# TWO DIMENSIONAL ECHOCARDIOGRAPHY

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## SYNOPSIS

**The technique of two dimensional echocardiography is described. The value of this investigation in the various cardiovascular disorders and its current and future place in cardiological assessment is discussed.**

## INTRODUCTION

In the past decade, M mode echocardiography has become one of the most important investigations for the evaluation of the cardiovascular system. The major reasons for the phenomenal growth in popularity of M mode echocardiography are (1) it is entirely non-invasive and therefore non-harmful to the individual (2) it can be easily performed at the bedside and is thus applicable to those who are critically ill, as well as to those who are physically well (3) it is repeatable and reproducible[1]. However, since M mode echocardiography can produce only a one dimensional ("ice-pick") view of the heart, it is limited in its ability to provide information regarding the spatial orientation of the different cardiac structures. The second major disadvantage of M mode echocardiography is that the various cardiac structures are displayed in an unfamiliar format which bears no resemblance to the actual anatomical structures. For example, Figure 1 is an M mode echocardiographic study of the normal mitral valve. It is clear that the image which is obtained does not at all resemble anatomically the mitral valve, and is thus unrecognisable to those who are untrained in M mode echocardiography. Two dimensional or cross sectional echocardiography however overcomes both these major disadvantages of M mode echocardiography. By enabling a wide portion of the heart to be imaged simultaneously, the spatial orientation of the different cardiac structures are clearly defined. The images that are reproduced resemble the actual cardiac anatomy and can be easily recognised even by the uninitiated.

Two dimensional echocardiography first began in the late 1960's and in the early 1970's. However, significant development in this technique was seen only in the past few years. Currently, there are three different methods of doing two-dimensional echocardiography. They are (1) mechanical sector scanning (2) multielement linear array (multi scan) and (3) electronic sector scanner or phased array system[2].

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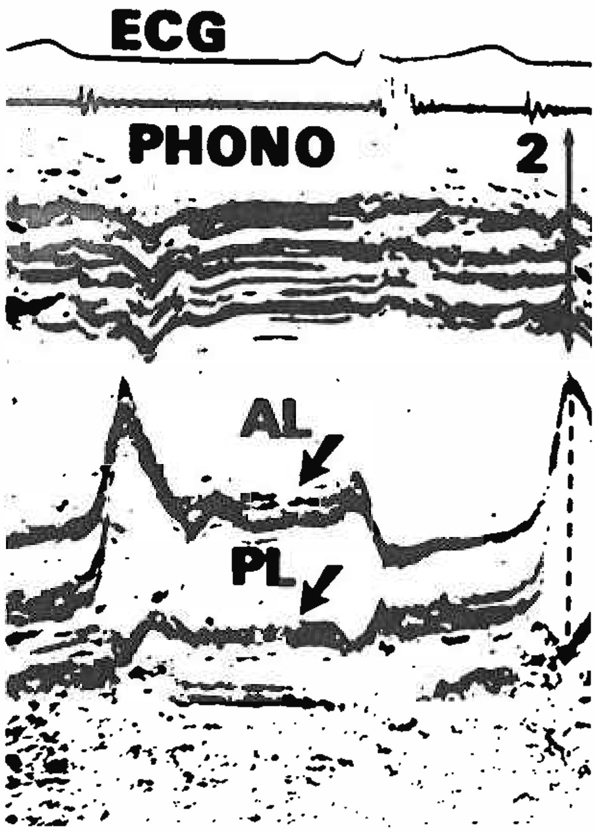


Figure 1. M mode echo study of normal mitral valve.

M Mode echocardiography was started in the Department of Medicine, National University of Singapore in 1975[3]. In July 1980, we embarked on two dimensional echocardiography ("2D echo"). This paper describes our initial experience with this technique in the examination of patients with a wide variety of cardiovascular disorders. As far as we are aware, this is the first report of two dimensional echocardiography in the Singapore-Malaysia region.

## TECHNIQUE OF EXAMINATION

We are currently employing a commercially available mechanical sector scanner (ATL Mark IV) as shown in Figure 2. The patients are examined supine or turned slightly towards the left. Cross section views of the heart are obtained by first placing the transducer over the left parasternal region in the praecordium. The long axis view of the heart is initially obtained by appropriate manipulation of the transducer (Fig. 3). The short axis of the heart is then obtained by rotating the transducer 90°. By angling the transducer inferiorly and superiorly, various structures of the heart can be imaged in the short axis (Figs 4 & 5). Another very useful view is the apical four chamber view obtained by positioning the transducer at the apex of the heart (Fig 6). If the transducer is then rotated 90°, a view equivalent to the angiographic right anterior oblique view can be obtained. Two other useful but less commonly employed views are the subxiphoid and the suprasternal views. The images which are obtained are displayed in a real time fashion on an oscilloscope and can be stored on video-tape for future replay. This form of presentation enables the actual movement of the various structures of the heart to be visualized in real time and is quite dramatic. Still photographs of single frames of the videotape can be taken from the tape. This sector scanner also has the capability of recording a simultaneous M mode echogram along any selected line in the sector arc.

Figure 2. Technique of two-dimensional examination of the heart.

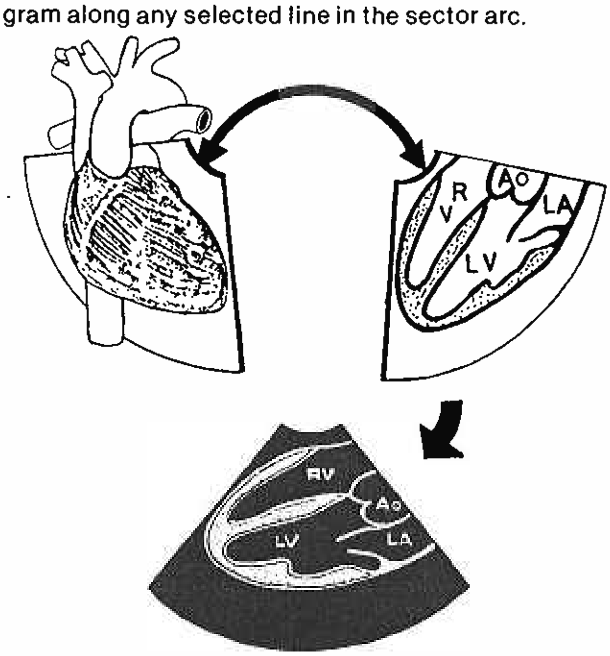


Figure 3. Long axis view of heart.

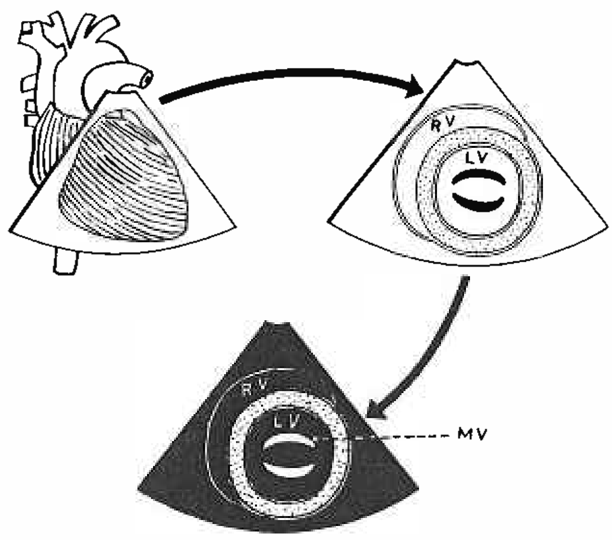


Figure 4. Short axis view of heart at level of mitral valve.

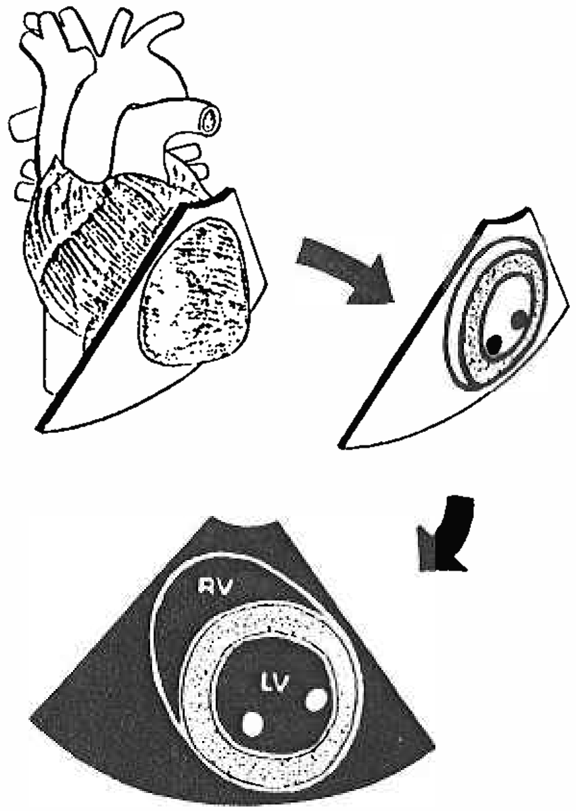


Figure 5. Short axis view of heart at level of papillary muscle.

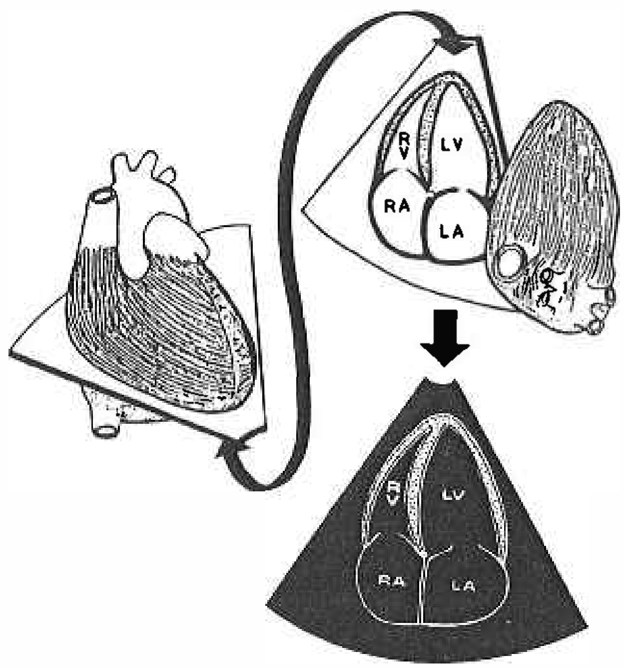


Figure 6. Apical 4 chamber view of heart.

**RESULTS**

Table 1 shows the number of cases we have studied and their respective diagnoses over the past six months.

**TABLE 1**
**ECHOCARDIOGRAPHIC DIAGNOSIS**

| | | No. of Cases |
|---|---|---|
| (1) | Rheumatic mitral stenosis ± mild mitral incompetence | 11 |
| (2) | Rheumatic mitral incompetence | 3 |
| (3) | Giant left atrium (secondary to rheumatic mitral valve disease) | 2 |
| (4) | Mitral prosthetic valve replacement (Starr-Edwards) | 2 |
| (5) | Prolapsing mitral valve syndrome | 7 |
| (6) | Ruptured chordae tendinae of anterior mitral valve leaflet | 1 |
| (7) | Congestive cardiomyopathy | 5 |
| (8) | Hypertrophic cardiomyopathy | 4 |
| (9) | Left ventricular aneurysm | 2 |
| (10) | Abdominal aneurysm | 1 |
| (11) | Hypertensive heart disease | 2 |
| (12) | Aortic valvular stenosis | 5 |
| (13) | Ruptured aortic valve (due to infective endocarditis) | 2 |
| (14) | Total anomalous pulmonary venous drainage | 1 |
| (15) | Eisenmenger Syndrome | 2 |
| (16) | Fallot's Tetralogy | 4 |
| (17) | Infundibular pulmonary stenosis | 1 |
| (18) | Pericardial effusion | 3 |
| (19) | Single ventricle | 2 |
| (20) | Normal | 15 |

The number of patients examined totalled 75. In five patients the examination was totally unsatisfactory and no diagnosis could be made. Ten patients who clinically were thought to be normal showed normal echocardiographic examination. Three patients diagnosed clinically as prolapsing mitral valve and 2 patients as possible hypertrophic cardiomyopathy had normal echocardiographic studies. But in all others the clinical diagnosis was confirmed.

## ECHOCARDIOGRAPHIC ILLUSTRATIONS:

### Aortic root aneurysm

Figure 7 is the 2D echo of a 40 year old Malay man presenting with severe aortic incompetence and a typical Marfan's habitus. In the long axis view, the aortic root is seen to be aneurysmally dilated. This is also confirmed in the short axis view. The left ventricle is noted to be dilated and in real time is seen to contract normally. The left and right atria are of normal dimensions and the mitral valve is also morphologically normal but exhibits diastolic fluttering due to the regurgitant jet of the aortic incompetence.

This patient is scheduled for aortic valve replacement shortly.

### Comment

This case shows the great value of 2D echo in the diagnosis of aortic root dilatation. In fact, in this patient the massive aortic dilatation was not apparent in the chest x-ray as is the usual case in lesions involving only the aortic root (Fig 8) but is clearly demonstrated in the 2D echo. The aneurysmally dilated aortic root can also be appreciated in the aortogram (Fig 9). The finding of a normal mitral valve and a dilated but normally contracting left ventricle is clearly of great importance in the evaluation of suitability and risk of operation in this patient.

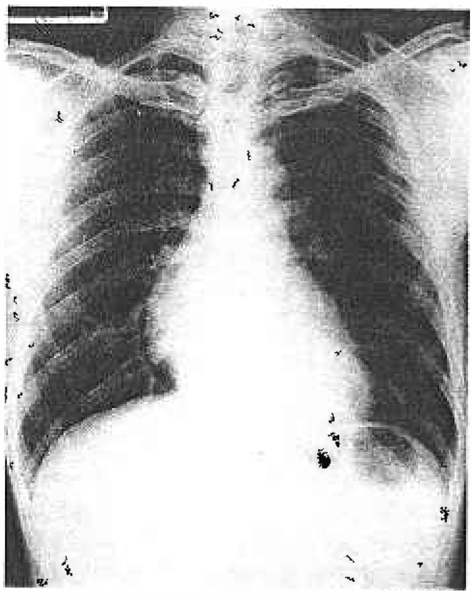

Figure 8. Chest X-ray of patient with aortic root aneurysm.

### Massive pericardial effusion

Figure 10 is the 2D echo of a 35 year old Chinese man presenting with cardiac tamponade due to pericardial effusion resulting from infiltration of the pericardium by mediastinal lymphoma. The huge pericardial effusion surrounding the heart can clearly be

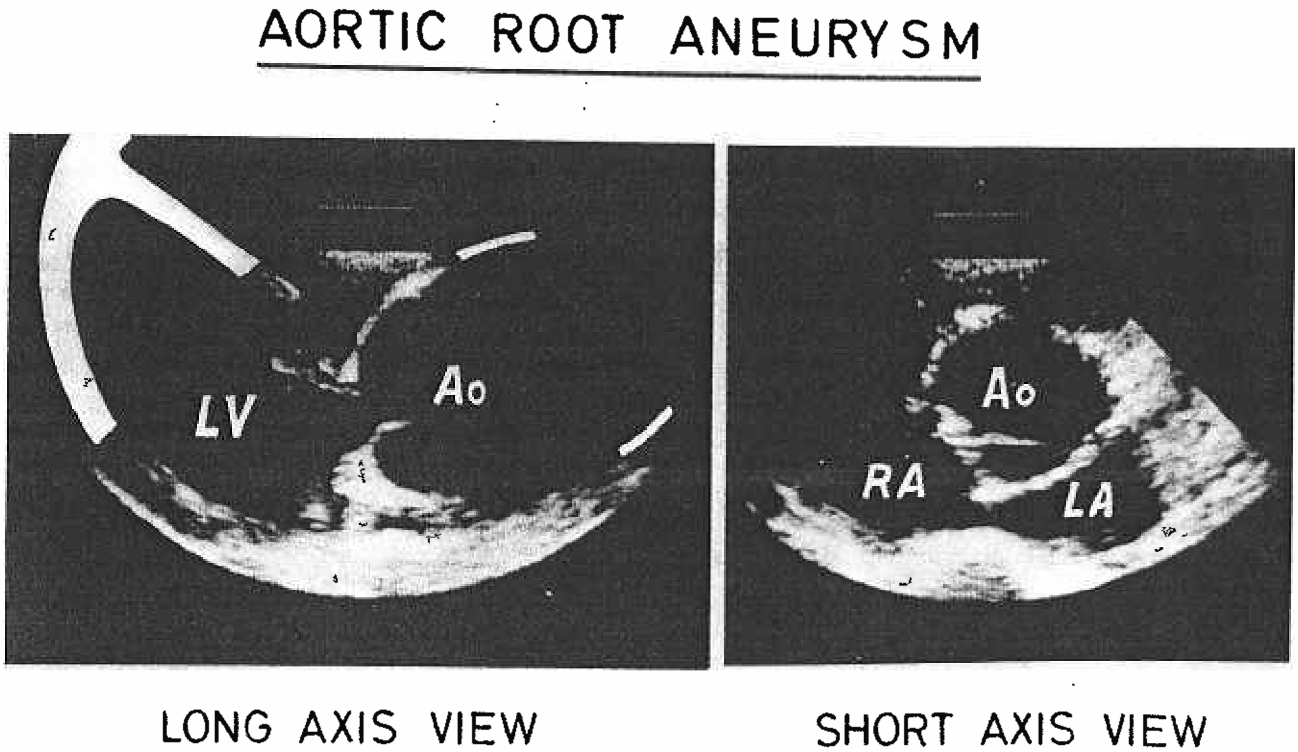


Figure 7. 2D echo showing aortic root aneurysm.

appreciated and in real time the whole heart is seen "swinging" in the pericardial sac. The cardiac tamponade was relieved by pericardiocentesis but the patient died shortly afterwards from the generalized lymphoma.

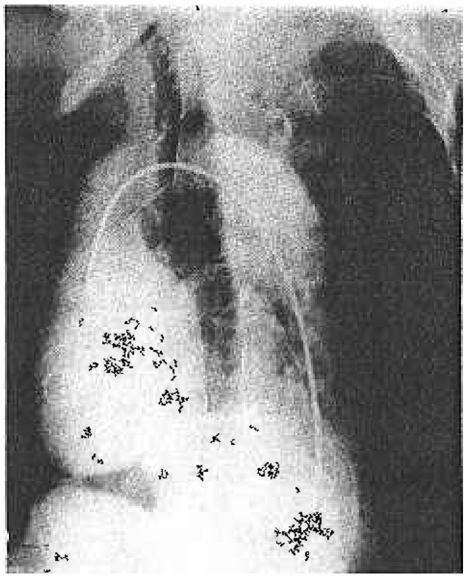

Figure 9. Aortogram showing aneurysmal dilatation of aortic root and severe aortic incompetence.

**Comment**

M mode echocardiography is the most sensitive technique of detecting pericardial fluid and as little as 16cc of pericardial fluid can be successfully imaged. Two-D echo is probably equally useful. However, because of its ability to visualize large areas of the heart at the same time, the actual distribution of the fluid in the pericardial sac is better assessed by 2D echo[4]. In cases of localized pericardial effusion, 2D echo is clearly superior.

**Congestive Cardiomyopathy**

Figure 11 is the 2D echo of a 48 year old man who presented with severe heart failure and was found to have a dilated heart in the chest x-ray. In the four chamber and long axis views, the left ventricle can be seen to be uniformly dilated. In real time, the whole left ventricle can be seen to contract very poorly diffusely and this picture is highly suggestive of congestive cardiomyopathy. He is currently treated with diuretics, digoxin and hydrallazine, and the heart failure is reasonably well controlled.

**Comment**

In the study of myocardial function of the left ventricle, 2D echo is distinctly superior to M mode echocardiography. Because of the "ice-pick" view of the heart, only a small portion of the left ventricle can be examined at a time by M mode echocardiography and this may not be representative of the left ventricle as a whole. Serious errors of assessment may arise particularly in the presence of segmental left ventricular disease such as is found in coronary artery disease. Most of these pitfalls are obviated by 2D echo. Diffuse left ventricle disease as is seen in this patient or segmental left ventricular disease such as a left ventricular aneurysm can be distinguished[5]. The presence of left ventricular clots has also been documented in the literatures.

**Hypertrophic Cardiomyopathy**

Figure 12 is the 2D echo of a 28 year old Chinese male with hypertrophic cardiomyopathy. Asymmetric septal hypertrophy as evidenced by a thickened interventricular septum with a normal thickness of the posterior wall of the left ventricle is apparent. The mitral valve is morphologically normal and no systolic anterior motion is seen.

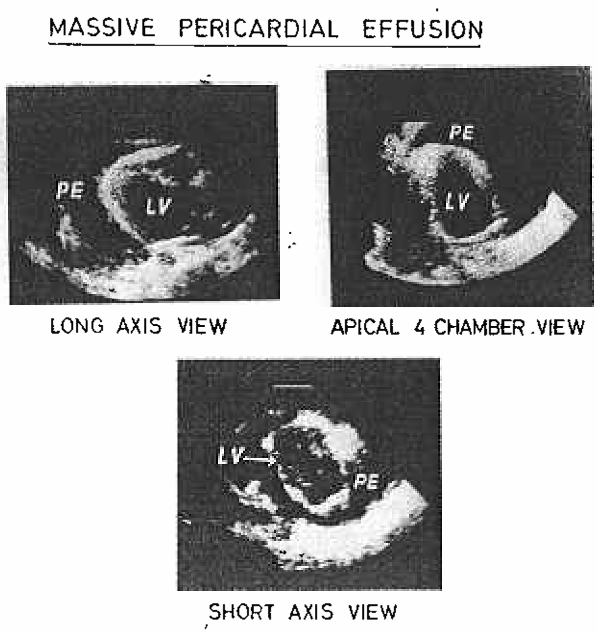


Figure 10. 2D echo showing massive pericardial effusion.

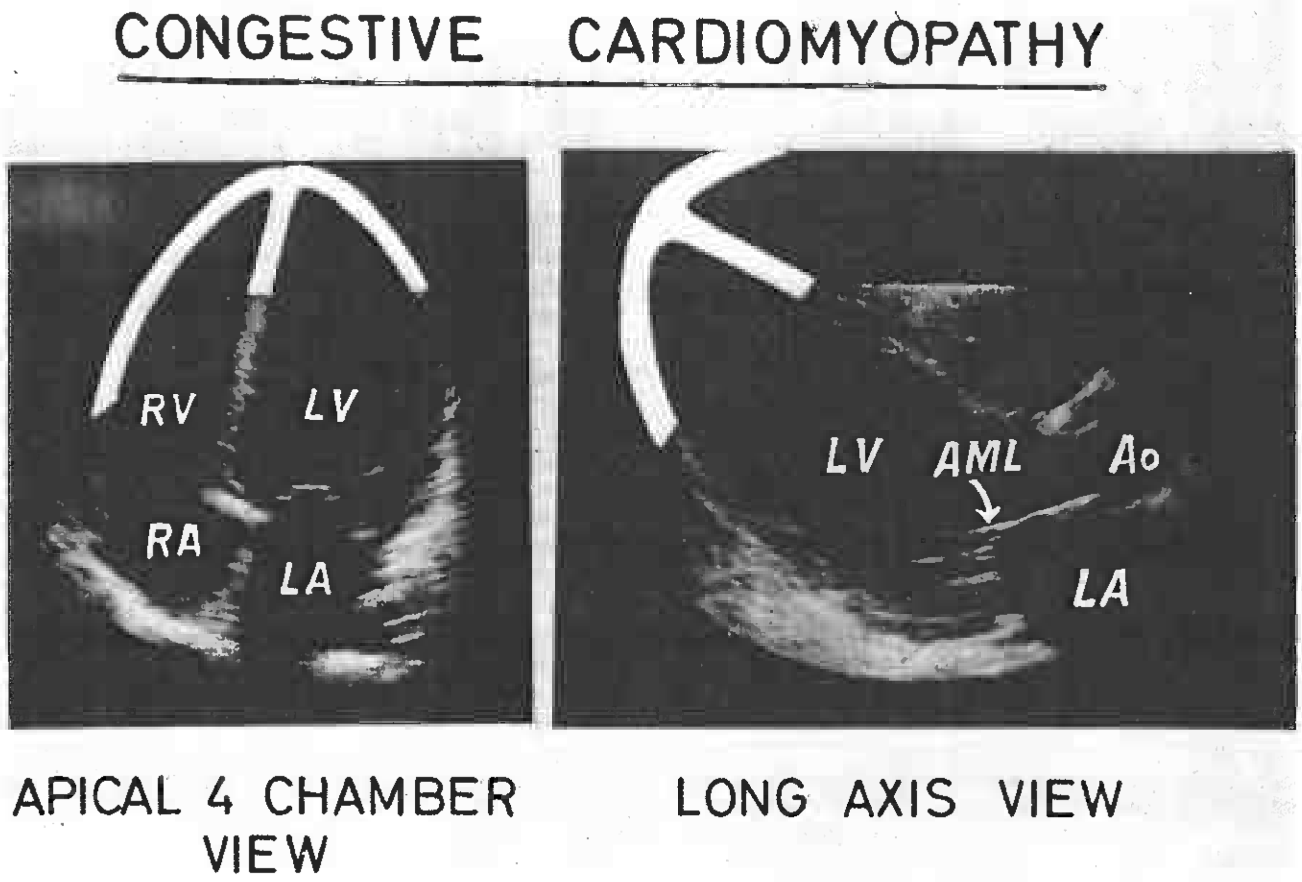


Figure 11. 2D echo showing congestive cardiomyopathy.

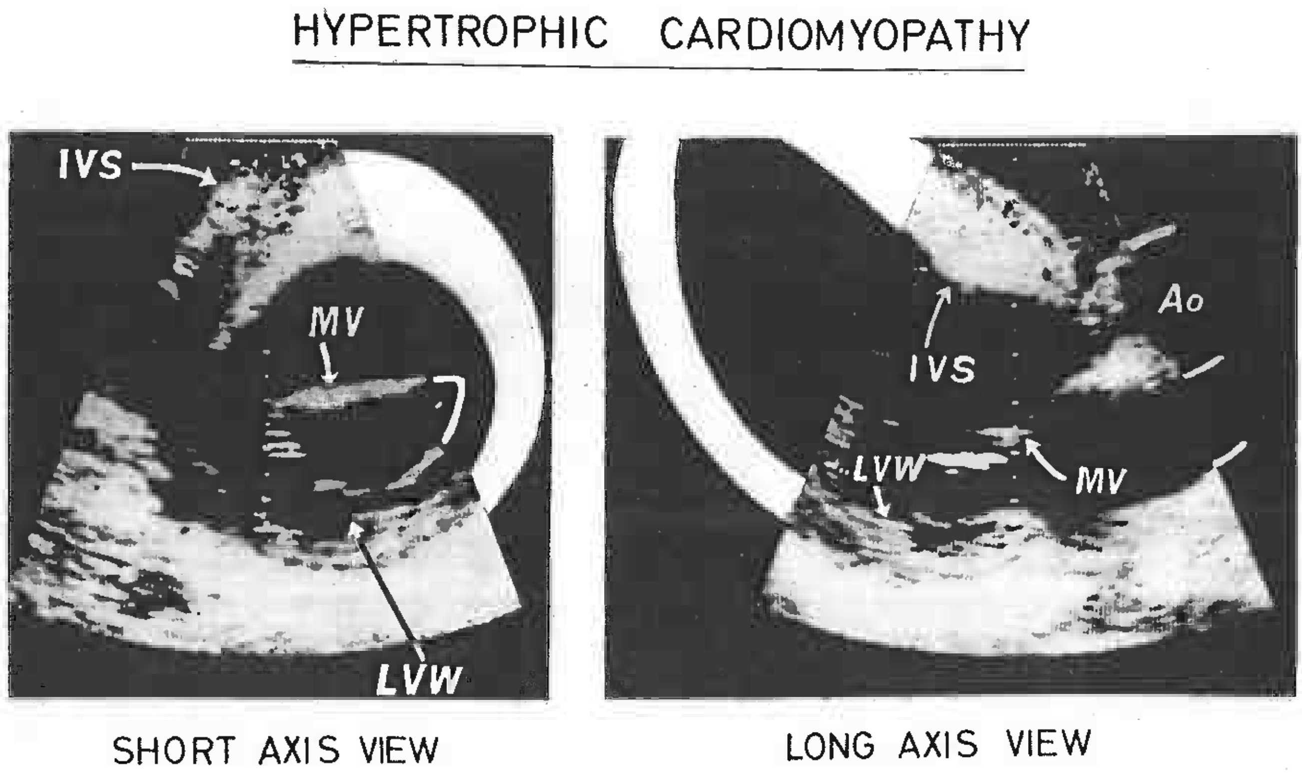


Figure 12. 2D echo showing hypertrophic cardiomyopathy.

**Comment**

Since the advent of echocardiography, the need to do cardiac catheterization and angiography to diagnose hypertrophic cardiomyopathy is fast diminishing. Both 2D and M mode echocardiography are equally useful for confirming hypertrophic cardiomyopathy. However, 2D echo is clearly superior in its ability to define the exact site of hypertrophy e.g. high, mid or apical interventricular septum and/or left ventricular free wall.

**Eisenmenger atrial septal defect**

Figure 13 is the M mode echo study of an 80 year old Chinese woman with the Eisenmenger syndrome due to atrial septal defect. It shows a dilated right ventricular cavity, normal mitral and tricuspid valves and systolic notching of the pulmonary valve. All these findings suggest severe pulmonary hypertension but the aetiology of this is unclear. Two D echo 4 chamber study (Figure 14) on the other hand, clearly shows a large atrial septal defect. When 20 cc of normal saline was rapidly injected in a peripheral vein, the micro bubbles are seen to cross from the right atrium to the left atrium via the large atrial septal defect confirming this diagnosis and also a reversal of the shunt. The main and lobar pulmonary arteries are seen to be enormously dilated.

**Comment**

There are significant limitations in the M mode assessment of congenital heart disease which is clearly illustrated by this case. Because of the "ice-pick" view, spatial orientation of the various cardiac structures which is the key to the recognition of the various congential heart diseases is frequently not possible. However, all these problems are obviated by 2D echo which is therefore the technique of choice for evaluation of congenital heart diseases[6].

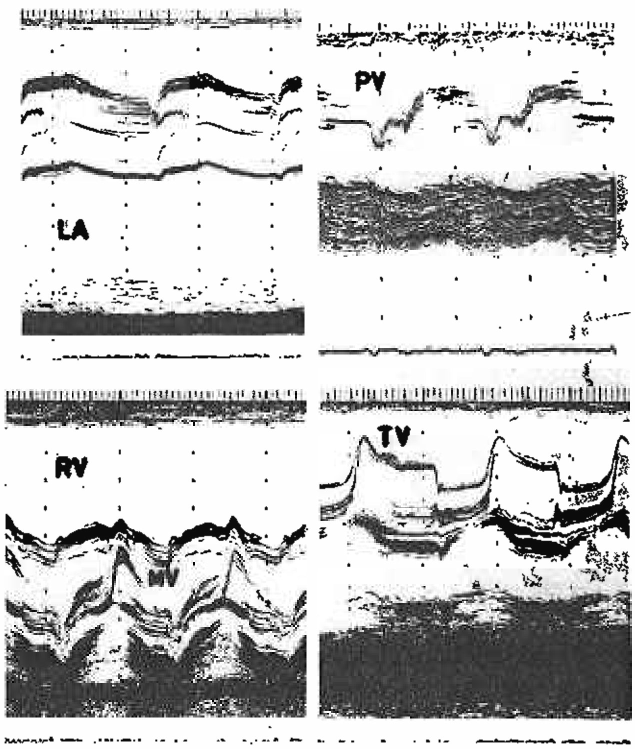

Figure 13. M mode echo of Eisenmenger atrial septal defect.

**Ruptured Chordae Tendinae**

Figure 15 is the 2D echo of a 13 year old Malay male who presented with severe mitral incompetence. The anterior mitral valve leaflet moves posteriorly beyond the point of coaptation strongly suggesting that the leaflet is flail. At surgery the diagnosis of a flail anterior leaflet due to ruptured chordae tendinae was confirmed and mitral valve replacement was performed.

**Comment**

Ruptured chordae tendinae usually presents with

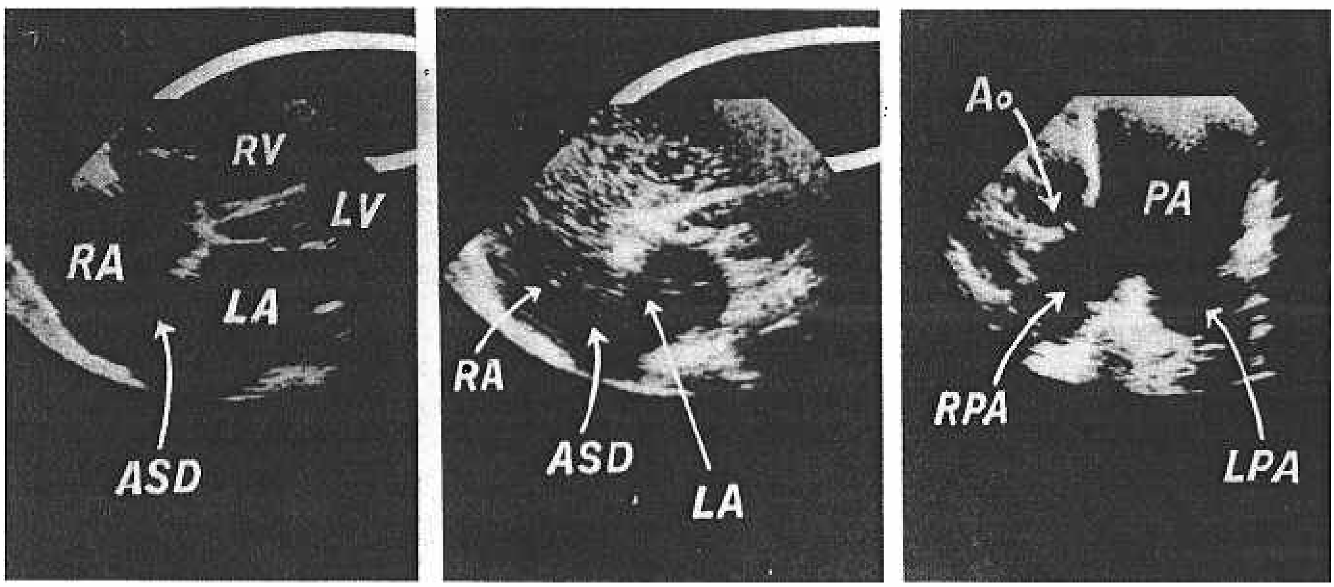

Figure 14. 2D echo of Eisenmenger atrial septal defect.

## RUPTURED CHORDAE

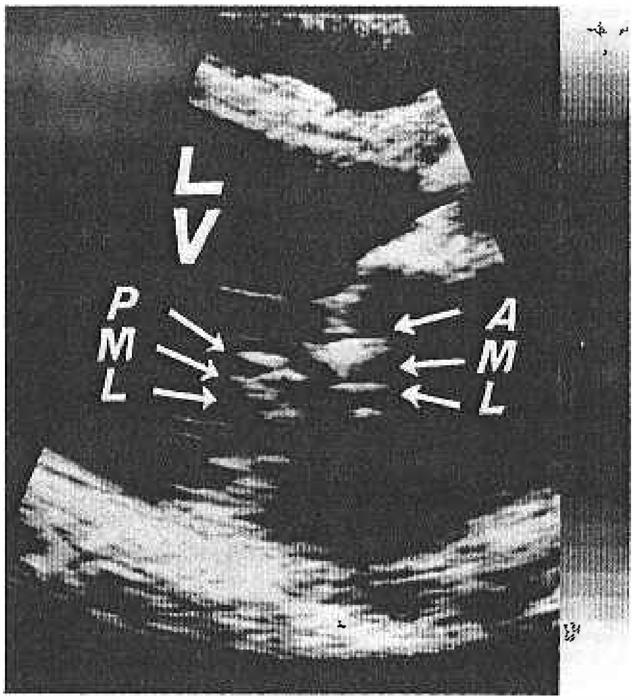


Figure 15. 2D echo of ruptured chordae tendinae of anterior mitral valve leaflet.

severe mitral incompetence and cardiac failure and the prognosis is generally very poor unless surgery is performed early. Therefore diagnosis of this condition is extremely important. Although M mode echocardiographic changes for ruptured chordae tendinae of both the anterior as well as the posterior valve leaflets have been described several years ago, the low sensitivity and specificity of these findings have been a source of difficulty in diagnosis. Two D echo on the other hand enables a much more precise diagnosis to be made[7].

**Infective Endocarditis**

Figure 16 is the 2D echo of a 22 year old Malay woman who was treated successfully for infective endocarditis occuring on a background of chronic rheumatic mitral regurgitation one year ago. A vegetation attached to the anterior mitral valve leaflet can clearly be seen in real time to oscillate through the mitral valve orifice between the left atrial and ventricular cavities.

**Comment**

Although M mode echocardiography can also detect vegetations due to infective endocarditis, its sensitivity and specificity is lower than 2D echo[8]. In many instances, vegetative lesions and their consequences (e.g. ruptured chordae tendinae) which are not detected by M mode study have been diagnosed using 2D echo. Furthermore, in several cases reported

## INFECTIVE ENDOCARDITIS

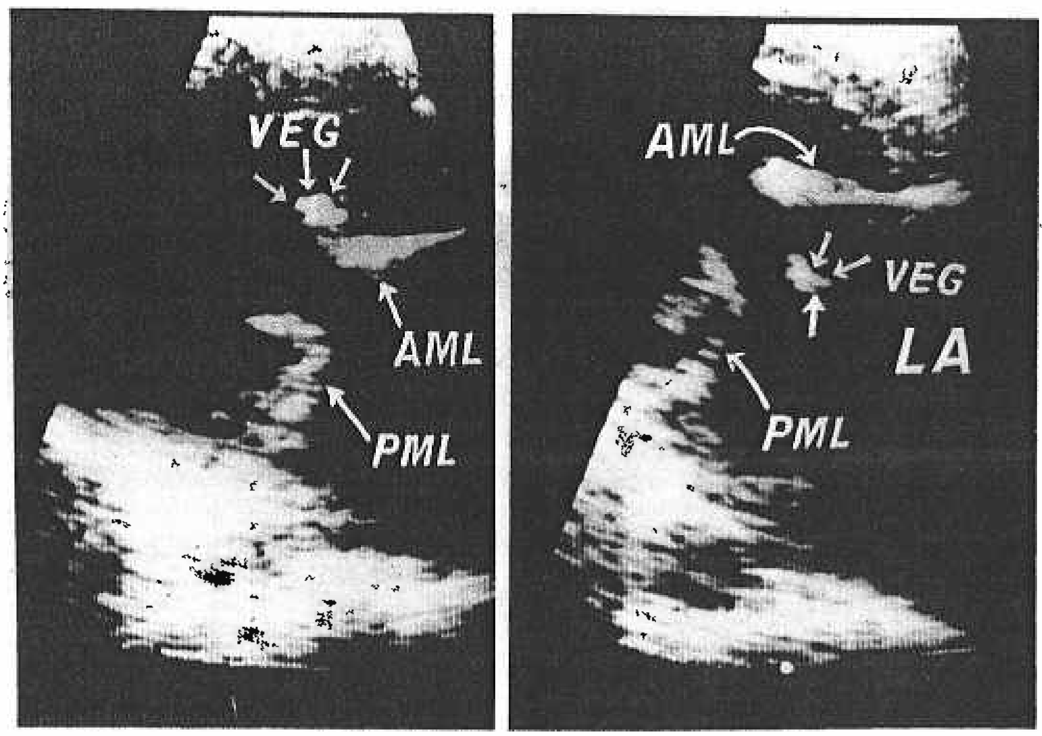


Figure 16. 2D echo of infective vegetation.

in the literature M mode changes which resemble intracardiac myxoma have been found to be actually vegetative masses on 2D echo examinations.

**Mitral Stenosis**

Figure 17 is the 2D echo of a 20 year old Chinese male with moderately severe mitral stenosis. In the long axis view the fusion and nodular thickening of the commissures of the valve leaflets together with the "buckling" of the belly of the anterior leaflet in systole are clearly seen. In the short axis the "fish mouth" appearance of the mitral valve due to commissural fusion is also apparent. The planimetered mitral valve area was found to be 1.52cm$^2$.

**Comment**

Both M mode and 2D echocardiography is equally sensitive in detecting chronic rheumatic mitral valve disease. However, the accuracy of M mode in predicting severity of mitral stenosis is poor. On the other hand, echo assessment of mitral valve area by planimetry of the valve orifice in the short axis in diastole has been shown to be highly accurate[9]. Furthermore, 2D echo enables a better evaluation of the infra valvular structures such as the presence or absence of chordal fusion.

**Hepatocellular Carcinoma**

With the use of the same machine and employing similar scanning techniques, various intra-abdominal structures such as the liver, spleen, kidney and the foetus can be scanned. Figure 18 is the echo study of a 40 year old man with hepatocellular carcinoma showing multiple filling defects due to tumour infiltration.

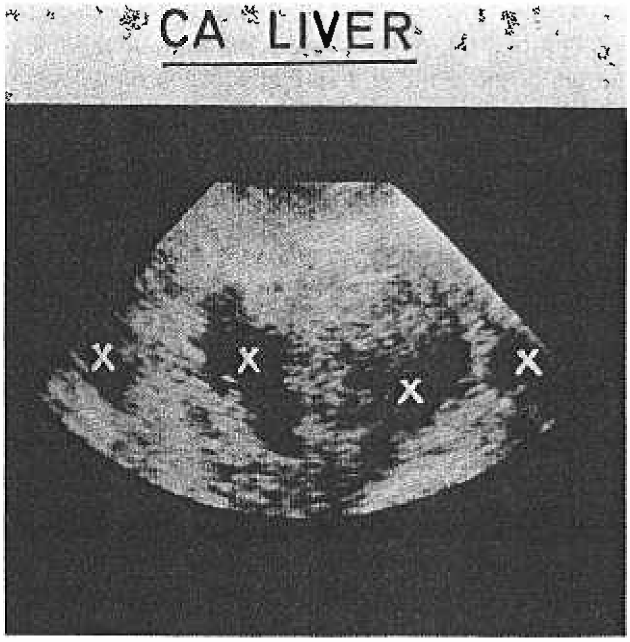


Figure 18. 2D ultrasound study of hepatocellular carcinoma.

**CONCLUSION**

It is clear from the above examples that 2D echo has expanded even further the scope and value of echocardiography. Significant advances in development such as technological improvement in the quality of the images can be anticipated in the near

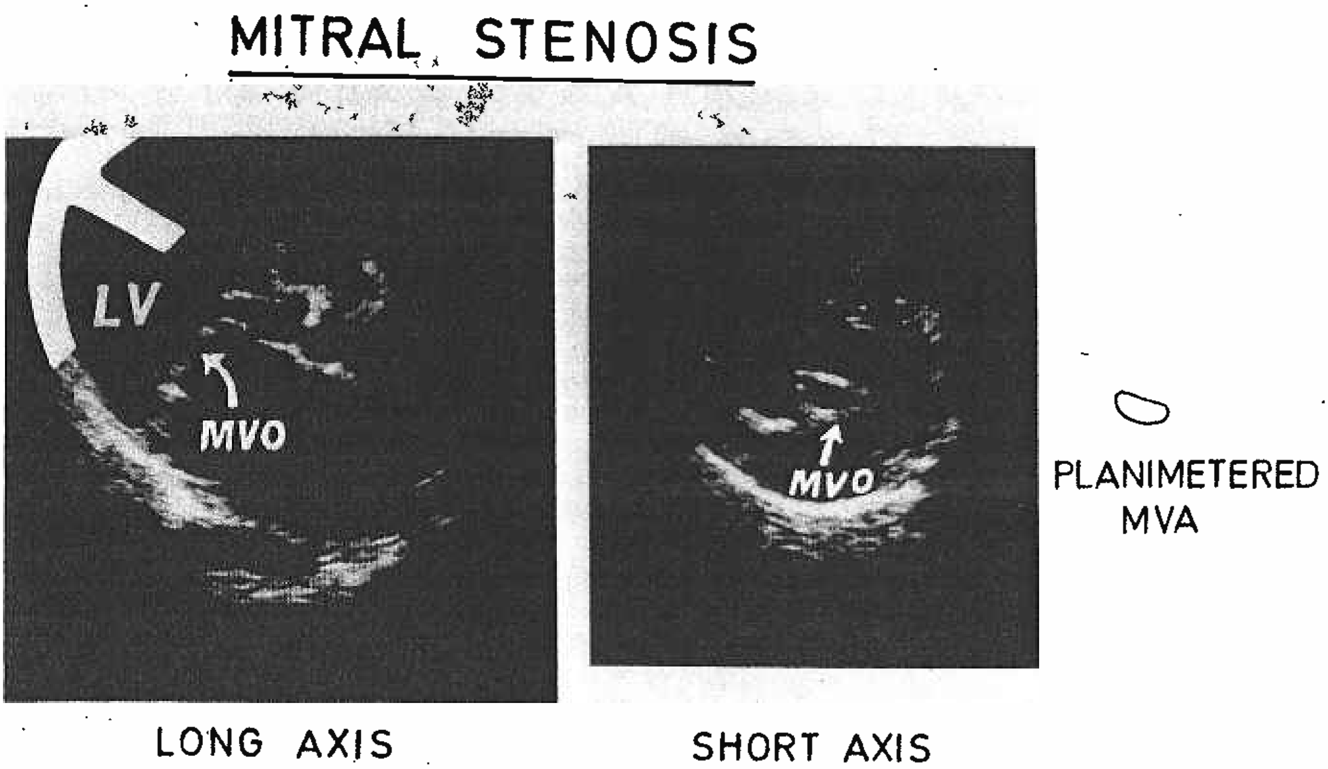


Figure 17. 2D echo of mitral stenosis.

future. An interesting recent development is the introduction of a small portable echocardiographic machine which when placed on the praecordium can produce a real time 2D echocardiographic image of the heart[10]. It is conceivable that such an equipment could in the future form part of the routine armamentarium of the clinician together with the stethoscope and the sphygmomanometer. The physician of the future may thus not only feel and hear the heart, but also look at its various structures in his routine bedside evaluation of the cardiovascular system.

## ACKNOWLEDGEMENTS

Figure 18 was studied and supplied by courtesy of Dr Ho Kok Tong and Figure 8 by Dr M. M. Htoo. Figs 3-6 are modified from Popp R. et al. Chest 75: 579, 1979.

## ABBREVIATIONS USED IN ILLUSTRATIONS

AL = anterior leaflet of mitral valve.
PL = posterior leaflet of mitral valve (Fig 1).
AML = anterior leaflet of mitral valve.
PML = posterior leaflet of mitral valve (Fig 15).
VEG = vegetative mass (Fig 16).
RV = right ventricular cavity.
LV = left ventricular cavity.
Ao = Aortic root.
RA = right atrial cavity.
LA = left atrial cavity.
ASD = atrial septal defect.
PA = main pulmonary artery.
RPA = right pulmonary artery.
LPA = left pulmonary artery.
IVS = interventricular septum.
LVW = posterior wall of left ventricle.
PE = pericardial effusion.

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