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TRANSESOPHAGEAL ECHOCARDIOGRAPHY AND THE ANAESTHESIOLOGIST

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Since the first transesophageal echocardiography examination in 1975, using M-mode imaging with mechanical scanner contained in oil bag having limited control of direction, there have been a lot of modifications and technical advances in the equipment1. In its infancy, the main application of TEE was assessment of global left ventricular function and regional wall motion abnormalities (RWMA). In the modern equipment, with provision of multiplaner & multifrequency probes (3.5 to7 MHz), colour flow mapping, pulse & continuous wave doppler, cine loop displays and digital image processing, now it has become possible to have same information rather of better quality than transthoracic echocardiography. Another advantages of TEE include the stability of the transducer and continuous recordings for extended periods of time, which are very desirable for monitoring in operation theatre. With advancing technology and experience of anaesthesiologists, the number of clinical applications and scope of TEE is increasing further and getting more defined.

Indications The common indications are:

1. Assessment of valvular function intra and postoperatively.
2. Evaluation of mitral valve repair and prosthetic valve surgery.
3. Assessment of global left ventricular function and regional wall motion abnormalities (RWMA).
4. Assessment of aorta for arteriosclerosis, calcification and dissections.
5. Detection of intracardiac defects, masses and vegetations.
6. To see optimal deairing after open-heart surgery.
7. For quick evaluation of severe hypotension intra and postoperatively by ruling out conditions requiring immediate intervention like cardiac temponade,poor left ventricular volume status ,RWMA , mal function of prosthetic valve or systolic anterior motion of septum after MVR and aortic dissections,etc.
8. Inadequate or impossible transthoracic echocardiography. Other areas where its use is increasing these days are critical care units and emergency rooms to have quick evaluation of polytrauma and sick patients to ascertain the cause of shock.

Although TEE is a fast and relatively non-invasive technique, its routine use for noncardiac surgery is yet to be established. Many studies have revealed that echocardiography is more sensitive than electrocardiography for early detection of ischaemia2-6. But as it is difficult to monitor all areas continuously, it gives low yield even in coronary artery disease patients undergoing noncardiac surgery.

Secondly as the probe is placed after induction of anaesthesia and removed before extubation ,critical periods of stress are left unmonitored.However quick assessment of loading status and measurement of cardiac output can be very useful in variety of surgeries involving major shifts in the intravascular volume of the patient. Another indication of TEE in noncardiac anesthesia is to detect persistent fossa ovalis and venous air embolism in intra cranial and orthopedic surgery.

Equipment and Its placement

TEE equipment includes the basic echocardiography unit and TEE probe. All TEE probes have some common features. Currently employed equipment hoses a 5 MHz transducer in the tip of probe. The tip can be directed antero-posteriorly and sideways by adjusting the two knobs placed in the proximal handle. Another feature is a temperature sensor at the tip to warn of possible heat injury. Often TEE probe is placed once general anaesthesia is induced, however it can be placed in awake patients under local anaesthesia (Xylocaine 2% viscous and Xylocaine 4% topical spray) and mild sedation with midazolam 2 mg . It is always safe to use bite block in awake patients. Probe should be lubricated with xylocaine 2% jelly and introduced gently through oral cavity till 25 cm mark at incisior level, with transducer facing anteriorly. At this level one may see 3 or 4-chamber view and can adjust gains and depth.

Standard Projections

Once TEE probe passes 3-5 cms down to inferior constrictor (20-25 cms from incisors), one starts getting images of great vessels and cardiac chambers. The common projections of interest to an anesthesiologist are:

Transverse Views

1. Basal View or 3Chamber view In transverse axis at about 25 -30 cms from incisors this view is obtained. One can see aortic valve and sinuses in the center,coronaries,parts of both atria and interatrial septum. This view can be used to study aortic valve anatomy, degree of calcification and measuring aortic cross sectional area.Adjusting the probe little in and out one can focus the pulmonary artery and its main branches(Fig 1):
2. Mid esophageal View or 4 Chamber View (Fig-2).:
   Once probe is further enhanced 2-3 cms down(30-35 cms from incisiors),4 chambers are seen in a single viewThis provides plenimetry of chamber sizes,detection of intracardiac air bubbles after open cardiac surgery and mitral valve evaluation.Detailed mitral valve examination can be done using different angles to study mitral leaflets, their coaptation and regurgitation in systole,mital valve flow studies using pulse wave Doppler or continous wave Doppler and colour flow mapping. This view is very useful judging the adequacy of repair of mitral valve.
3. Short-axis Transgastric View (Fig 3):
   This view is obtained by introducing further to 40 cms or so and anteflexing the probe so that transducer faces towards the apex of heart.This view is very useful for monitoring LV function, studying RWMA,ischaemia,LV aneurysm and preload of LV.

   Longitudinal Views(90 degrees)

4. **Wrap View or RVOT View**. (Fig 4):
   At basal level once 3 chamber view is obtained,the probe is rotated to 60 to 90 degree angles to

get the Right atrium,RV and pulmonary trunk in one view.At times one can see the PA catheter transversing to one pulmonary arteries at this level.

5. **Midoesophageal View**
   This view is obtained by rotating the probe anticlockwise at mid esophageal level and is used to make the detailed evaluation of left atrium , its appendage(LAA),left pulmonary veins and pulmonary venous flow pattern.
6. **Trans gastric View**
   In longitudinal view it is possible to see longitudinal section of LV,papillary muscles and LA.

Common Clinical Applications

1. **Left Ventricular assessment**
   Global LV assessment includes measurement of dynamic indices and segmental wall motion abnormalities. Assessment of global and regional ventricular performance has become the cornerstone for evaluation of patients with ischemic heart disease The ejection fraction (EF),a commonly used contractility index can be derived from the ventricular volumes in end -daiastole (EDV) and end systole (ESV) using the following formula:

   $$EF\ \% = EDV-ESV/\ EDV \times 100$$

   A fractional area change can be calculated from the 2D trans esophageal echocardiography images,end systolic area ,and end daiastolic area obtained from the transgastric short axis view at the midpapillary level.

   $$FAC\% = EDA-ESA/EDA \times 100$$

   Fractional shortening is inaccurate if ventricular asynergy exists. Further it has been shown that EF is more sensitive than cardiac out put measurement in detection of cardiac contractility[8] to decrease further ambiguity from dyskinesia, it is possible to measure LV volume using Simpson's formula,although it is impractical to use it in routine clinical settings[9]. Measurement of wall thickening and assessment RWMA are important tools to assess cardiac contractility.

   Diastolic dysfunction can be checked using mitral valve flow studies with pulse wave Doppler or continuous wave Doppler. Normally E wave (wave of early ventricular filling) is greater than A wave (wave of late ventricular filling by atrial contraction).In diastolic dysfunction A wave is greater than E.

2. **Detection of Myocardial Ischaemia**[2-7,13]

   The superiority of TEE in the detection of myocardial ischaemia over traditional monitoring like EKG and pressure data changes has been proved by various authors[3-7]. Transesophageal echocardiography clearly delineates regional wall motion abnormalities. The changes in global systolic function & diastolic dysfunction do not match the efficacy of RWMA to detect the onset of ischaemia. The onset of visible RWMA within 10 to 15 seconds of coronary occulusion has been demonstrated experimentally[3-4]

The trans gastric short axis view of the left ventricle is obtained at six levels to evaluate different parts of LV for RWMA. Echocardiographic criteria for RWMA include an alteration in left ventricular radial shortening and wall thickening that usually accompanies normal contraction[6]. Normal contraction is defined as greater than 30% shortening of radius from the centre to the endocardial border. Mild hypokinesia relates to shortening of radius between 10 % to 30%. Severe hypokinesia is defined as less than 10% shortening, while akinesia is the absence of motion. Dyskinesia is paradoxic outward movement during systole[7].

Segmental Wall Motion Scoring System

Wall motion	Radial Shortening	Myocardial Thickening
Normal Motion	less than 30%	+++
Hypokinesia	10-30%	+
Akinesia	0%	0
Dyskinesia	systolic lengthening	systolic thinning

3. **Assessment of Mitral valve and its repair:**
   After examination of the anatomic features of the valve, colour flow mapping and Doppler studies should be used to evalauate the flow pattern across the valve.All regugitant jets should be traced to thieir origin as occasionally pulmonary venous in flow jets can be mistaken for mitral regurgitation.After surgical repair of the mitral valve,the surgeons often used to check valvular competence by injectining saline into the LV.Czer and colleagues found that, this saline filling is associated with 40% false positive results and 30% false negative results10.The only definitive test for mitral competence is echocardiography.

4. **Assessment of septal closures and repairs of Congenital Heart Disease.**
   TEE is useful to detect the residual ASD and VSD defects.By injecting saline into RA through central line with a syringe can reveal residual ASD if any by showing air bubble shadows in left atrium.VSD defects can easily be seen using colour flow mapping.

5. **Assessment of Air Removal after Open heart surgery**
   Air collects often at nondependent sites of heart and major vessels;apex of LV,aorta near origin of right coronary artery and pulmonary artery.

6. **Assessment of Prosthetic Valves**
   Each of the mechanical and bioprosthetic valve has characteristic forward transvalular flow patterns, a certain frequency of anticipated valvular regurgitation.In general ,Starr-Edwards(caged ball mechanical prostheses) and bioprosthetic valves normally exhibit a small central color Doppler signal of mitral regugitaion confined to early systole. In contrast,Bjork-Shiley(tilting disc type)exhibit small peripheral jets throughout the systole Problems with these valves can be obstruction, valvular and paravalvular significant regugitaions or infective vegetations.

7. **Evaluation for Hypotension**
During cardiac and non cardiac major surgery, hypotension is a common occurance.The cause may not be apparent from routine haemodynamic parameters.TEE affords essential or additional information of the cardiac events causing hypotension.Anaesthesiologists often use 4 chamber view and transgastric view at mid papillary level for quick evaluation of hypotension in the immediate post operative period or critical care areas.It has been very useful to detect hypovolumia,cardiac temponade,valve dysfunction,poor contractiality of LV,dissection of aorta.In hypovolumic states,both papillary muscles are seen as kissing to each other in transgastric view at mid papillary level and this view is very reliable as 80% of the stroke volume is ejected by contraction LV at this level[11].TEE offers a superior index of preload compared with pulmonary artery occuluding pressure[12].

8. **Evaluation of Aorta for Cannulations and Dissections**
Tee is very useful to assess aorta for atheromatous plaques,calcification and dissections etc. Anaesthesiologists can guide the surgeon to find the proper site for aortic cannultion.

9. **Detection of intracrdiac masses,thrombus and vegetations.**
TEE is better than transthorcic echocardiography in evaluation of intracardiac masses because of better quality images and resolution.

10. **Measurement of Cardiac Out put[2,7,12]**
Cardiac out put can be derived from either 2D echocardiography or Doppler imaging techniques. The accuracy of 2D scanning is limited by geometric assumptions that this method implies.

Cardiac Output (CO) = (EDV-ESV) x Heart Rate

Where EDV and ESV are end diastolic and systolic volumes respectively.
Doppler technique applies determination of cross sectional area of aortic orifice and velocity measurement at the same level.Cross sectional area of aortic orifice can be measured from 3 chamber view (Fig 1) using either formulae from equqtion 1 or 2, and calculating velocity time integral (VTI) using pulse wave Doppler at orifice level through transgastric view.. Then cardiac output can be measured by multiplying stroke volume to heart rate.

Cross sectional area= 0.433 x L2 …………Equation -1

Or

p $(D/2)^2$ = 0.785 x D2 …………………….. Equation-2

SV = CSA x VTI ……………………….Equqtion-3

Cardiac Out Put = Stroke Volume x Heart Rate

where L=length of cusp
D=Diameter of orifice

SV= Stroke Volume
CSA= Cross Sectional Area
VTI= Velocity Time Integral

Complications:

TEE is very safe and atraumatic if used gently. However few cases of esophageal tears and burns have been reported. To avoid such complications the probe should be introduced with gentleness and care.And when lying idle in the esophagous the probe should be locked and equipment switched off to prevent the burns.Absolute contraindications to TEE in intubated patients are esophageal stricture,tumour,recent suture lines and diverticula.Relative contraindications include hiatal hernia,esophageal varices, esophagitis and unexplained upper gastrointestinal bleeding.

In coming era, I hope TEE will become a routine tool in emergency room to assess the critically ill and trauma patients to have quick information regarding the patient's ventricular performance, loading status, physiological and mechanical compressions by pericardial effusion or temponade, myocardial contusions, major vessel tears and haematoma. Another area which needs consideration is training and quality assurance for TEE. Although there are no specific guidelines for quality assurance so far in India and equipment is available only in limited centres, but proficiency can be achieved by dedicated training like cardiac fellowships, reading scientific fundamentals of echocardiography, TEE atlas, self assessment, image re-evaluation by cardiologists and practice.

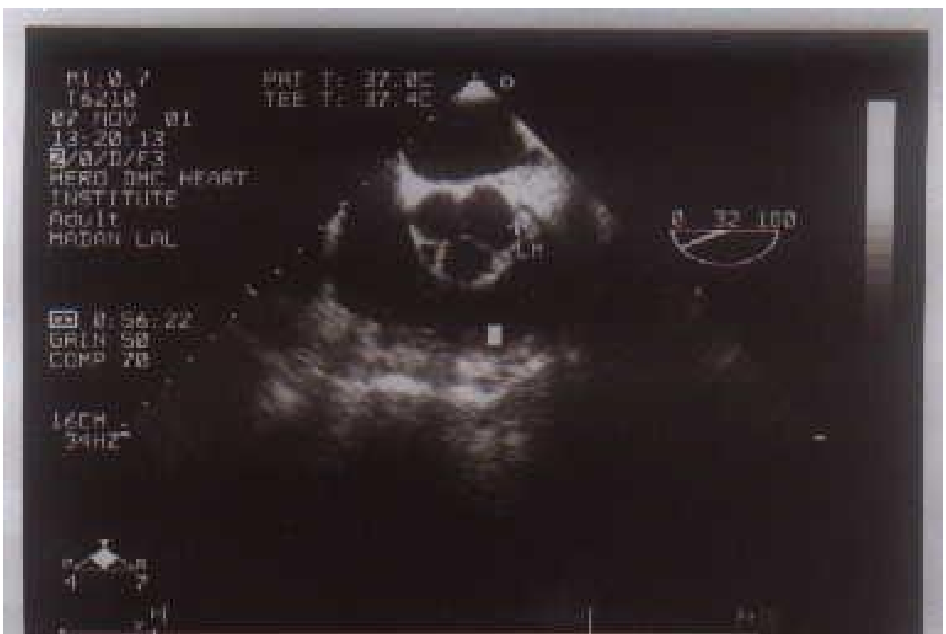

Fig.1 Short axis view at basal level showing aortic valve and origin of left main artery(LM).

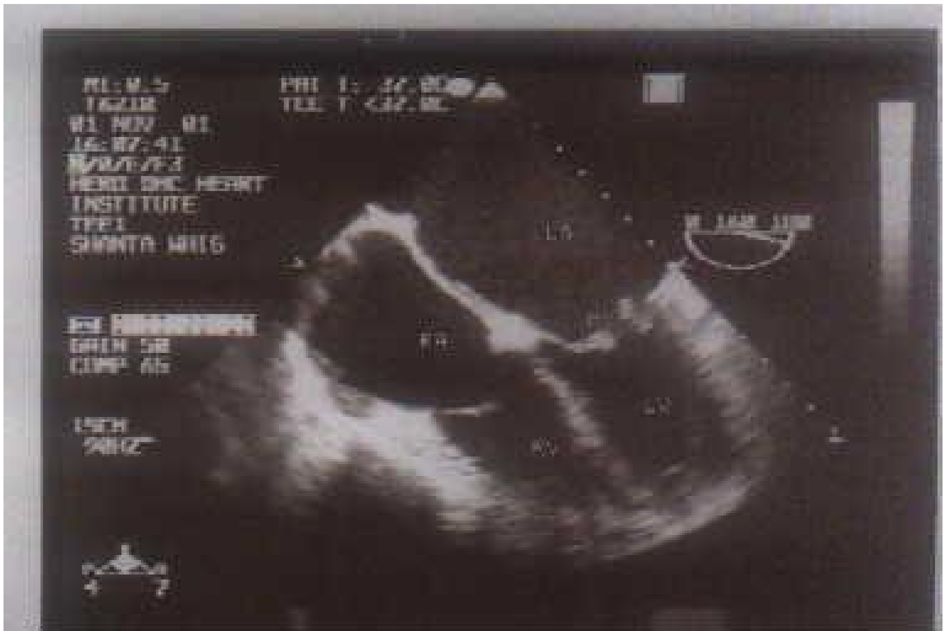

Fig 2 Short axis 4 Chamber view at mid esophageal level showing vegetations on mitral valve.

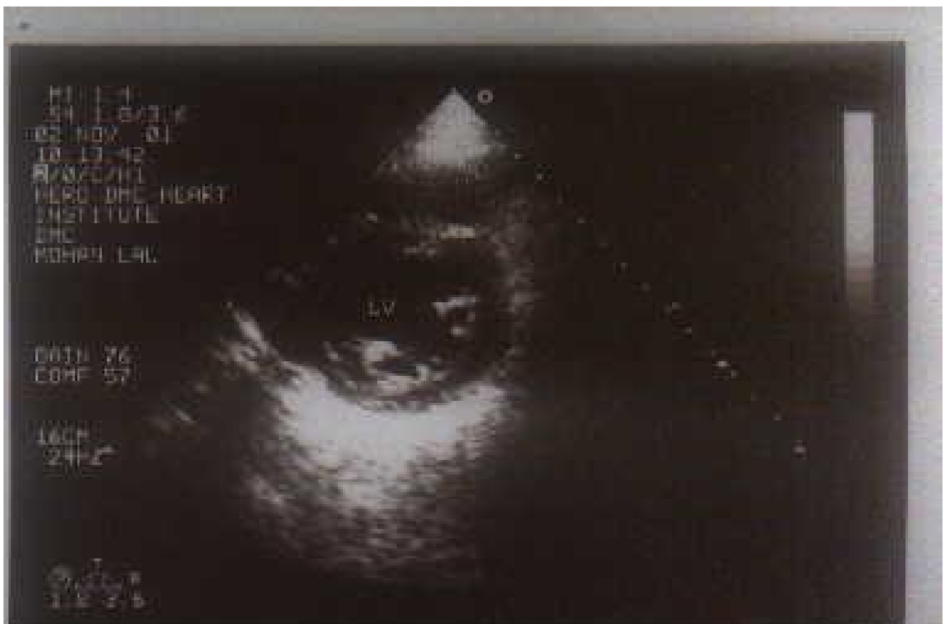

Fig 3 Short axis trans gastric view showing left ventricle and papillary muscles in cross section.

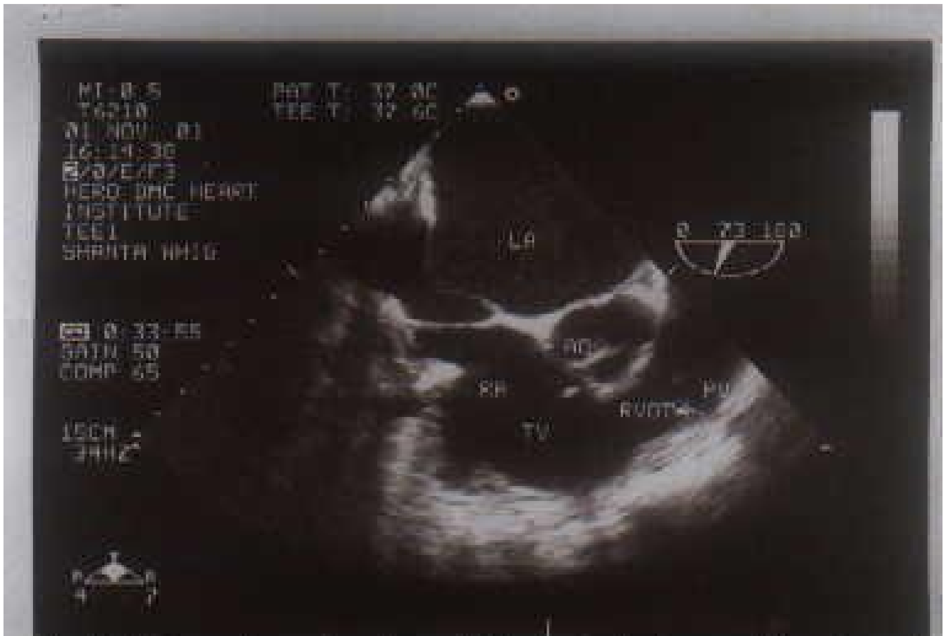

Fig 4 Wrap view showing right ventricular outflow tract (RVOT),aortic valve(AO) and left atrium(LA).

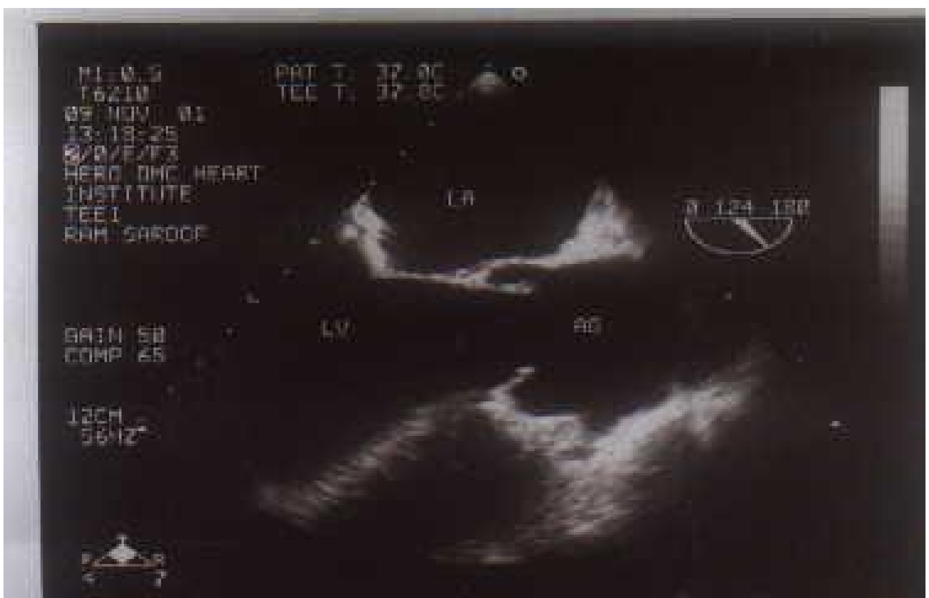

Fig 5 Long axis view at midesophageal level showing left ventriclar outflow tract(LVOT) and aorta(AO).

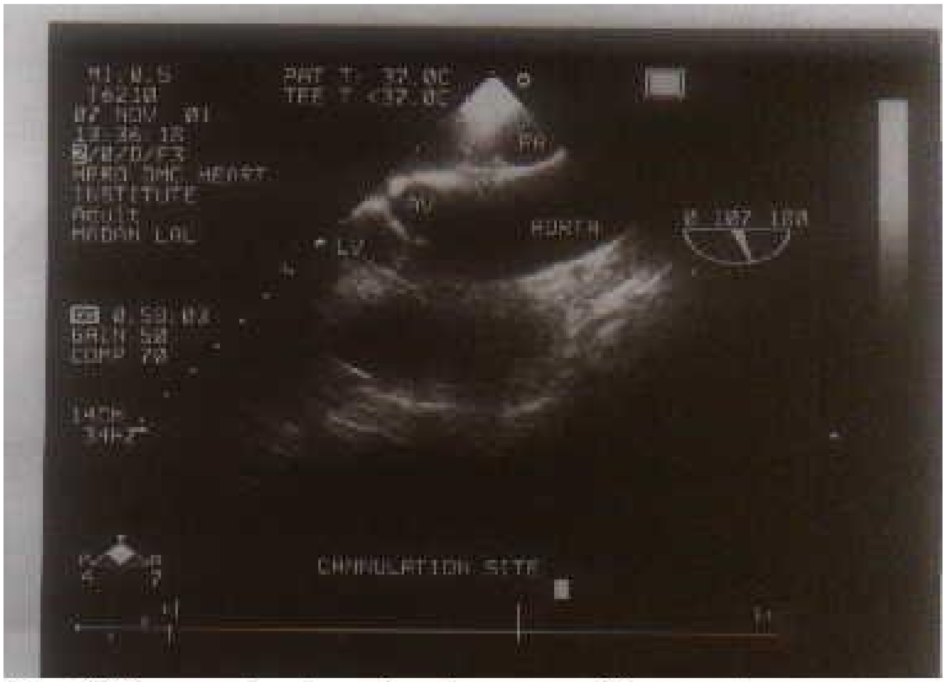

Fig 6 Long axis view showing ascending aorta.

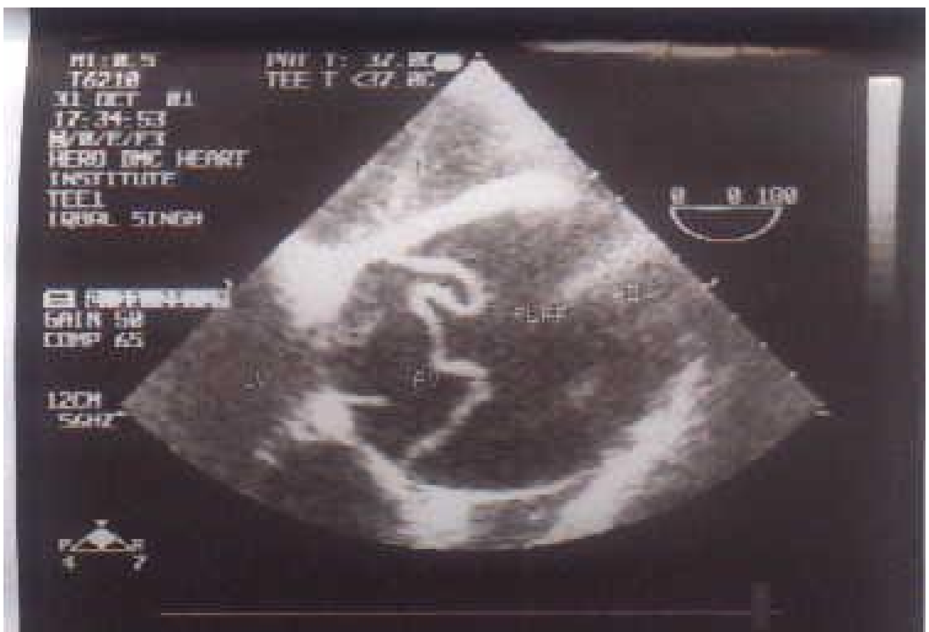

Fig 7 Short axis view showing dissection of aorta

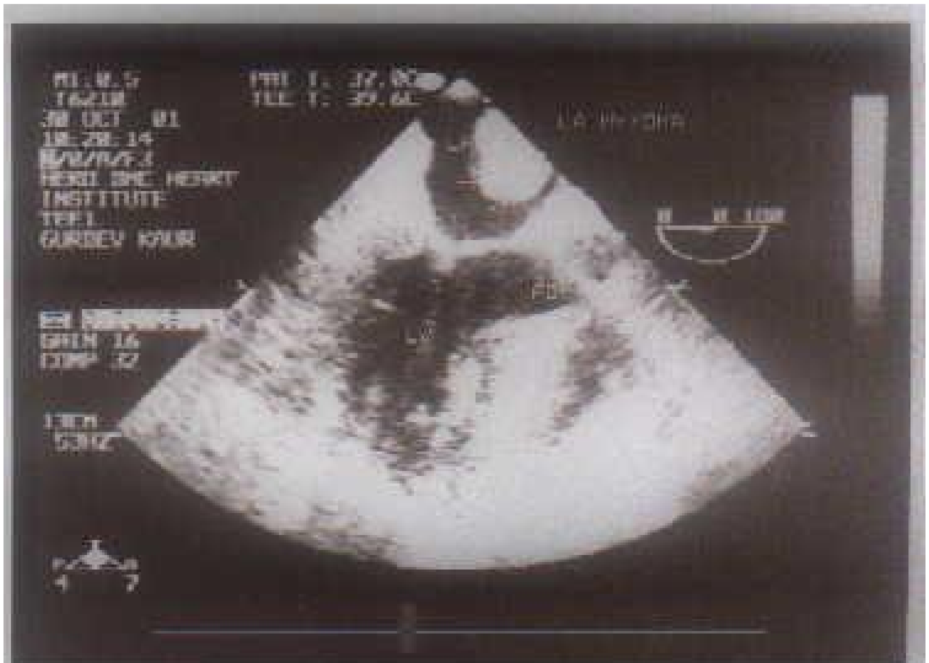

Fig 8 Short axis view showing left atrial myxoma.

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