SNS COLLEGE OF ALLIED HEALTH SCIENCES
SNS Kalvi Nagar, Coimbatore - 35
Affiliated to Dr MGR Medical University, Chennai

DEPARTMENT OF CARDIAC TECHNOLOGY-III YEAR

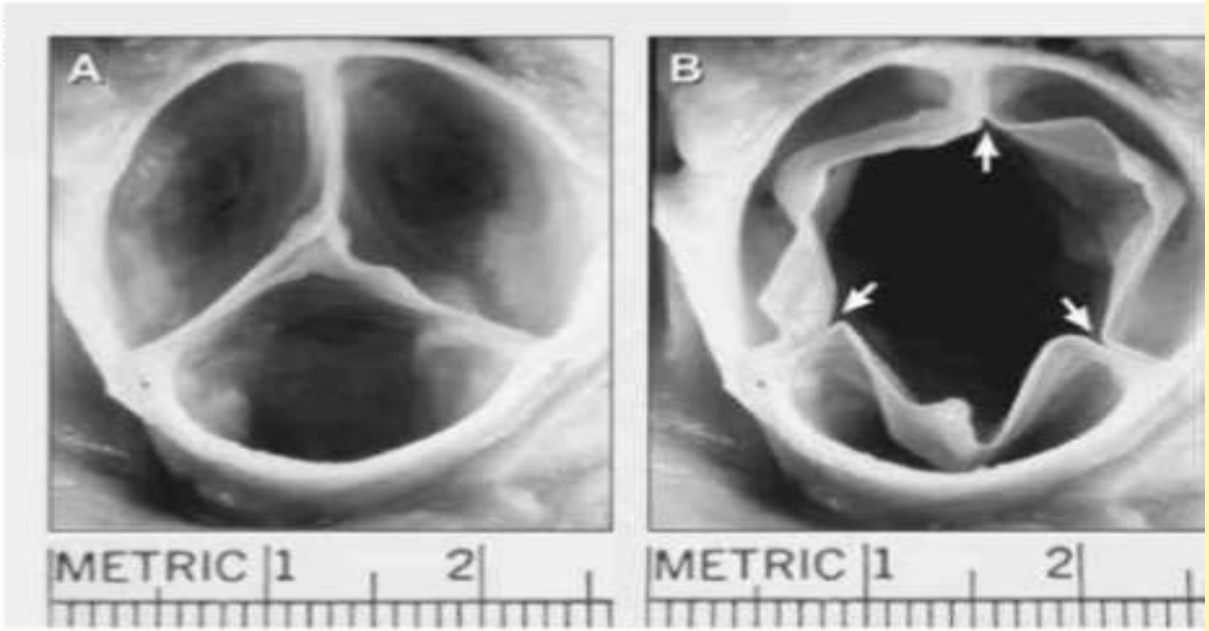
PAPER III- ECHOCARDIOGRAPHY

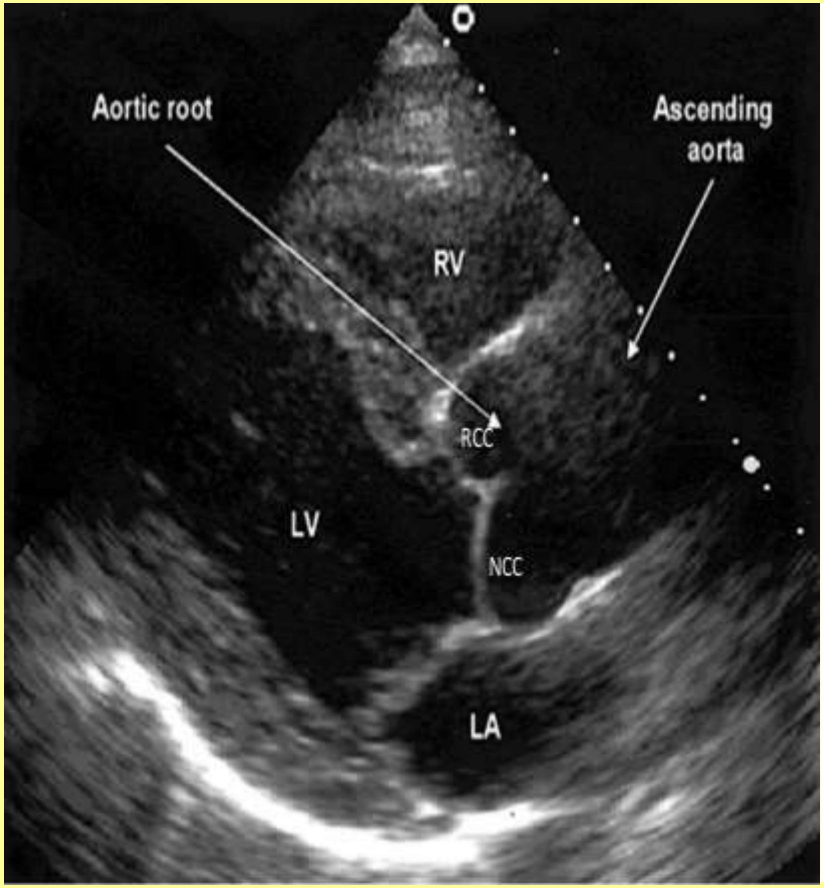
UNIT III : VALVULAR HEART DISEASES - AR

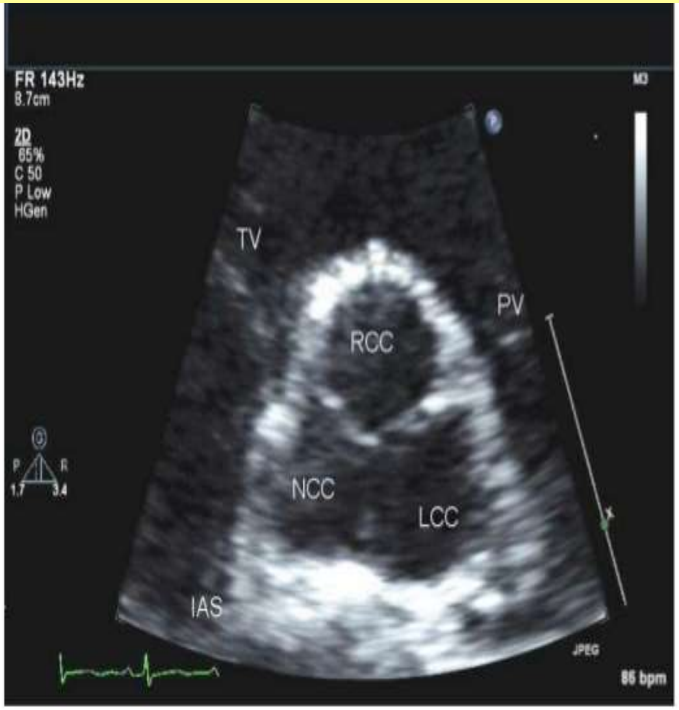
AORTIC REGURGITATION

Aortic valve anatomy

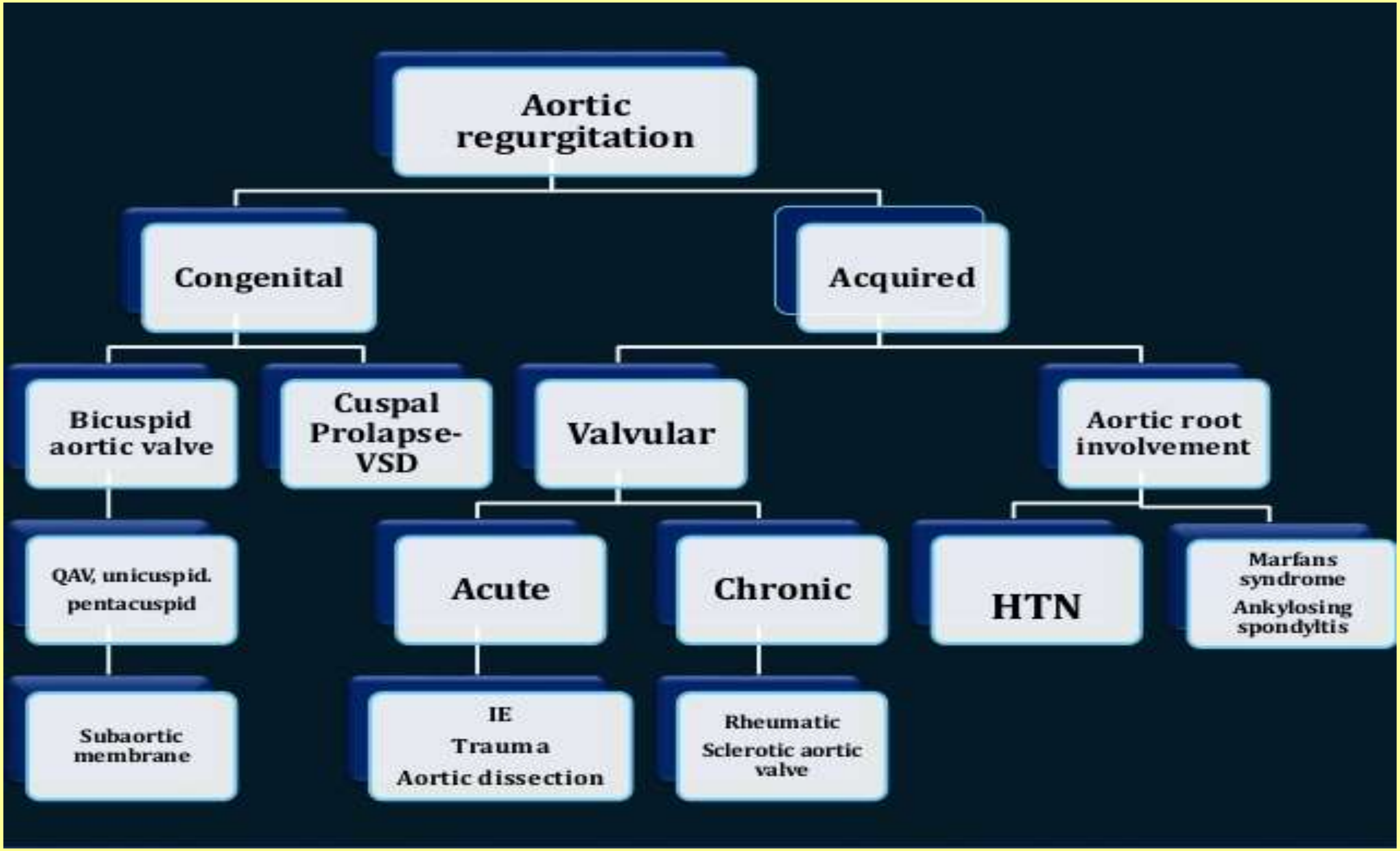
- 3 cusp, 3 commisure
- 3-4 cm sq





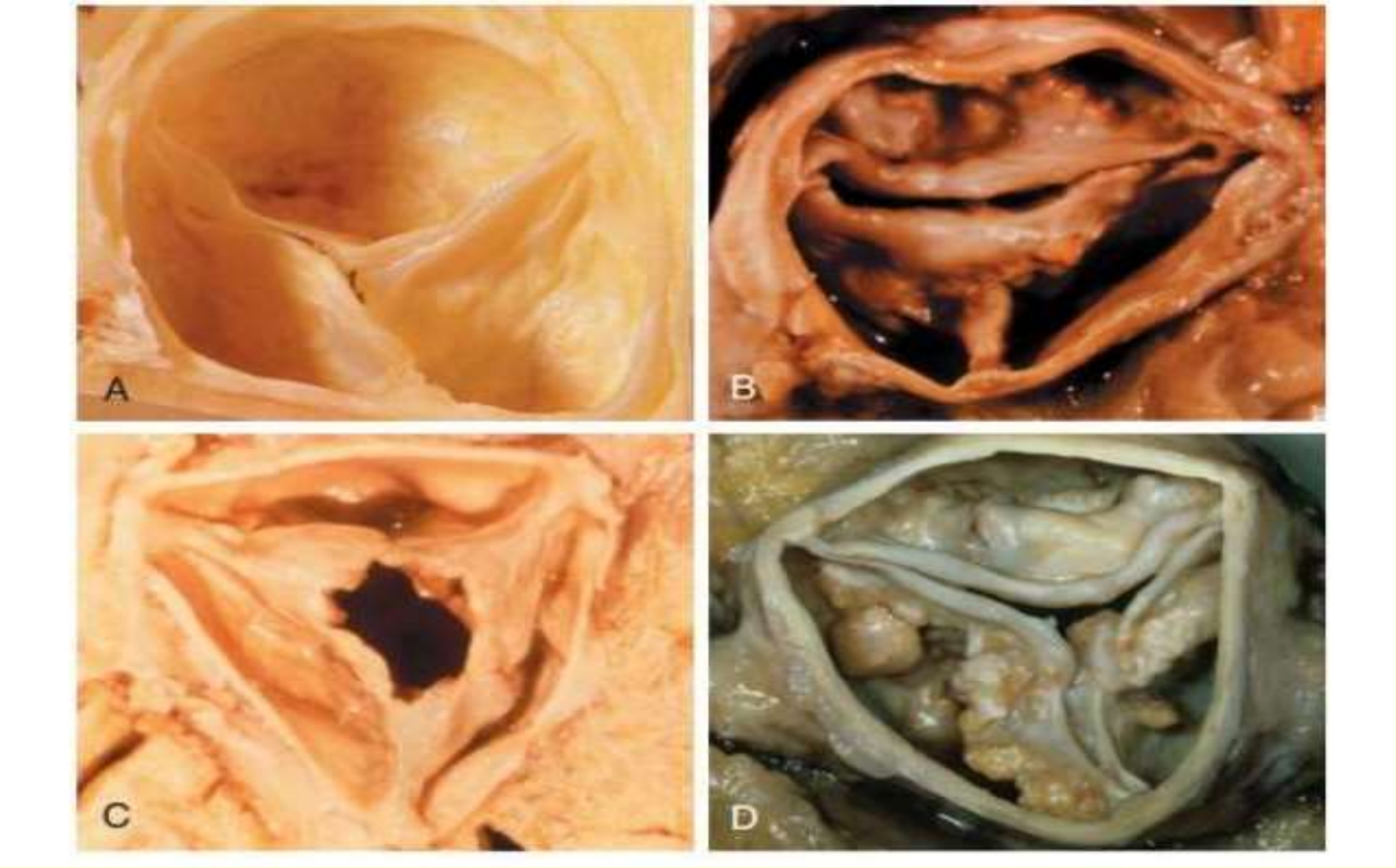


NoRmaL – clock wise


Aortic regurgitation
Congenital
Acquired
Bicuspid aortic valve
Cuspal Prolapse-VSD
Valvular
Aortic root involvement
QAV, unicuspid. pentacuspid
Acute
Chronic
HTN
Marfans syndrome
Ankylosing spondyltis
Subaortic membrane
IE
Trauma
Aortic dissection
Rheumatic
Sclerotic aortic valve

Common Causes of AR

- Bicuspid aortic valve
- Rheumatic disease
- Calcific degeneration
- Infective endocarditis
- Idiopathic aortic dilatation
- Myxomatous degeneration
- Dissection of the ascending aorta


A
B
C
D

Aim of echocardiographic evaluation

- Define the cause of stenosis
- Quantification of severity
- Evaluation of co existing valvular lesions
- Assessment of LV systolic function
- Detection of response of chronic volume load over cardiac chambers

Options

- TTE
- TEE
- 3D echocardiography

TTE

- 1. M MODE
- 2.COLOR M MODE
- 3.2D ECHO
- 4.COLOR DOPPLER--- JET WIDTH ,JET AREA,VENA CONTRACTA WIDTH
- 5.PULSED WAVE DOPPLER METHODS – PISA,Volumetric methods - RV,RF,ROA
- 6.CW DOPPLER
- 7.LV size and function
- 8.LA size

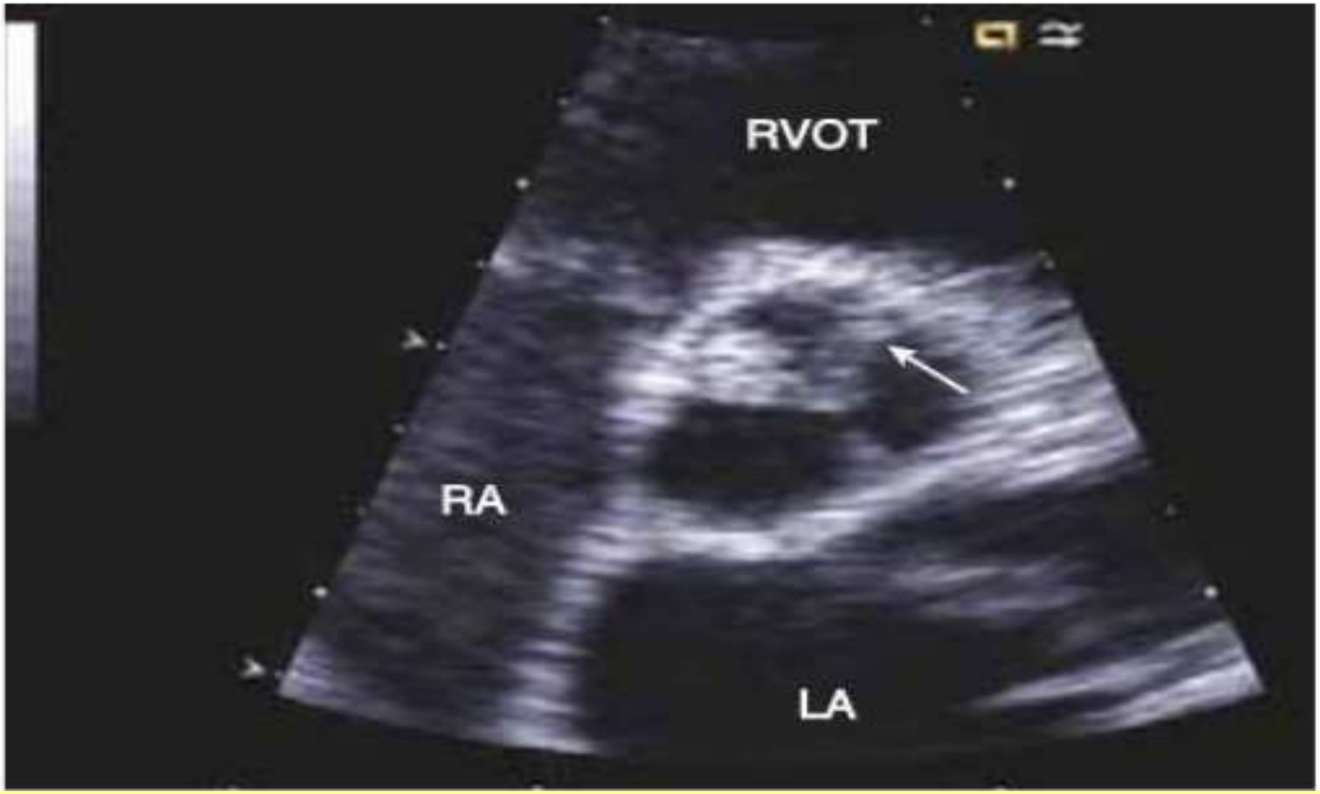
Echocardiographic Views

- PLAX
- PSAX at the level of great vessels
- Apical views – A4CV, Apical long axis views

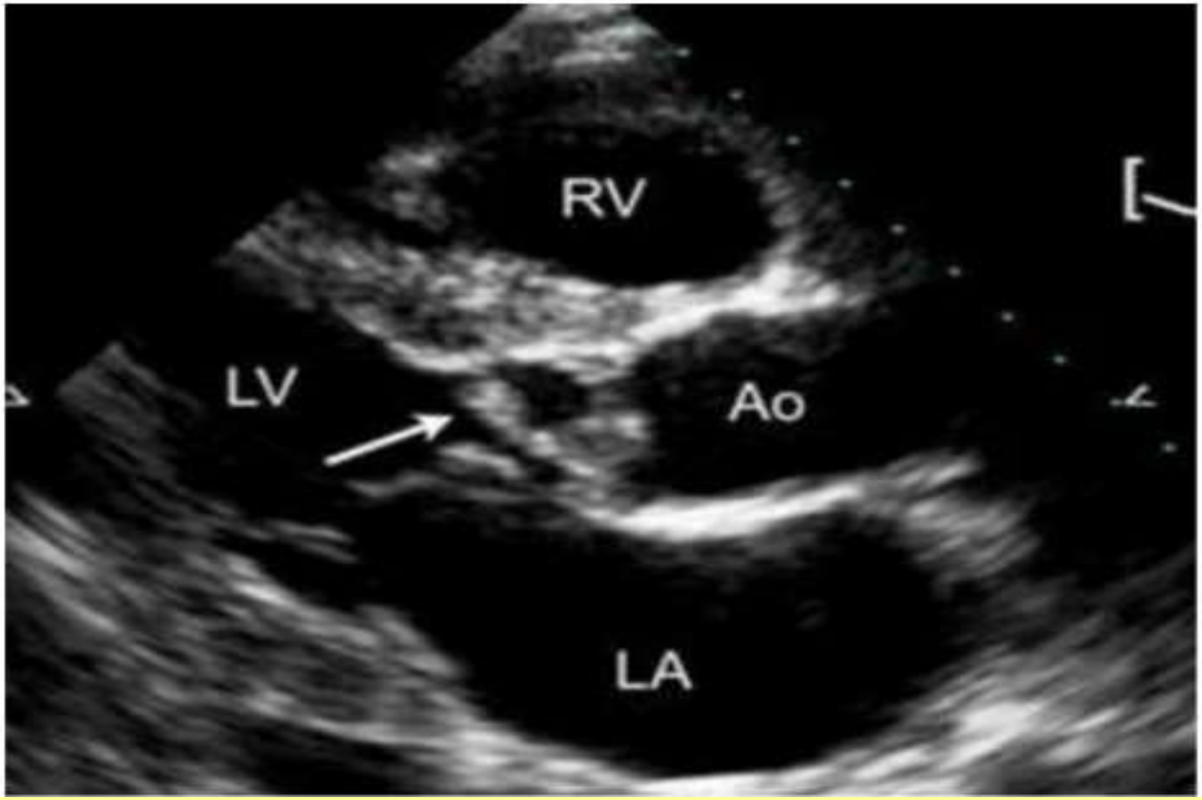
2 D assessment of AR

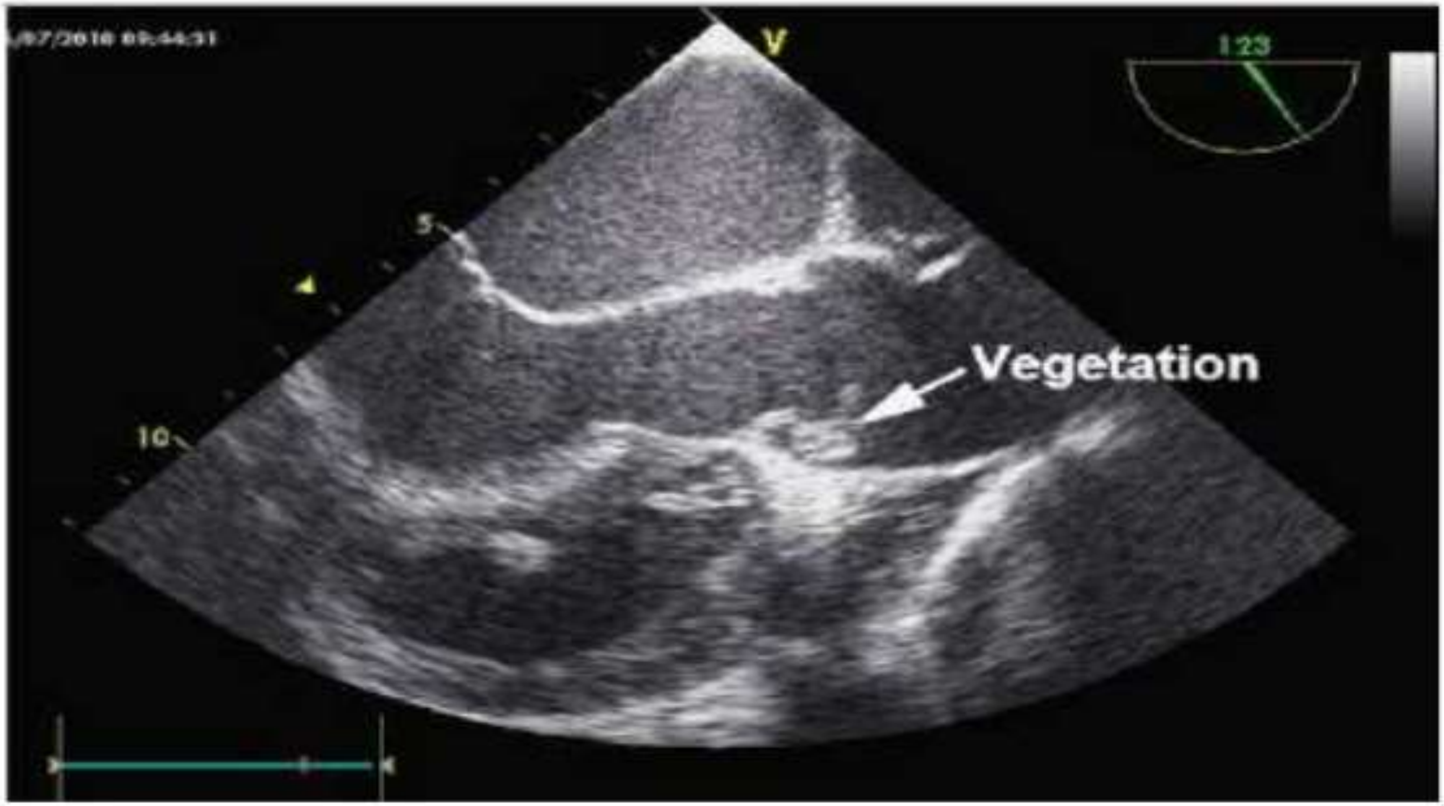
- Leaflets
  - Prolapse
  - Number
  - Vegetation
  - Calcification

PSAX view

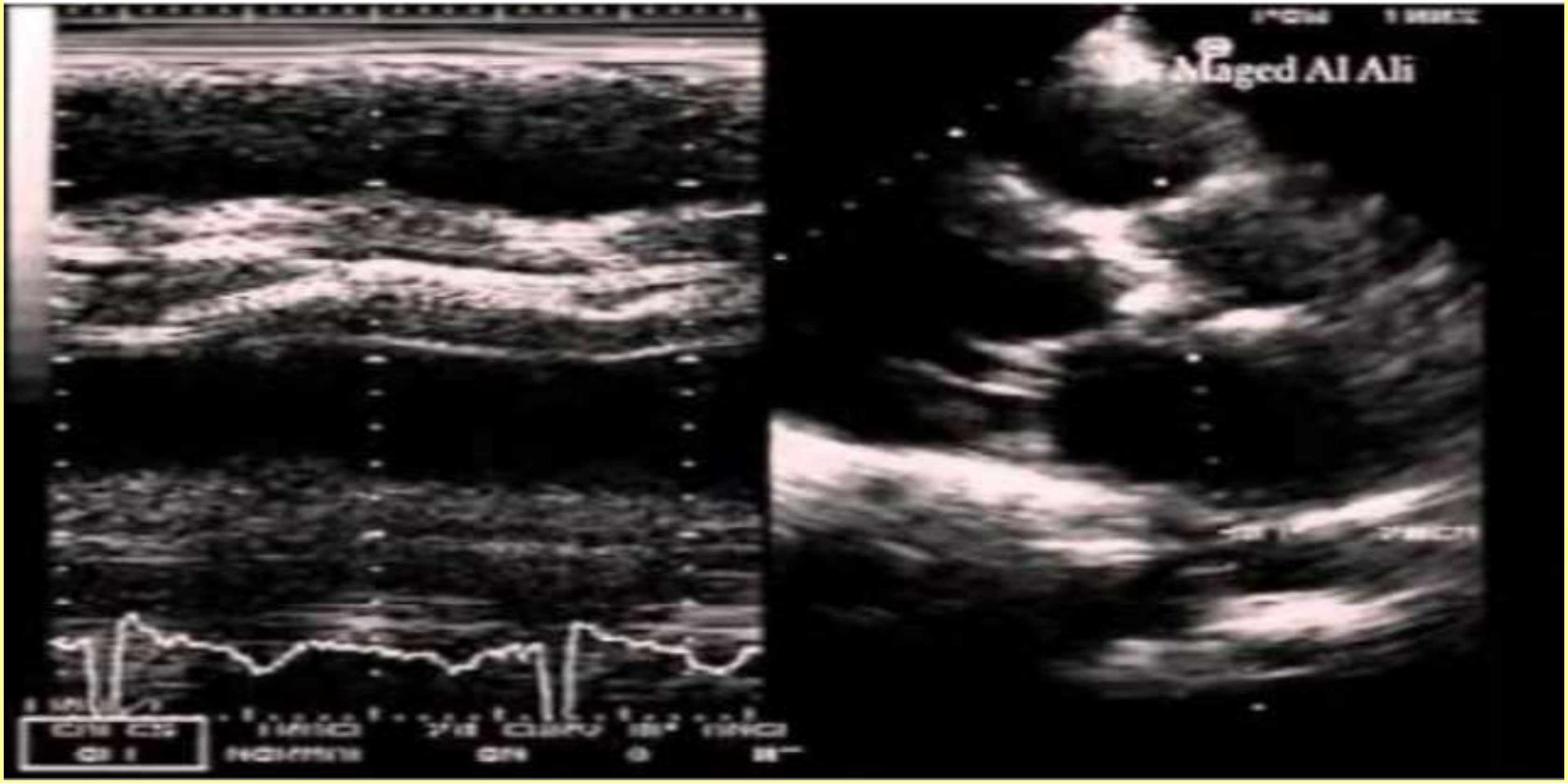


Vegetation



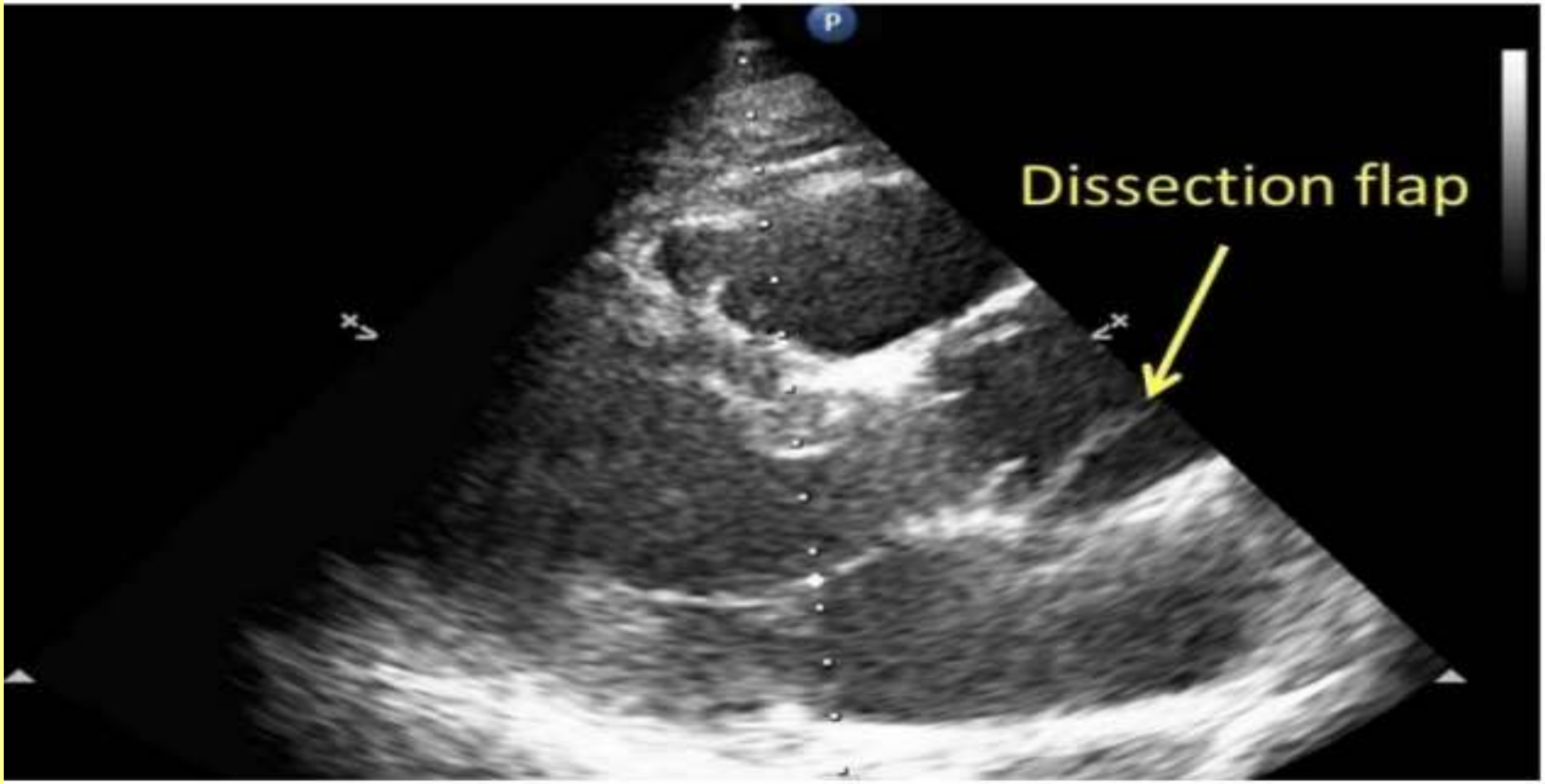

V
123
5
10
Vegetation

Calcification



Any dissection?

In PLAX, PSAX, Suprasternal view


Dissection flap

Two dimensional imaging

- 1.Abnormal mitral valve motion due to impingement on the anterior leaflet by a posteriorly directed aortic regurgitation jet – **deformation of leaflet during diastole.**
- 2.Dilation of the sinotubular junction – loss of the geometry of aortic leaflet coaptation **– jet arises centrally.**
- 3.Causes of acute AR – IE can be identified.
- 4.Paravalvular abscess leading to acute AR.
- 5.Aortic dissection causing AR can be detected.
- 6.LV response to volume overload - dilation of LV –**spherical shape.**
- 7.LV mass increases.
- 8.Hyperdynamic IVS motion.

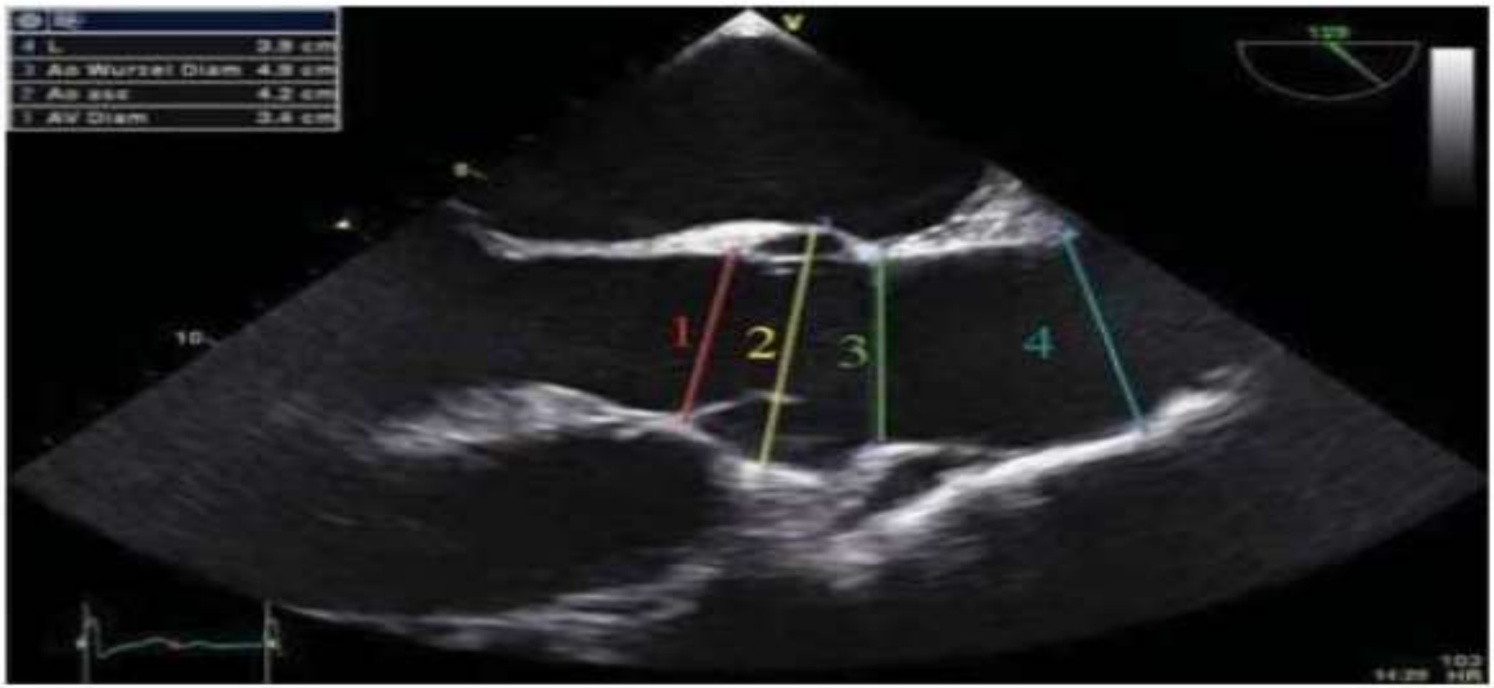
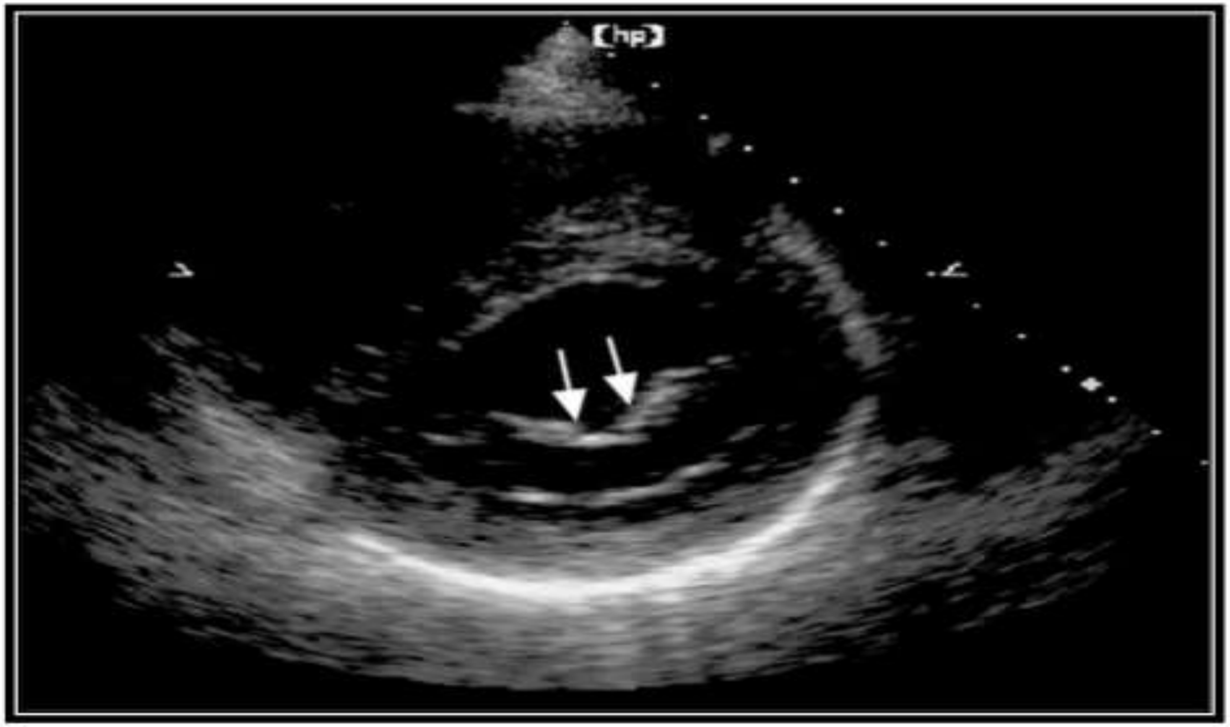


Figure 5 Measurements of the aortic diameters. 1, valve annulus; 2, aortic sinuses; 3, sinotubular junction; 4, proximal ascending aorta.

Reverse doming

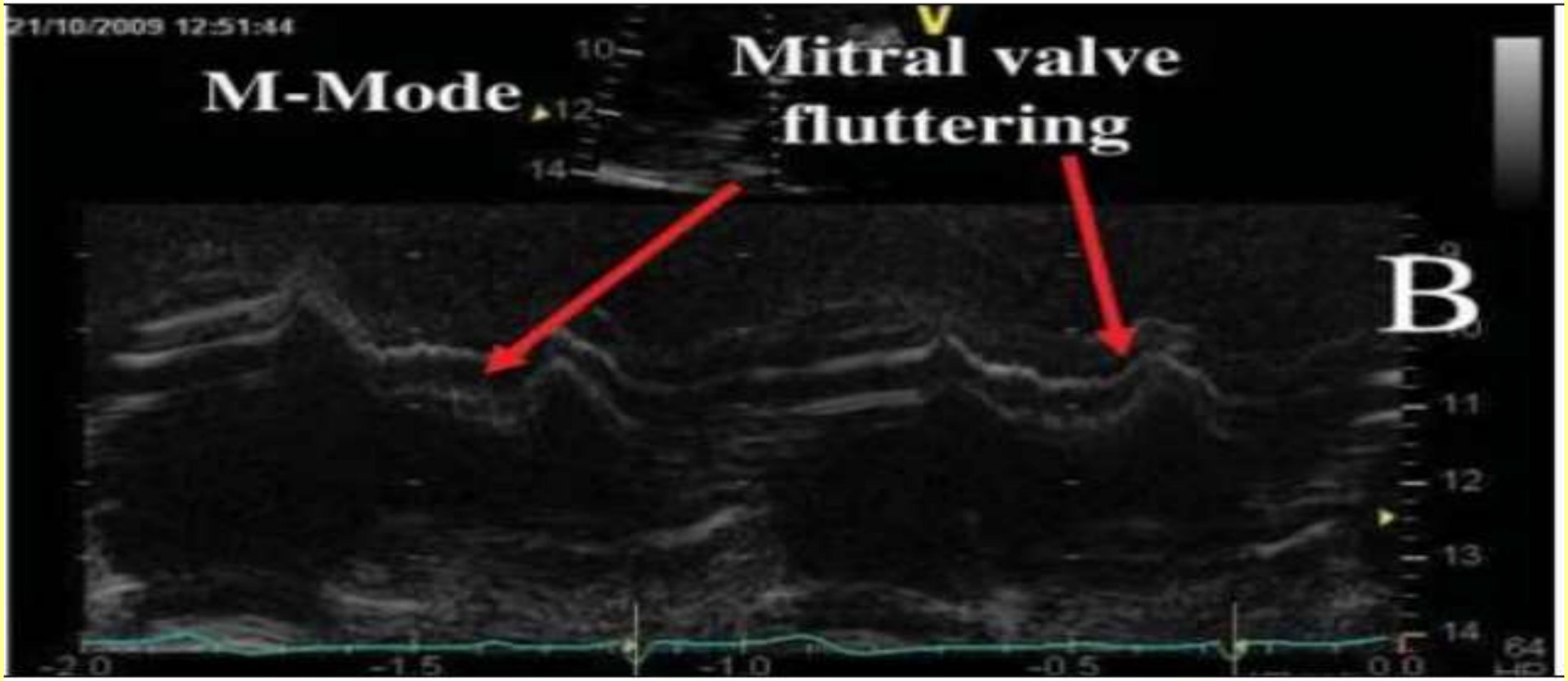
- When AR is directed at the anterior mitral leaflet,an abnormal diastolic curved contour with concavity facing the interventricular septum may occur;referred to as reverse doming(as the concavity is opposite to that seen in rheumatic mitral stenosis.

C.M.Otto,Textbook of clinical echocardiography,4th ed.

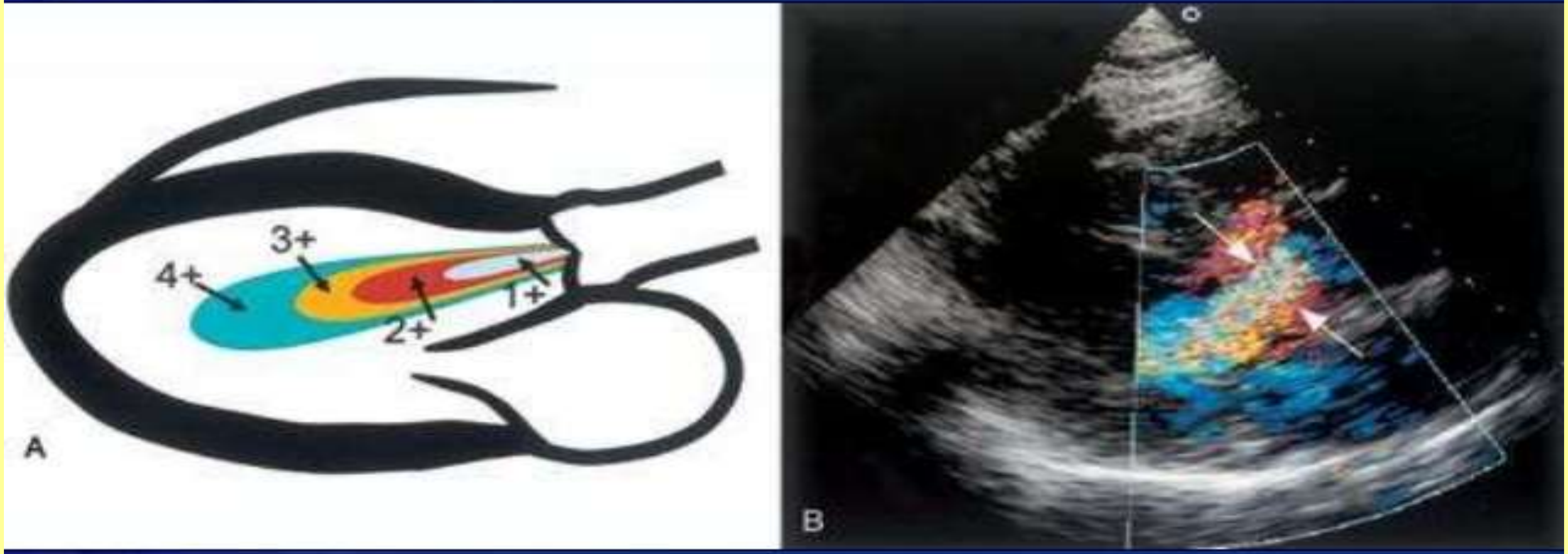

hp

M mode

- As the aortic jet cascades across the anterior mitral leaflet, it creates a **high frequency fluttering**.
- Rapid sampling rate of M mode echo needed for detection.
- One of the earliest examples of use of M mode echocardiography to indirectly assess valve disease.
- In Acute AR, **premature closure of the** mitral valve due to rapidly increasing LV diastolic pressure.
- **Hyperdynamic IVS motion** due to excessive volume overload on LV due to chronic AR. – exaggeration of normal diastolic septal dip, increase in amplitude of septal motion compared to posterior wall.


21/10/2009 12:51:44
M-Mode
Mitral valve
fluttering
B

Length of the AR jet



1+	Localised to just below the valve
2+	Flow disturbance extends upto the mitral valve
3+	Upto the papillary muscle
4+	Beyond the papillary muscle

Height of AR jet

- From parasternal long axis view – the height of the jet just below the valve can be measured using electronic calipers.
- Dimension expressed as the percentage of LVOT dimension to provide an estimate of severity.

Jet height/outflow tract dimension ratio.

- Greater the percentage – the more severe the regurgitation.
- ***A jet that occupies more than 60% of the LVOT(either height or area)usually indicates severe AR.***
- Short axis view at the level of great arteries – area of jet compared to aortic orifice.

Jet Height/LVOT height (PL ax)

1+	1-24%
2+	25-46%
3+	47-64%
4+	>65%

DOPPLER

Pulsed wave doppler

- As AR velocity is high,aliasing occurs inevitably.
- Highly sensitive.
- Multiple views required sometimes.
- False positive –MS, prosthetic mitral valve.

Continous wave doppler

- Because of high velocity of AR jet.
- Differentiates AR from MS.
- Density of the jet – a qualitative indication of the volume of regurgitation can also be assessed.(density is a function of number of RBC,increases with increase in regurgitant volume).
- Velocity of the regurgitant jet.
- Rate of deceleration of retrograde flow.

Doppler Assessment of AR (Qualitative)

- Color doppler jet width

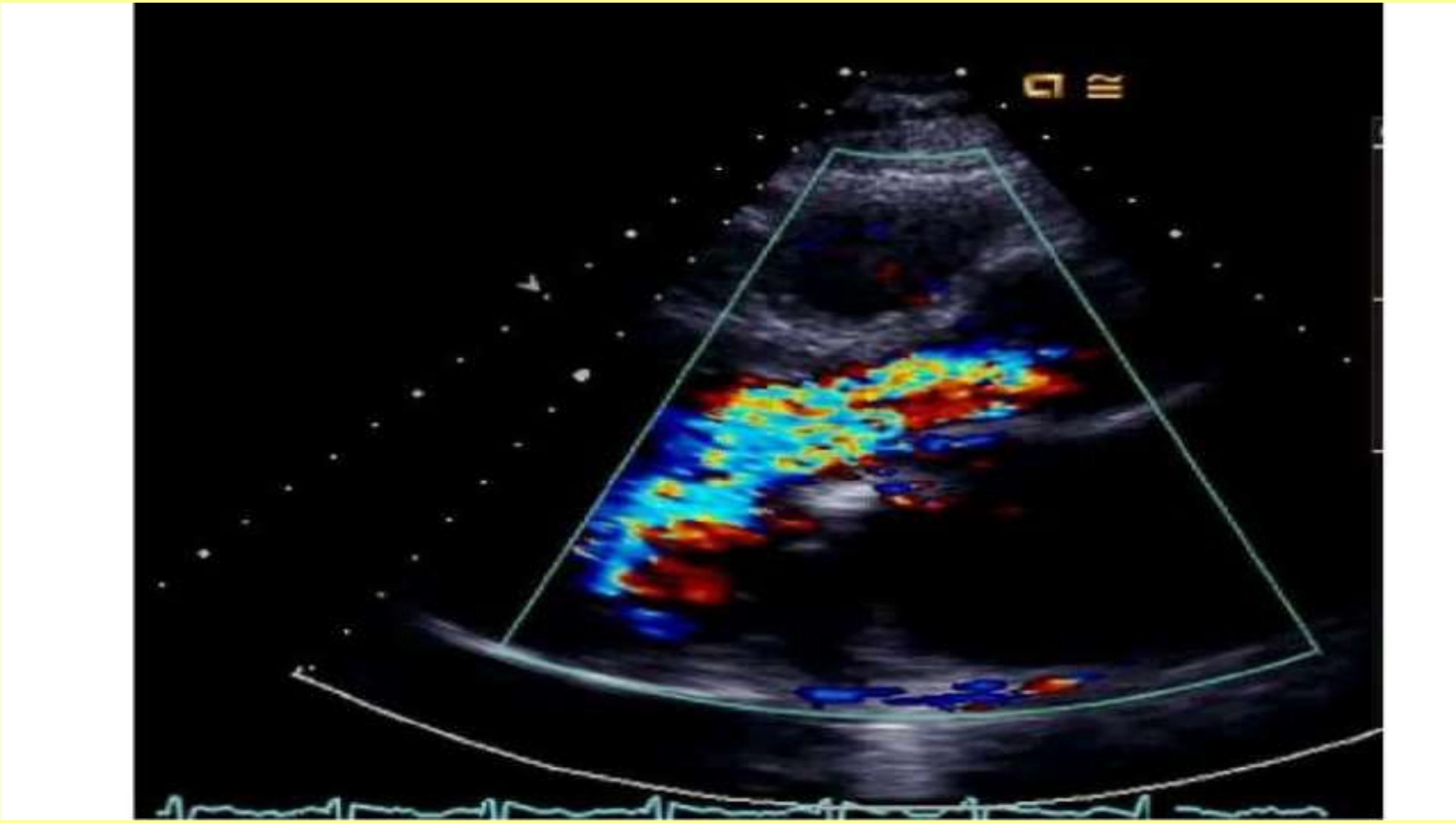
Color jet width vs LVOT width in PLAX or PSAX view

Overestimated in apical views

Mild AR <25%

Severe AR ≥65 %

Length of AR jet should not be used to assess AR severity



- Vena contracta width

Reflects diameter of regurgitant orifice

Avoids erroneous measurement of jet when it expands in LVOT

PLAX or PSAX zoomed view

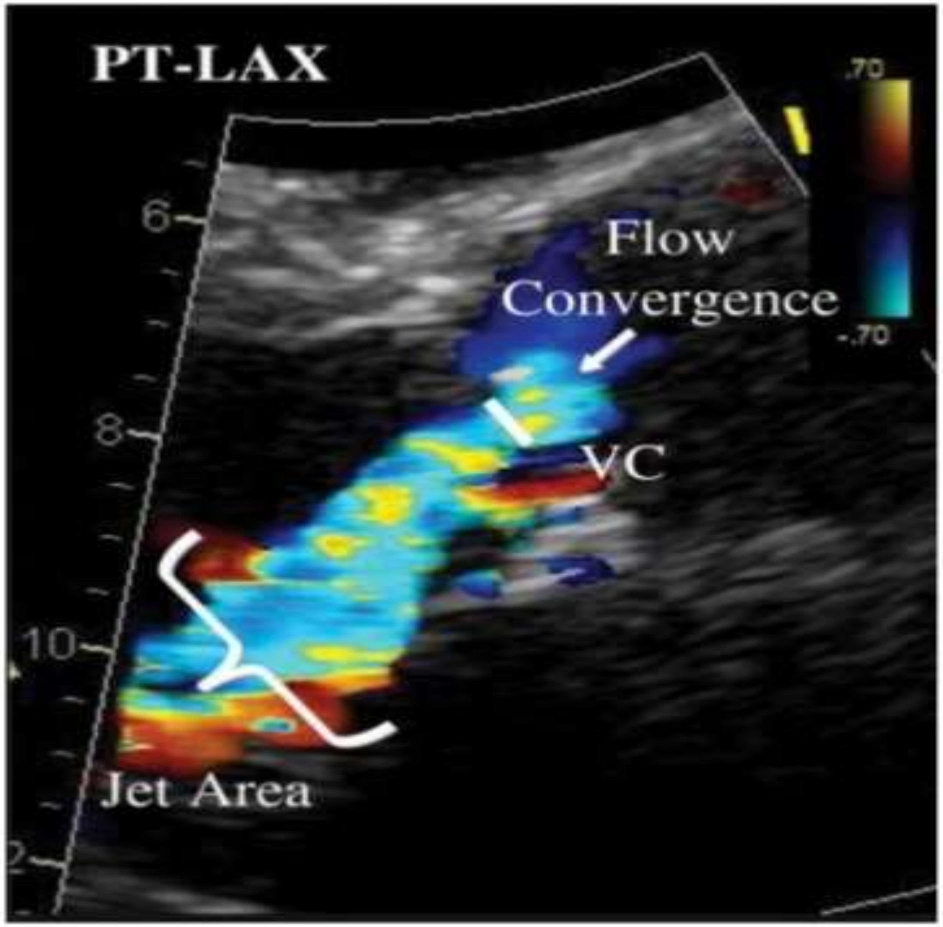
Mild AR < 0.3 cm

Severe AR> 0.6 cm

Three components

Of regurgitant jet:

1. PFC
2. VC
3. Broadening in LVOT



Slope of AR ,PHT

- The deceleration of jet velocity can be described as either the slope or the pressure half time of the jet.
- A **pressure half time less than 250 msec** or a **slope greater than 400cm/sec2 is an indicator of severe AR.**
- **Affected by aortic compliance,blood pressure,LV size, compliance of LV**.

- Pressure half time (PHT)

CW doppler in Apical three or five chamber views

Mild AR >500 ms

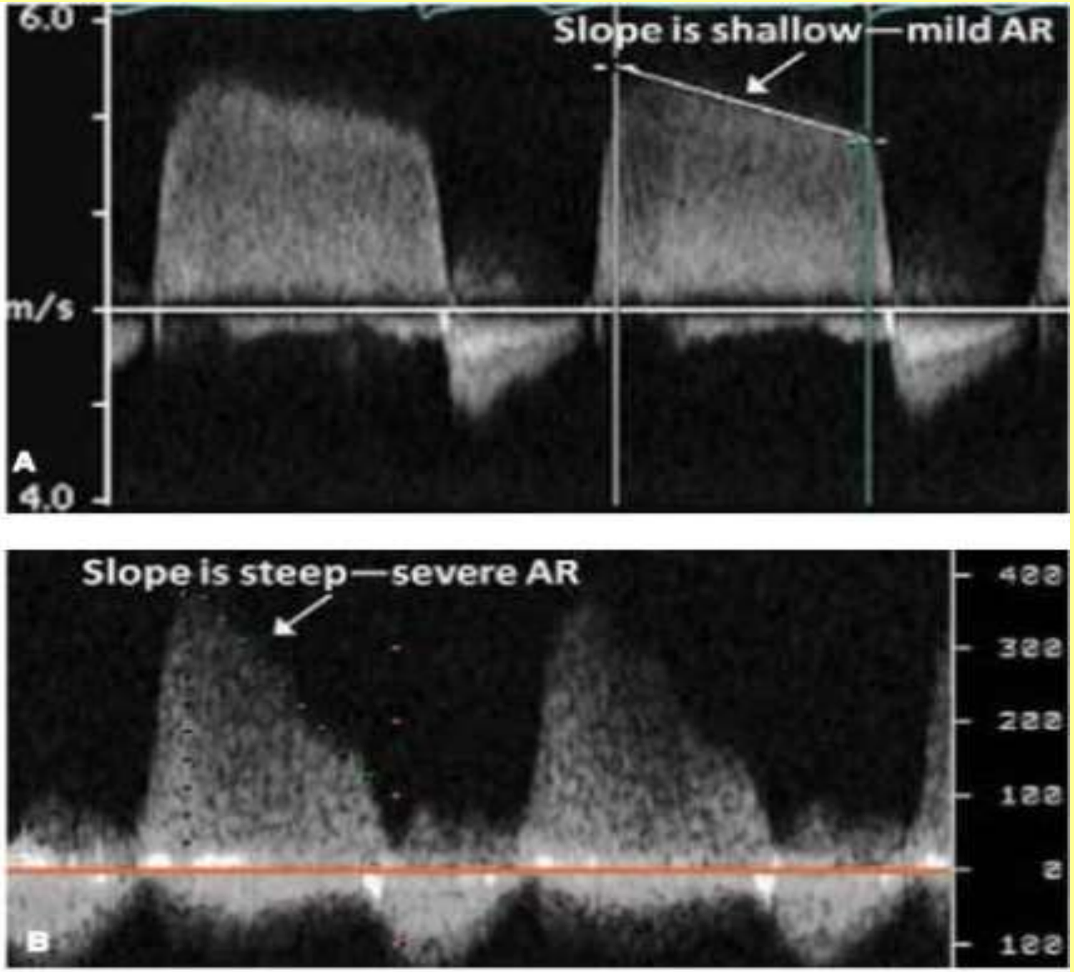
Severe AR < 200 ms

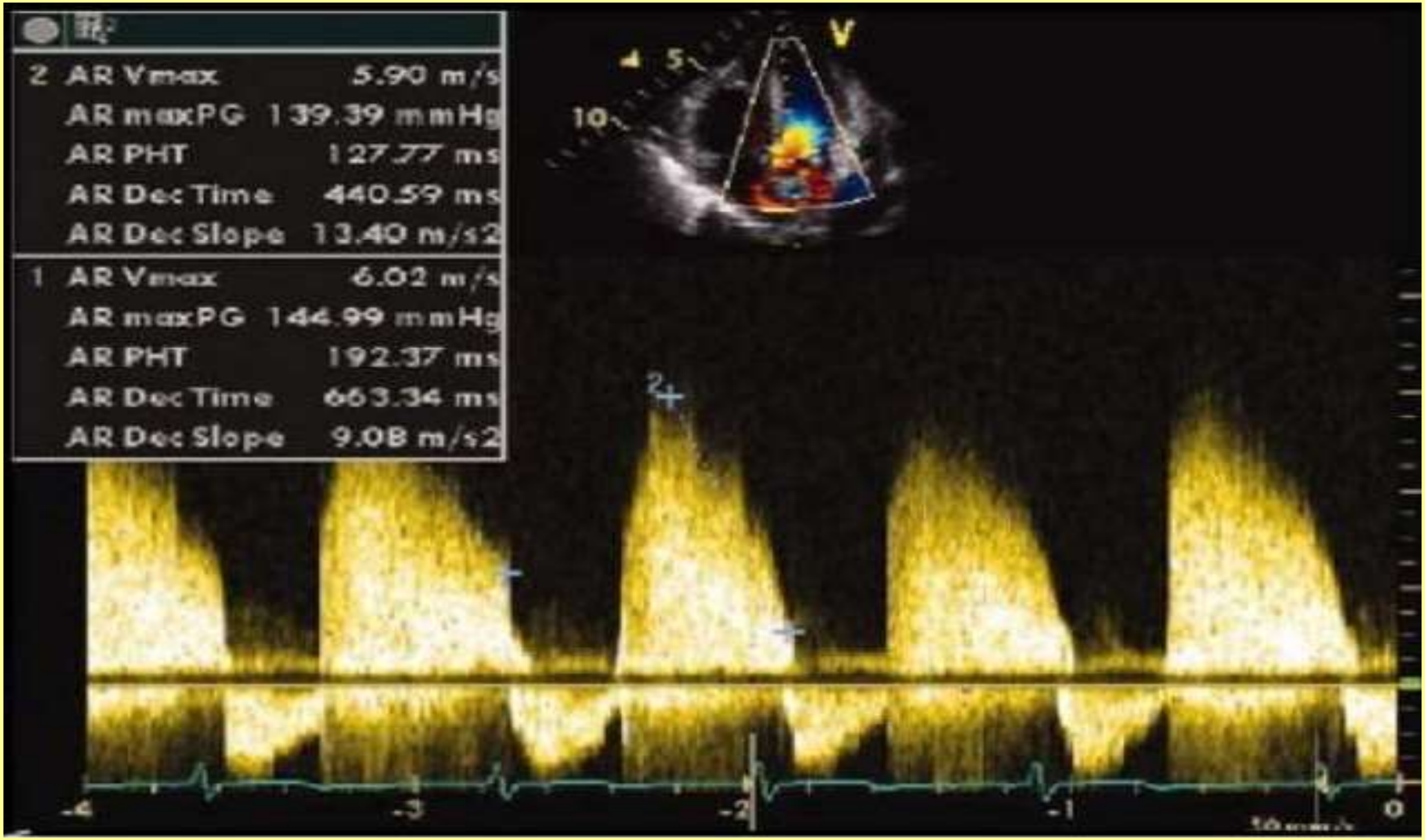
Density of signal of doppler envelope also a sign of severity

	Slope(cm/sec2)	PHT(msec)	DT (msec)
Mild	<250	>500	>1800
Moderate	250-400	250-500	800-1800
Severe	>400	<250(200)	<800

Labovitz et al compared both PHT and the slope with the gold standard angiography, and found that slope correlated well with angiographic findings than PHT . Circulation 1983:68:229.

Steeper is severe




2 AR Vmax 5.90 m/s
AR maxPG 139.39 mmHg
AR PHT 127.77 ms
AR Dec Time 440.59 ms
AR Dec Slope 13.40 m/s2
1 AR Vmax 6.02 m/s
AR maxPG 144.99 mmHg
AR PHT 192.37 ms
AR Dec Time 663.34 ms
AR Dec Slope 9.08 m/s2
-4
-3
-2
-1
0

Assessing the severity

Nonquantitative approach

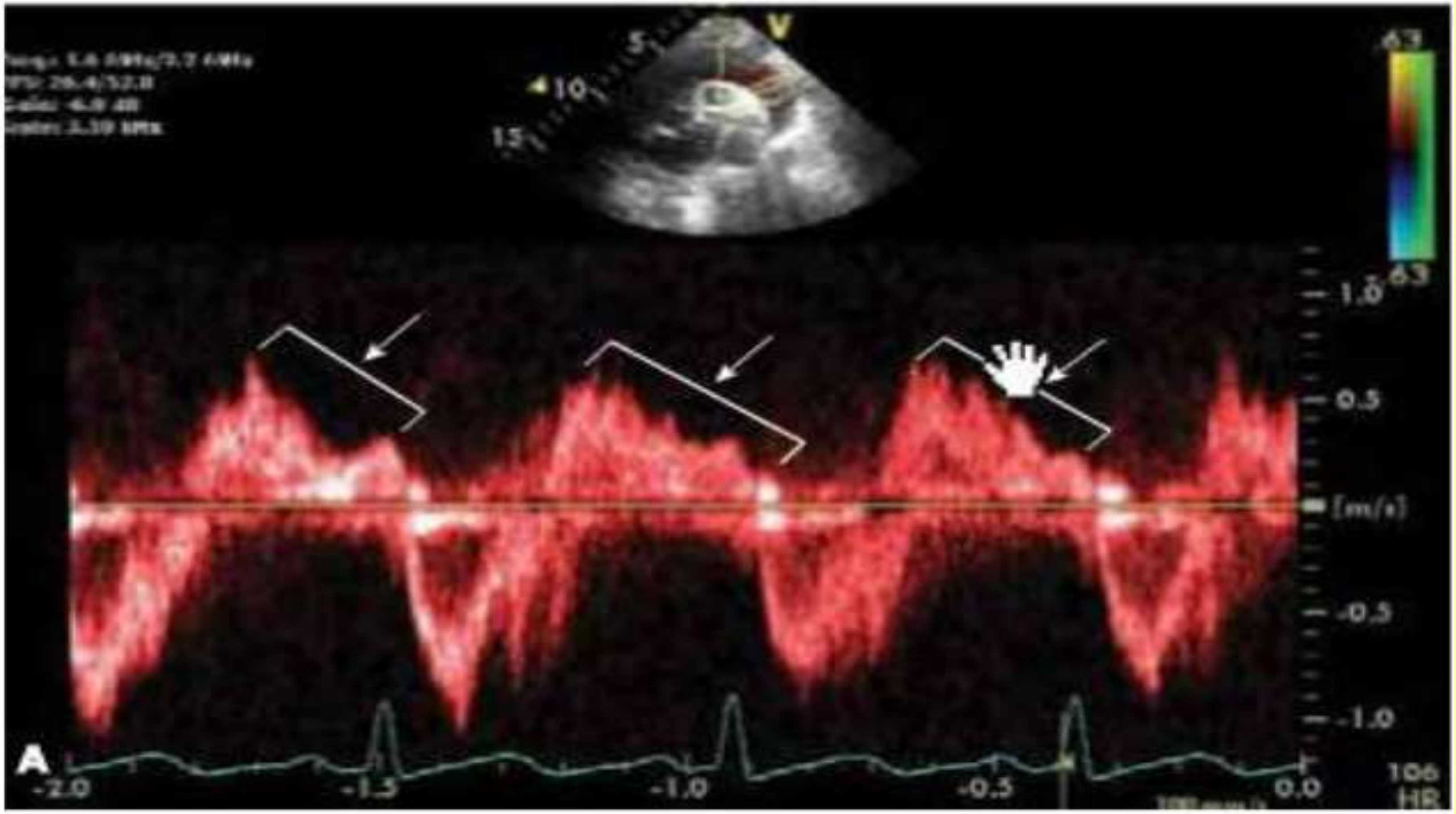
- **Diastolic flow reversal** in the descending aorta.
- Retrograde velocities can be recorded through out diastole.
- Dependent on vessel compliance, location of sample volume.
- Simple and practical marker of severity.
- ***Holodiastolic flow reversal in the descending aorta has been correlated with severe AR.***

- Diastolic flow reversal in aorta

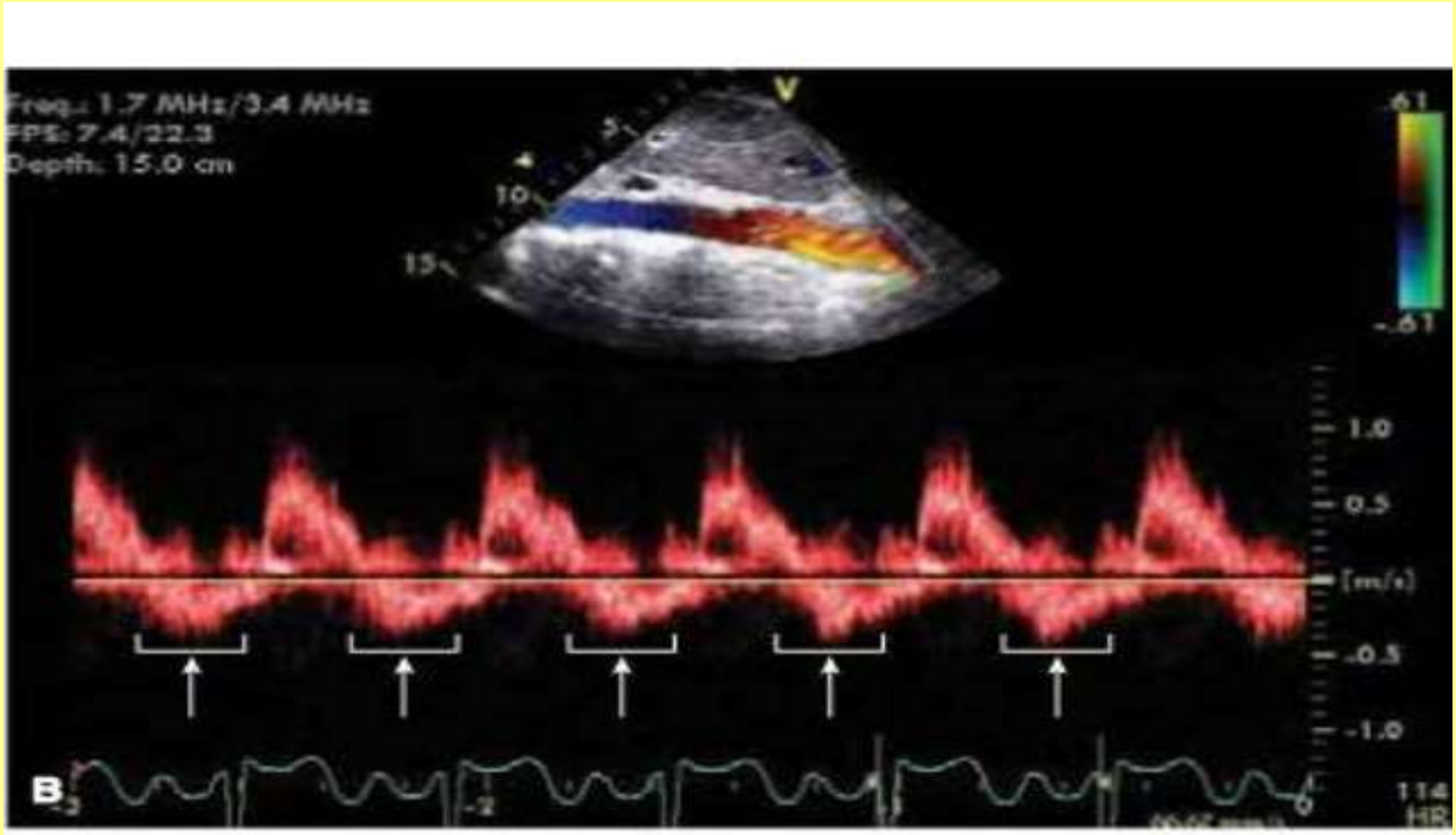
PW doppler in suprasternal (descending thoracic aorta) or subcostal (abdominal aorta) view

ECG gated echo needed

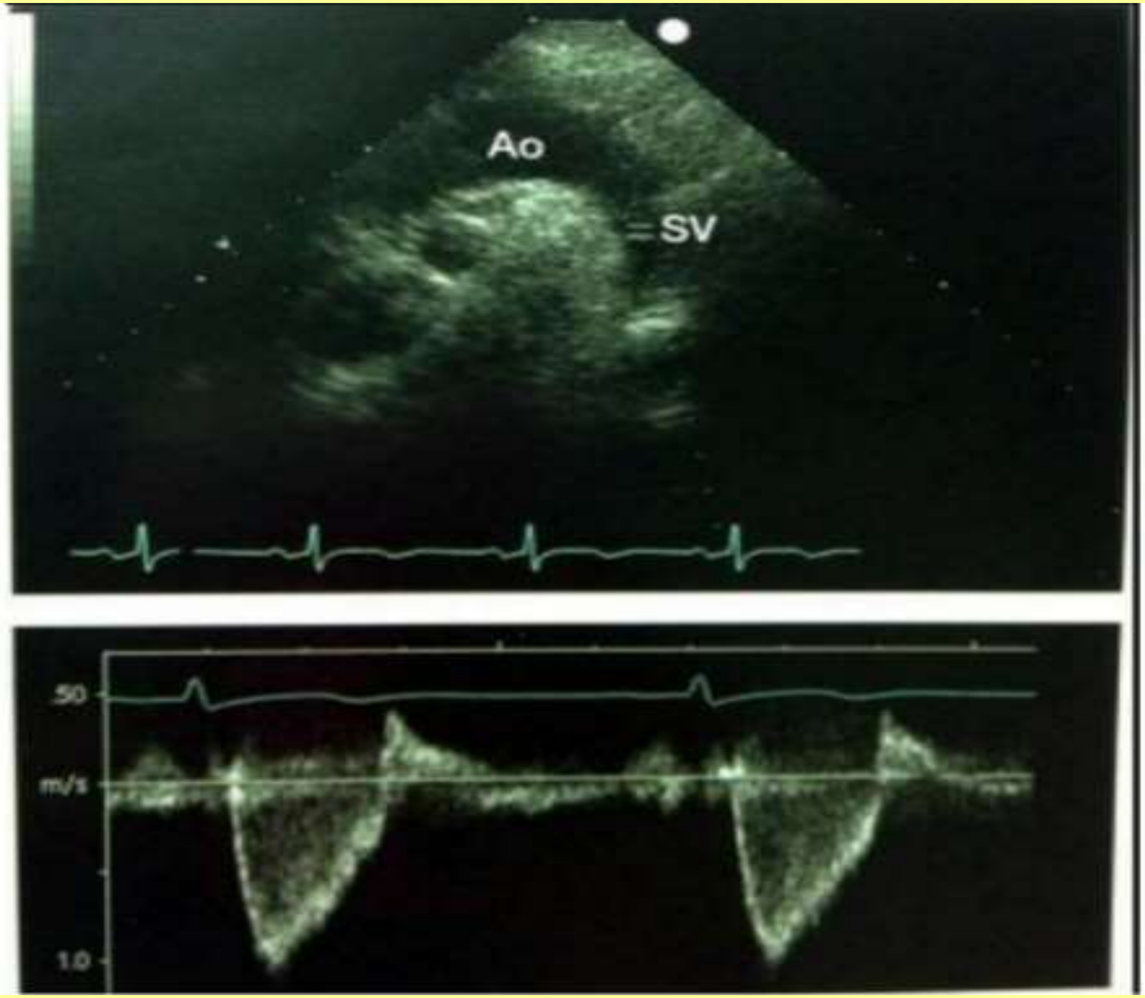
Holodiastolic flow reversal is abnormal. Brief flow reversal may be present normally.



5
10
15
V
1.0
0.5
[m/s]
-0.5
-1.0
A
-2.0
-1.5
-1.0
-0.5
0.0
106
HR



Freq.: 1.7 MHz/3.4 MHz
FPS: 7.4/22.3
Depth: 15.0 cm
V
5
10
15
.61
-.61
1.0
0.5
[m/s]
-0.5
-1.0
B
114
HR


Ao
SV
.50
m/s
1.0

Doppler Assessemnt of AR (Quantitative)

Not frequently done

Often be determined by combination of qualitative methods and 2D assessment

Options:

PISA (Proximal Isovelocity Surface Area)

Regurgitant volume

Regurgitant fraction

Effective regurgitant orifice area (EROA)

Volumetric method

- The four valves in the heart are in series,the flow or stroke volume at any point must be equal.
- In AR,the total stroke volume through the aortic valve in systole must equal the forward stroke volume(other nonregurgitant valve) plus the regurgitant volume.
- Stroke volume = product of CSA x TVI.
- Forward stroke volume at mitral vlave (in competent)
- Total stroke volume at aortic valve – forward + regurgitant.
- Regurgitant volume = aortic – mitral.
- Validated.
- Regurgitant fraction = RV/SV *100

Regurgitant volume = AV stroke volume –MV stroke volume

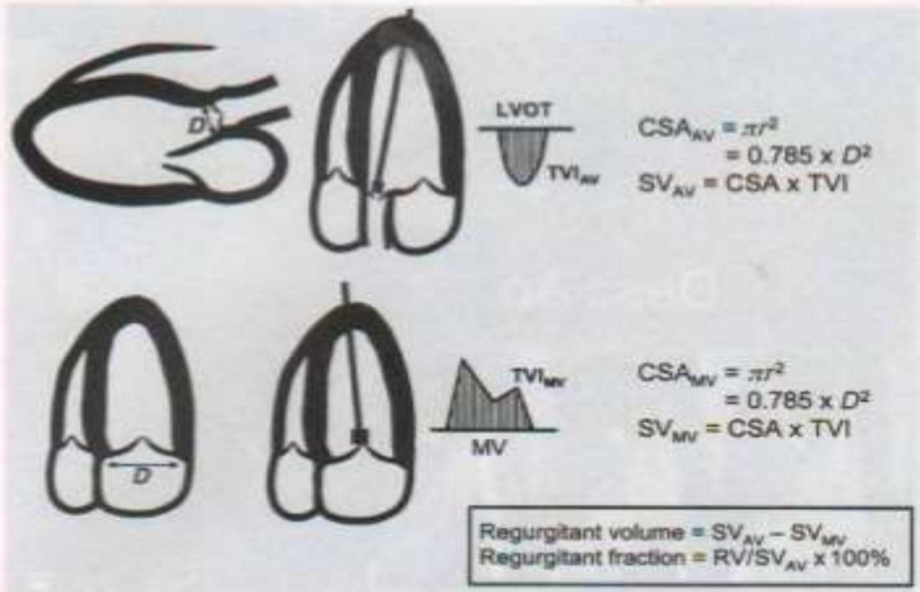


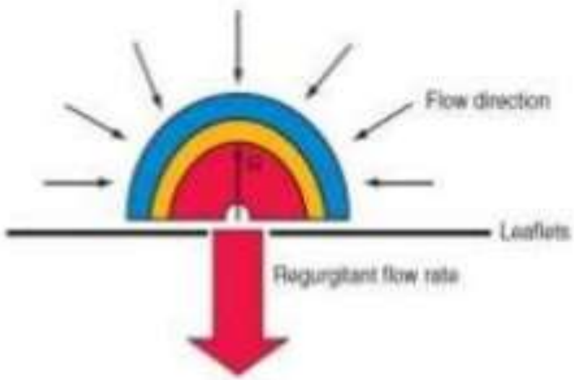
FIGURE 11.54. Stroke volume can be measured through any valve within the heart. This schematic demonstrates how stroke volume can be calculated at the level of the aortic valve (#1) and mitral valve (#2). The difference in stroke volume represents the regurgitant volume. In addition, the regurgitant fraction can be calculated. See text for details. CSA, cross-sectional area; TVI, time velocity integral.

- Regurgitant volume greater than 60 ml indicates severe AR.
- Regurgitant fraction greater than 50%

PISA

It's the surface area of blood moving back from the aorta towards the closed aortic valve at the given aliasing velocity

Proximal isovelocity surface area=PISA



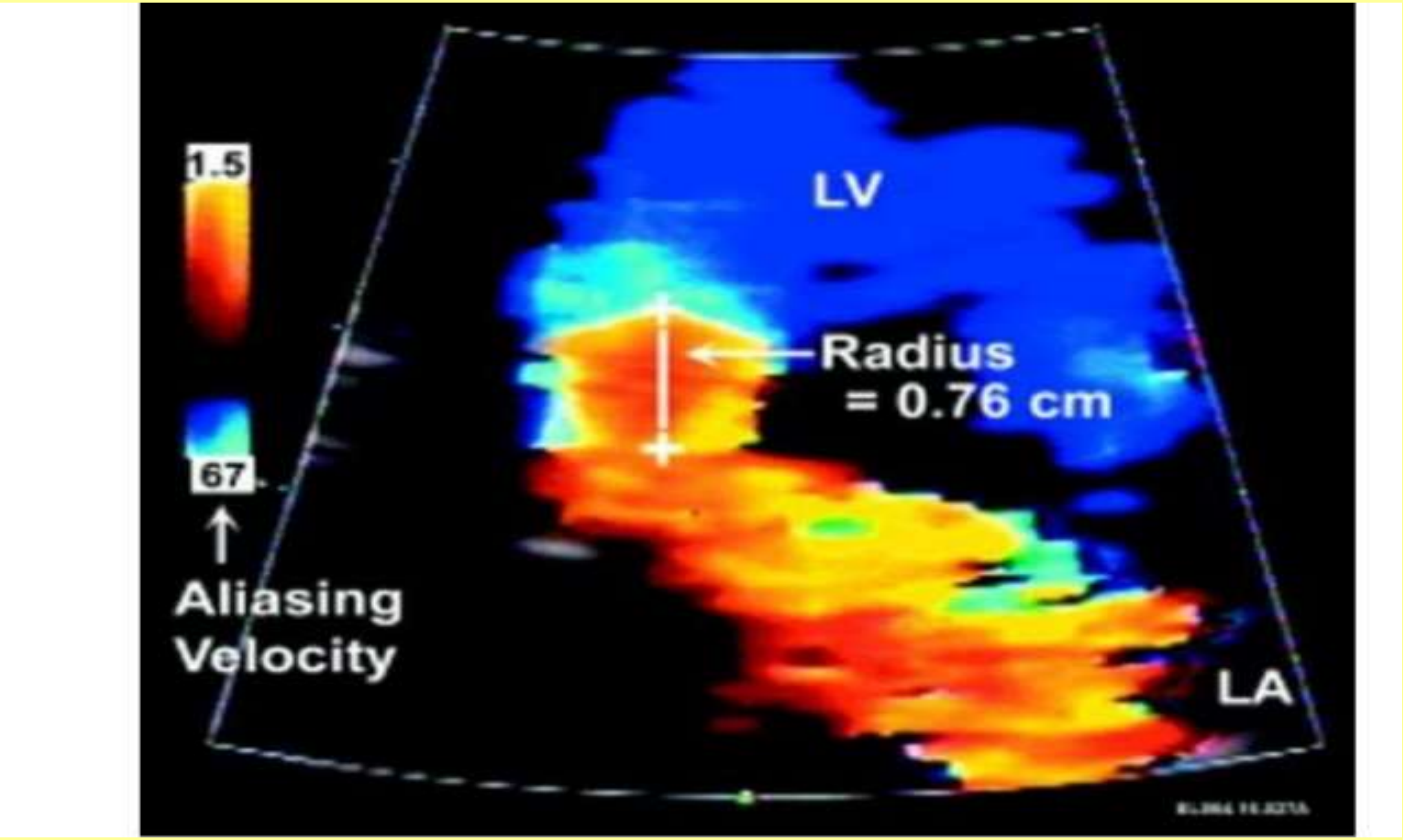
- Fluid dynamic theory predicts that as flow approaches a circular finite orifice, it forms a series of concentric hemispheric shells with gradually decreasing area and increasing velocity. *Arrows* refer to direction of flow as it approaches the proximal isovelocity surface area region. *R* is the radius of a hemispherical shell.With principle of conservation of mass, flow through the regurgitant orifice = flow through the isovelocity surface = 2πr2 × aliasing velocity

Zoomed A3CV or A5CV

Decreasing the depth

Narrow sector

PISA = $2\pi r2$


1.5
67
Aliasing
Velocity
LV
Radius
= 0.76 cm
LA

- **Regurgitant Volume** =

Volume of blood that regurgitates across the valve per beat

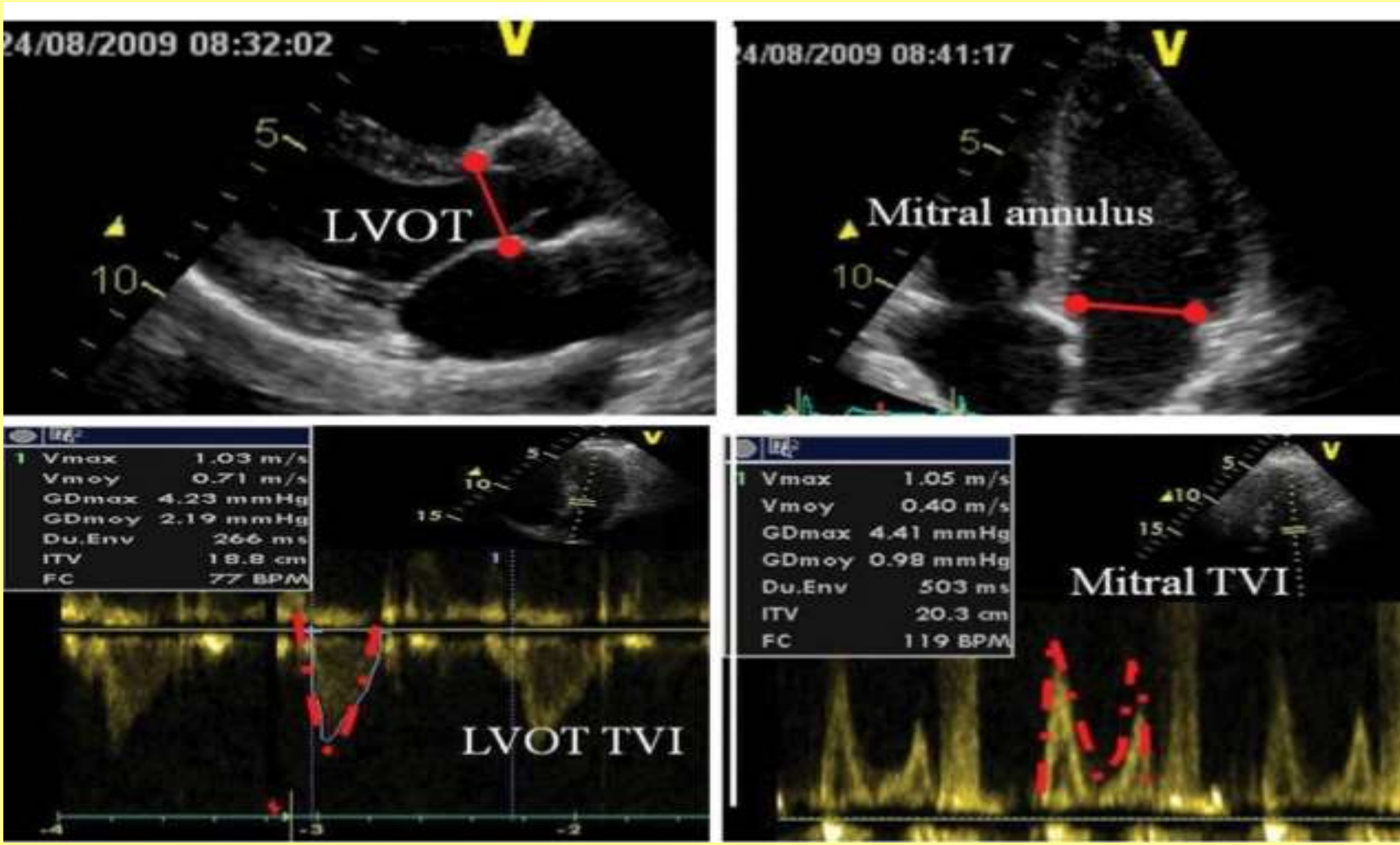
Volumes calculated according to **continuity equation**

RegrugV = SV total – SV forward

SV total = Transaortic volume =CSA LVOT x VTI LVOT

SV forward = Transmitral volume = CSA mitral annulus x VTI mitral annulus

- SV total can be measure by LVEDV – LEVSV (Simpsons method)
- For SV forward or transmitral volume PW doppler at the level of MV; should be used not at mitral tip



24/08/2009 08:32:02
LVOT
24/08/2009 08:41:17
Mitral annulus
Vmax 1.03 m/s
Vmoy 0.71 m/s
GDmax 4.23 mmHg
GDmoy 2.19 mmHg
Du.Env 266 ms
ITV 18.8 cm
FC 77 BPM
LVOT TVI
Vmax 1.05 m/s
Vmoy 0.40 m/s
GDmax 4.41 mmHg
GDmoy 0.98 mmHg
Du.Env 503 ms
ITV 20.3 cm
FC 119 BPM
Mitral TVI

Regurg. Volume calculated by **PISA method**

Regurg Volume = EROA x VTI AR jet

Mild AR < 30ml/ beat

Severe AR ≥ 60ml/ beat

- Regurgitation fraction = Regurg V/ SV total

Mild AR < 30 %

Severe AR ≥ 50%

- EROA (Effective regurgitation orifice area)

  = PISA x aliasing velocity / AR Vmax

  or

  = Regurg V / VTI AR jet

Mild AR < 0.1 cm sq. Severe ≥ 0.3 cm sq.

Rheumatic AR

- Acute rheumatic fever can cause mitral regurgitation and less commonly mild to moderate AR and focal nodules on valve leaflets.
- Cusp fibrosis and calcification can occur resulting in varying degrees of AR.
- AS with+/- AR is more common and results from commisural fusion –CRHD.
- Aortic valve involement in the absence of rheumatic mitral valve disease is uncommon.

Calcific /Degenerative AR

- Atherosclerotic degeneration.
- Myxomatous degeneration.

Bicuspid aortopathy

- MC congenital cardiac defect
- Prevalence between 0.5% -2%.
- Systolic doming seen in Plax.
- Psax at great arteries level in systole.
- Heavy calcification difficult to identify BAV.
- Thoracic aneurysms and coarctation can be assosciated.
- Increased risk of dissection.

Ankylosing spondylitis

- Thickening of the aortic wall.
- Thickening of the aortic cusps.
- Localised basal AML thickening – suboartic bump.

ROLDAN et al, Aortic root disease and valve disease assosciated with Ankylosing spondylitis.
JACC 1998;32(5):1397:404.

Behcet's syndrome

- Anuerysmal changes with redundant coronary cusp motion.
- Vegetation like mobile lesions.
- Echo free spaces mimicking abscess pockets.
- Poor prognosis after AVR –valve dehiscence.

Han JK et al ,Bechcet's disease as a frequently unrecognised cause of AR suggestive and misleading echocardiographic findings.
J Am Soc Echocardiography.2009;22(11):1269-74.

AR due to LVAD

- Commissural fusion
- Typically diastolic or continuous.
- Only systole.

Mudd Jet al, Fusion of aortic valve commisssures in patients supported by a continous Axial flow left ventricular assist devices.
J Heart Lung Transplantation.2008;27(12):1269-74.

APPENDIX 20

QUALITATIVE AND QUANTITATIVE PARAMETERS USEFUL IN GRADING AORTIC REGURGITATION SEVERITY

Parameter	Aortic Regurgitation: Mild	Moderate		Severe
Structural				
LA size	Normal[a]	Normal or dilated		Usually dilated[b]
Aortic leaflets	Normal or abnormal	Normal or abnormal		Abnormal/flail, or wide coaptation defect
Doppler				
Jet width in LVOT—color flow[e]	Small in central jets	Intermediate		Large in central jets; variable in eccentric jet
Jet density—CW	Incomplete or faint	Dense		Dense
Jet deceleration rate—CW (PHT, ms)[c]	Slow >500	Medium 500–200		Steep <200
Diastolic flow reversal in descending aorta—PW	Brief, early diastolic reversal	Intermediate		Prominent holodiastolic reversal
Quantitative[d]				
VC width, cm[e]	<0.3	0.3–0.60		>0.6
Jet width/LVOT width, %[e]	<25	25–45	46–64	≥65
Jet CSA/LVOT CSA, %[e]	<5	5–20	21–59	≥60
R Vol, mL/beat	<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

Chronic Aortic Regurgitation

Early Compensated

- Enlarged chamber size → ↑ afterload → hypertrophy of LV which preserves compliance → normal filling pressures
- LVH → ↑ LV mass → normal LV vol/mass ratio & EF
- Progressive LV dilation and systolic HTN → ↑ wall stress and vol/mass ratio
- ↑ wall stress eventually leads to overt LV dysfunction.

Decompensated

- LV systolic dysfunction accompanied by decreased LV diastolic compliance due to hypertrophy and fibrosis
- Leads to high filling pressures and CHF symptoms
- Exertional dyspnea common; angina can occur due to reduced coronary flow reserve with predominantly systolic coronary flow

Courtesy: Ali Mahajerin, MD