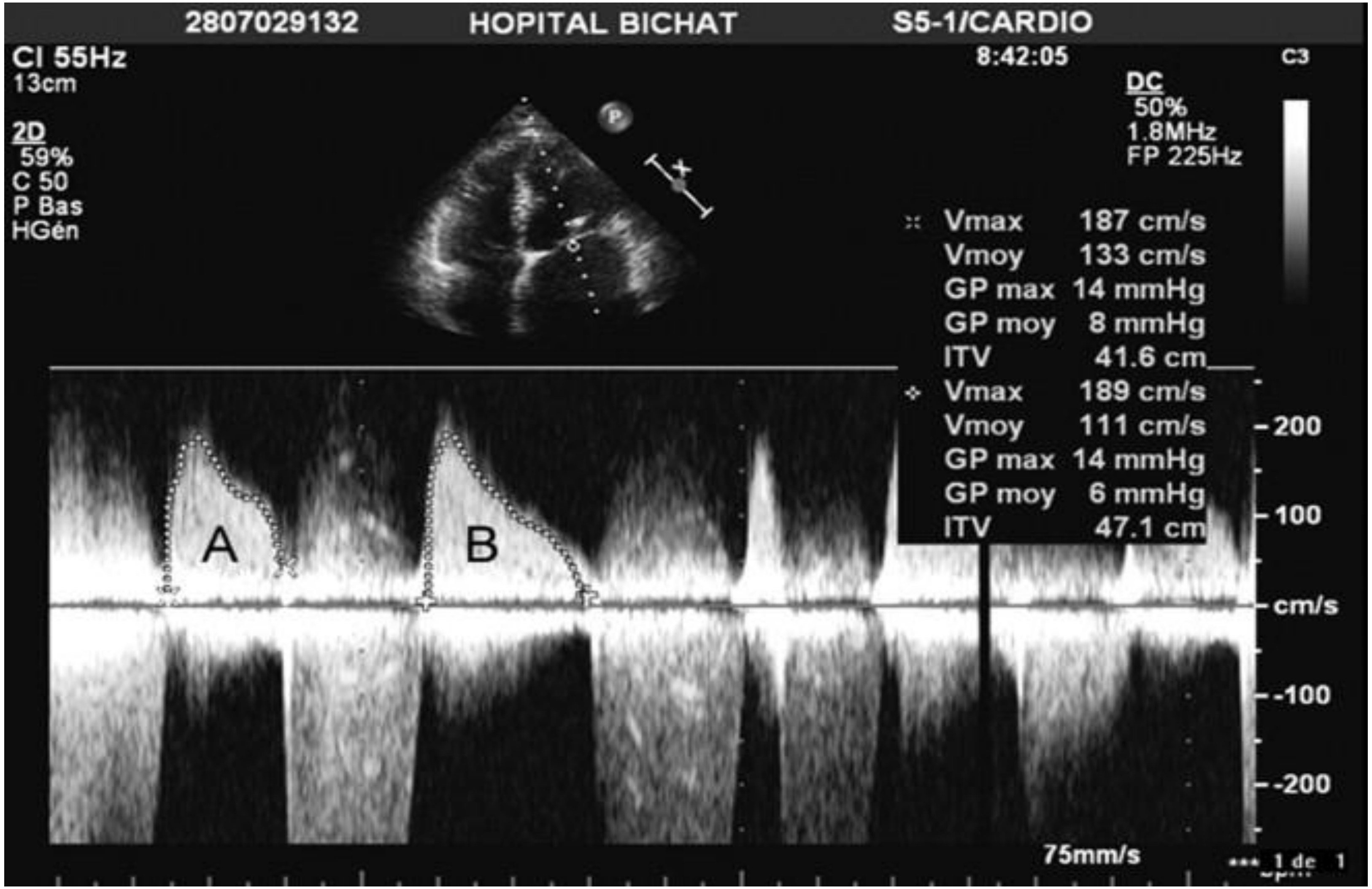
- Estimation of diastolic pressure gradient is based on simplified Bernoulli equation **$\Delta P = 4V^2$**
- Estimation has good correlation with invasive measurement using transseptal catheterization
- Gradient is measured in the apical window.
- Continuous wave doppler is preferred.
- Color doppler is used to identify eccentric mitral jets.

Pressure gradient

- Not the best marker of severity of MS.
- Depend on heart rate, cardiac output(CO) & associated MR.
- Tachycardia, increased CO & associated MR overestimates gradient.

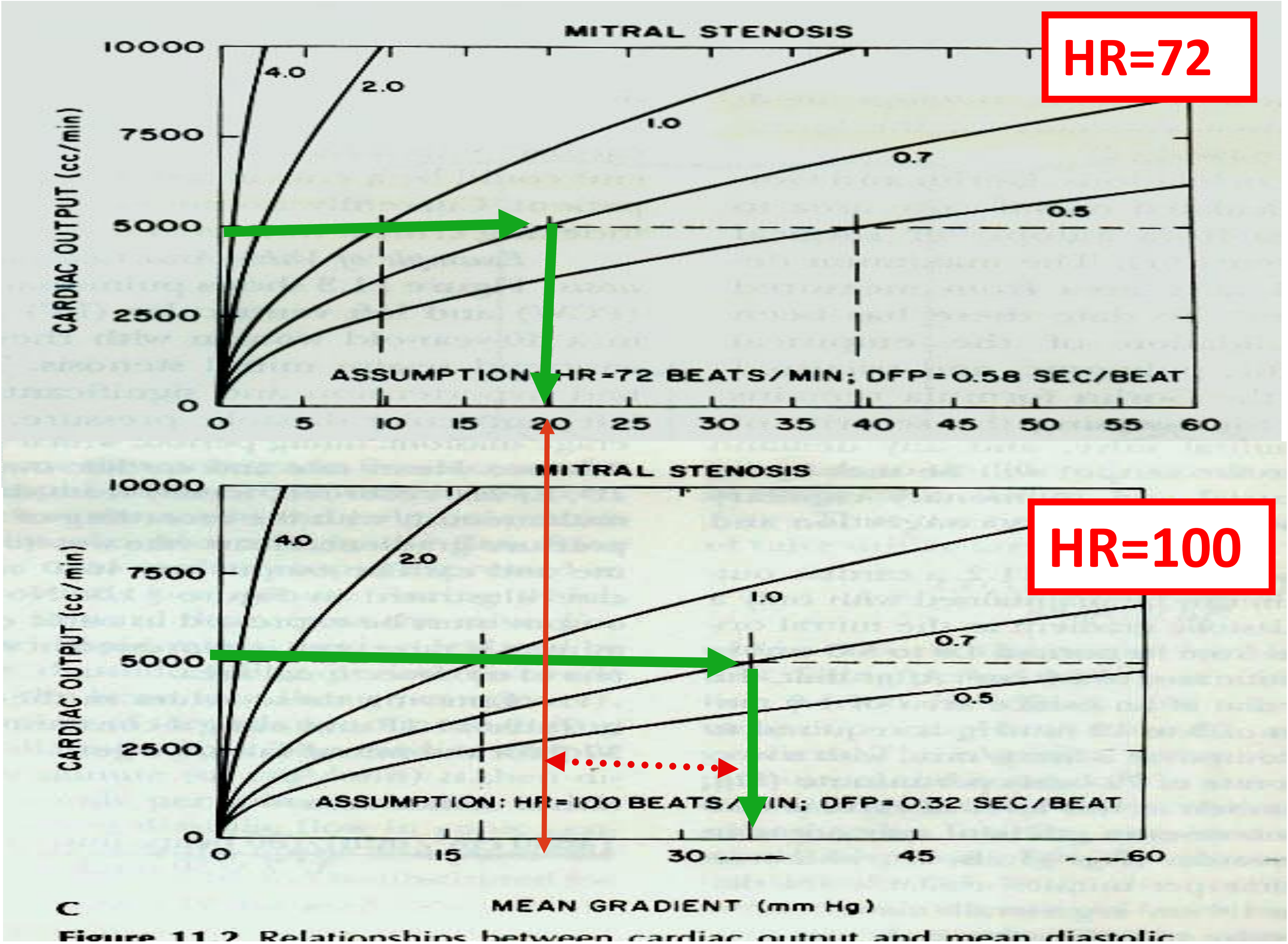


MV P½t
Vmax 282 cm/s
Slope 219 cm/s²
P½t 377 ms
Vmax 278 cm/s
Vmean 207 cm/s
Max PG 31 mmHg
Mean PG 18 mmHg
VTI 187 cm
MVA (P½t) 0.58 cm²
70%
1.8MHz
WF 225H



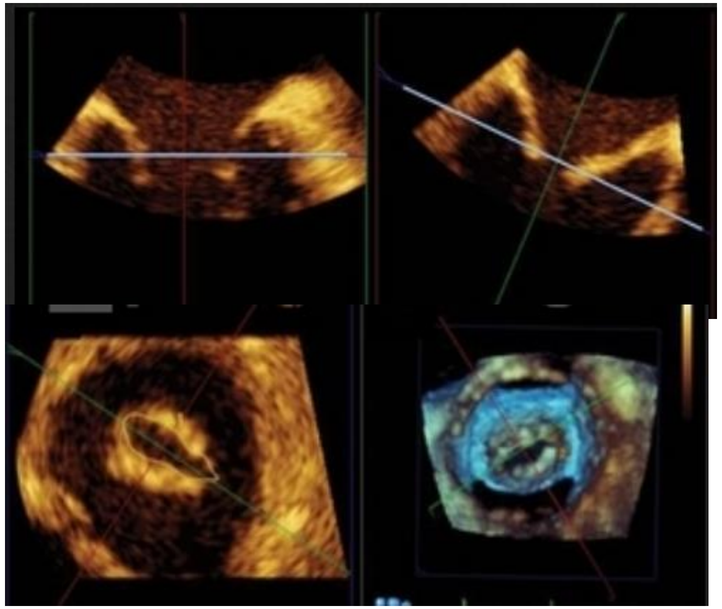
2807029132
HOPITAL BICHAT
S5-1/CARDIO
CI 55Hz
13cm
8:42:05
C3
2D
59%
C 50
P Bas
HGén
DC
50%
1.8MHz
FP 225Hz
Vmax 187 cm/s
Vmoy 133 cm/s
GP max 14 mmHg
GP moy 8 mmHg
ITV 41.6 cm
Vmax 189 cm/s
Vmoy 111 cm/s
GP max 14 mmHg
GP moy 6 mmHg
ITV 47.1 cm
A
B
200
100
cm/s
-100
-200
75mm/s
1 de 1

Pressure Gradients varies with HR



MVA by Planimetry

- Planimetry is considered as **reference measurement** of MVA.
- Direct tracing of mitral orifice including opened commissures in PSAX view at mid-diastole.
- CSA is measured at the leaflet tips.

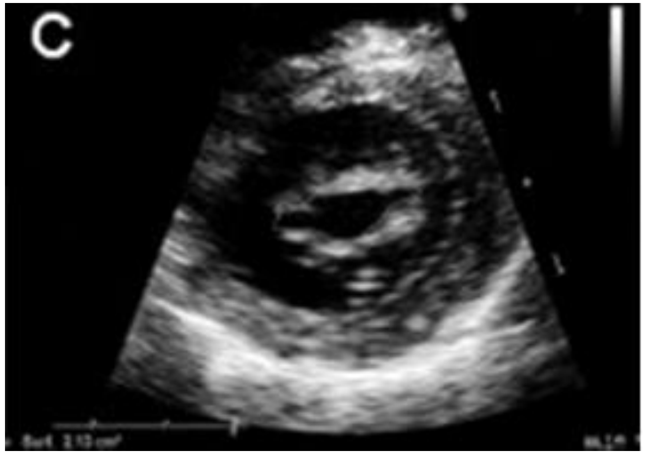


MVA by Planimetry

- Gain setting should be just sufficient to visualize the contour of the mitral orifice.
- Excessive gain setting may cause underestimation of valve area.
- 3D echo imaging improves reproducibility and accuracy of planimetry measurement.

Both commissures are fused

Unicommissural opening



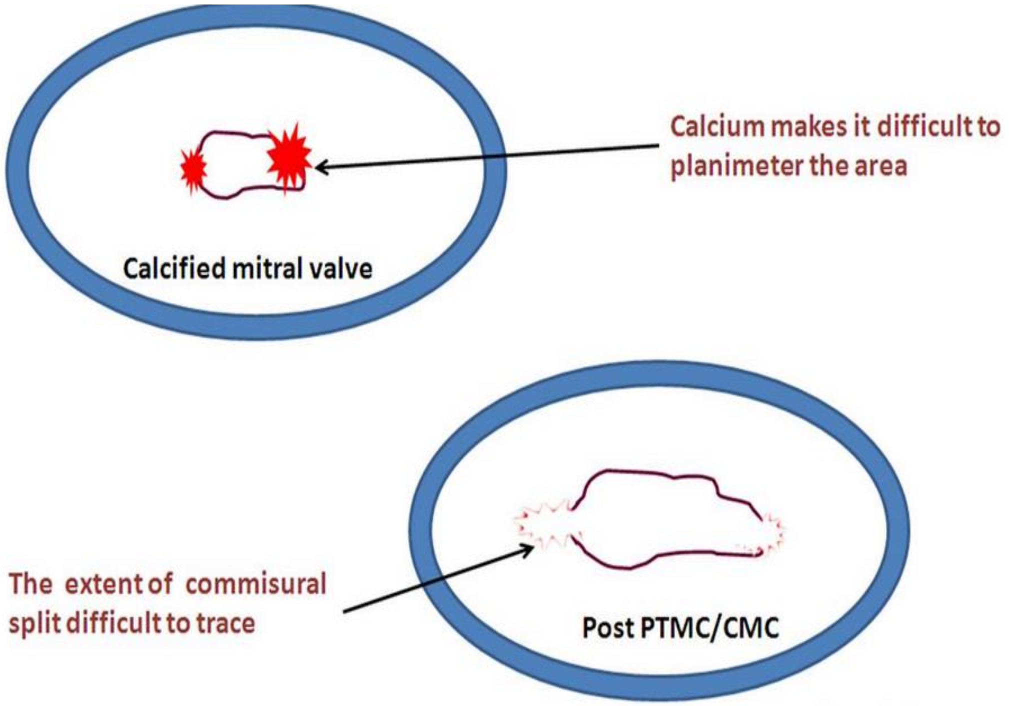
Bicommissural opening

Advantages of planimetry

- Direct measurement of MVA.
- Does not depend on flow conditions, cardiac chamber compliance or associated valvular lesions.
- Best correlation with anatomic valve area of explanted valves.

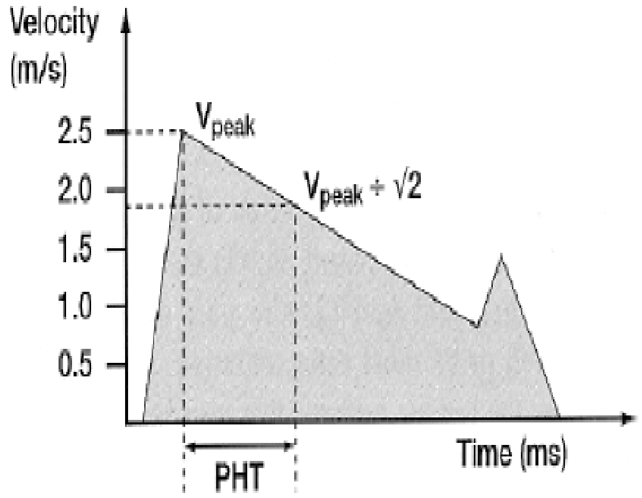
Disadvantage

- Not feasible in poor acoustic window and severe valve calcification.



Pressure half-time (PHT)

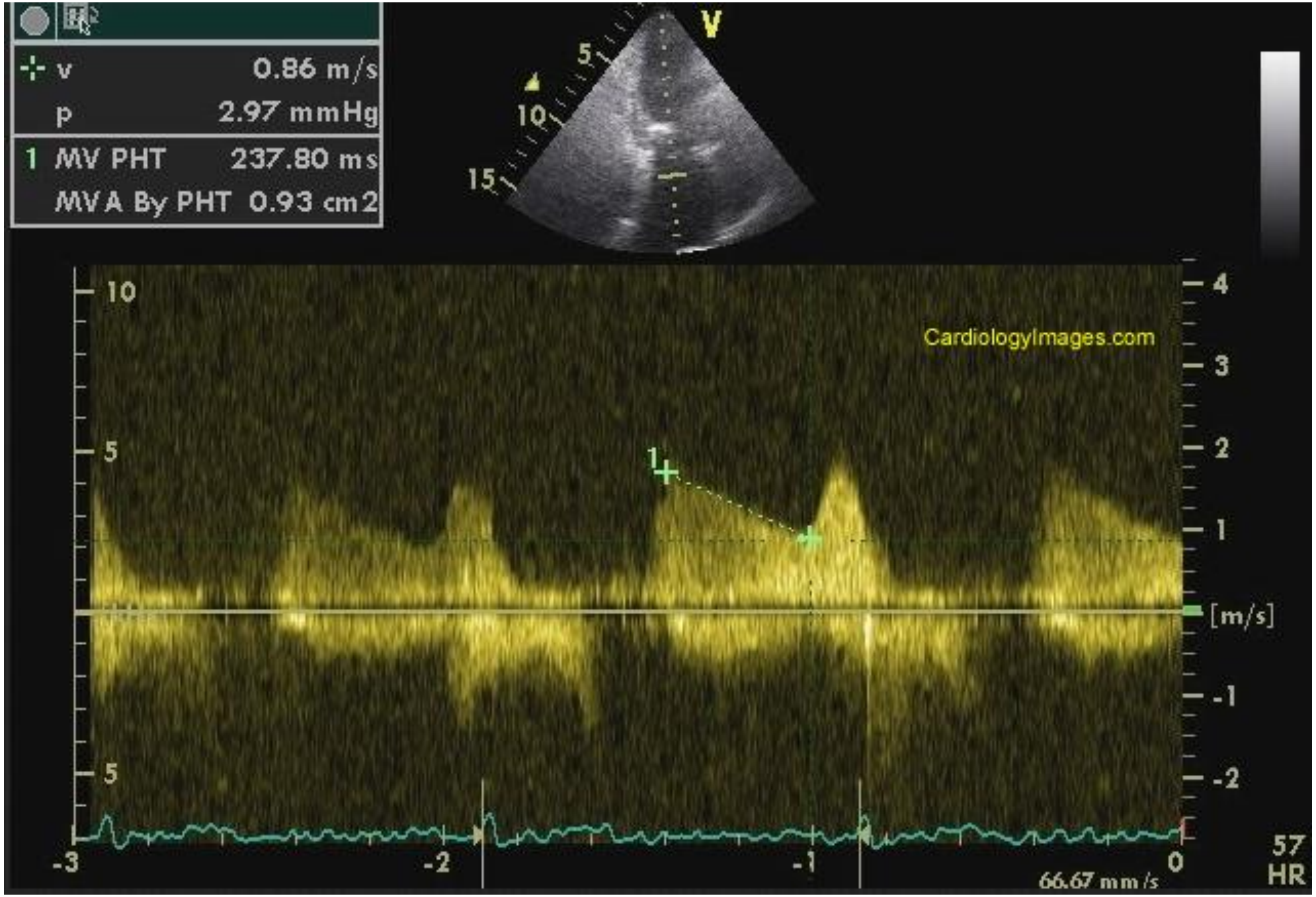
- PHT is defined as time interval in msec between maximum mitral gradient in early diastole & time point where the gradient is half the maximum initial value.



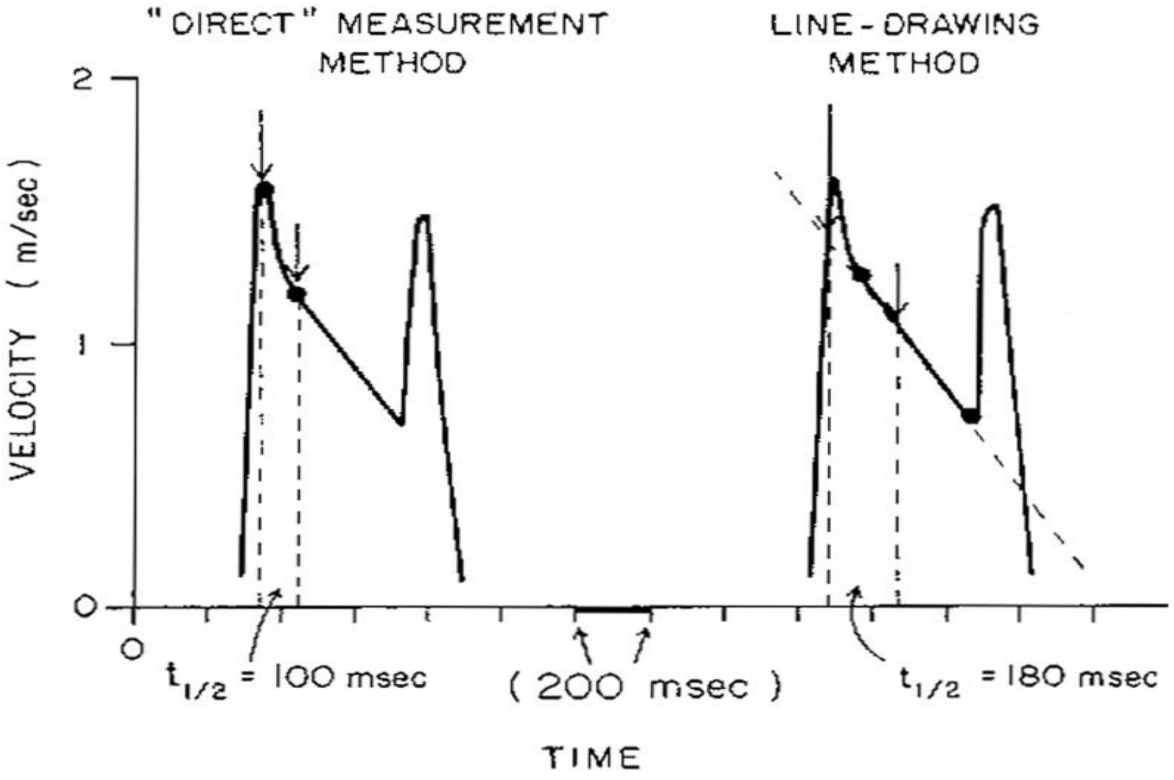
- Decline of the velocity of diastolic transmitral blood flow is inversely proportional to valve area.

- MVA is derived using the empirical formula

  MVA = 220/PHT


v 0.86 m/s
p 2.97 mmHg
1 MV PHT 237.80 ms
MVA By PHT 0.93 cm2
V
CardiologyImages.com
[m/s]
66.67 mm/s
57
HR

Measuring $T_{1/2}$ with a bimodal slope of E-wave



Deceleration slope in mid-diastole rather than early to be traced

MITRAL STENOSIS

Valve morphology – rheumatic, calcification

Determination of Wilkins score

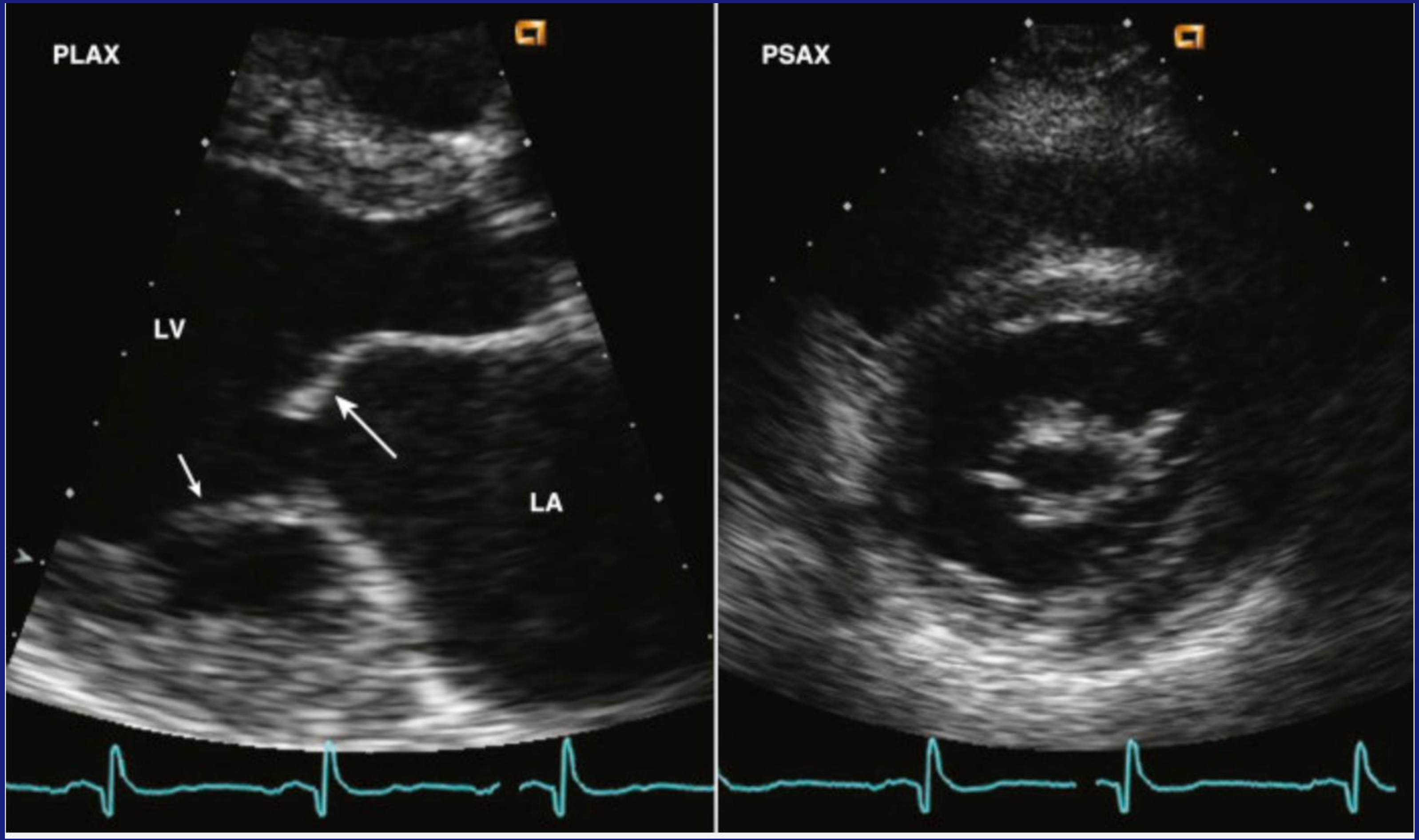
Stenosis severity / presence of MR and its severity

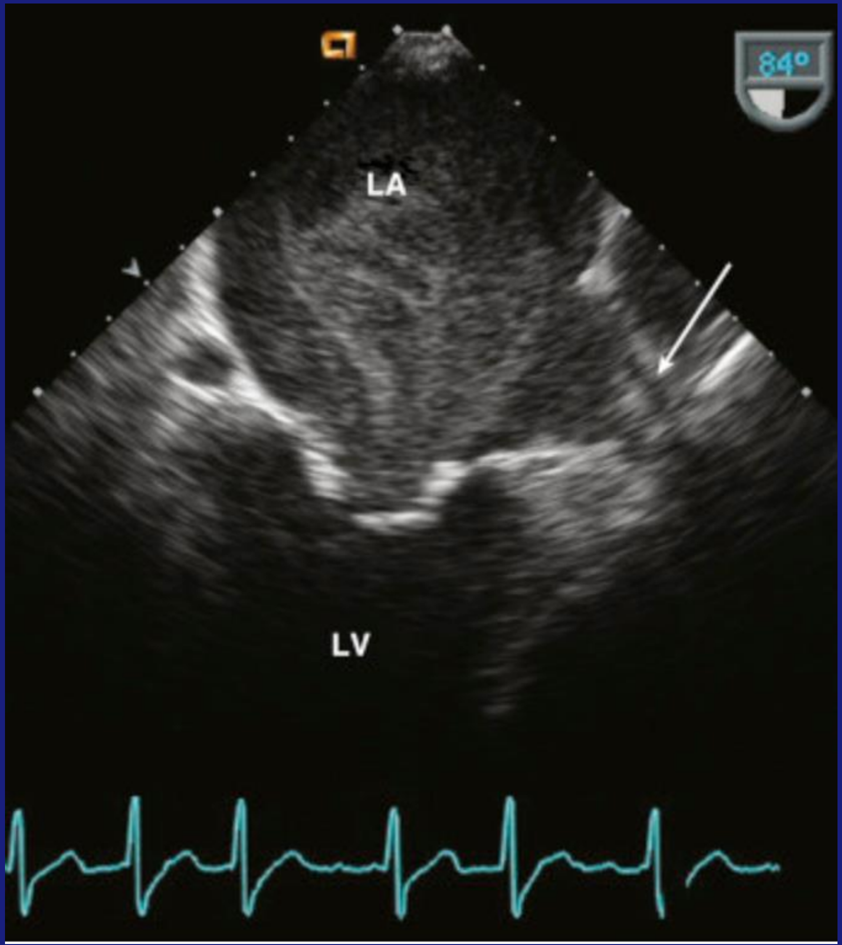
LV measurements and function

LA size / presence of clot

Pulmonary artery systolic pressure (TR velocity)

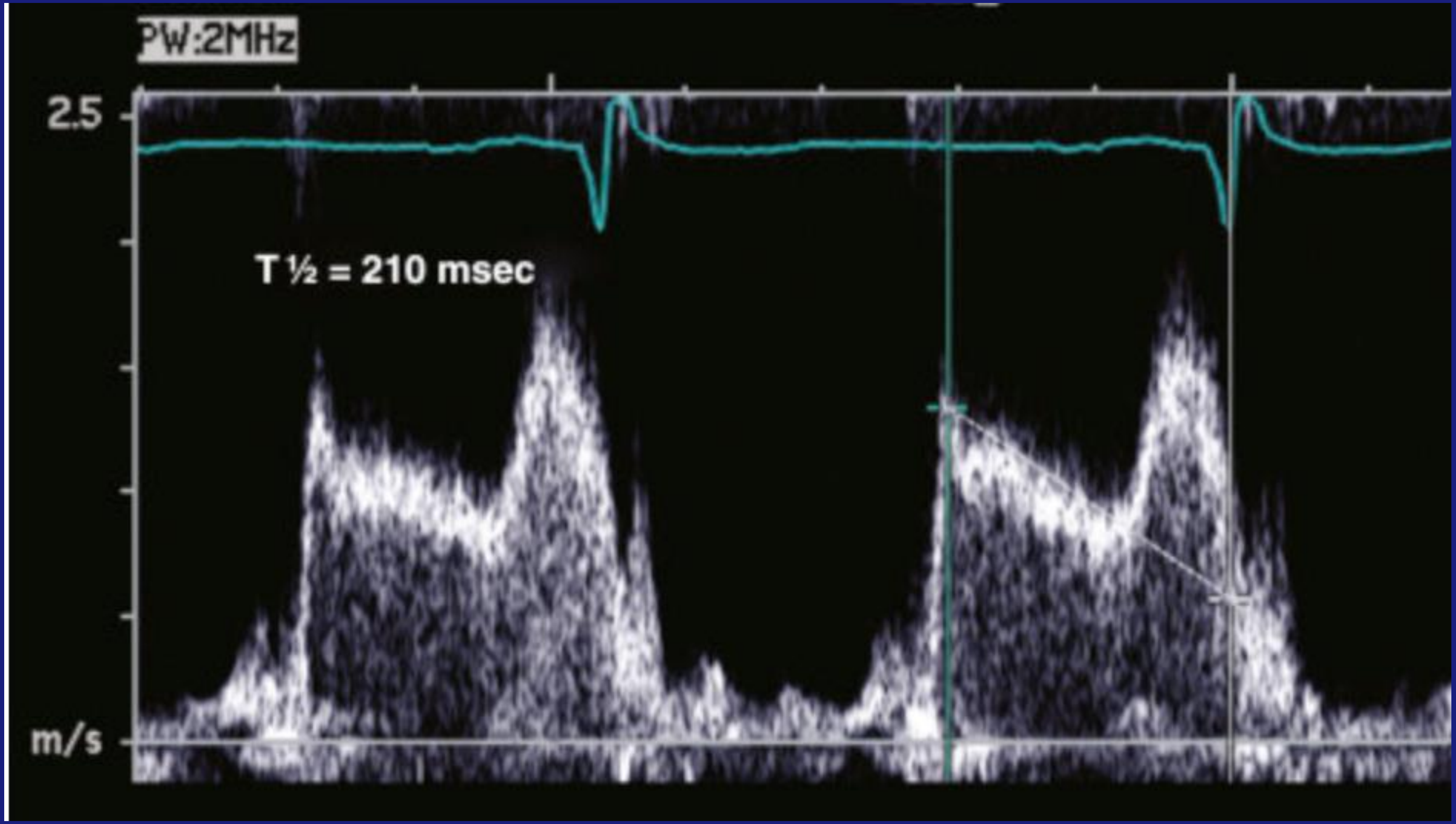
RV function


PLAX
LV
LA
PSAX


84°
LA
LV

Pressure Half-Time

220 / P1/2 T



Grade *	Mobility	Thickening	Calcification	Subvalvular Thickening
1	Highly mobile valve with only leaflet tips restricted	Leaflets near normal in thickness (4-5 mm)	A single area of increased echo brightness	Minimal thickening just below the mitral leaflets
2	Leaflet mid and base portions have normal mobility.	Mid-leaflets normal, considerable thickening of margins (5-8 mm)	Scattered areas of brightness confined to leaflet margins	Thickening of chordal structures extending to one third of the chordal length
3	Valve continues to move forward in diastole, mainly from the base.	Thickening extending through the entire leaflet (5-8 mm)	Brightness extending into the mid portions of the leaflets	Thickening extended to distal third of the chords
4	No or minimal forward movement of the leaflets occurs in diastole.	Considerable thickening of all leaflet tissue (>8–10 mm)	Extensive brightness throughout much of leaflet tissue	Extensive thickening and shortening of all chordal structures extending down to papillary muscles

MITRAL STENOSIS SEVERITY

	MILD	MODERATE	SEVERE
MVA	>1.5	1.0-1.5	<1.0
MEAN GRADIENT	<5	5-10	>10
PASP	>30	30-50	>50

VALVE REGURGITATION

Complete echocardiographic evaluation of in a patient with valvular regurgitation includes:

Assessment of the valve anatomy
Determine the severity of regurgitation
Chamber dilation due to imposed volume overload
Evaluation of coexisting other valve lesion
Ventricular function
Degree of pulmonary hypertension

Etiology of valvular regurgitation

Primary vs Secondary

MR severity assessment

Semi-quantitative Methods

M-Mode,2D Echocardiography
Color flow imaging
PW Doppler
CW Doppler

Quantitative Methods

Volumetric Method
PISA Method

Real Time 3D Echo-TTE-TEE

M-Mode & 2D Echo

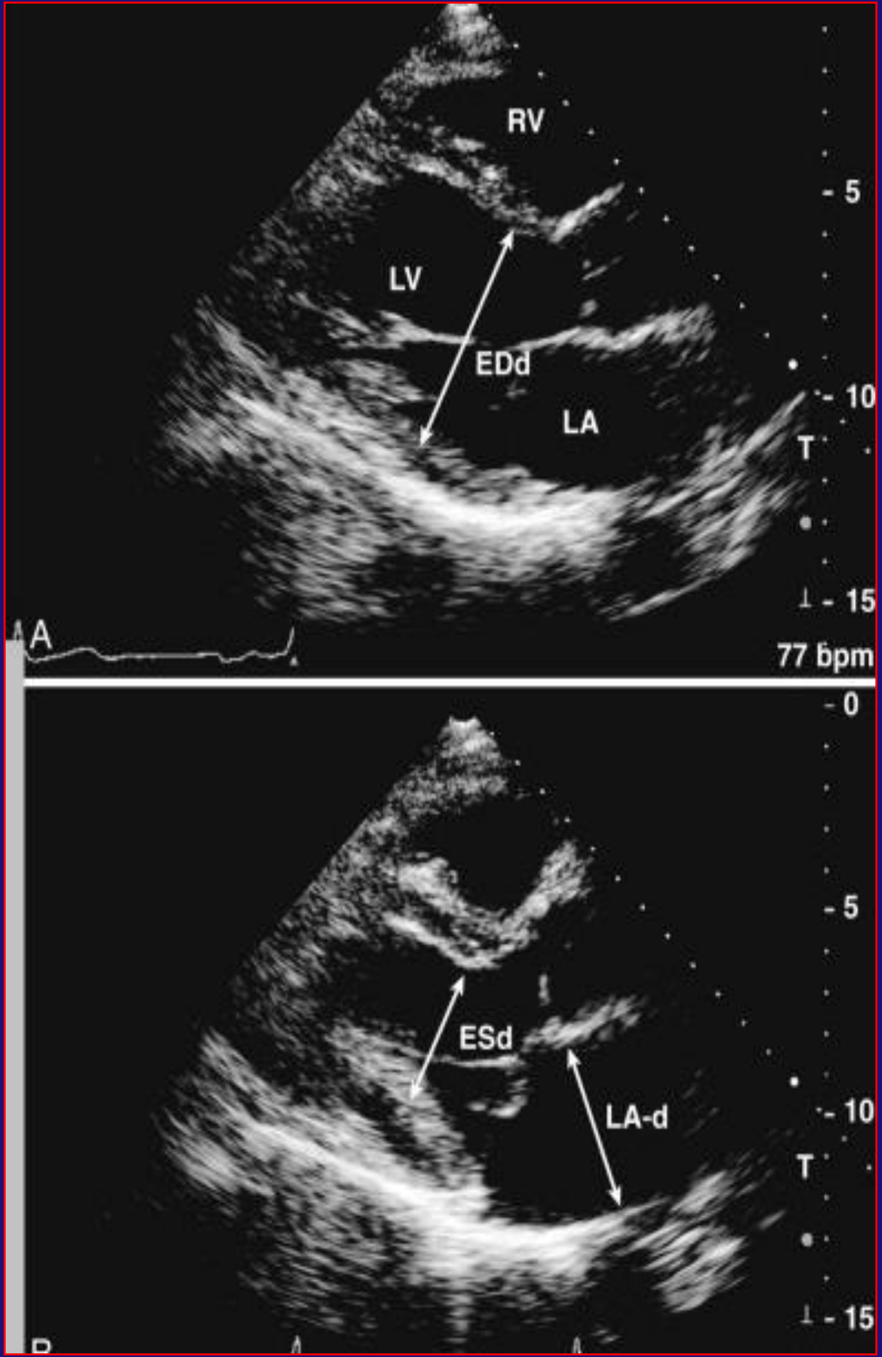
Normal 2D measurements:

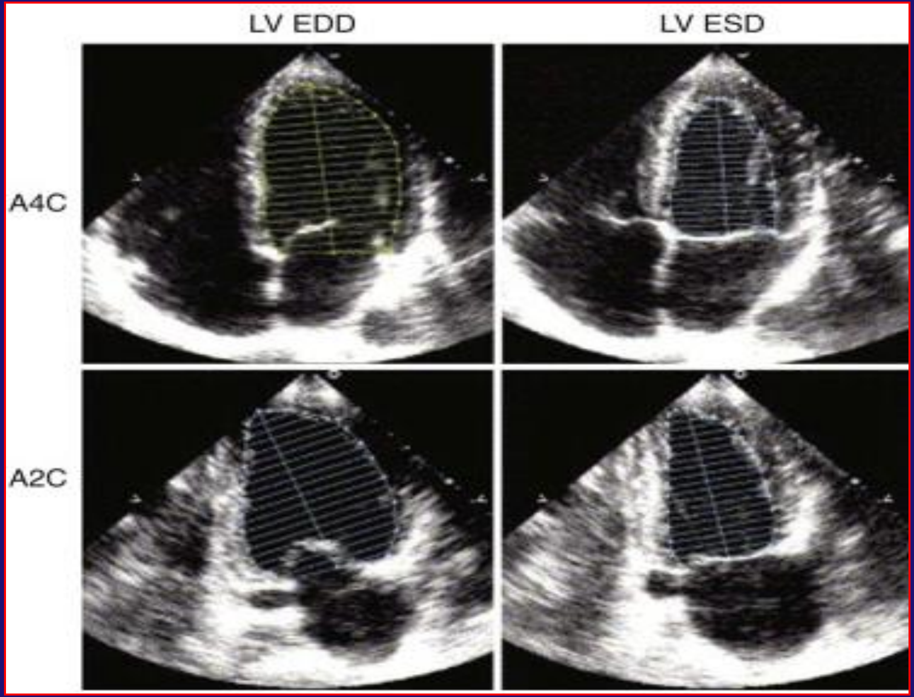
LV minor axis 2.8 cm/m^2

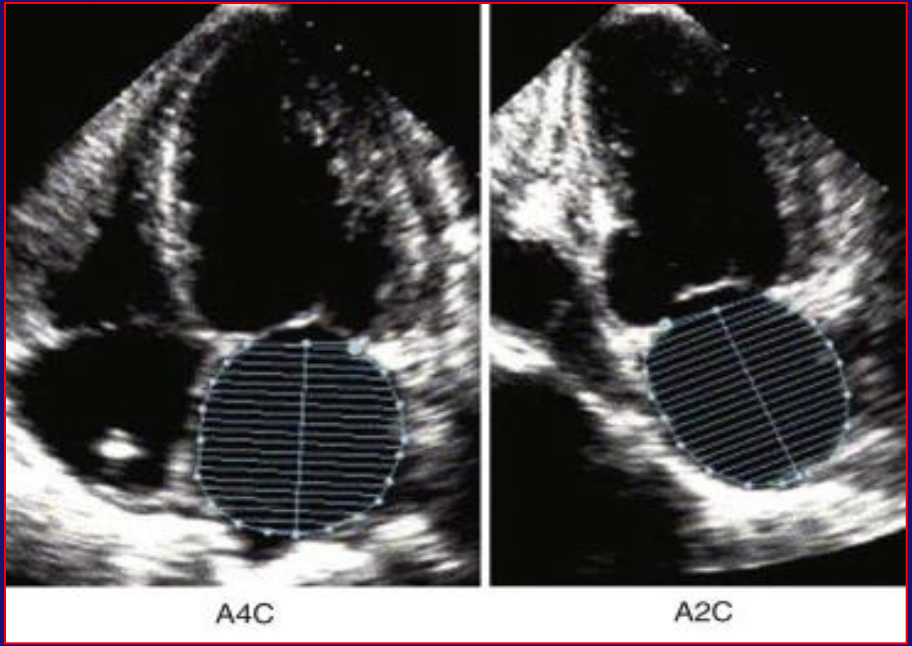
LV end-diastolic volume 82 ml/m^2

Maximal LA AP diameter 2 cm/m^2

Maximal LA volume 36 ml/m^2


RV
5
LV
EDd
LA
10
T
15
A
77 bpm
0
5
ESd
LA-d
10
T
15
B


LV EDD
LV ESD
A4C
A2C


A4C
A2C

Colour flow Doppler

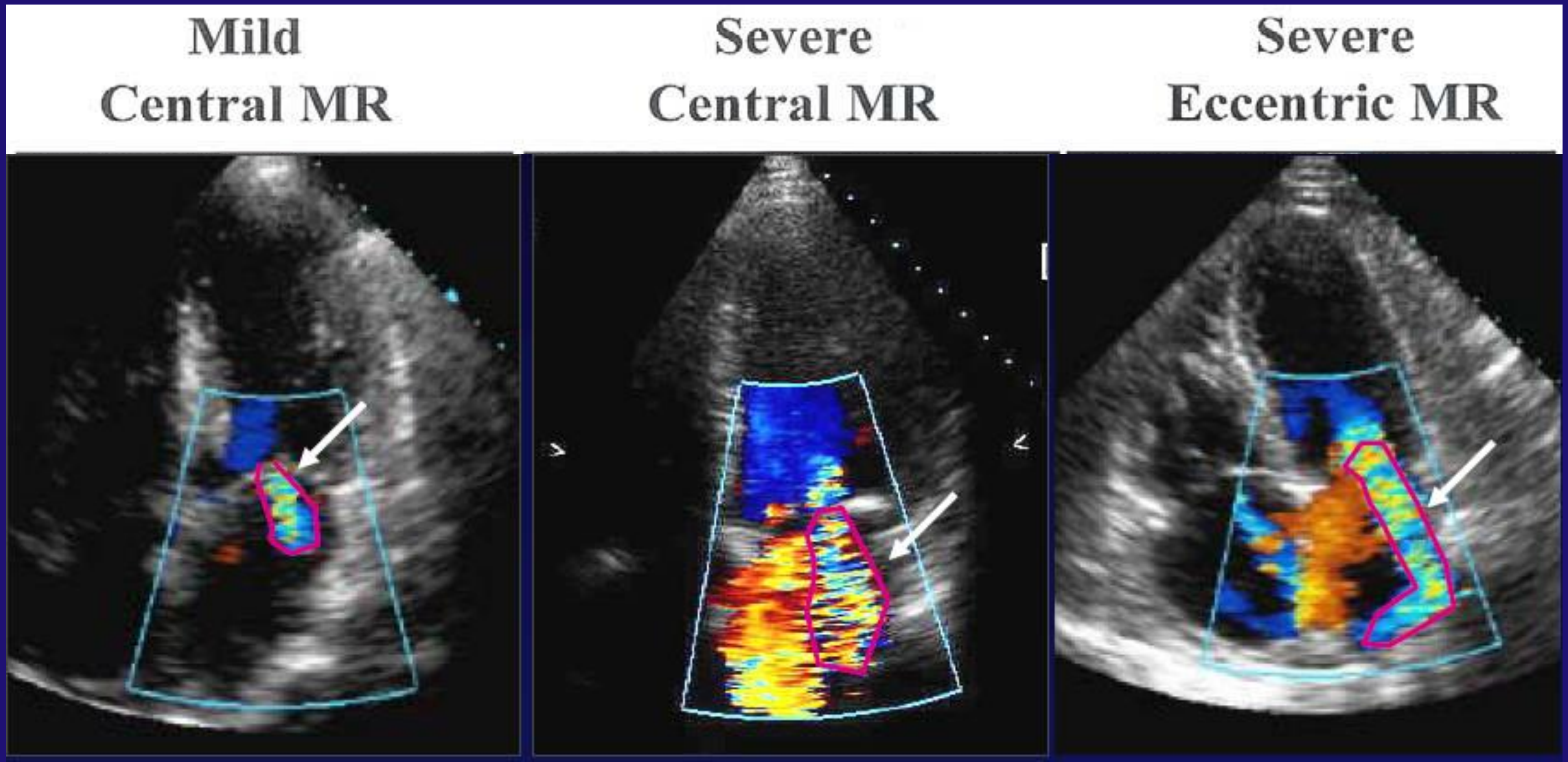
- Most common way to assess MR severity
- Assumption:

  as the severity of the MR increases, the size and the extent of the jet into the LA also increases.

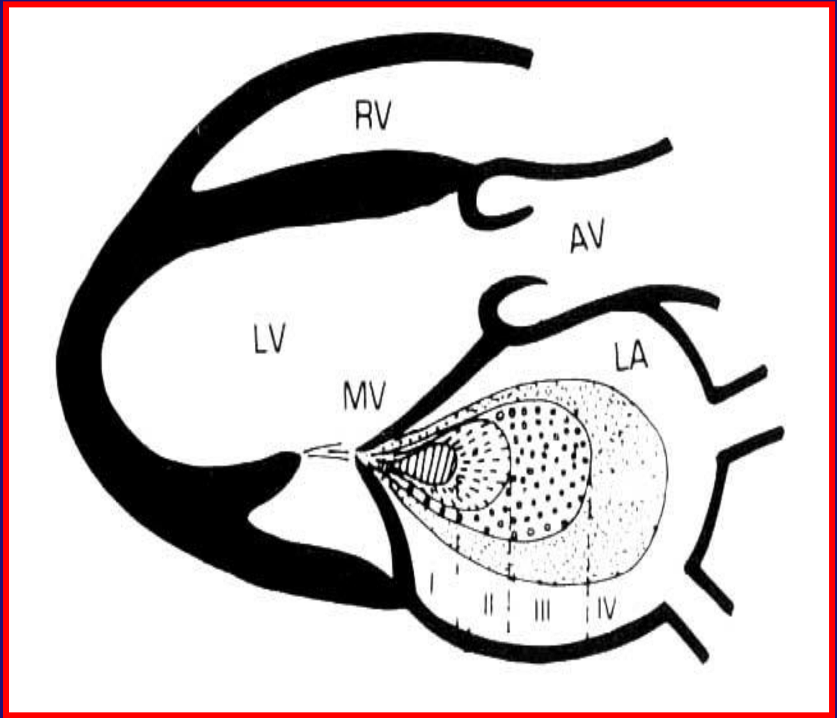
- Relation between jet size and MR severity presents a large range of variability.

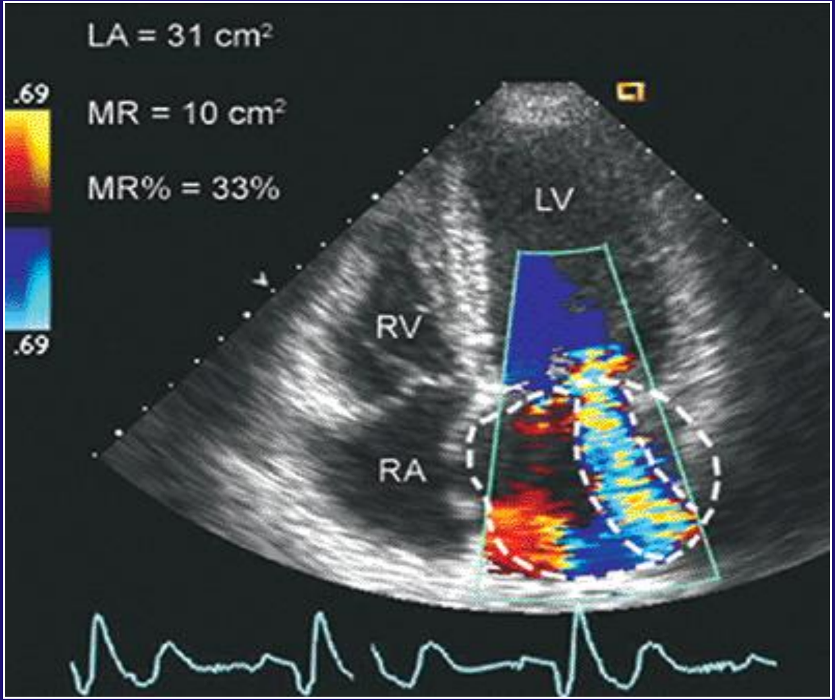
- Patients with <u>increased LA pressure or with eccentric jets that hug the LA wall or in whom the LA is enlarged</u> may exhibit smaller jets area than those with normal LA pressure and size or with central jets

Colour flow Doppler –jet area



Colour flow Doppler –jet area





Mild **= Less than 20% of LA area** **(<4cm²)**
moderate **= 20 to 40%**
severe **= More than 40%** **(>10 cm²)**

Zoghbi et al. ASE valve regurg document (JASE 03)

Factors affecting jet area-instrument factors

- Use a Nyquist limit (aliasing velocity) of 50-60cm/sec.
- Use Color gain that just eliminates random color speckle from nonmoving regions.
- Jet area inversely proportional to pulse repetition frequency (higher or lower settings –substantial error can occur)

Key point :

- The colour flow area of the regurgitant jet is not recommended to quantify the severity of MR.

- The colour flow imaging should only be used for diagnosing MR.

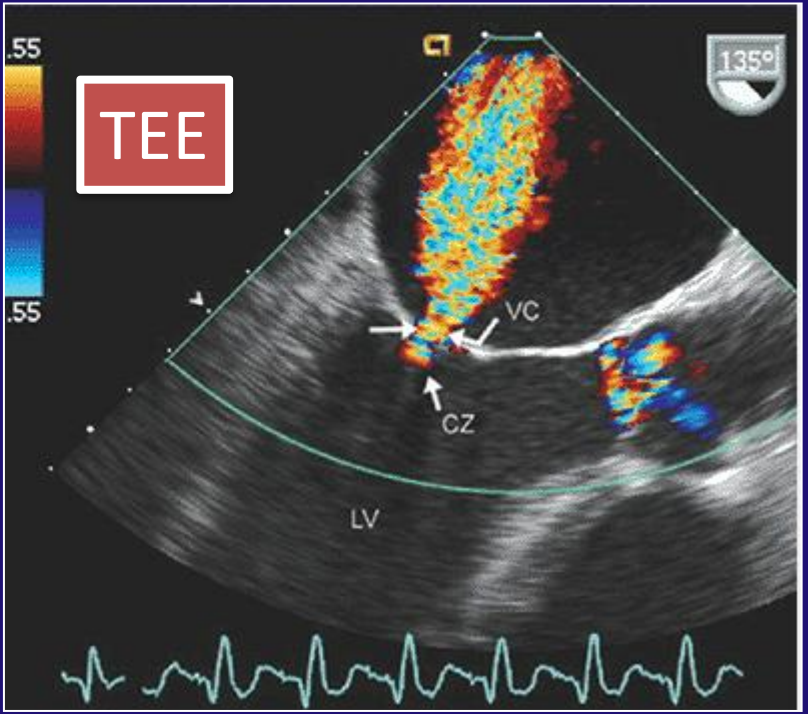
Vena contracta width

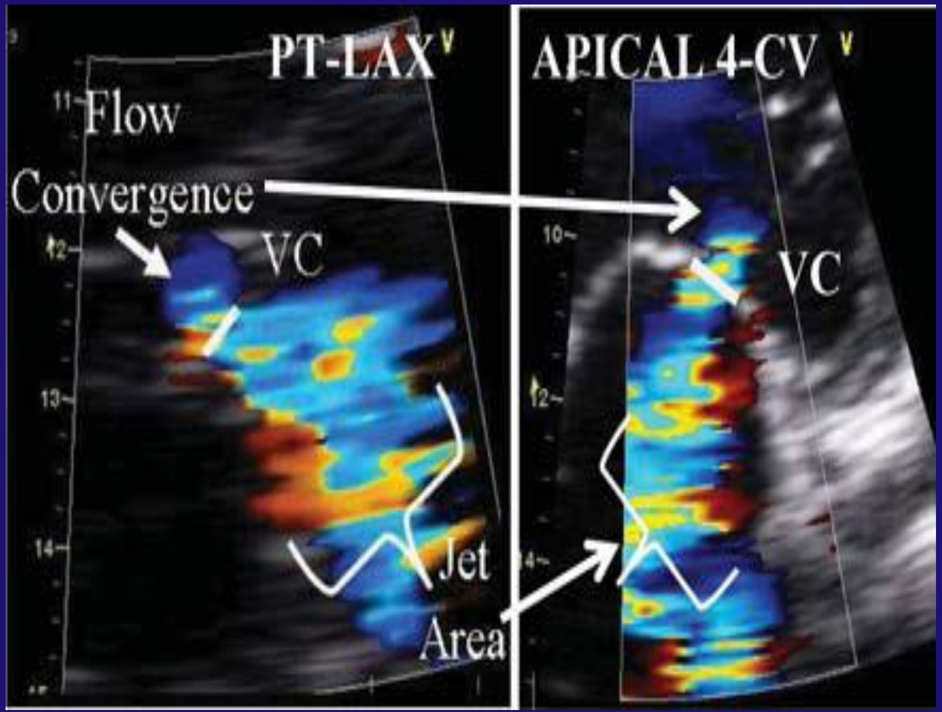
Narrowest portion of a jet that occurs at or just downstream from the orifice.

CSA of the VC represents a measure of EROA which is the narrowest area of actual flow.

Size of the VC independent of flow rate and driving pressure for a fixed orifice.
May change with hemodynamic or during the cardiac cycle

Vena contracta width





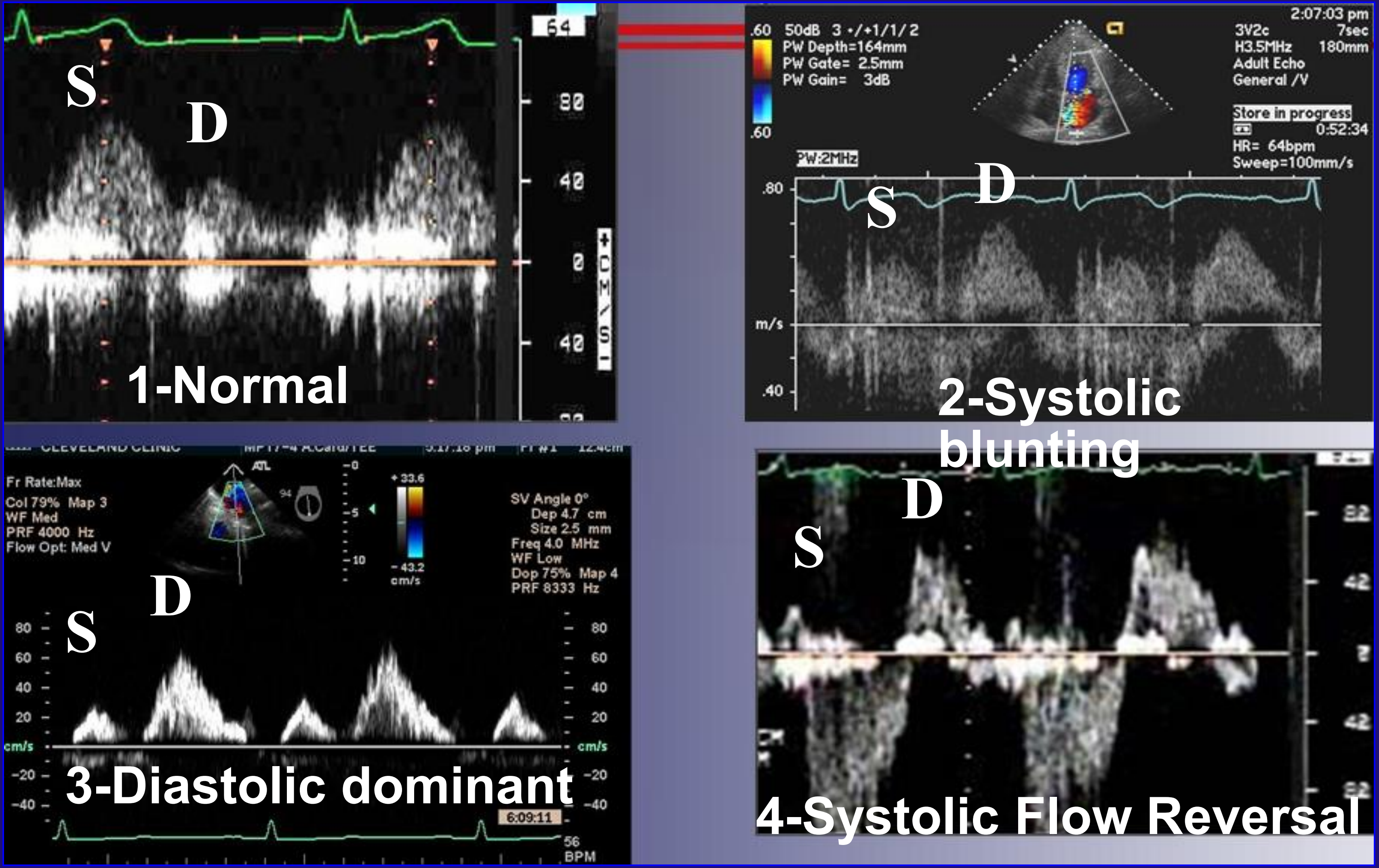
Recommended approach

- perpendicular to jet direction
- Narrow sector width
- Zoom mode
- Minimum depth

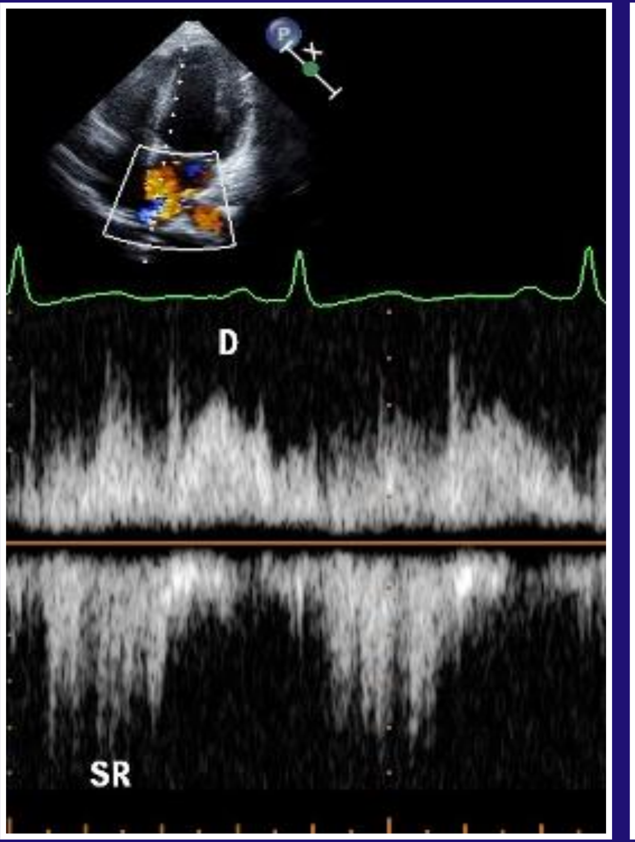
	Mild	Moderate	Severe
VC width (cm)	<0.3	0.3-0.69	≥0.7

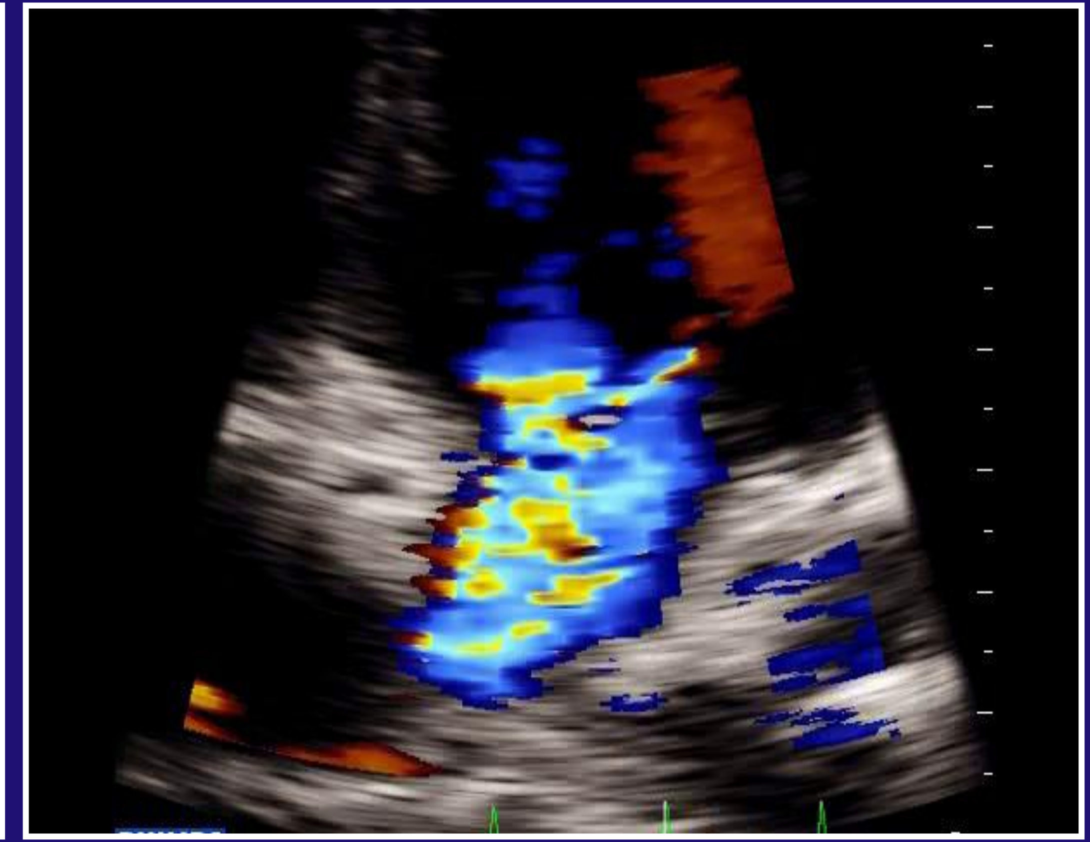
- Simple Quantitative measurement
- Intermediate values require confirmation
- Usefull for Central/Eccentric jets
- Not useful for Multiple jets

Pulmonary vein flow



Severe MR:
Pulmonary vein systolic flow reversal





Pulmonary vein flow

- Atrial fibrillation and elevated LA pressure :
  blunted forward systolic pulmonary
  vein flow.
- Systolic flow reversal in more than one pulmonary vein is specific for severe.
- Absence does not rule out severe MR

Pulmonary Vein Flow-Pitfalls

False – positive results
Eccentric jet directed into PV

False – negative results
Severely dilated and compliant LA

Trans Mitral Flow

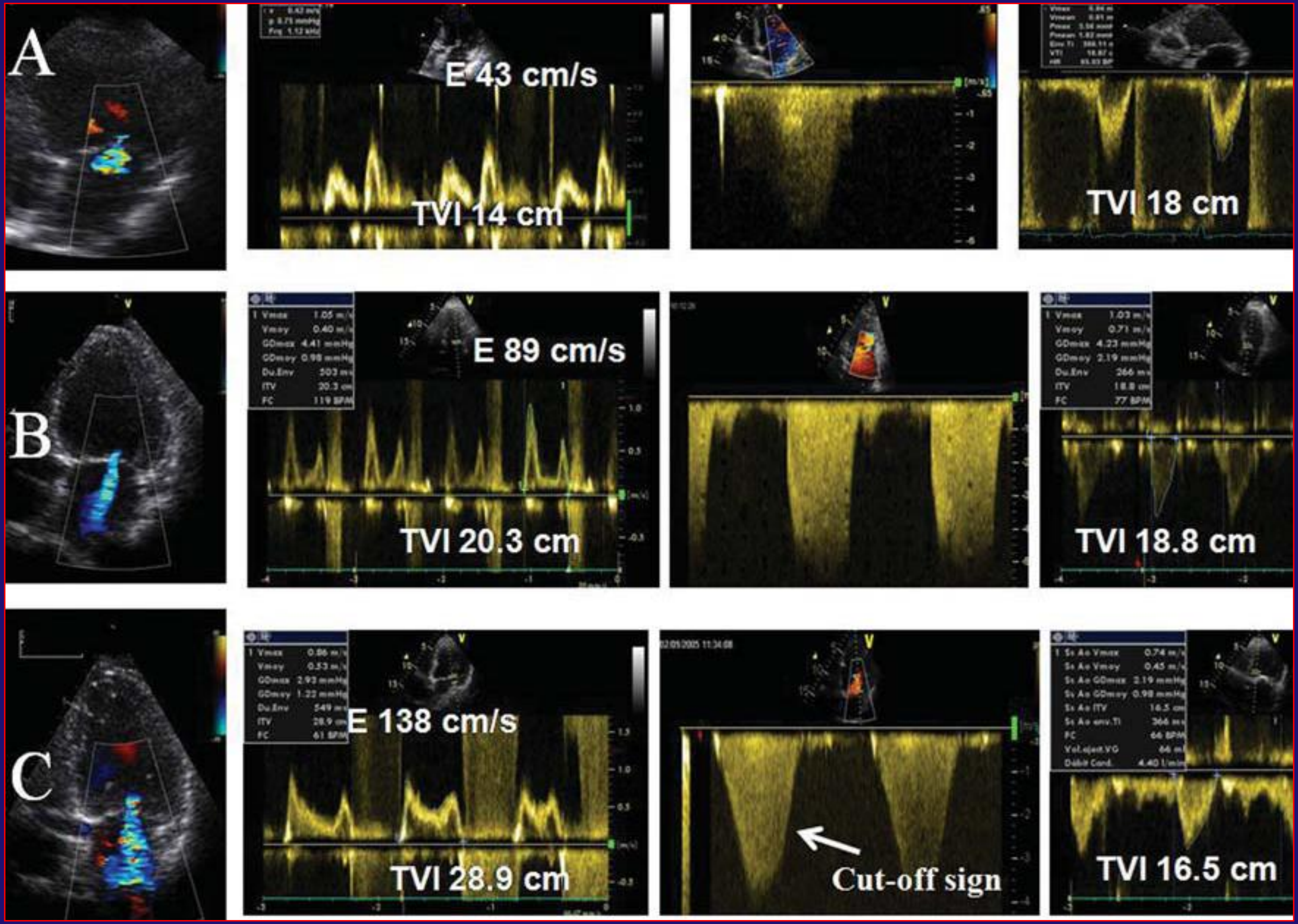
MR results in increased flow rate across mitral valve

Mitral inflow velocity ↑ in significant MR

"E" velocity > 1.5 m/sec

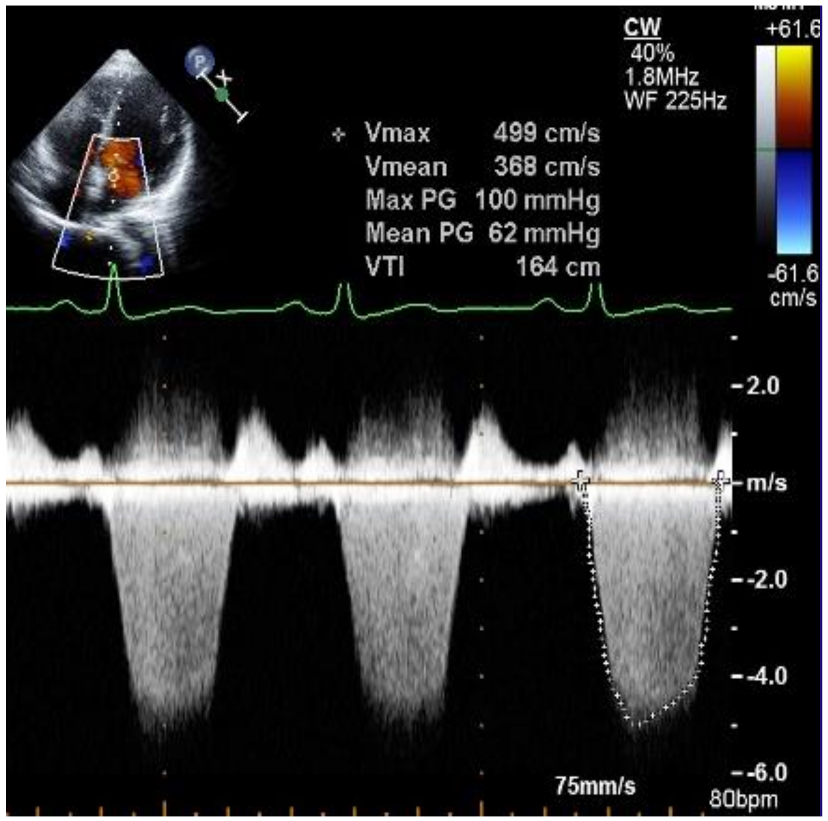
Rule out coexisting MS

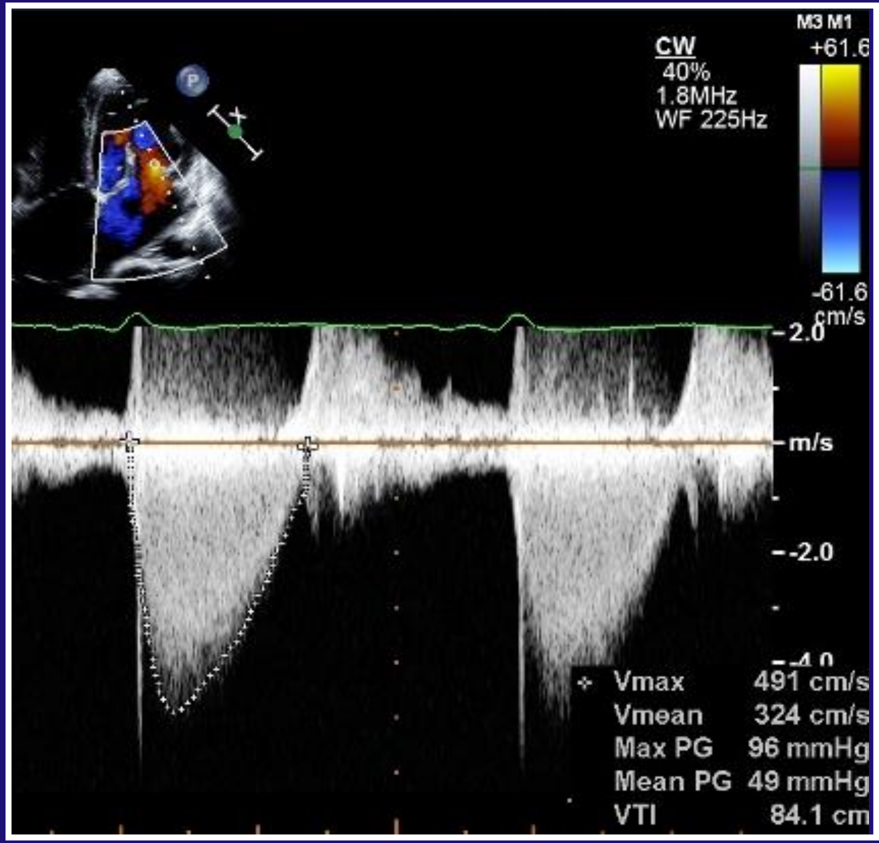
Normal PHT



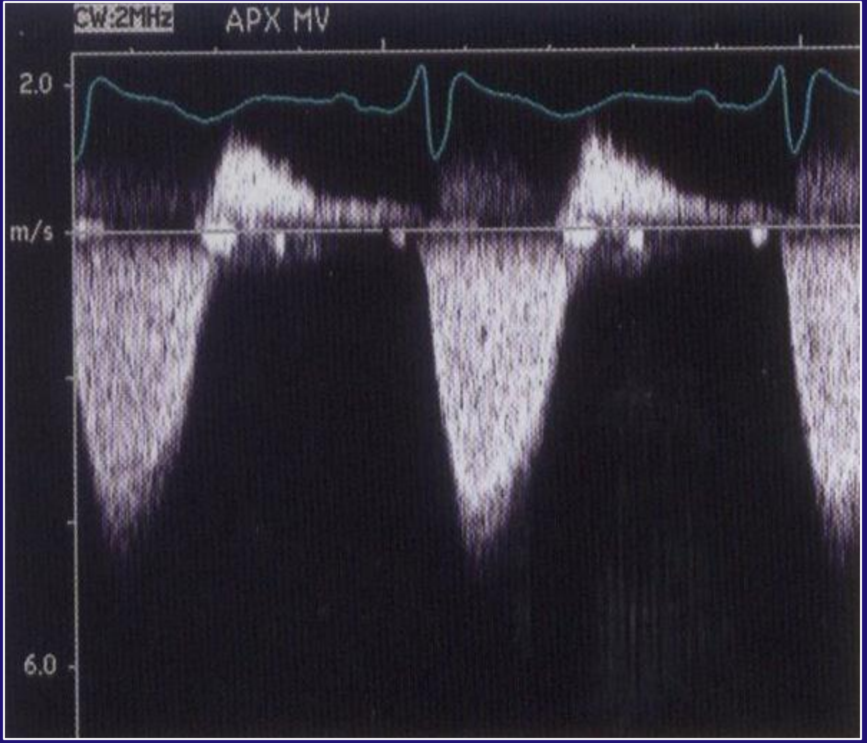
A
E 43 cm/s
TVI 14 cm
TVI 18 cm
B
E 89 cm/s
TVI 20.3 cm
TVI 18.8 cm
C
E 138 cm/s
TVI 28.9 cm
Cut-off sign
TVI 16.5 cm

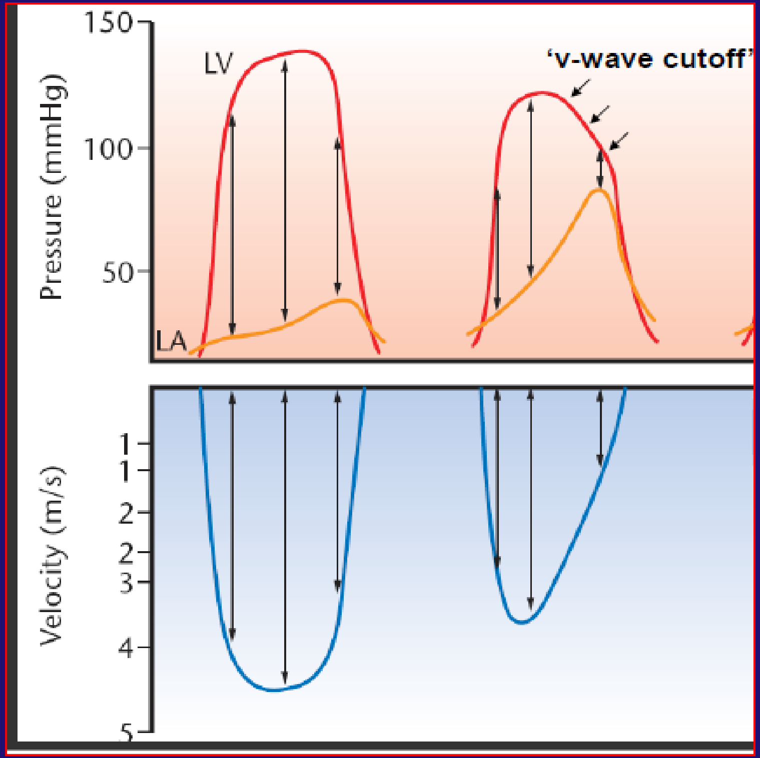
Continuous Wave Doppler





Shape of regurgitant signal-V cut off sign





- Mild MR : atrial pressure low and gradient remain high throughout systole
- Significant MR : atrial pressure increased in end systole and gradient decreases
- Produces a V shaped doppler signal

Continuous Wave Doppler

	MILD	SEVERE
# Density	Faint	Dense
# Shape	Symmetrical	Asymmetrical

PISA Method

The PISA method is based on

- the properties of flow dynamics
- the continuity principle.

Goal of the PISA method:

to calculate the effective regurgitant orifice area (EROA)

Flow rate is the same at all points along the circuit

$$A_1 \times V_1 = A_2 \times V_2$$

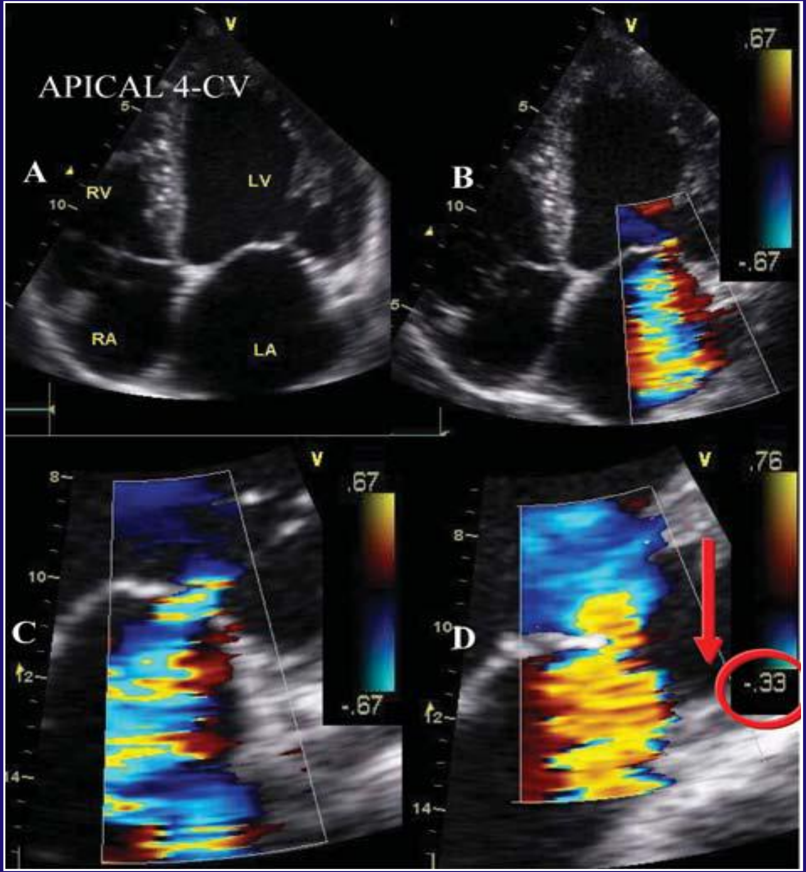
Flow proximal= flow distal

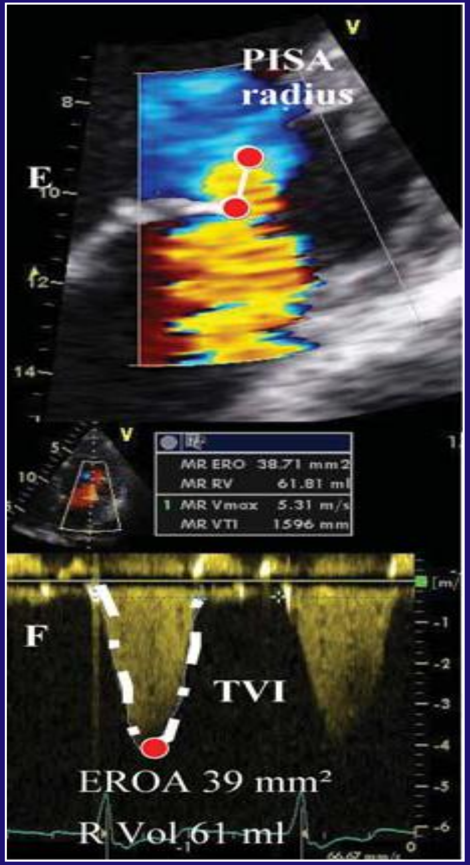
PISA Method

Flow (cc/sec) = 6.28 x [r (cm)]^2 x V_a (cm/sec)

ERO (cm^2) = $\dfrac{\text{Flow (cc/sec)}}{V_{MR}\text{ (cm/sec)}}$

RV (CC) = ERO (cm^2) x TVI_{MR} (cm)





Stepwise analysis of MR:
(A) Apical four-chamber view
(B) colour-flow display
(C) Zoom of the selected zone
(D) Downward shift of zero baseline to obtain an hemispheric PISA
(E) Measure of the PISA radius using the first aliasing
(F) CW Doppler of MR jet allowing calculation the effective regurgitant orifice area (EROA) regurgitant volume (R Vol)

Values for EROA,RV, and RF by PISA Method

	Mild	Moderate		Severe
	Grade I	Grade 2	Grade3	Grade 4
Regurgitation volume ml / beat	<30	30-44	45-59	>60
Regurgitation Fraction %	<30	30-39	40-49	>50
Regurgitation Orifice area cm^2	<0.20	0.20-0.29	0.30-0.39	>0.40

In functional ischemic MR: EROA ≥ 20 mm^2 or a R Vol ≥ 30 mL identifies a subset of patients at increased risk of cardiovascular events.

Severe MR

Specific signs of severity :

- Large central MR jet > $8cm^2$
- MR area / LA area > 40%
- Eccentric wall- impinging jet of any size, swirling in LA
- Vena contracta width > 7mm
- Large flow convergence
- Systolic reversal in pulmonary veins

Supportive signs :

- Dense, triangular CW Doppler MR jet
- E-wave dominant mitral inflow (> 1.2 m/sec)
- Enlarged LV and LA
- (particularly with normal LV function)

Quantitative Parameters:

R Vol (ml / beat) $\geq$ 60 // RF (%) $\geq$ 50 // EROA (cm^2) $\geq$ 0.40

Specific signs of severity :

MILD MR

- Small central jet < $4cm^2$
- MR area / LA area < 20%
- Vena contracta width < 3mm
- No or minimal flow convergence

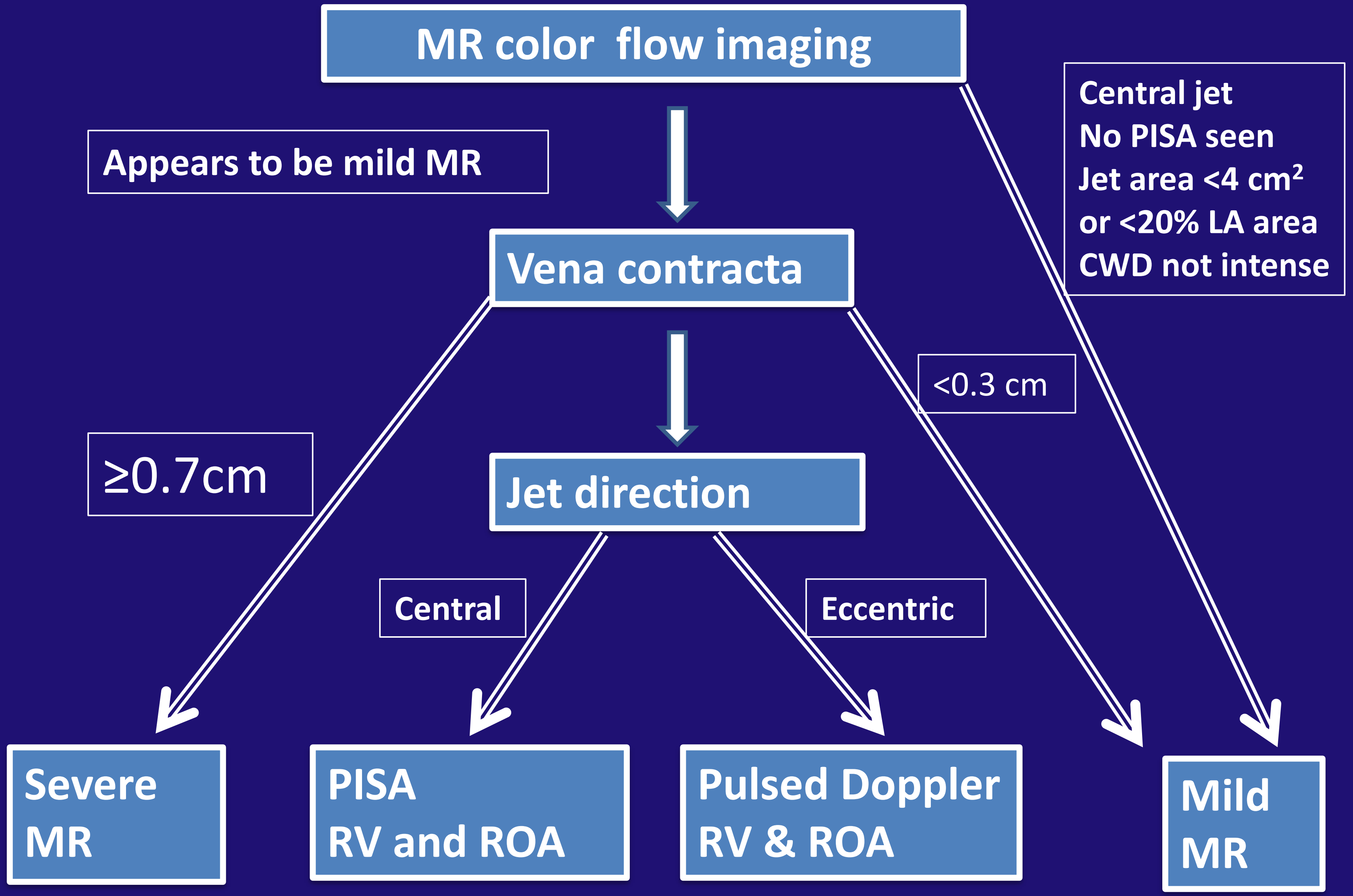
Supportive sings :

- Systolic dominant flow in pulmonary veins
- A – wave dominant mitral Inflow
- Soft density, parabolic CW Doppler MR signal
- Normal LV,LA size

Quantitative Parameters:

R Vol (ml / beat) < 30 / RF (%) < 30 / EROA (cm^2) < 0.20

Summary : approach to quantitaion of MR severity



AORTIC REGURGITATION SEVERITY

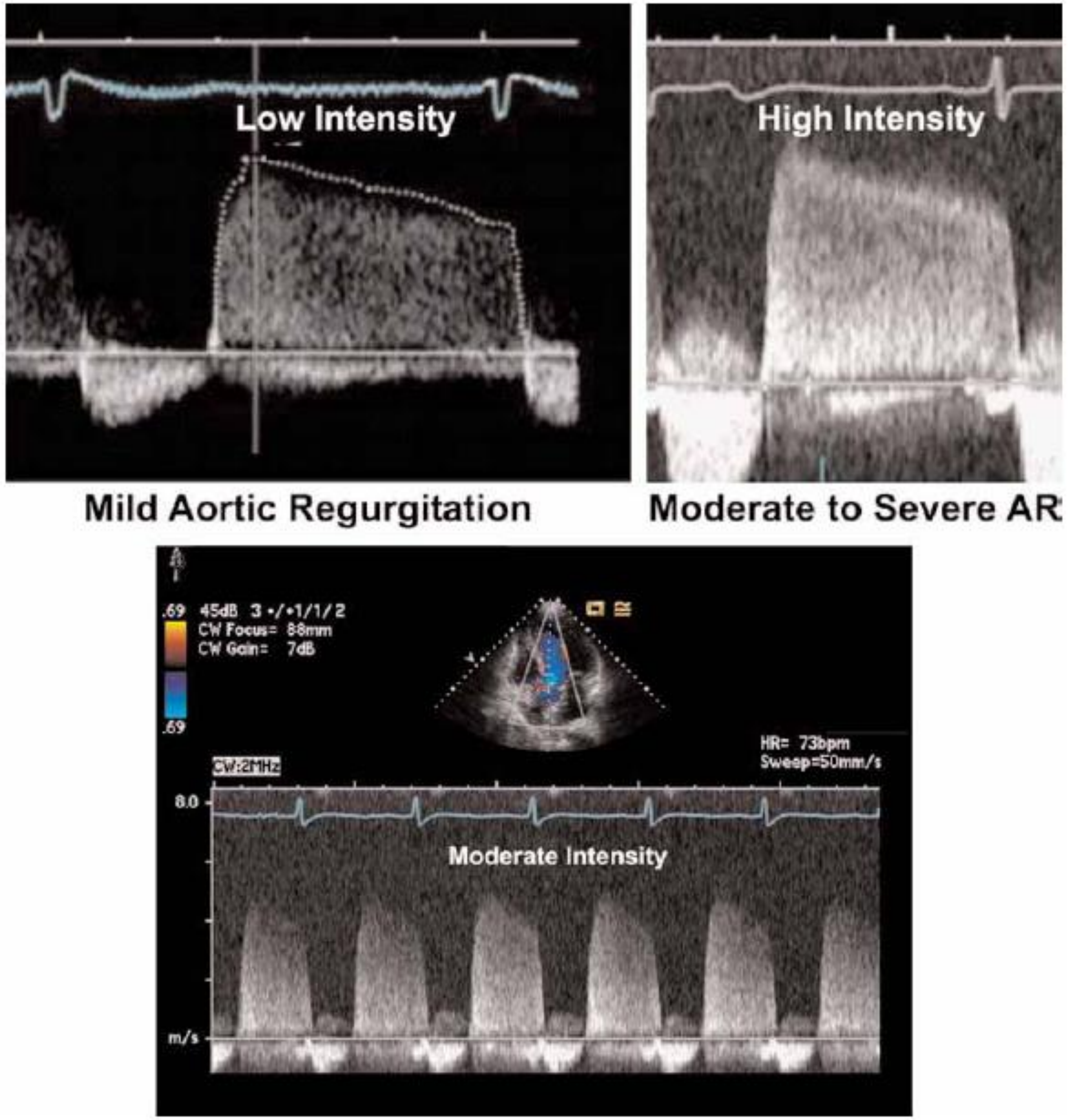
- **1.** Regurgitant **jet width/LVOT diameter** ratio greater than or equal to 60 percent
- **2.** **Vena contracta** greater than 6 mm
- **3.** Regurgitant **jet area/LVOT area** ratio greater than or equal to 60 percent
- **4.** Aortic regurgitation **pressure half-time** less than or equal to 250 ms
- **5.** Holodiastolic **flow reversal** in the descending thoracic or abdominal aorta
- **6.** **Regurgitant volume** greater than or equal to 60 mL
- **7.** **Regurgitant fraction** greater than or equal to 50 percent
- **8.** **Effective regurgitant orifice** greater than or equal to 0.30cm2
- **9.** **Restrictive mitral flow pattern** (usually in acute setting)

- Regurgitant jet height measured as maximal diameter of regurgitant jet just below AV,PLAX view
- LVOT diameter in end diastole

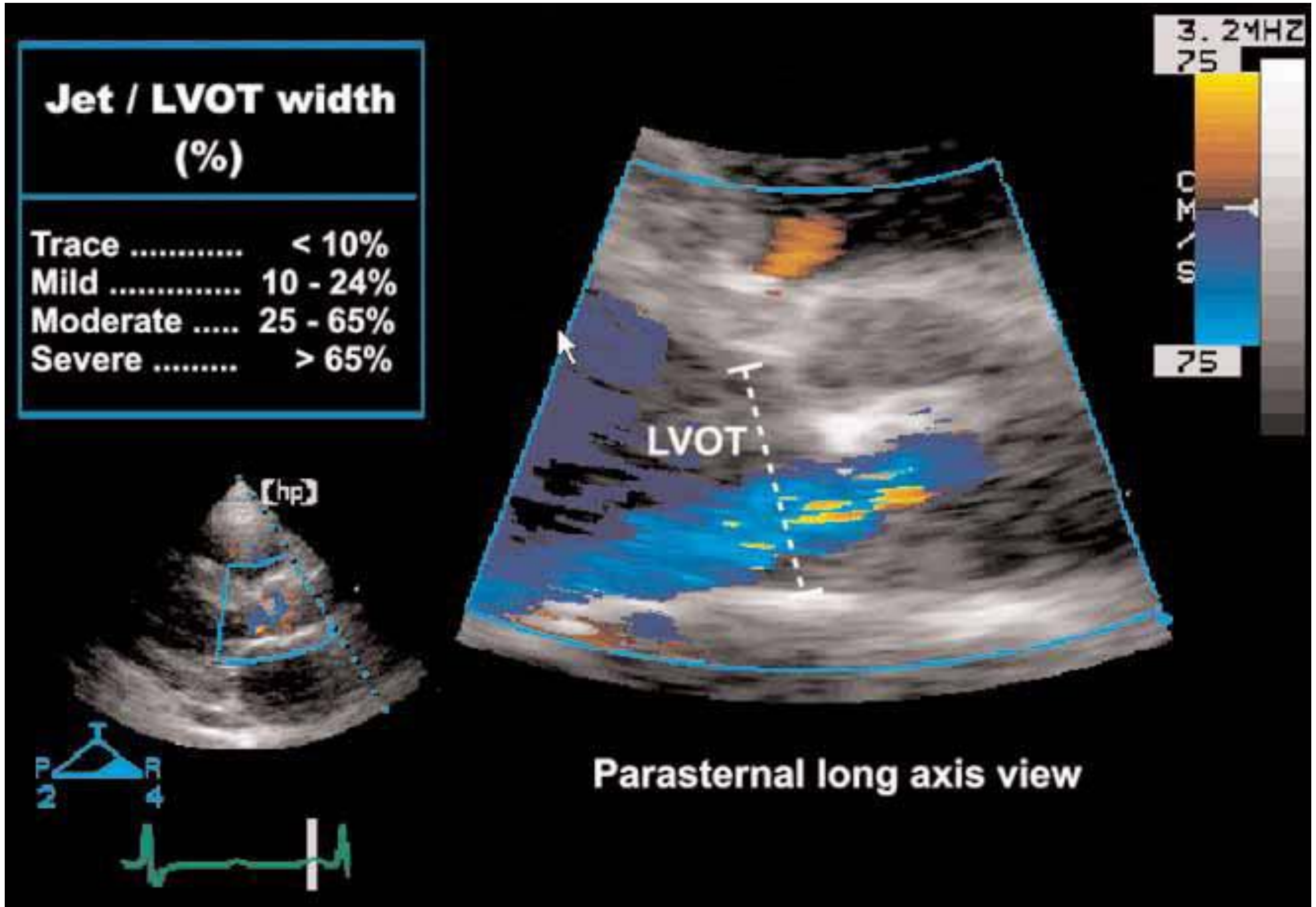
Extent of jet

- *Trivial*—just below aortic leaflets.
- *Mild*—LVOT.
- *Moderate*—AR extends to mitral leaflet level.
- *Severe*—body of the LV.

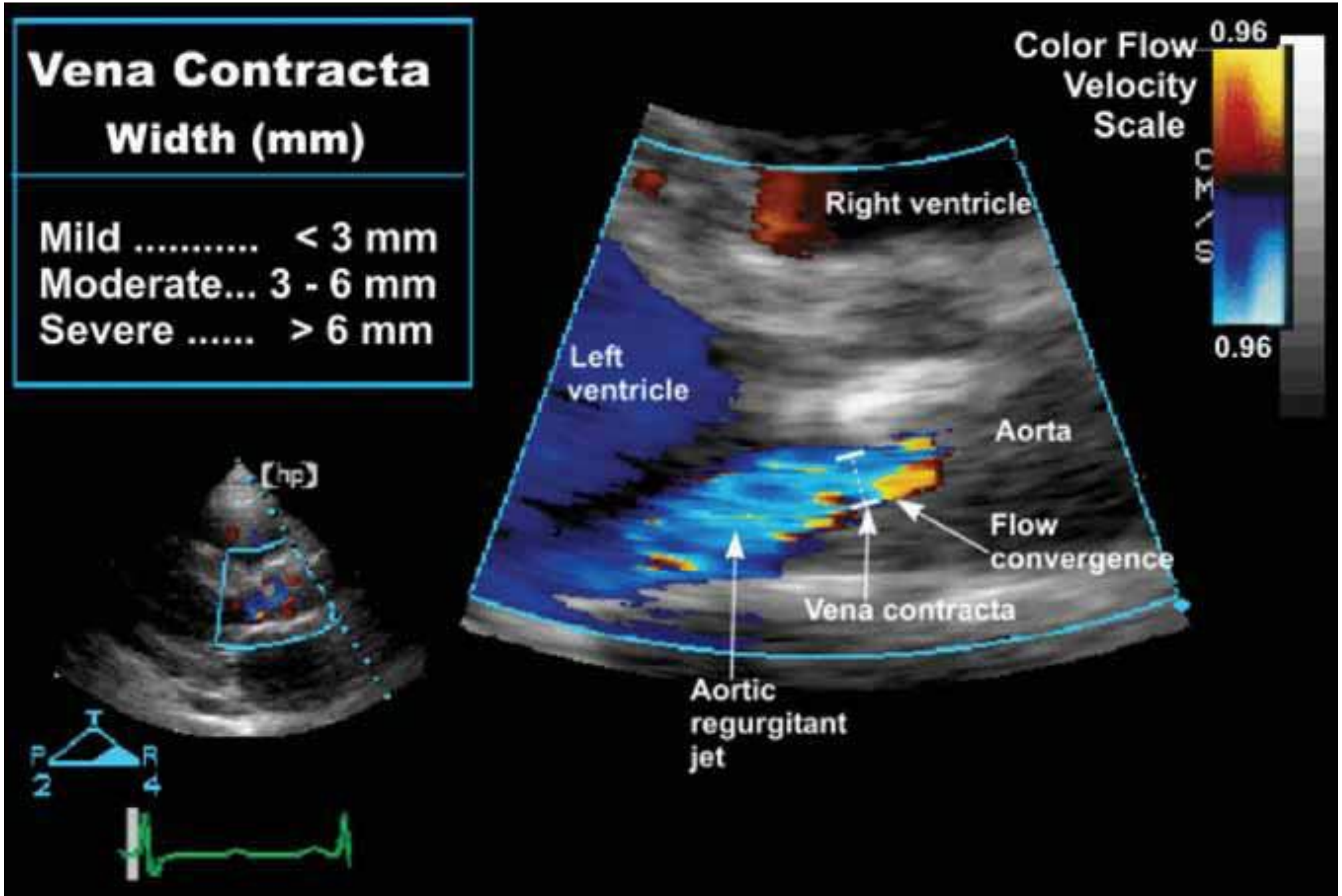
Signal intensity



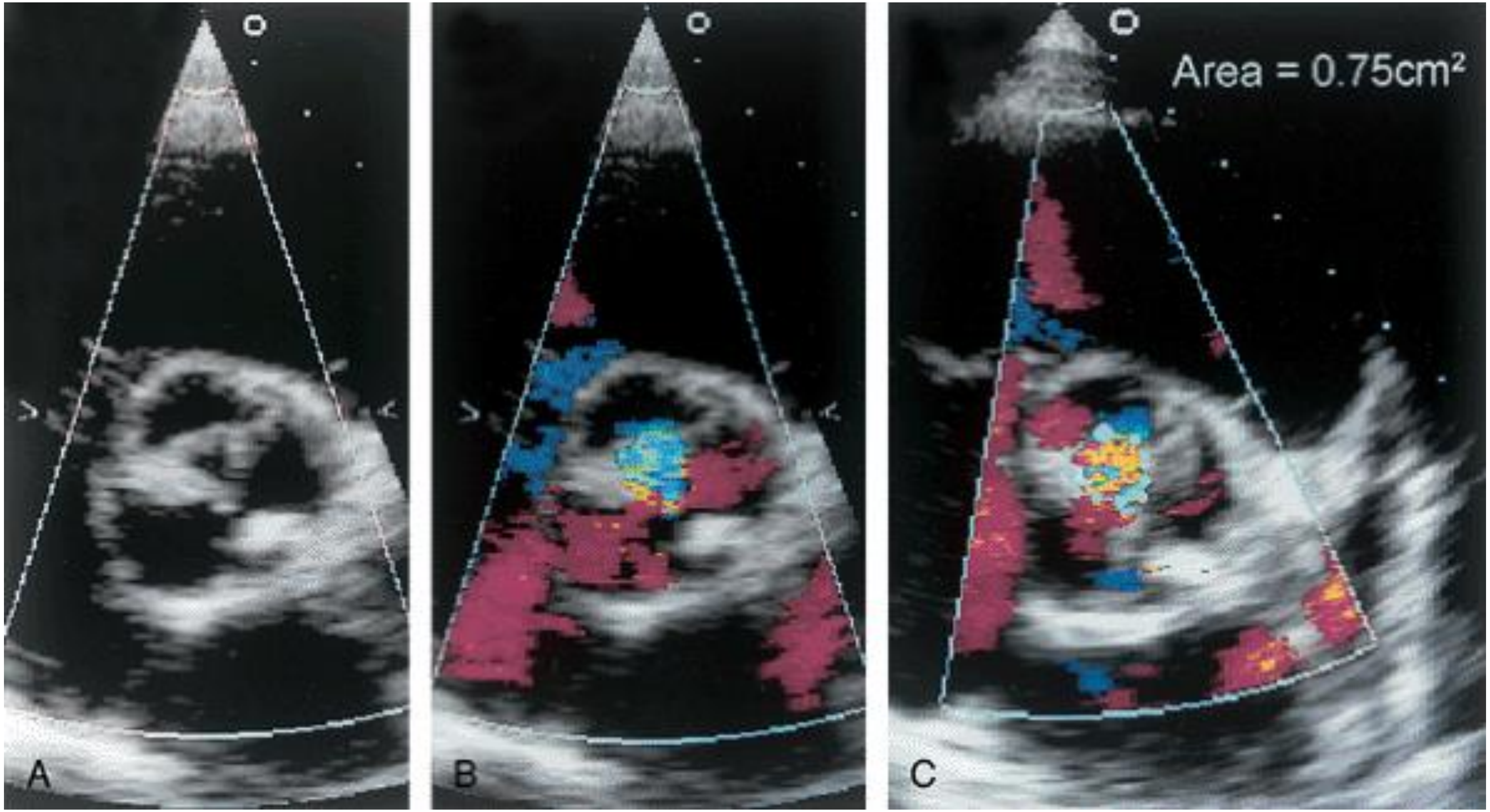
Regurgitant jet width/LVOT diameter ratio greater than or equal to 60 percent



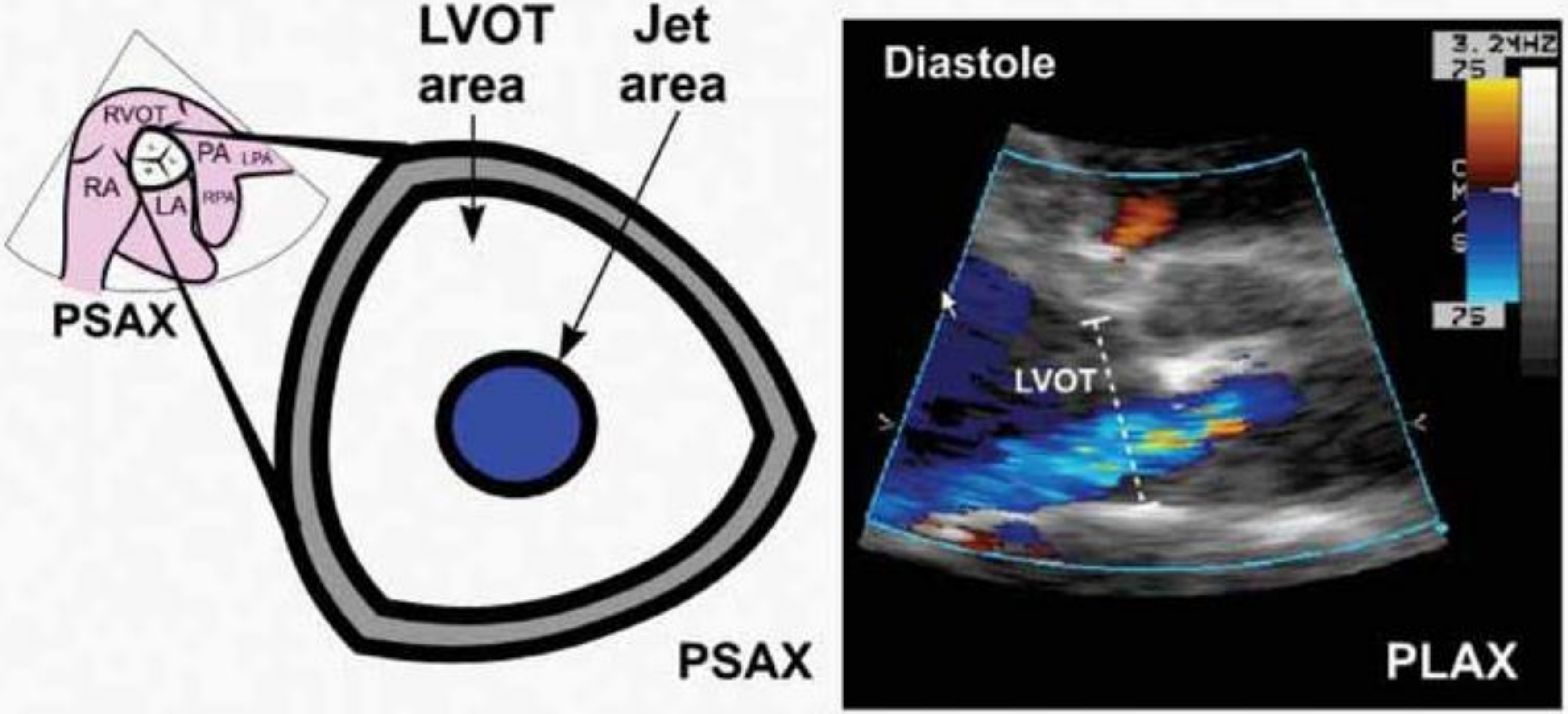
Vena contracta greater than 6 mm



- Regurgitant jet area measured from PSAX view at level of LVOT
- LVOA measured at end diastole at same site
- Ratio calculated



Area = 0.75cm²
A
B
C

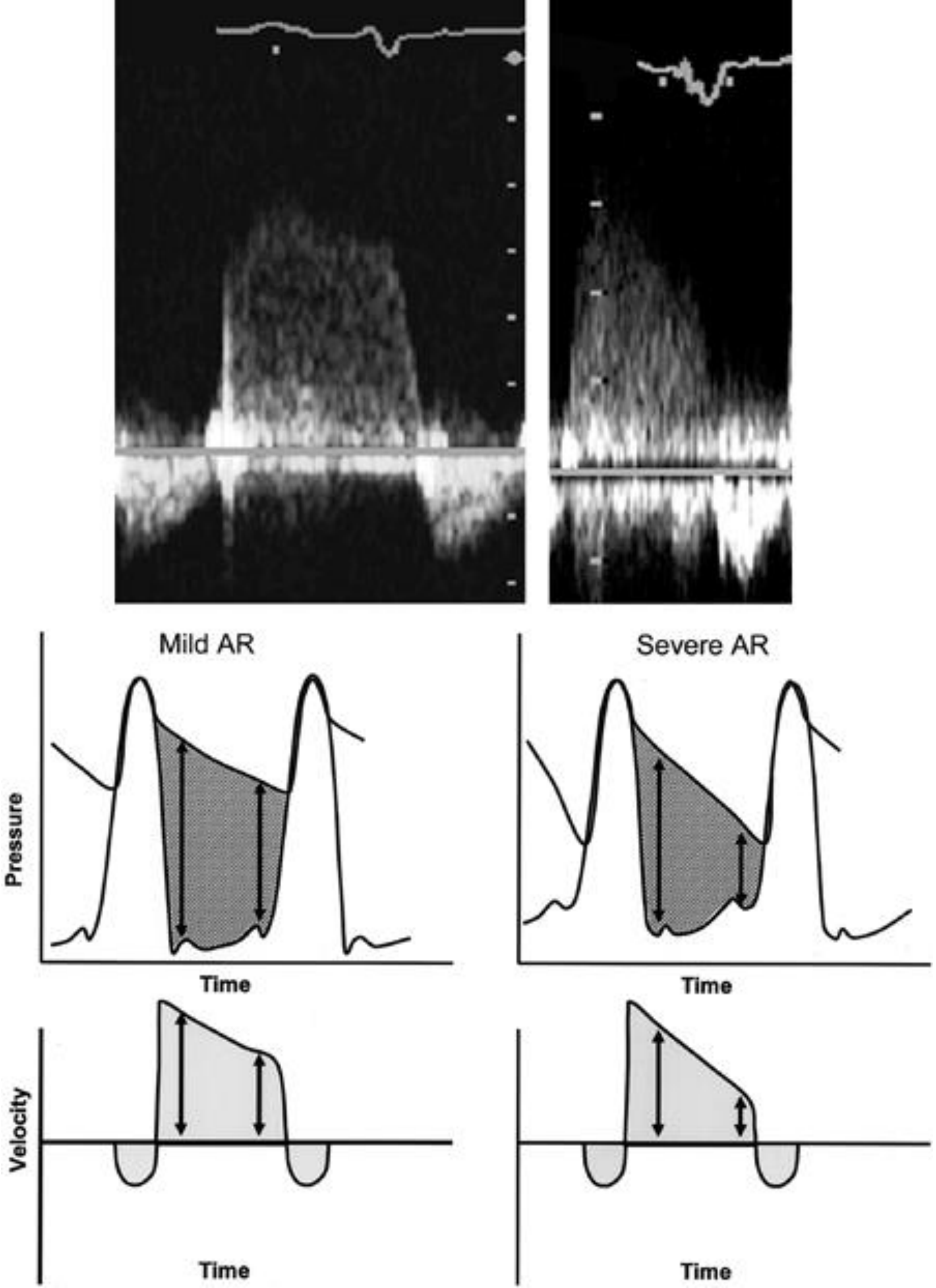


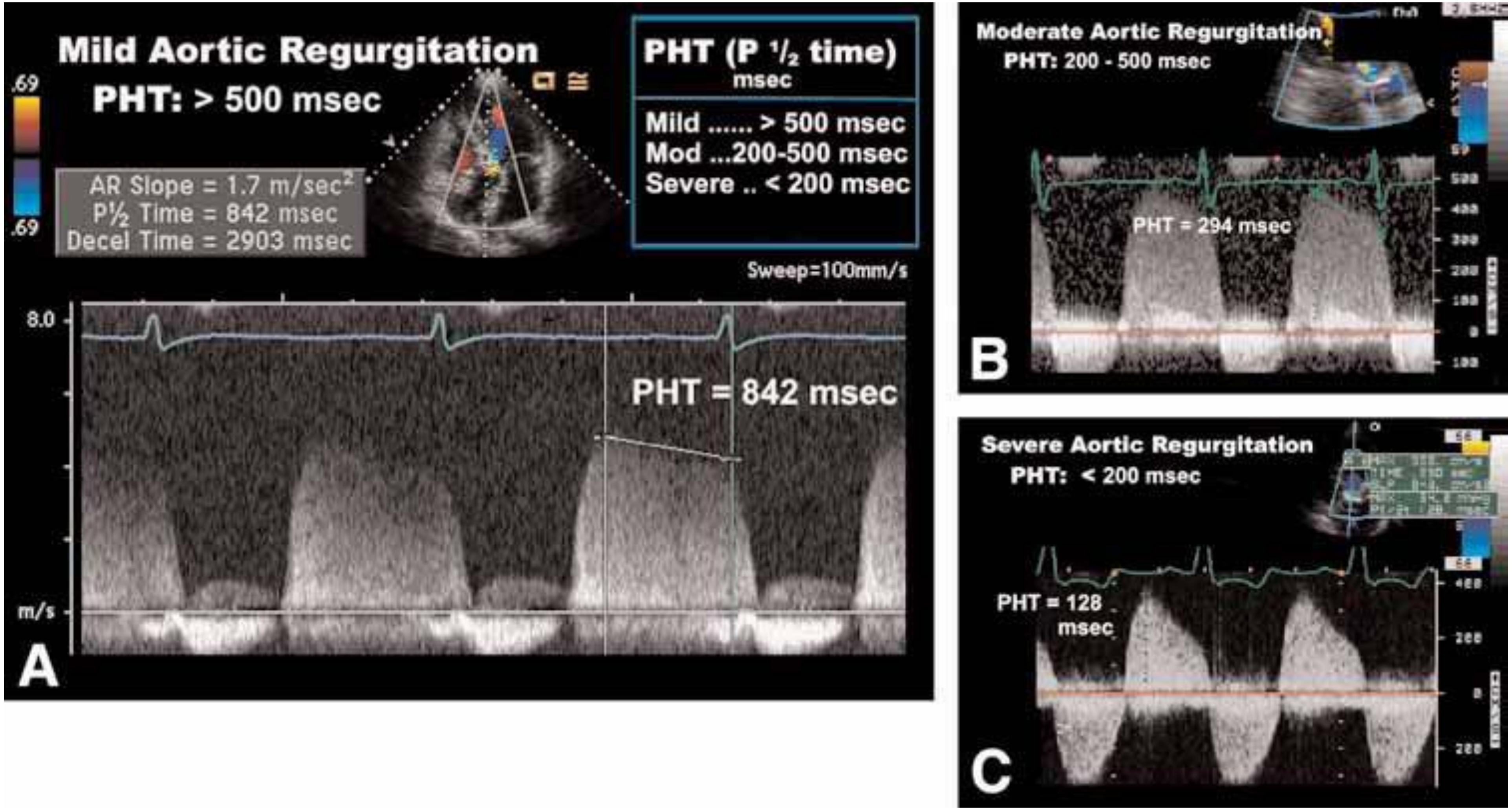
$$\text{Jet / LVOT Area Ratio} = \frac{\text{Jet Area}}{(0.785 \times \text{LVOT diameter})^2}$$

Simplified

Mild < 5%
Moderate 5 – 60%
Severe > 60%

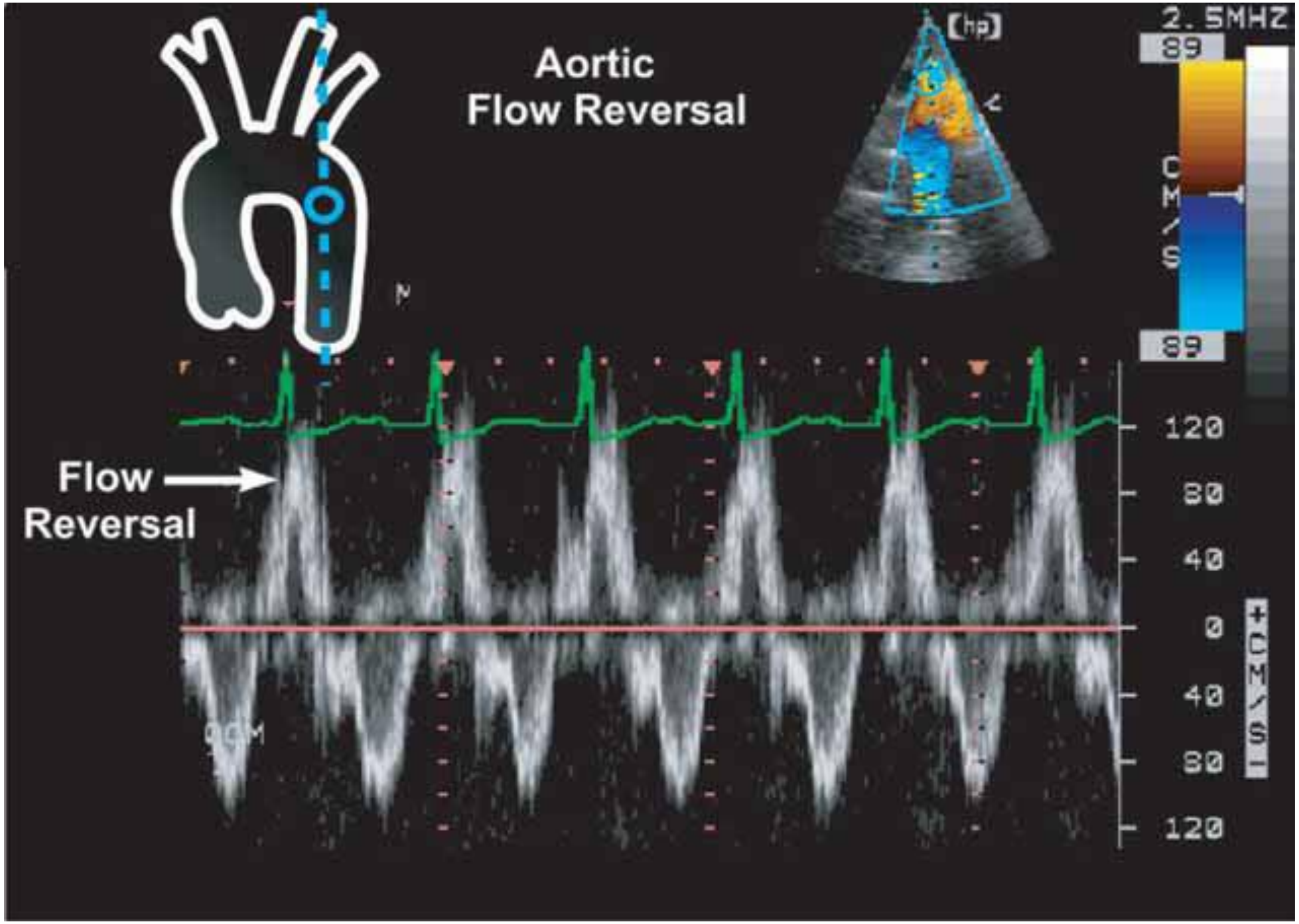
- Regurgitant doppler signal is a function of pressure gradient between aorta and LV
- Mild AR –small increase in LVEDP-gradual decline and flat deceleration slope
- Severe AR –LVEDP rises rapidly-rapid decline


Mild AR
Severe AR
Pressure
Time
Time
Velocity
Time
Time

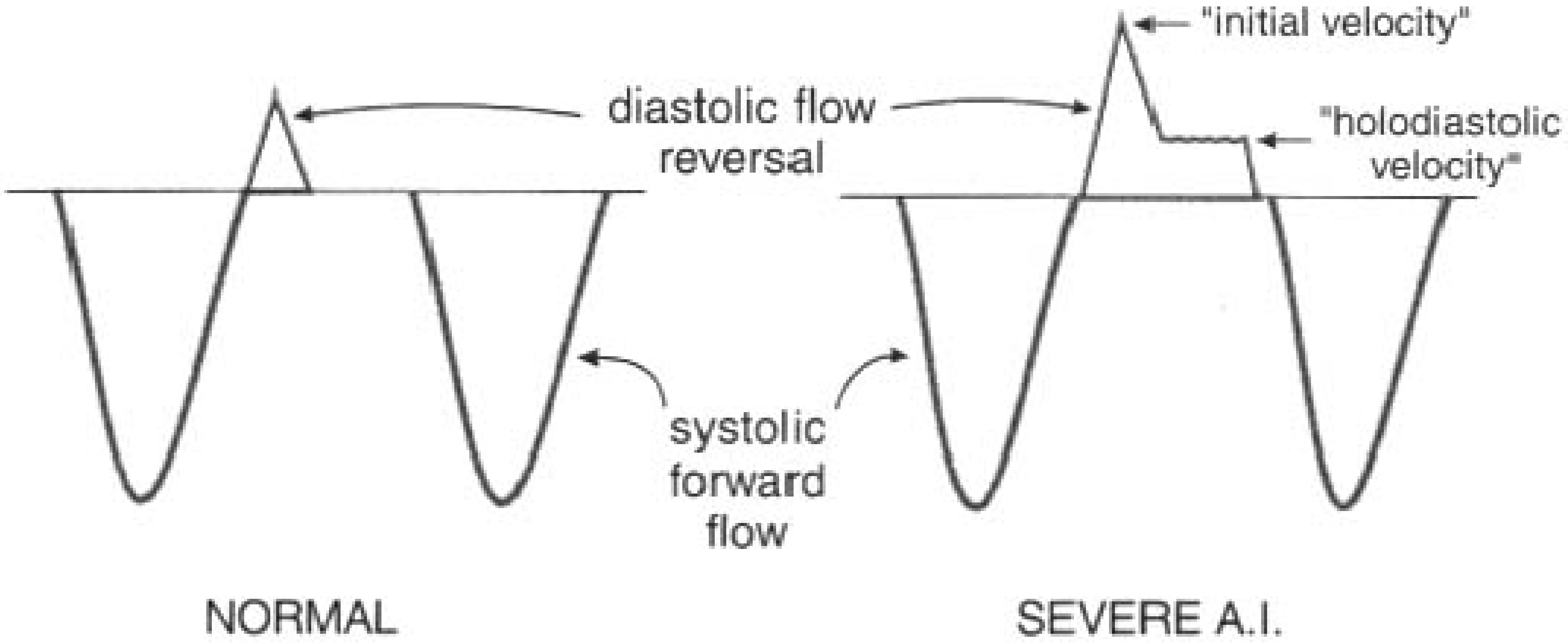


Mild Aortic Regurgitation
PHT: > 500 msec
AR Slope = 1.7 m/sec²
P½ Time = 842 msec
Decel Time = 2903 msec
PHT (P ½ time)
msec
Mild ...... > 500 msec
Mod ...200-500 msec
Severe .. < 200 msec
Sweep=100mm/s
8.0
m/s
PHT = 842 msec
A
Moderate Aortic Regurgitation
PHT: 200 - 500 msec
PHT = 294 msec
B
Severe Aortic Regurgitation
PHT: < 200 msec
PHT = 128
msec
C

- Suprasternal window-descending aortic flow profile
- Short period of low velocity flow reversal-normal
- Pan diastolic flow reversal with end diastolic velocity>20cm/s

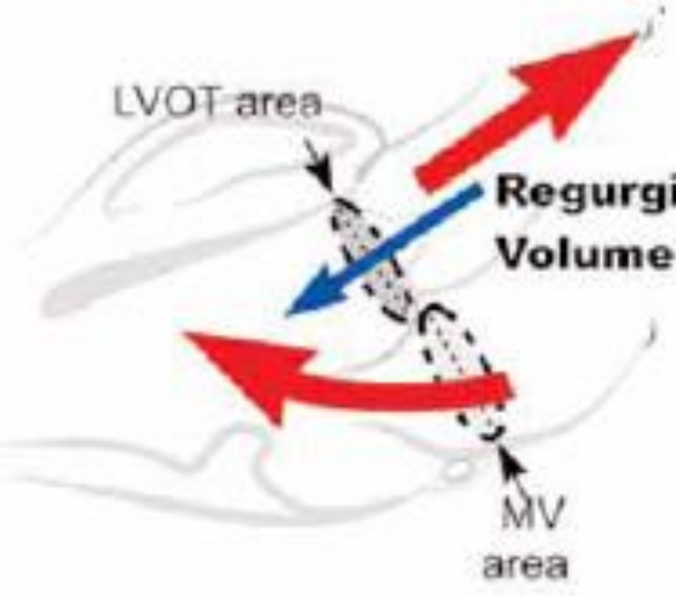


Aortic
Flow Reversal
Flow
Reversal
2.5MHZ
89
CM/S
89
120
80
40
0
40
80
120
+CM/S-

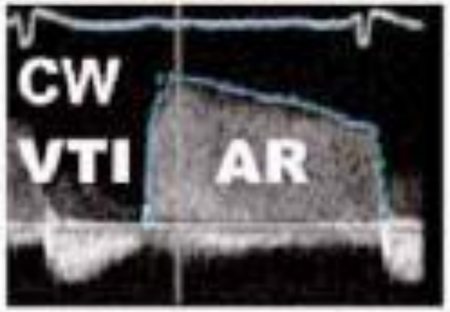

"initial velocity"
diastolic flow
reversal
"holodiastolic
velocity"
systolic
forward
flow
NORMAL
SEVERE A.I.

Calculation of R.Volume and R.fraction

- SV=CSAxVTI
- R.Volume=SV[lvot]-SV[mv]
- RF=R.Volume/SV[lvot]
- ERO=R.Volume/VTI[ARjet]
- R.V>60ml,RF>50%,ERO>0.3cm^2 indicate severe AR



$$\text{Regurgitant Volume (RV)} = SV_{AV} - SV_{MV}$$

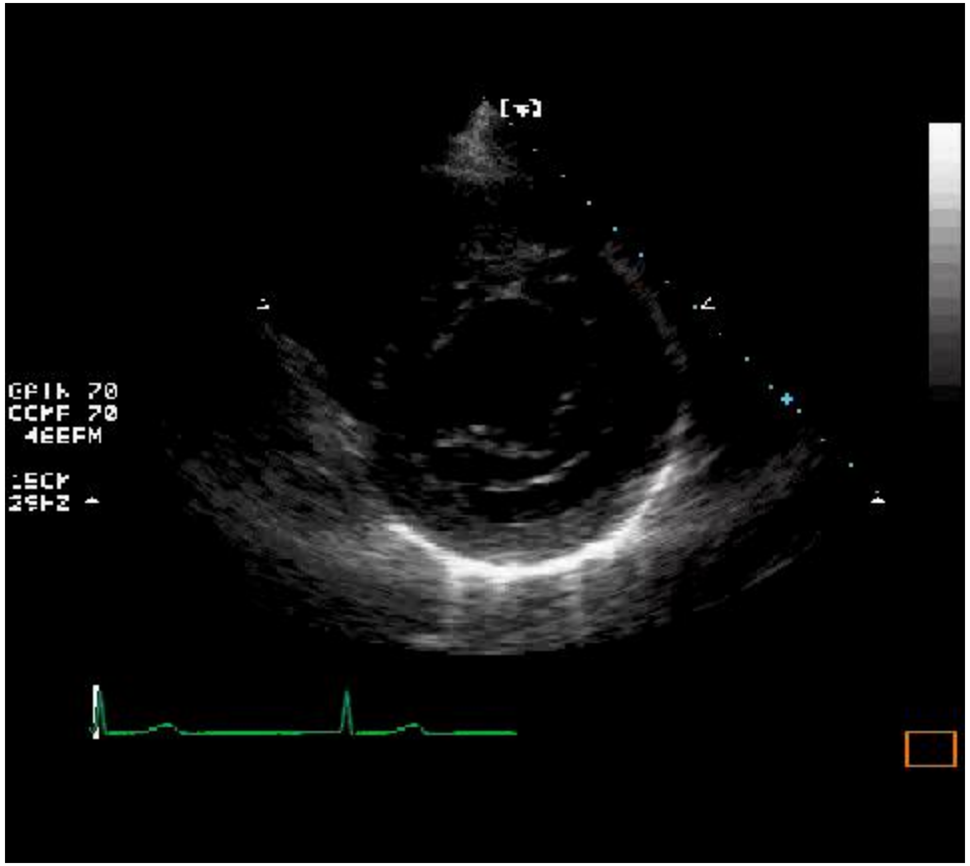


$$\text{Effective Regurgitant Orifice Area (EROA)} = \frac{\text{Regurgitant Volume}}{VTI_{AR\ CW\ Doppler}}$$

Regurgitation Severity (by EROA) mm^2

Mild	$< 0.10\ cm^2$
Moderate	$0.10 - 0.19\ cm^2$
Moderate - Severe	$0.20 - 0.29\ cm^2$
Severe	$> 0.30\ cm^2$

Restrictive mitral flow pattern



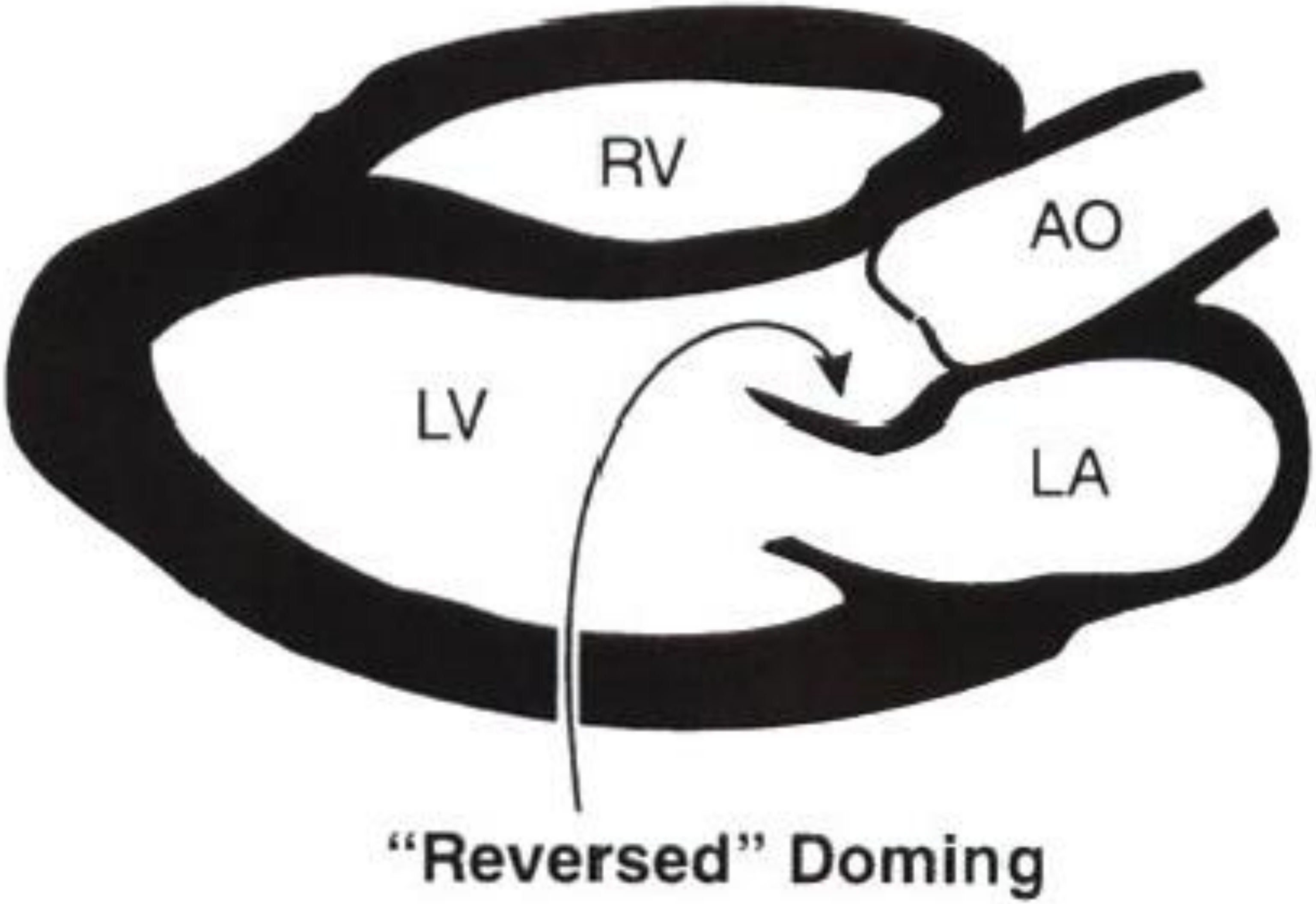
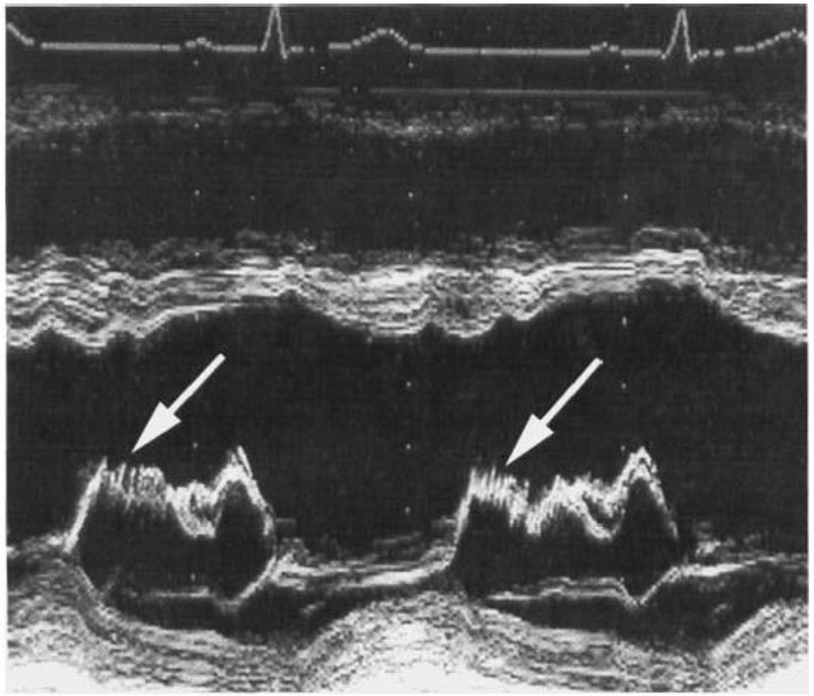


Fig. 7.26 Diagram of a 2-D image of a patient with AR. The regurgitant jet strikes the anterior leaflet of the mitral valve, not allowing it to open fully, giving the appearance of "*reversed doming.*"


(a)

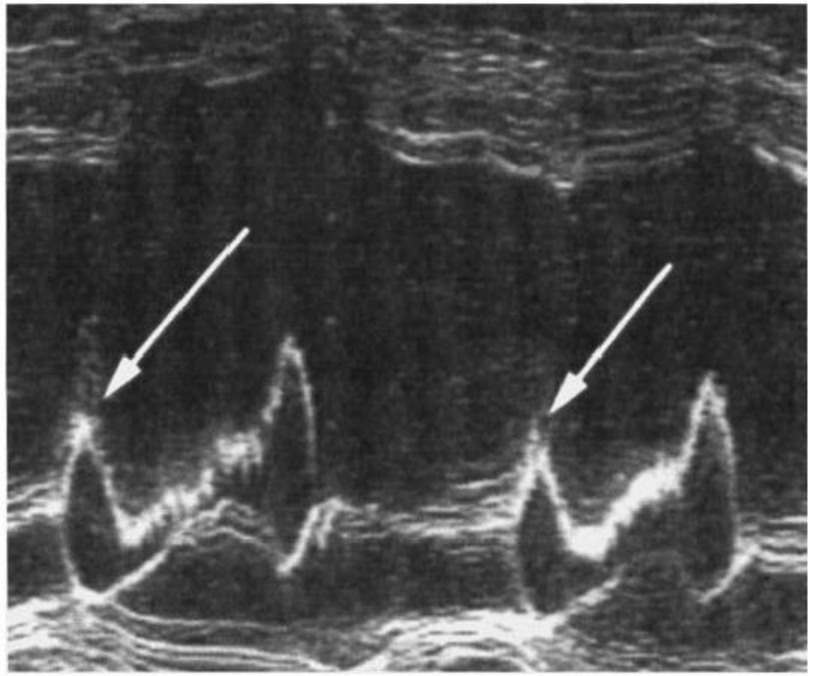

(b)

Fig. 7.25 Depressed E wave (arrows) noted by M-mode of the mitral valve (a & b) in two different patients with severe AR. Diastolic fluttering is also noted on the mitral valve leaflet.

	MILD	MODERATE	SEVERE
Jet width/LVOT diameter	<25%		>/=65%
Vena contracta	<3mm		>/=6mm
Jet area/LVOT area	<5%		>60%
PHT	>500 ms		</= 250ms
Holodiastolic flow reversal			present

	MILD	MODERATE	SEVERE
Reg vol	< 30 ml		>/= 60 ml
Reg fraction	< 30 %		>/= 50%
ERO	< 0.1 cm^2		>/= 0.3 cm^2
Mitral inflow restriction			Present

Thank you

ACUTE VS CHRONIC

- Shape of the envelope CW doppler
- Rate of deceleration of flow
- Premature mitral valve closure
- Endocarditis,dissection
- Normal lv dimensions

Table 1
Etiology of Aortic Regurgitation

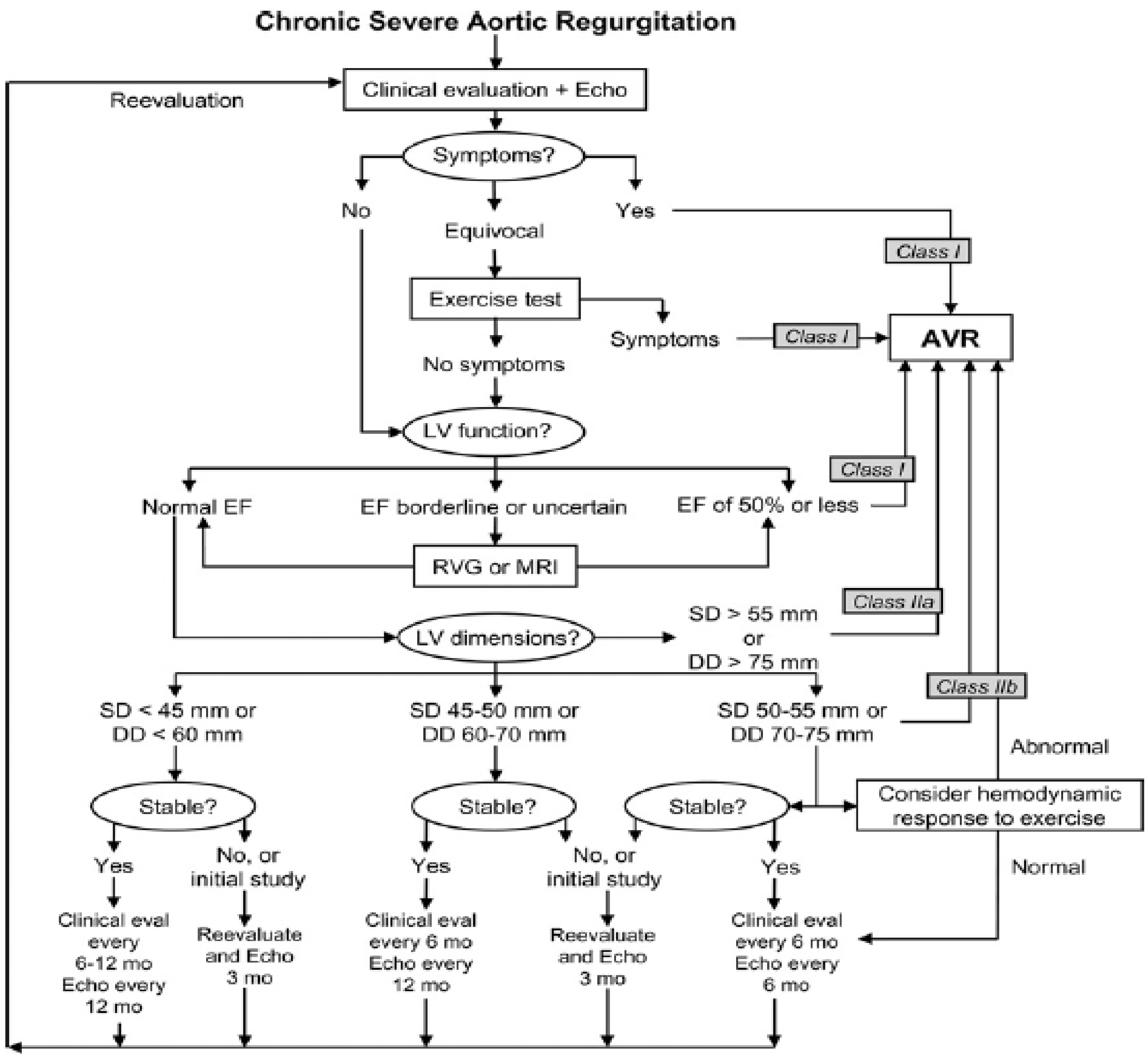
Diseases involving the aortic cusps (leaflets)

- Senile calcific degeneration
- Bicuspid aortic valves
- Rheumatic valvular heart disease
- Endocarditis

Diseases involving the aortic root

- Hypertension
- Bicuspid aortic valve complex
- Collagen disorders, e.g., Marfan and Ehlers Danlos syndromes
- Aortic dissection (Type A)
- Trauma
- Aortitis (vasculitic, infectious)
- Ventricular septal defect

- LV chamber dimensions
- LV systolic function
- Aortic root dilatation

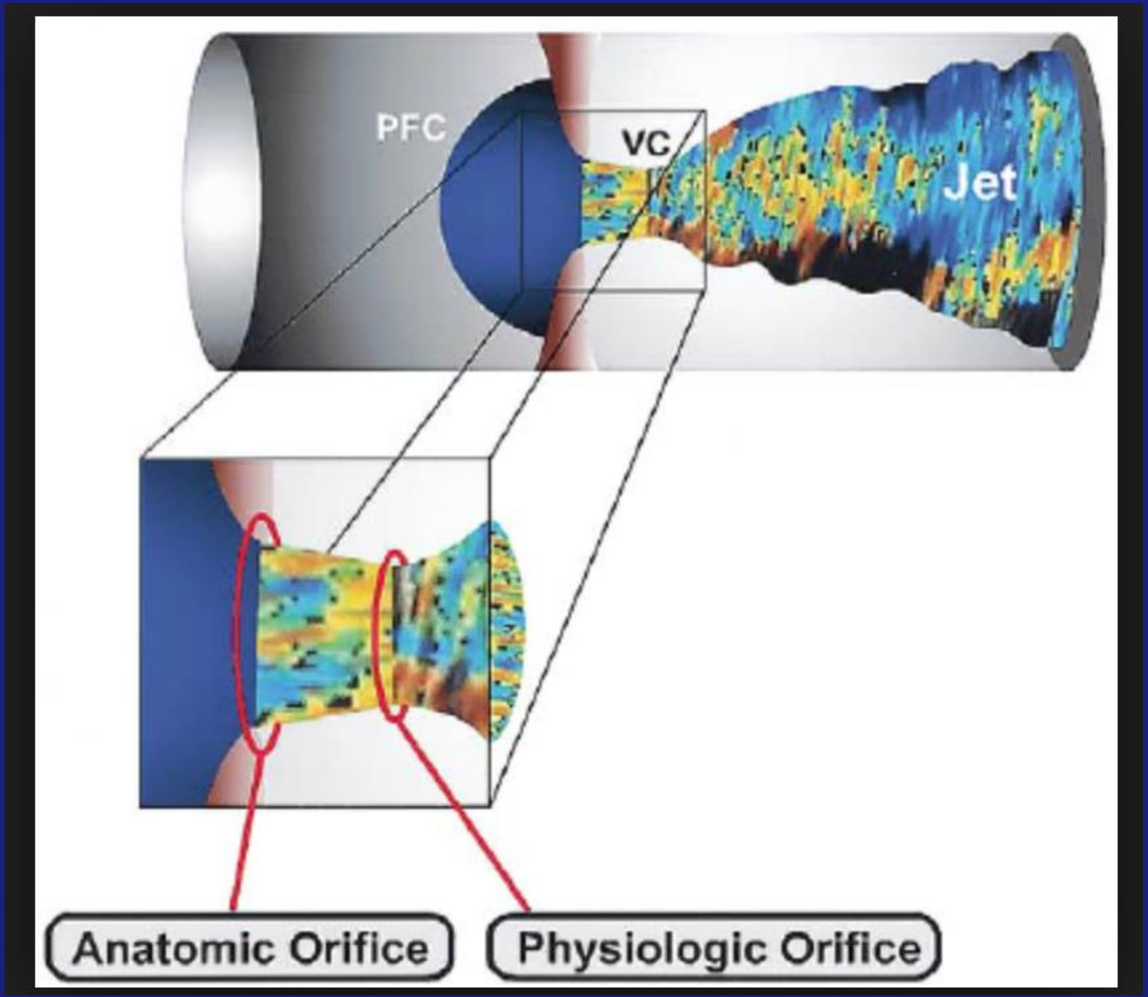


Chronic Severe Aortic Regurgitation
Clinical evaluation + Echo
Reevaluation
Symptoms?
No
Equivocal
Yes
Class I
Exercise test
Symptoms
Class I
AVR
No symptoms
LV function?
Class I
Normal EF
EF borderline or uncertain
EF of 50% or less
RVG or MRI
Class IIa
LV dimensions?
SD > 55 mm or DD > 75 mm
Class IIb
SD < 45 mm or DD < 60 mm
SD 45-50 mm or DD 60-70 mm
SD 50-55 mm or DD 70-75 mm
Abnormal
Stable?
Stable?
Stable?
Consider hemodynamic response to exercise
Yes
No, or initial study
Yes
No, or initial study
Yes
Normal
Clinical eval every 6-12 mo Echo every 12 mo
Reevaluate and Echo 3 mo
Clinical eval every 6 mo Echo every 12 mo
Reevaluate and Echo 3 mo
Clinical eval every 6 mo Echo every 6 mo

Fluids dynamics of valvular regurgitation

Characterized by:

Regurgitant orifice area (ROA)
High velocity regurgitant jet
Proximal flow convergence region
Downstream flow disturbance
Increased antegrade flow volume



Factors that affect regurgitant jet size and shape

Physiological:
Regurgitant volume
Driving pressure
Size and shape of regurgitant orifice
Receiving chamber constraints
Wall impingement
Timing relative to cardiac cycle
Influence of coexisting jets or flow streams

Technical:
Ultrasound gain, PRF, transducer frequency, frame rate, image plane, depth, signal strength

Echo Assessment of AR

2D assessment: Leaflet motion – is there prolapse? Anything extra attached to the valve (vegetation), degree of calcification.

Aortic root and dimensions

LV dimensions

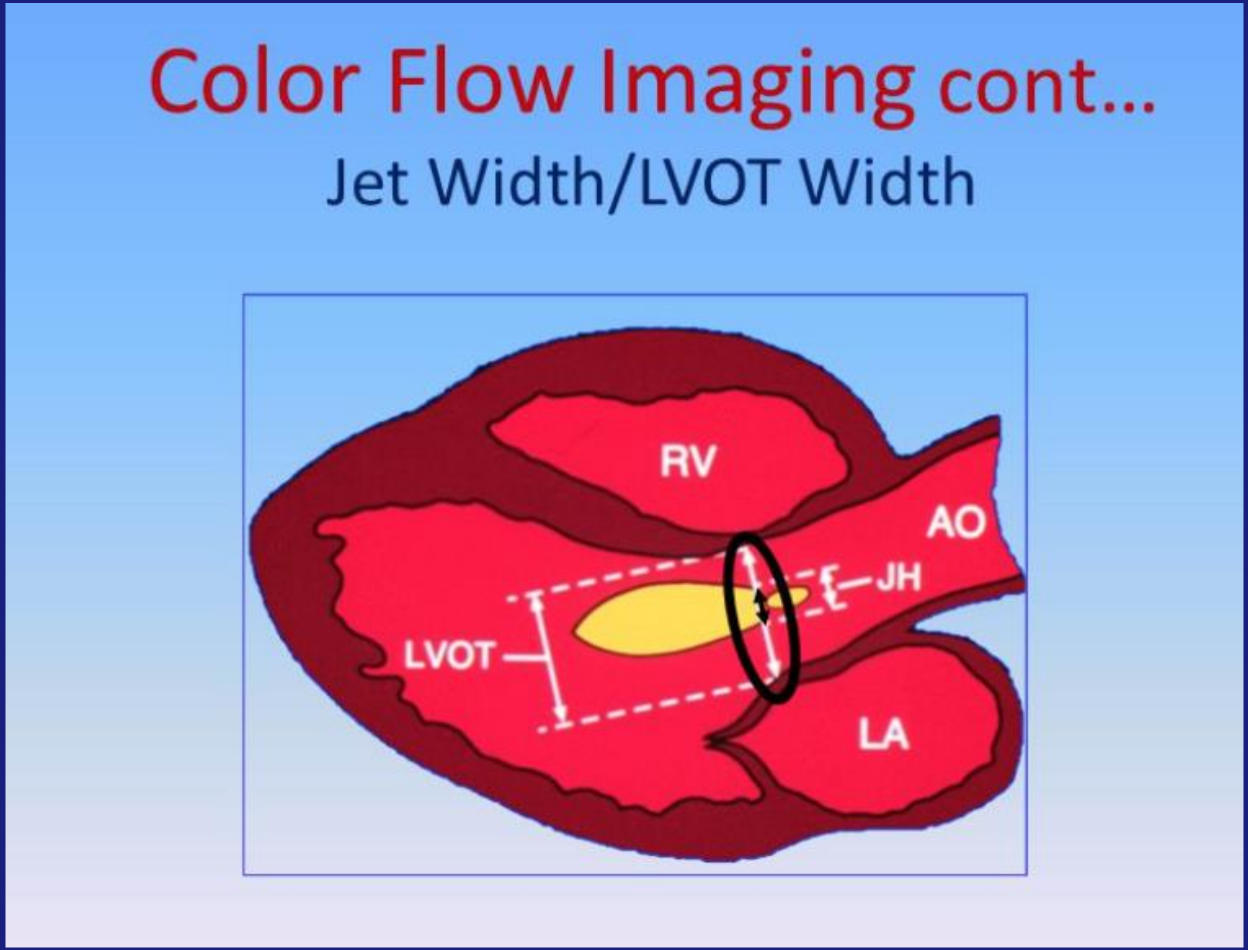
LV function

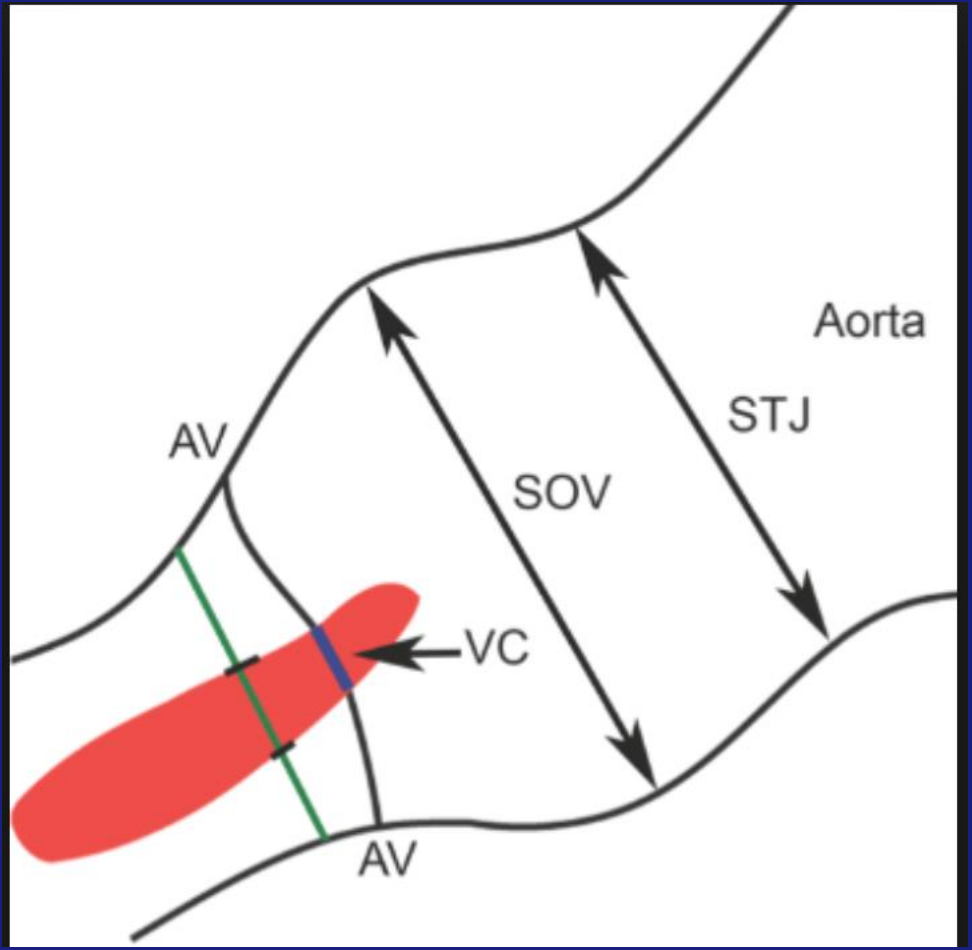
Doppler Assessment: Color-flow imaging

CW Doppler

Method	Doppler Parameters	Limitations	Invasive Analog
Color flow imaging	Jet origin Jet direction Jet size	Variation with technical and physiologic factors	Angiography
CW Doppler	Signal intensity Shape of velocity curve	Qualitative	Hemodynamics
Vena contracta width	Width of jet origin	Small values, careful measurement needed	None
Proximal isovelocity surface area (PISA)	Calculation of RV and ROA	Less accurate with eccentric jets Peak values only	None
Volume flow at two sites	Calculation of RV and ROA	Tedious	Invasive RV and RF
Distal flow reversals	Pulmonary vein (MR) or aorta (AR)	Qualitative, affected by LA pressure, AF (MR)	None

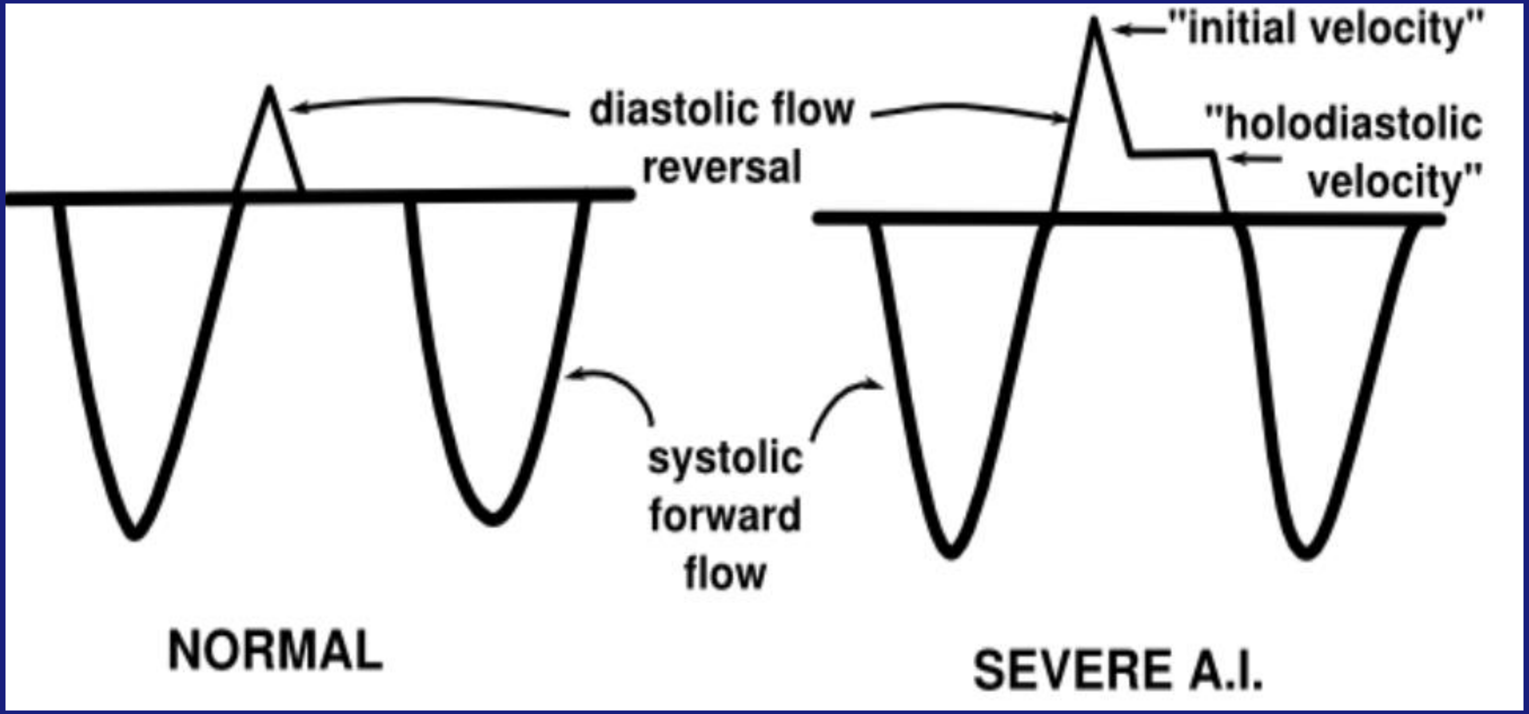
Color Flow ratio in LVOT

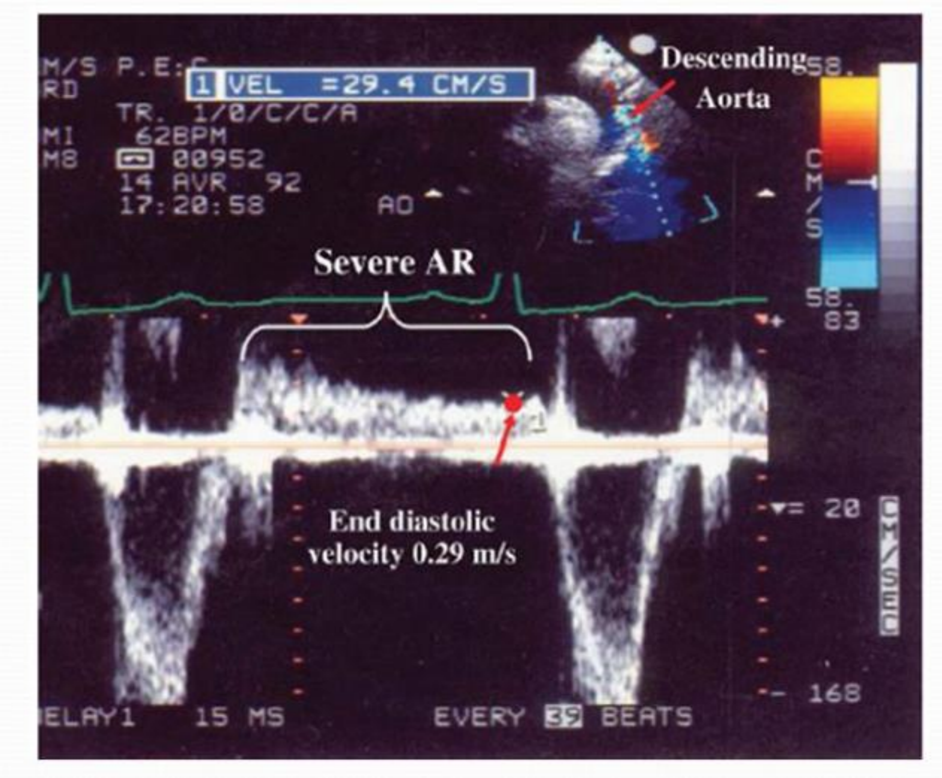




MILD < 25%
SEVERE > 65%

Diastolic flow reversal in the descending aorta





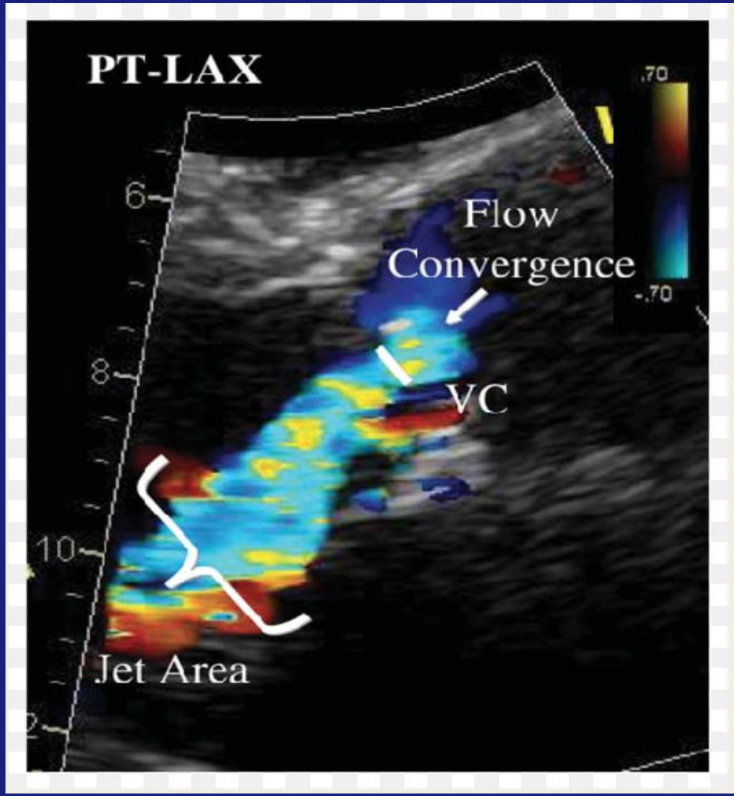
DOPPLER VENA CONTRACTA

Narrowest diameter of the regurgitant flow stream.

Identify all 3 components of the regurgitant jet, measure only the high velocity color width, not the lower velocity that is drawn to the regurgitant jet stream.

Measure in PLX or PSX(zoomed).

MILD < 0.3CM
SEVERE >0.6CM



OTHERS:

Pressure half-time

Time it takes for the pressure difference between the aorta and LV to decrease by one-half during diastole.
PHT < 200ms (SEVERE), PHT > 500ms (MILD)

The intensity/density of the doppler signal of the regurgitant doppler profile is also a qualitative sign of the amount of AR.

Influenced by LV compliance, LV filling pressure, presence of significant MR, and chronicity of AR.

QUANTITATIVE METHODS

REGURGITANT VOLUME

REGURGITANT FRACTION

REGURGITANT ORIFICE AREA

REGURGITANT VOLUME

Blood that regurgitates across the valve per beat.

Calculated by 3 methods

(1)Difference between tranaortic and transmitral volume measured by PW Doppler. Transaortic volume is SV (forward and regurgitant volumes) and transmitral volume is SV(forward only)

SV total = CSA(LVOT) x VTI(LVOT)

SV forward – CSA(mitral annulus) x VTI (mitral annulus)

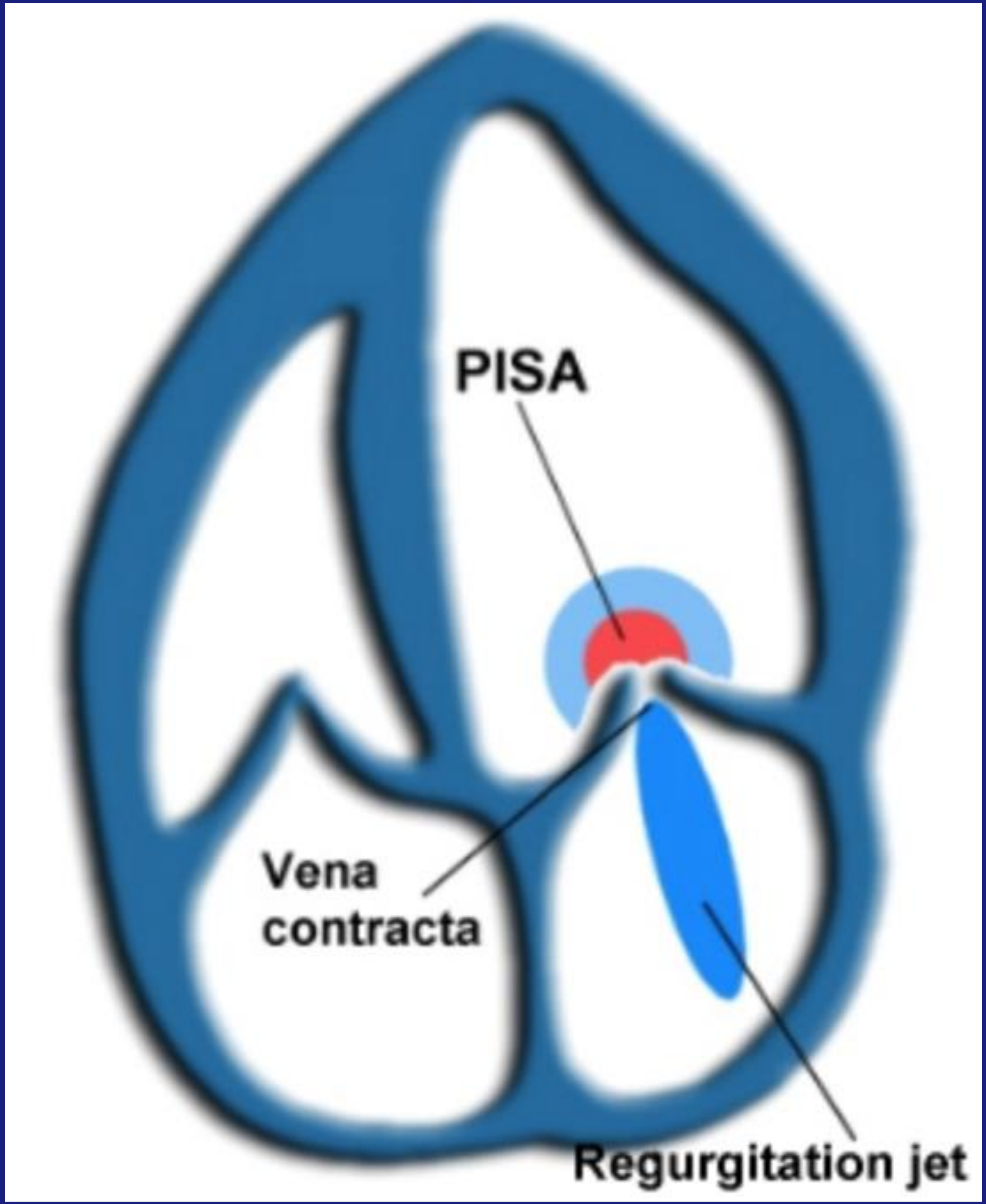
RV = SV total – SV forward

Measure of severity of AR

	MILD	MODERATE	SEVERE
JET WIDTH	SMALL	INTERMEDIATE	LARGE
JET DENSITY	INCOMPLETE /FAINT	DENSE	DENSE
PHT	> 500	200-500	< 200
DIASTOLIC FLOW	BRIEF	INTERMEDIATE	PROMINENT

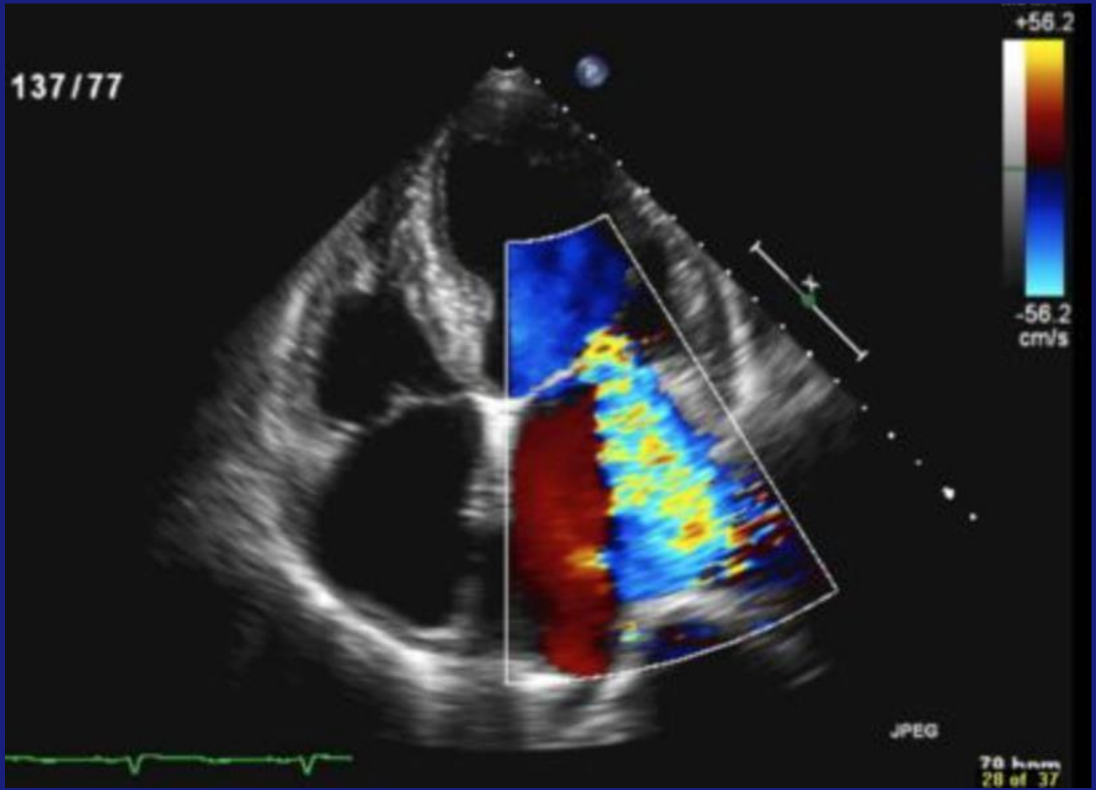
	MILD	MODERATE	MODERATE	SEVERE
VC Width	<0.3	0.3-0.6	0.3-0.6	>0.6
Jet width/LVOT	<25%	25-45	45-64	>65%
RV	<30ml	30-44ml	44-59ml	>60ml
RF	<30%	30-44	44-59	>60%
EROA	<0.10	0.10-0.19	0.20-0.29	>0.3

MITRAL REGURGITATION

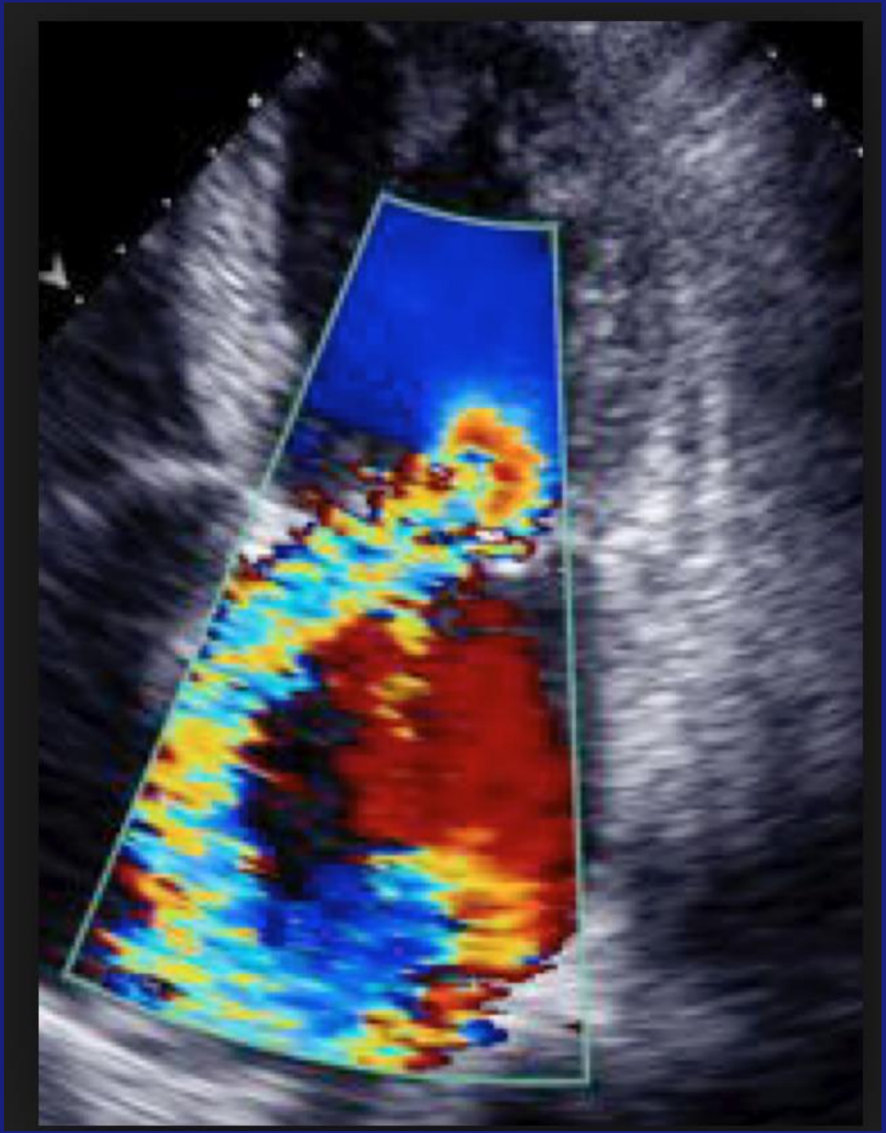


EVALUATION OF ALL COMPONENTS OF MITRAL VALVE APPARATUS

- 2D
- COLOR FLOW DOPPLER
- PW AND CW DOPPLER



MR : Central and eccentric jet



INDIRECT MEASURES:

- The density of the MR jet (dense) and the shape of the MR jet (early peaking)
- Systolic flow reversal seen in the pulmonary veins
- Pulmonary pressures are invariably increase in chronic MR
- Doppler LV filling has a high “E” wave velocity (>120)

QUANTITATIVE METHOD

Regurgitant volume:

The volume of blood that regurgitate across the valve per beat

Difference between transaortic and transmitral volume flow
Volume transaortic = CSA(LVOT) x VTI(LVOT)
Volume transmitral = CSA(mitral annulus) x VTI(mitral annulus)
RV = Volume transmitral – volume transaortic

Assessment of MR Severity

	MILD	MODERATE	SEVERE
SPECIFIC SIGN	Small jet central < 4cm2, < 20% of LA	Signs more than mild but less than severe	VC > 0.7cm, large central jet, large flow convergence, systolic flow reversal
SUPPORTIVE SIGN	Systolic dominant flow in PV, A wave dominant mitral inflow, parabolic CW tracing	Intermediate	Dense, triangular CW Doppler profile, E wave dominant, enlarged LV and LA

QUANTITATIVE PARAMETER

	MILD	MODERATE	MODERATE	SEVERE
RVOL	< 30	30-44	45-59	>60
RF	<30	30-39	40-49	>50
EROA	<0.2	0.2-0.29	0.3-0.39	>0.4

Thank you very much and good luck