ECHOCARDIOGRAPHY

cc@sp

ECHOCARDIOGRAPHY

- Use of ultrasound to examine the heart.
- Safe, powerful, non invasive and painless technique.
- Commonly and frequently used.
- Uses ultrasound of frequencies ranging from 1.5 MHz to 7.5 MHz

BASIC PRINCIPLE

- Piezoelectric and reverse piezoelectric effect. Crystal is made up of lead zerconate titanate.
- Crystal can receive as long as it is not transmitting at that time i.e., it emits a pulse and then listens for a reflection.
- At interfaces (2 parts of medium having different densities), some of the ultrasound is reflected back.

- Bone or calcium are more reflective than blood and appear as echo bright reflections.

ECHO WINDOWS AND VIEWS

WINDOW- Standard positions on chest wall for the transducer that allows good penetration by ultrasound without too much masking and absorption by lungs or ribs.

1. Left Parasternal window: 2nd – 4th intercostal space; Left sternal edge.

2. <u>Apical window:</u> apex of the heart.
3. <u>Subcostal window:</u> under the xyphisternum.
4. <u>Suprasternal window:</u> suprasternal notch, for imaging the coarctation of aorta.
5. <u>Right parasternal window:</u> to examine ascending aorta.

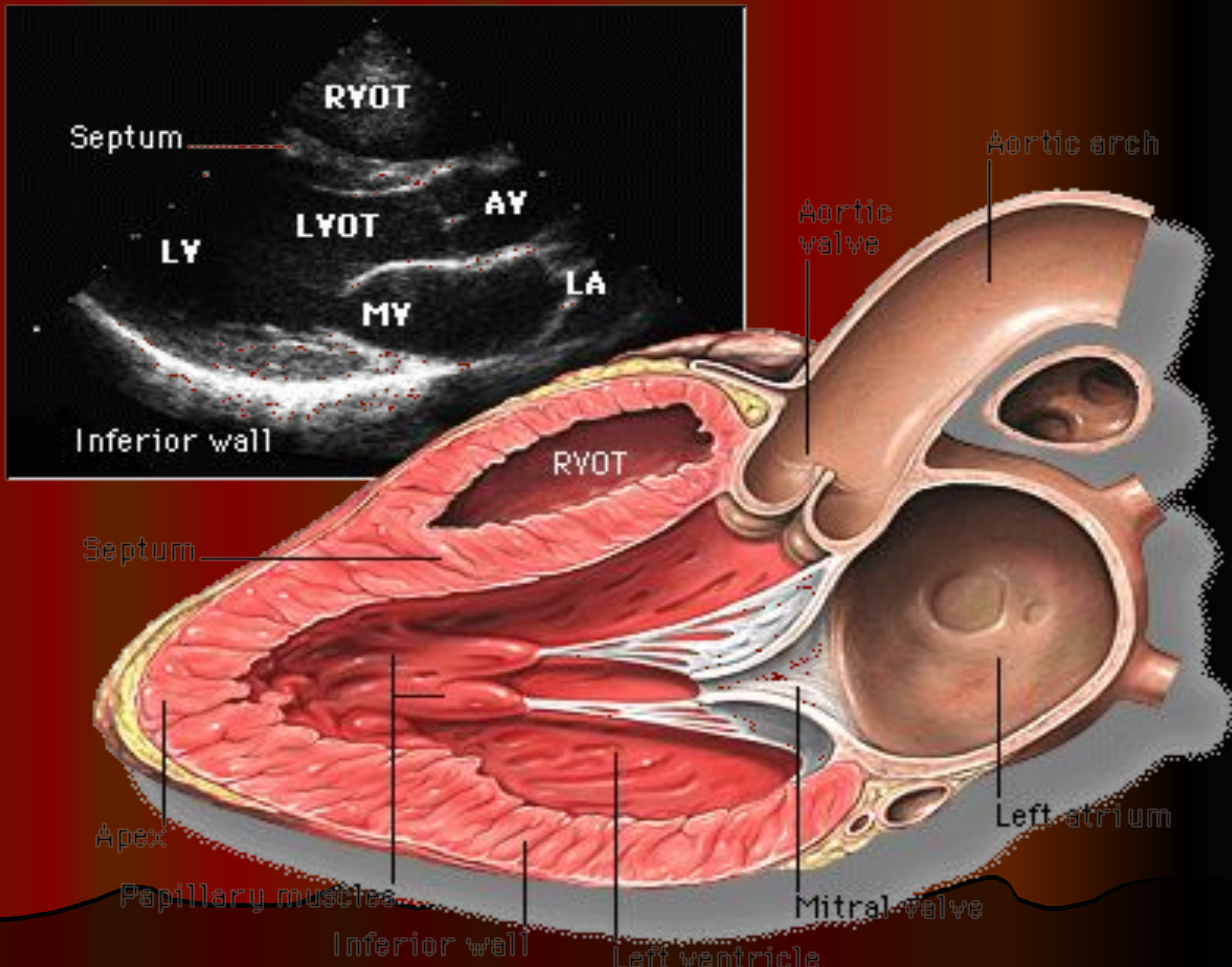
<u>AXIS -</u> The plane in which the ultrasound beam travels through the heart.

1. Long-axis view: Images in long axis are obtained, with slices from the base to the apex of the heart

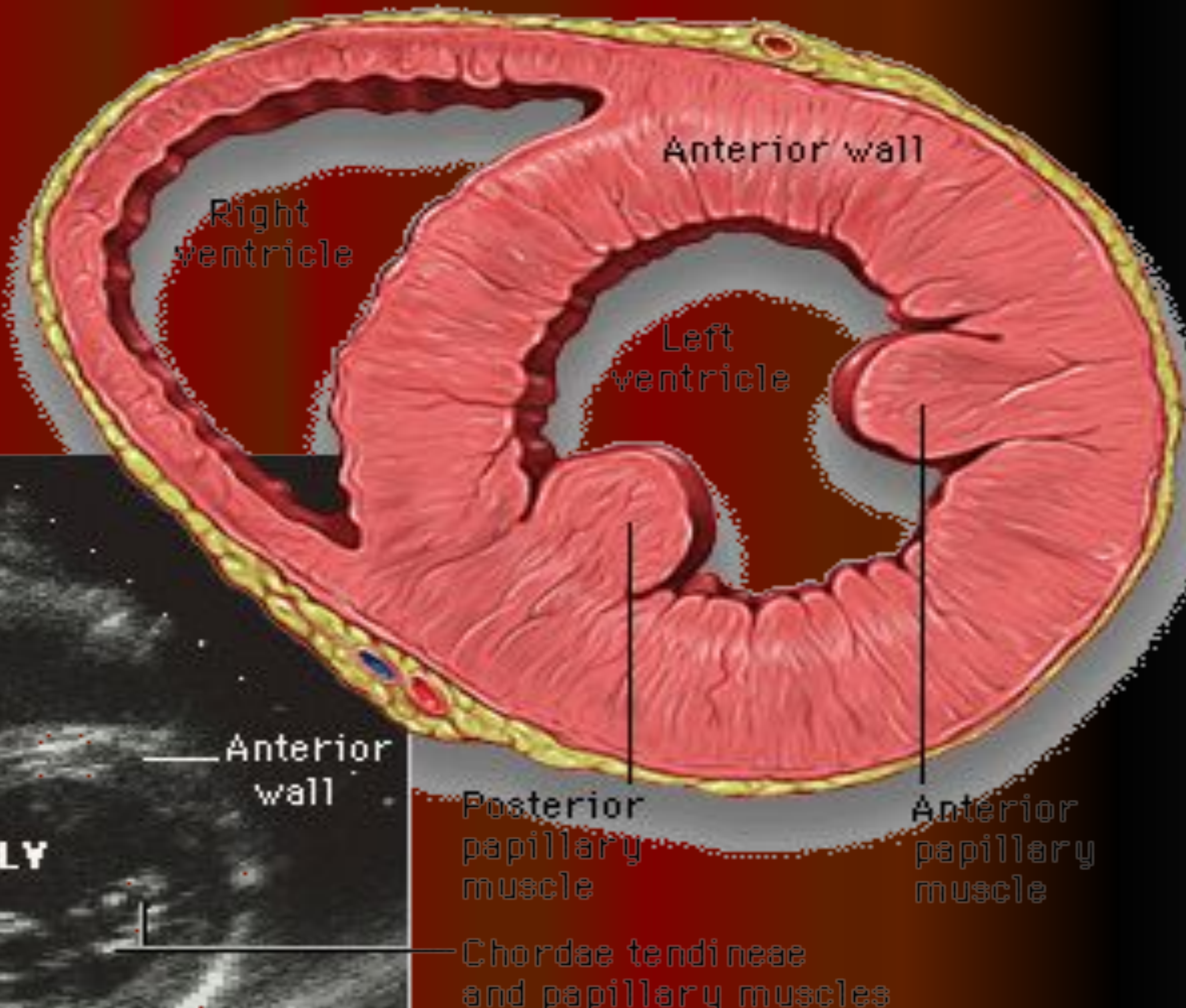
2. Short-axis views: Heart is cut in transverse sections. The standard 4 short axis views are at the level of aortic valve, mitral valve, left ventricular papillary muscles and left ventricular apex.

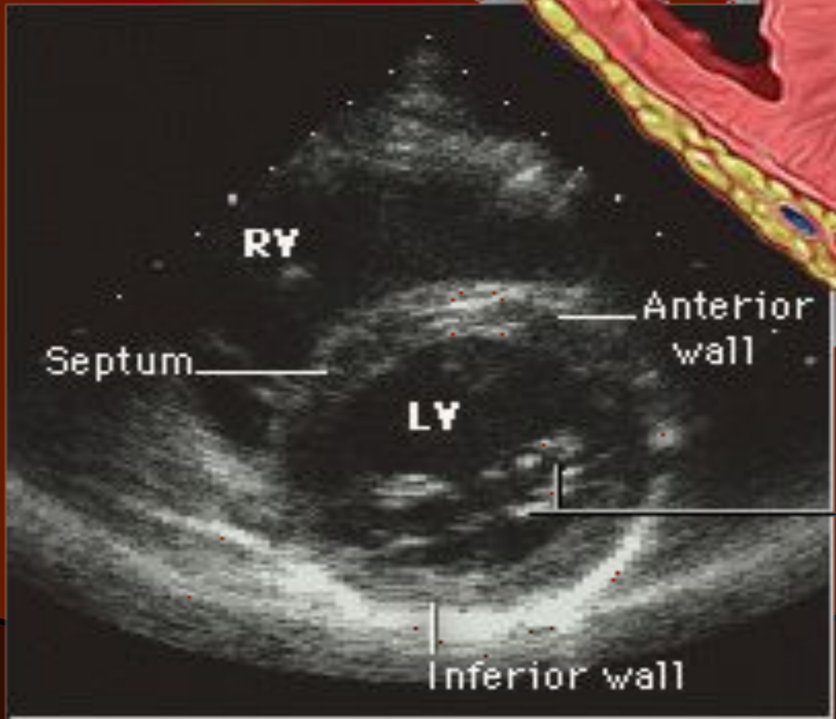
3. 4-chamber view: Typical ‘heart shaped’ 4-chamber view is obtained by placing transducer at the apex.

PARASTERNAL LONG AXIS VIEW

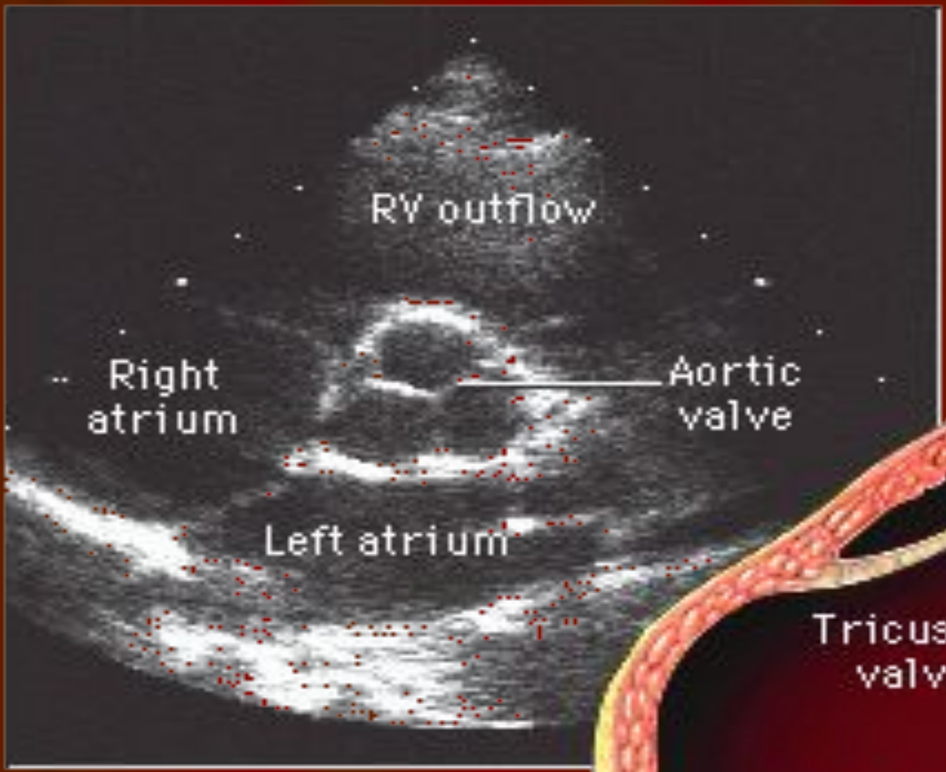


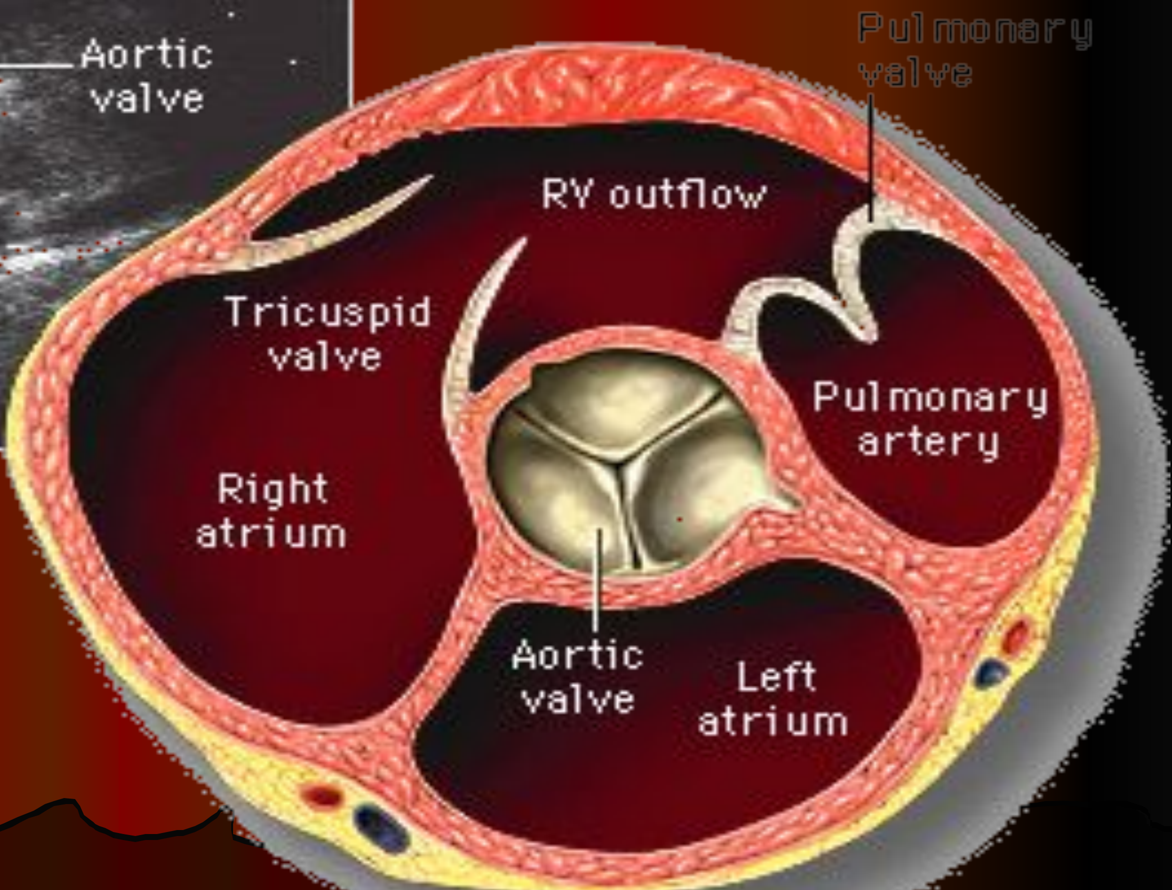
2-D ECHO SHORT AXIS VIEW



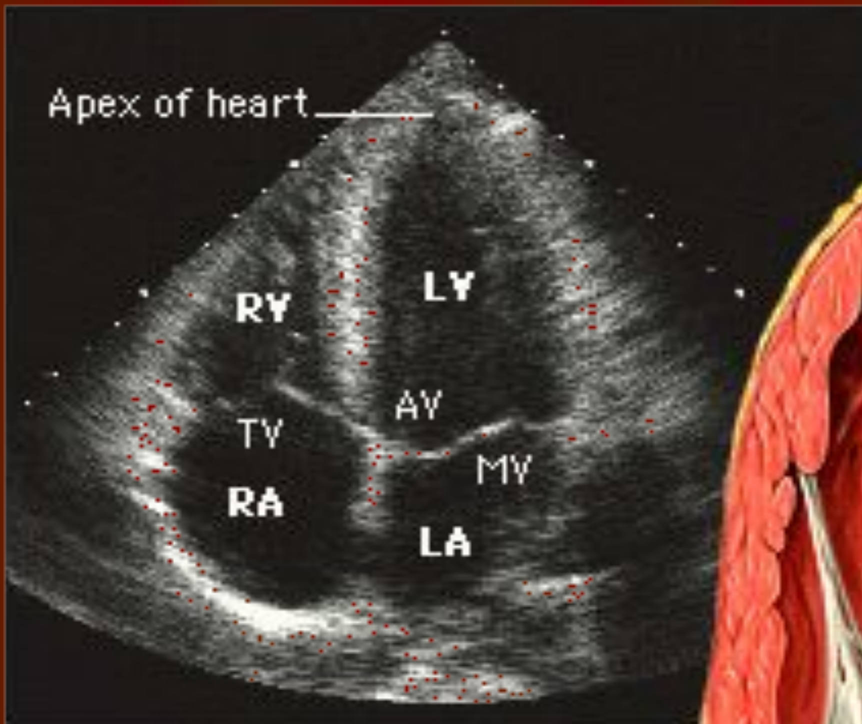


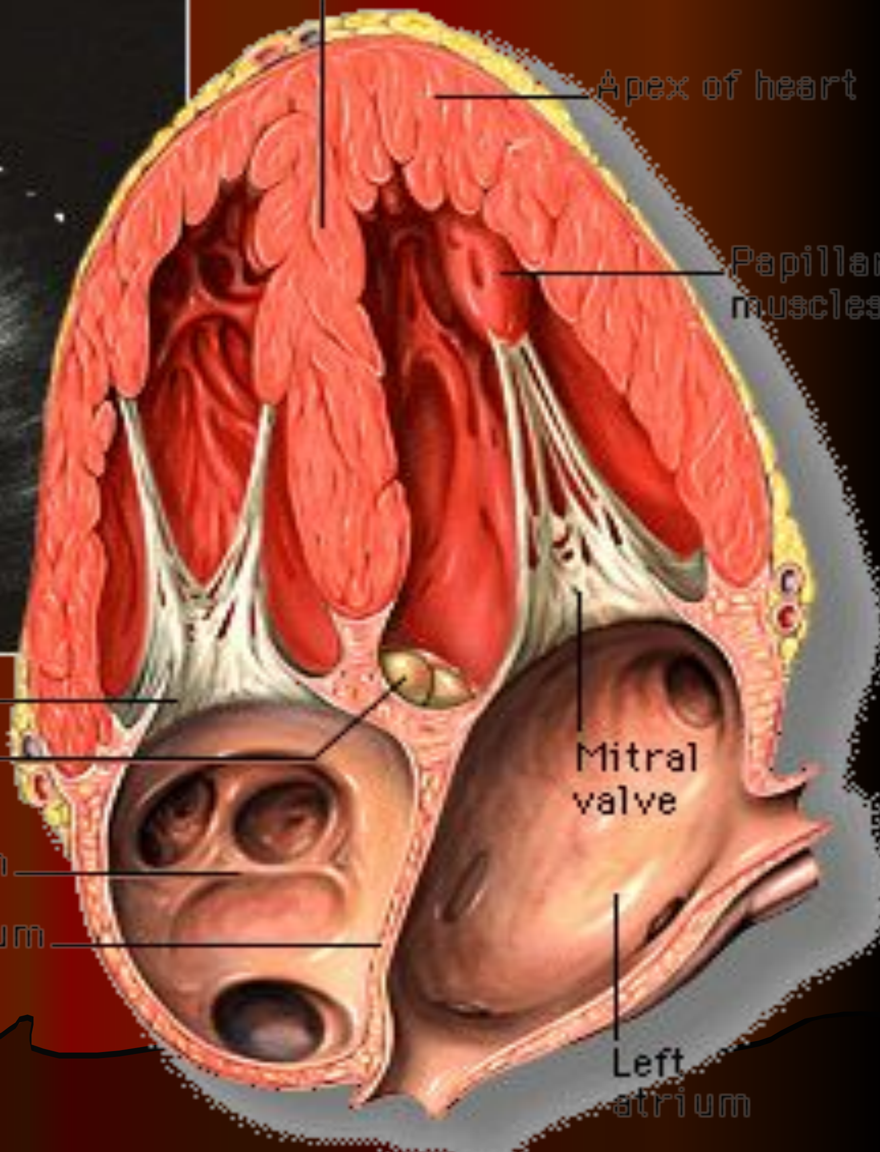
2-D ECHO SHORT AXIS



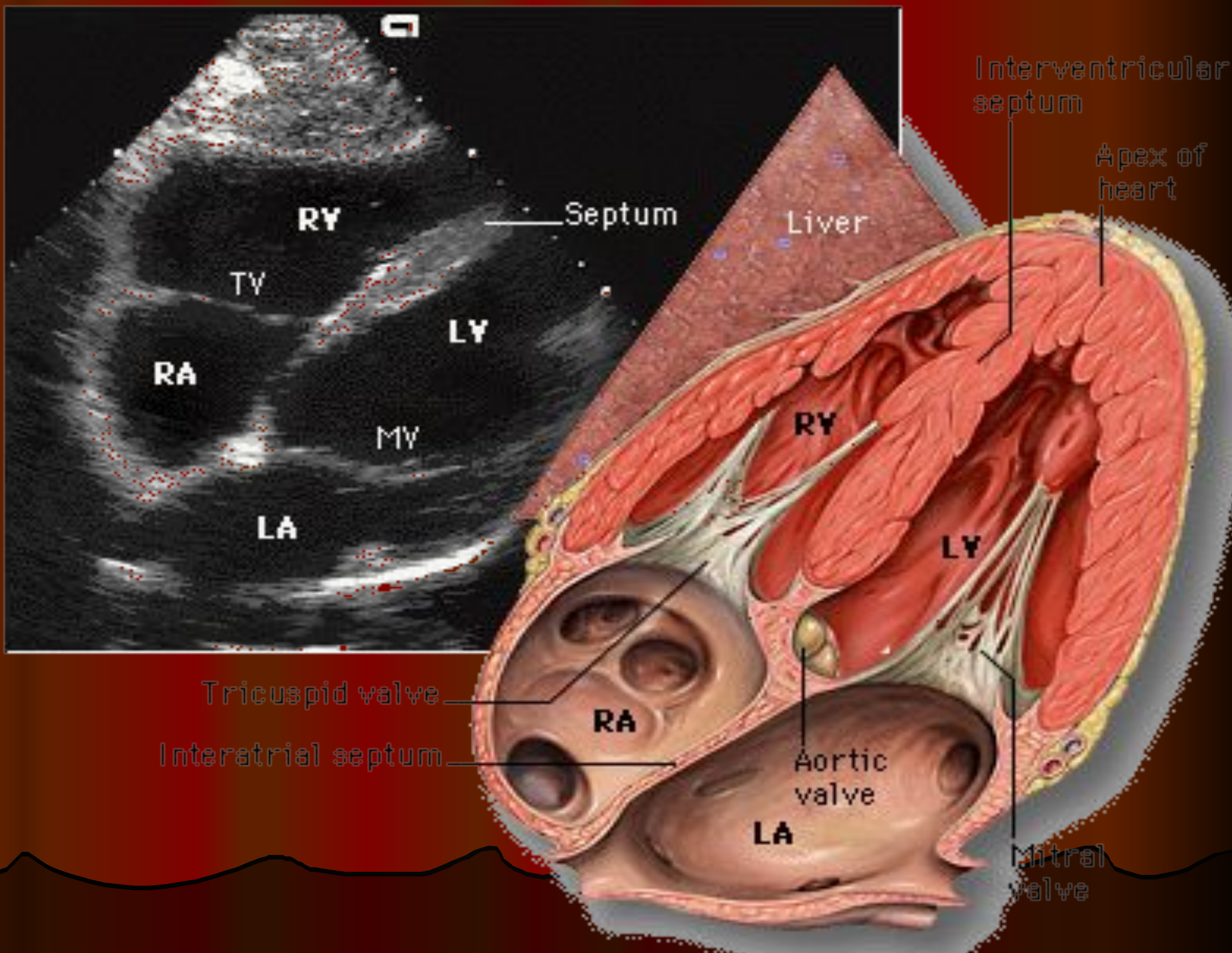


APICAL 4-CHAMBER VIEW





LONG AXIS SUBCOSTAL VIEW



COMMON TYPES OF ECHO TECHNIQUES

- M MODE
- 2 DIMENSIONAL ECHO
- DOPPLER ECHO

2-D ECHO –

- Gives a snapshot in time of cross section of a tissue.
- Gives expanded view of cardiac anatomy.

MOTION OR M - MODE ECHO –

- Gives a high sensitivity for recording moving pictures.
- Produces a graph of depth and strength of reflection with time.
- Changes in opening and closing of valves or ventricular wall movement can be displayed.

DOPPLER ECHO –

- Frequency of reflected ultrasound is altered by moving RBCs (red -flow towards; blue-flow away)
- Gives haemodynamic information regarding the heart and great vessels.
- Measures the severity of valvular stenosis, regurgitation, ventricular filling patterns, diastolic abnormalities and can show intra-cardiac shunts like VSD and ASD.

ASSESSMENT OF LV SYSTOLIC FUNCTION

M – mode echo is usually used to assess LV cavity dimensions, wall motion and thickness.

Poor LV systolic function is usually associated with increased dimensions as ‘a big heart is a bad heart’.

But sometimes regional wall motion abnormalities may also result in impaired systolic function.

FRACTIONAL SHORTENING

Commonly used measure for LV systolic function.

Is the percentage change in LV internal dimensions (not volumes) between systole and diastole.

$$FS = \frac{LVEDD - LVESD}{LVEDD} \times 100$$

Where,

LVEDD – LV end diastolic dimension.

LVESD – LV end systolic dimension.

NORMAL VALUES –

LVEDD = 3.5 - 5.6 cm

LVESD = 2.0 – 4.0 cm

FS = 30 – 45%

EJECTION FRACTION

Is the percentage change in LV volume between systole and diastole.

$$EF = \frac{(LVEDD)^3 - (LVESD)^3}{(LVEDD)^3} \times 100$$

Where,

LVEDD – LV end diastolic dimension.

LVESD – LV end systolic dimension.

Normal Value is 50 – 85%.

REGIONAL LV WALL MOTION

Is one of the important determinants of LV systolic function and can be useful to determine the location of coronary artery disease.

The wall motion score is as follows:

0 – Hyperdynamic

1 – Normal

1.5 – Mildly hypokinetic

2 – Hypokinetic

2.5 – Severely hypokinetic

3 - Akinetic

4 – Dyskinetic

5 – Aneurysm

6 – Akinetic with scar

7 – Dyskinetic with scar

Wall motion score index- Numerical score is applied to each of the predefined segments and then total score is divided by no. of segments evaluated. Normal value is 1.0 Higher score represents ventricular dysfunction.

ASSESSMENT OF LV DIASTOLIC FUNCTION

Is a complex function.

Has 4 periods – isovolumic relaxation, early rapid filling, late filling and atrial systole.

Not advisable to rely on a single echo measure.

Anatomical and haemodynamic features should also be considered.

From Newton's II Law of Motion:

Force = mass X acceleration

The only factor that causes blood to move from LA to LV is atrioventricular force or pressure gradient which is proportional to the blood acceleration.

Peak blood velocity thus depends not only on the peak pressure gradient but also on the time during which it has acted.

Doppler echo can provide useful information of LV diastolic function by measuring the transmitral flow pattern which reflects the flow into the LV.

The characteristic flow pattern includes:

1. The E-wave : Result of passive early diastolic LV filling.
2. The A-wave : Represents active late diastolic LV filling due to LA contraction.

3. Acceleration Time of E-wave (AT) : The time from the onset of diastolic flow to the peak of E-wave.

4. Deceleration Time of E-wave (DT) : Time from E-wave peak to the point where the deceleration slope hits the baseline.

Normal Values of :

	MEN	WOMEN
Peak E-wave (m/sec)	0.66 ± 0.15	0.70 ± 0.16
E-wave DT (sec)	0.21 ± 0.04	0.19 ± 0.04
Peak A-wave (m/sec)	0.67 ± 0.16	0.72 ± 0.18
E:A Ratio	1.04 ± 0.38	1.03 ± 0.34

ABNORMAL MITRAL FLOW PATTERNS

1. Slow-relaxation pattern : decreased LV relaxation due to diastolic dysfunction associated with LV hypertrophy or myocardial ischaemia

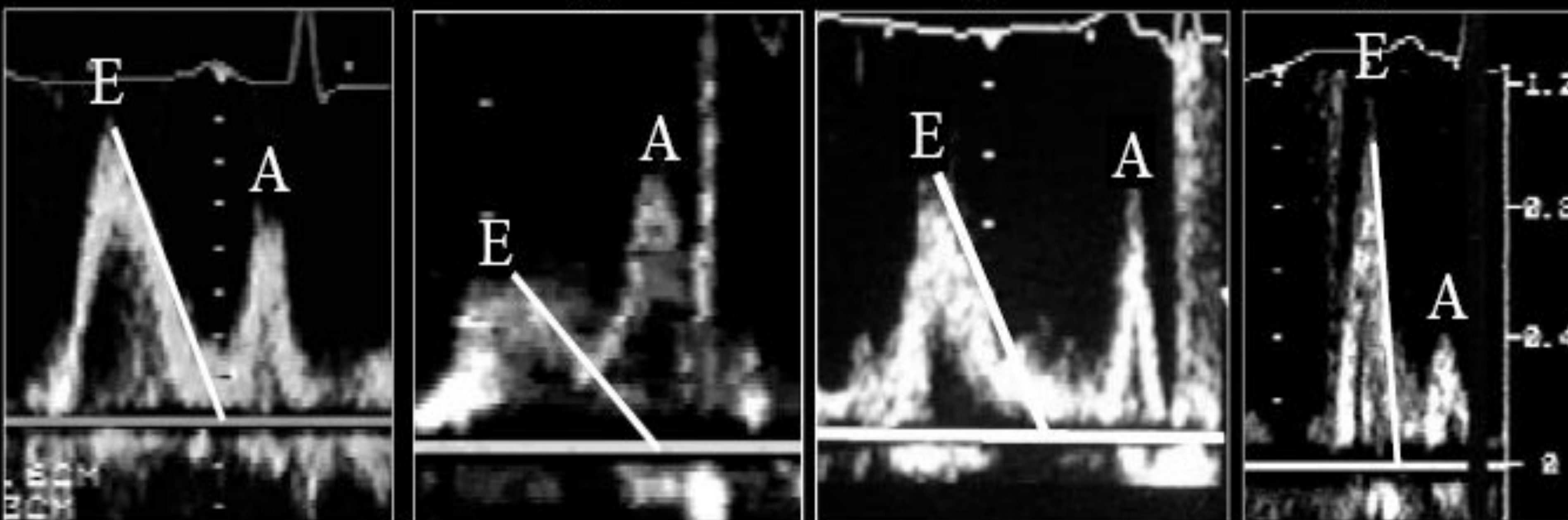
E-wave: Small; A-wave: Large; AT & IVRT: prolonged

2. Restrictive pattern : reduced LV filling due to conditions causing a rapid rise of LV diastolic pressure like restrictive cardiomyopathy or constrictive pericarditis, MR, HCM or systolic heart failure.

E-wave: very tall; A-wave: small; DT & IVRT: short

PATTERNS OF DIASTOLIC DYSFUNCTON

Normal	Impaired Relaxation Type I	Pseudo-normal Type II	Restrictive Type III



E/A >1	E/A < 1	E/A 1-1.5	E/A >2
DT 150-220	DT >250	DT 150-220	DT <150
IVRT <90ms	IVRT >90ms	IVRT <90ms	IVRT <70ms

ISOVOLUMIC RELAXATION TIME (IVRT)

- Represents the earliest phase of diastole.
- Defined as the time from aortic valve closure to the mitral valve opening.
- Normal value : 76 $\pm$ 13 msec.
- In this phase, systole contraction has ceased, but LV filling has not yet begun.

ISOVOLUMIC CONTRACTION TIME (IVCT)

- Represents the earliest phase of systole.
- Defined as the time from mitral valve closure to the aortic valve opening.
- Normal value : 35 $\pm$ 11 msec.
- In this phase, diastolic filling has ceased, but LV emptying (ejection) has not yet begun.

EJECTION TIME (ET)

- Time taken for ejection of the blood from the LV or RV outflow tract.
- It is the time interval between IVCT and IVRT.
- Normal value: LV ET is 294 ± 12 msec and RV ET is 302 ± 15 msec

MYOCARDIAL PERFORMANCE INDEX

- An expression of global ventricular performance.
- Includes both systolic and diastolic parameters.
- Can be applied to both LV as well as RV.

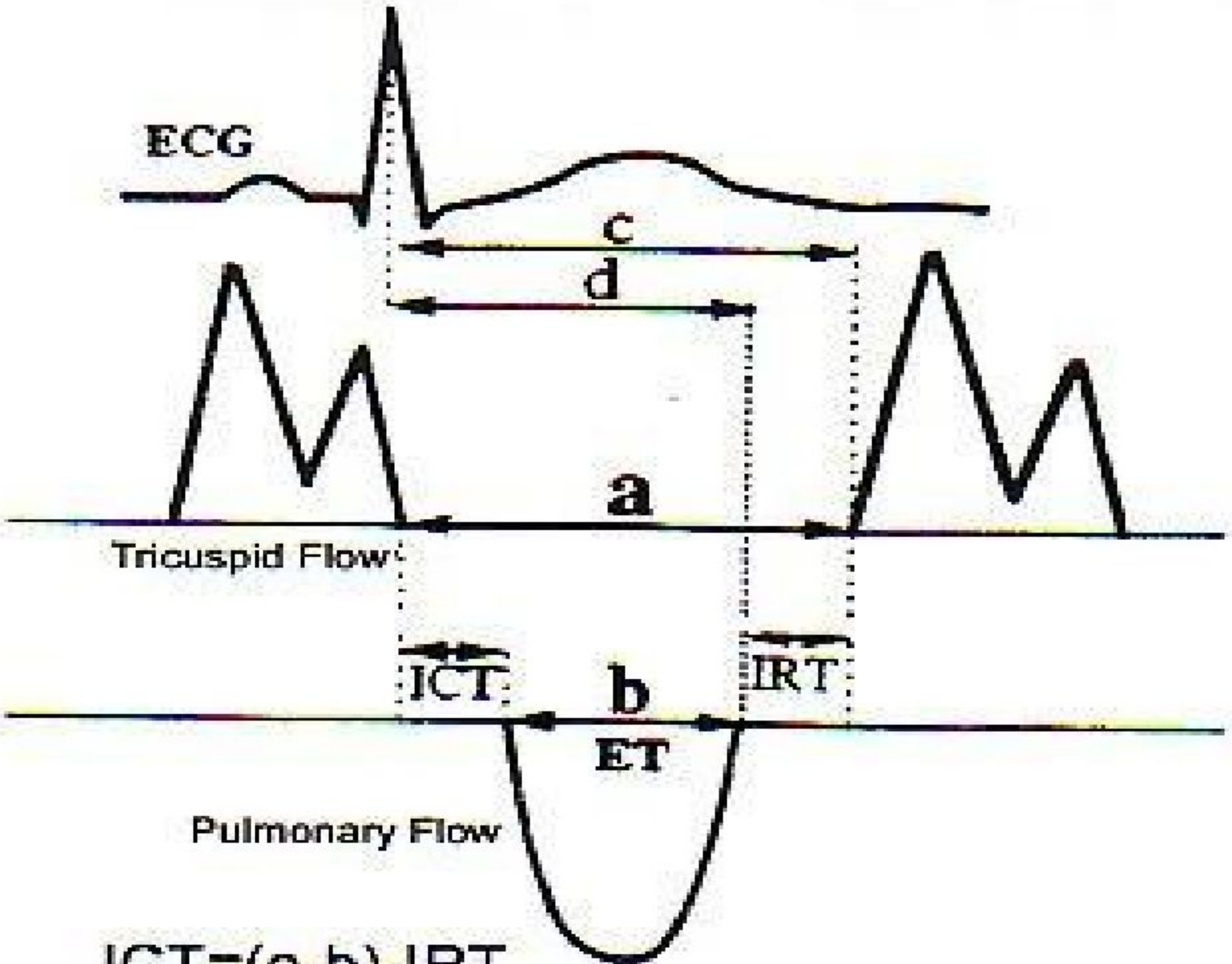
$$MPI = \frac{IVCT + IVRT}{ET}$$

- Normal value of LV MPI is 0.39 $\pm$ 0.05 and RV MPI is 0.28 $\pm$ 0.04

- Systolic dysfunction is associated with prolongation of IVCT and shortening of ET.
- Diastolic dysfunction leads to lengthening of IVRT.

Thus, both systolic as well as diastolic dysfunction will result in an increase in MPI.

MYOCARDIAL PERFORMANCE INDEX



$$ICT=(a-b)-IRT$$

$$IRT=c-d$$

$$Index=\frac{a-b}{b}=\frac{(ICT+IRT)}{ET}$$

PULMONARY ARTERY SYSTOLIC PRESSURE

- With continuous-wave Doppler, the maximum peak Tricuspid Regurgitation (TR) velocity (V) recorded from any view is used to determine the right ventricular systolic pressure (RVSP) with the simplified Bernoulli equation:

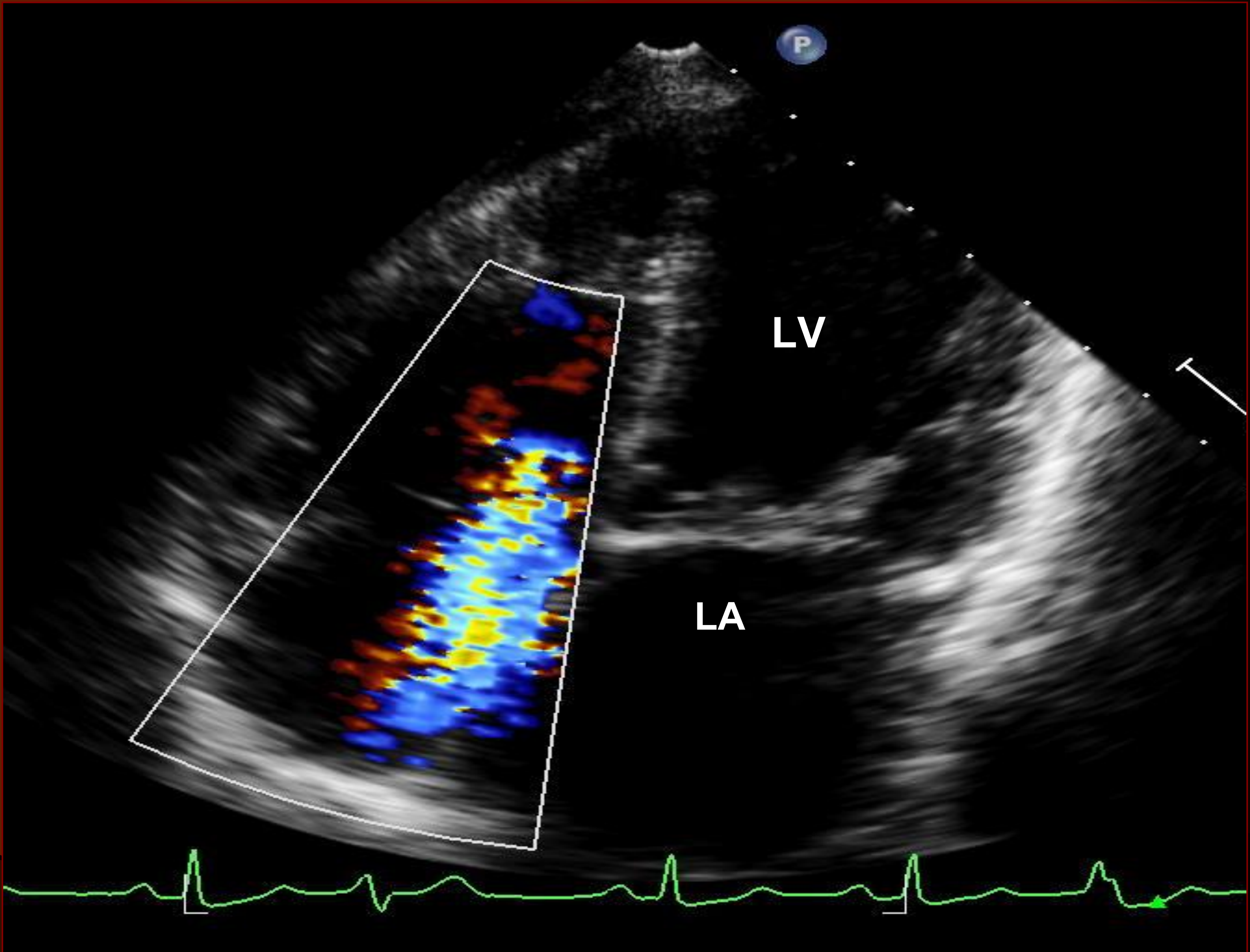
$$RVSP = 4V^2 + RAP$$

- PASP was assumed to equate the RVSP in the absence of pulmonic stenosis and RV outflow tract obstruction. Therefore,

$$PASP = RVSP = 4V^2 + RAP$$

where,
RVSP = right ventricular systolic pressure,
V = peak TR velocity and
RAP = right atrial pressure and is assumed to be 10 mm Hg.

TRICUSPID REGURGITATION



PULMONARY ARTERY HYPERTENSION

This is defined as abnormal increase in PA pressure above:

- 30/ 20 mm Hg (normal 25/10 mm Hg).
- Mean 20 mm Hg at rest
- Mean 30 mm Hg during exercise.

FUNCTIONAL CAPACITY

- It refers to the capability of performing tasks and activities which the people find necessary or desirable in their lives.

MEASUREMENT OF FUNCTIONAL CAPACITY

- Higginbotham M.B. et al (1983) in their study established that exercise capacity is best characterized as the maximum rate of total body oxygen consumptions (VO_2 max) during exercise.

- S. Miyamoto et al (2000) concluded that the distance walked during six minute walk test (6MWD) very well correlates with the functional capacity and has strong, independent association with mortality in mitral valve disease patients.

CERTAIN EVIDENCES

- Aleksandr Rovner, et al. 2004 [1] In their study population of Diastolic HF patients, clearly demonstrated the importance of LV relaxation (measured by E & A wave velocities and IVPG) as one of the determinants of VO2 max.

- Jong-Won Ha, et al 2005 concluded that Doppler derived indexes (E’, E/E’ ratio), an estimate of myocardial relaxation and LV filling pressures, correlate with exercise capacity in patients with Apical Hypertrophic cardiomyopathy, suggesting that abnormal diastolic function may be a factor limiting exercise capacity.

- Wei Li, et al 2004 fond out that systemic ventricular function is depressed in most patients with Mustard repair for transposition of great vessels. Quantitative echocardiographic evaluation shows systemic ventricular function to be a key determinant of exercise capacity.

- Ahmed Samman and co workers, 2008 demonstrated that impairment in LV and RV function, as measured by MPI, is associated with diminished exercise capacity in patients with repaired tetralogy of Fallot.

- Gilbert E. D’Alonzo, 1987 concluded that patients with PPH as measured echocardiographically have severe exercise limitation due to cardiovascular factors with an inability to maintain appropriate oxygen delivery to the body during exercise.

- Polcaro and co-workers, 2008 concluded that longer walked distances before and after the rehabilitation program are significantly associated with preserved or moderately depressed LV function (as measured by LV EF), whereas greater relative increases of the distance walked after rehabilitation program are significantly associated with poor LV function.

THANK YOU