Echocardiography in a district general hospital

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Summary
A referral service for echocardiography was established in a district general hospital. One hundred and three patients were studied and the benefits to defined groups of referrals were evaluated. It is concluded that the introduction of echocardiography into this setting is of advantage to many patients with cardiac disease and should therefore be encouraged.

Introduction
The population of adult patients with cardiac disease investigated in cardiac centres is likely to be different from that seen in a district general hospital. Patients with congenital and rheumatic heart disease and rarer conditions such as hypertrophic cardiomyopathy are often concentrated in cardiac centres where surgical facilities are available, while elderly and middle-aged patients with ischaemic heart disease or hypertension may form the majority in district general hospitals.

Echocardiography has been shown to be particularly useful in the diagnosis and management of the former group of conditions and is thus a very valuable procedure in cardiac centres. Currently, echocardiography is not generally available in district general hospitals, and in view of the likely difference in populations, an equal value cannot be presumed.

The study aims to evaluate the benefits and limitations of echocardiography in a district general hospital and to give the general physician a guide to the indications for referral.

Materials and methods
The first 9 months of a referral service for echocardiography within Edgware General Hospital (in which there are 636 acute beds, 176 for general medicine) is described.

A 'Nuclear Enterprises' diasonograph with attached cardiac module was used. This is housed in the maternity wing of the hospital, as its primary function is for obstetric patients. Oscilloscope pictures using a 'Polaroid' camera were obtained;

strip chart facilities were not available. An average of 30 min was spent studying each patient.

Suitable indications for referral, based on current reviews and monographs (Feigenbaum, 1976; Chang, 1976; Eslami, Roitman and Sheffield, 1974; Feigenbaum, 1975; Abbasi, 1976), were suggested to the physicians within the hospital. A total of 103 patients (of whom 32 were out-patients) were referred. The average age was 56 years (range 5–89 years; 25 were 65 years or over) including three children aged 5, 9 and 10 years. Three patients were studied twice to obtain follow-up data. The patients have been grouped as follows, according to the primary reason for referral.

Group 1
Patients with radiological enlargement of the heart – as defined by a single transverse diameter on the standard PA chest film exceeding 15.5 cm (Simon, 1971) (fourteen patients). The group comprised patients with congestive cardiac failure (seven), post-myocardial infarction (three), hypertension (two), pernicious anaemia with haemoglobin of 7.0 g/dl (one), acromegaly (one). Mean transverse diameter was 17 cm (range 15.5–20 cm).

Group 2
Sixty-four patients referred because of cardiac murmurs were divided up as follows:
(i) Mitral systolic murmurs
(a) Fourteen patients with pansystolic murmurs graded 2/4 or more, regarded clinically as lone mitral regurgitation;
(b) five patients with late systolic murmurs, and two with possible mid-systolic clicks.
(ii) Mitral stenosis – patients with known mitral stenosis, or patients in whom mitral diastolic murmurs were heard (twenty-three patients).
(iii) Aortic systolic murmurs (eight patients).
(iv) Mixed aortic valve disease (twelve patients in whom aortic systolic and diastolic, or just lone aortic diastolic murmurs were heard).

Group 3
Patients with atrial fibrillation; three who had been thyrotoxic but who were now not on therapy.
and were euthyroid both clinically and biochemically and seven who had been diagnosed as having idiopathic atrial fibrillation.

**Group 4**

A miscellaneous group of patients including three patients with known or suspected hypertrophic cardiomyopathy, three with myxoedema, five with pericarditis, one referred with a known atrial septal defect, another with established primary pulmonary hypertension, and two further patients: one with atrial ectopics, and the other referred because of syncopal attacks.

**Results**

**Group 1 (radiological enlargement of the heart)**

*Left ventricle.* The maximum diastolic dimension of the left ventricular (LV) cavity was measured, and the mean was 5·7 cm (range 4·0–7·5 cm). The normal mean is 4·7 cm (range 3·5–5·7 cm) (Chang, 1976).

In seven patients, the LV cavity was enlarged above the upper normal limit of 5·7 cm. In three of these (all of whom had congestive cardiac failure), and in a patient with a normal sized LV cavity (the patient with pernicious anaemia), a posterior pericardial effusion was demonstrated.

The two patients with hypertension had a normal sized LV cavity but a thickened ventricular wall. In one of these, the posterior left ventricular wall thickness (LVWT) and the interventricular septum (IVS) were both enlarged at 1·7 cm (normal range 0·6–1·1 cm). In the other patient, the LVWT was enlarged at 1·4 cm, although the IVS was normal at 0·8 cm.

Of the remaining patients, one showed a reversal of normal IVS movement (probably related to anterior descending coronary artery disease) and had a normal sized LV cavity of 5·0 cm, another had a normal sized LV cavity (4·6 cm), and in two more an adequate picture of the LV cavity could not be obtained.

*Other cardiac chambers.* In one patient with a dilated left ventricle and small effusion, the left atrium was dilated at 4·5 cm (normal ≤4·0 cm). In the patient with acromegaly, a dilated left ventricle of 6·0 cm, left atrium of 6·0 cm, and right ventricle of 3·8 cm (normal ≤2·6 cm) was demonstrated. In all other patients the left atrium was shown to be of normal size; the right ventricle was not sought for in most studies and the right atrium is not usually studied by echocardiography.

**Group 2 (cardiac murmurs)**

(i) (a) In the group considered to have lone mitral regurgitation, three patients had a thickened rheumatic mitral valve. In one of these (case history no. 1), the diagnosis was previously unsuspected, whereas in the other two a minority of doctors had heard a faint mitral diastolic murmur. Two patients had an enlarged left ventricle, of whom one had an increased stroke volume. This latter patient, at least, presumably has significant mitral regurgitation. In six further patients the mitral valve and the left ventricular size were normal, and in three more an adequate picture of both these structures could not be obtained.

(b) In four patients the mitral valve appeared normal, and in two an adequate study of the mitral valve was not obtained. The only abnormality to be detected in these patients with late systolic murmurs was a calcified mitral valve ring in one.

(ii) In nineteen patients, the diagnosis of mitral stenosis was confirmed, and the thickness of the cusps, the amplitude of movement, and the diastolic closure rate could be determined, giving a measure of the severity of the mitral valve disease. In four patients in whom a clinical diagnosis of mitral stenosis was made (e.g. case history no. 2) a normal mitral valve was demonstrated, thus refuting the diagnosis.

(iii) The findings in aortic systolic murmurs were less specific. Normal valve cusps were identified in four, thickened cusps in two, left ventricular enlargement in one, and an inadequate study of the aortic valve was obtained in a further two patients.

(iv) It was possible to demonstrate the haemodynamic effects of aortic regurgitation by estimating stroke volume from transverse diameter at end diastole and end systole. In two patients this was increased, indicating significant aortic regurgitation (case history no. 3). In two further patients the left ventricle was enlarged in diastole and systole with a normal stroke volume and in four the left ventricle was of normal size. In four patients an adequate study of the left ventricle could not be obtained.

**Group 3 (atrial fibrillation)**

Abnormalities of interventricular septal movement were the commonest finding in this group of patients. It was immobile in one and reversed in four. One of these and two further patients had left atrial enlargement (5·0, 5·0 and 4·4 cm respectively). In the remaining three the septum moved normally and the left atrium was of normal size. The mitral valve appeared normal in all ten patients.

**Group 4 (miscellaneous)**

Two patients were referred on clinical criteria because of suspected hypertrophic cardiomyopathy. In both, septal thickness was normal, and the
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diagnosis was refuted. Another patient in whom hypertrophic cardiomyopathy had been diagnosed elsewhere was studied and a thickened septum was found (of 1.4 cm).

Pericardial effusion was demonstrated in two of three patients with myxœdema.

Five patients were examined specifically for pericardial effusion; in one a pericardial rub was definitely heard and a posterior effusion was demonstrated (in spite of the fact that the transverse diameter of the heart on the PA chest film was 15.0 cm and the radiologist considered the film to be of normal size). In another patient, only a minority of doctors heard a rub and no effusion was demonstrated. In two others, the patients were suspected of having pericarditis four and six months before the echocardiogram (which was not available at that time), in the latter a small posterior effusion was demonstrated. In the final patient, a 5-year-old boy, an effusion was suspected clinically (although no rub was heard), but this was not confirmed on the echocardiogram.

A patient with a known atrial septal defect was studied and the typical findings of an enlarged right ventricle of 4.0 cm (normal ≤2.6 cm) and reversed septal movement were demonstrated. Another with known pulmonary hypertension demonstrated non-specific findings but silent mitral stenosis as a cause was definitely excluded. In two further patients referred because of syncopal attacks in one, and atrial ectopics in the other, the echocardiogram was non-contributory.

Success rate

The success with which each structure was sought and displayed correctly varied. An adequate demonstration of the left ventricle, including the left side of the septum and the endocardium of the posterior wall, in at least one cardiac cycle, was obtained in 77 of 101 studies (76%) in which this was sought. The anterior mitral cusp was displayed in 103 of 104 (99%), the posterior cusp in 56 of 104 (54%), the left atrium in 99 of 102 (97%) and the aortic root in 102 of 102 (100%). An adequate demonstration of the aortic valve in systole was obtained in 45 of 102 (44%). In the final third of patients studied, an adequate study of the LV was obtained in 88% of the posterior mitral cusp in 62% and the aortic valve in 55%.

Correlation with chest film

A direct comparison between the size of the heart on the PA chest X-ray and the left ventricular size as determined by the echocardiogram was made in fifty-eight patients in whom both a recent X-ray and an adequate echocardiographic record were available. There was no correlation with cardiothoracic ratio (r=0.17), and low correlation with transverse diameter (r=0.44). The scatter was very large, confirming that using these indices the chest X-ray was clearly unreliable as a guide to the size of the left ventricle.

Case history no. 1

A 74-year-old woman with a mitral systolic murmur, a radiologically enlarged heart (18 cm) and congestive cardiac failure was referred as lone mitral regurgitation. Unexpectedly she was shown to have a thickened rheumatic mitral valve, with the appearance of mitral stenosis, and the left atrium was dilated at 5 cm (the left ventricular size was normal at 4.1 cm).

Case history no. 2

A 71-year-old woman with fast, uncontrolled atrial fibrillation was admitted with a stroke. Auscultation was difficult in view of the tachycardia but some of the doctors heard a mitral diastolic murmur and a provisional diagnosis of mitral stenosis was made. However, the echocardiogram showed both mitral cusps moving normally. The left atrium was of normal size, at 3.8 cm.

Case history no. 3

A 40-year-old man with infective endocarditis and an aortic diastolic murmur was studied. He had no signs of heart failure but had clinical signs of moderate aortic regurgitation. The chest X-ray was normal (transverse diameter 12.5 cm, cardiothoracic rate 0.43). The echocardiogram showed an enlarged left ventricle of 7.0 cm in diastole, with an increased stroke volume of 230 ml. He did not go into failure, but the infection proved difficult to control, and he underwent aortic valve replacement 2 weeks after the echocardiogram. At operation a shrivelled bicuspid aortic valve was found.

Discussion

The aim of this study was to assess the value of a referral service for echocardiography within a district general hospital. This could be done by examining possible benefits to patient care in the defined groups of referrals. Such benefits include increased diagnostic accuracy leading to treatment, and a more accurate guide to prognosis. Several fruitful indications for echocardiography in the setting of a district general hospital were established. The cause of an increase in the transverse diameter of the heart on plain chest X-ray is often difficult to elucidate, and the present study has confirmed the work of others (Field et al., 1974; Cooperberg et al., 1976) that it is a poor predictor of the size of the LV cavity or the presence of a pericardial effusion. However the differential diagnosis has clear therapeutic
consequences, for if the radiological cardiac enlargement is shown to be due to an effusion with a normal sized left ventricle then diuretics may not need to be increased or indeed indicated, whereas they might be if the left ventricle is shown to be enlarged. Also, a better prognosis could perhaps be given if the cause of radiological enlargement was an effusion rather than a large left ventricle.

The demonstration of a pericardial effusion may be helpful in several cases. In low cardiac output states it may indicate the presence of tamponade and have considerable therapeutic significance. In malignant disease it may indicate mediastinal involvement. When pericardial rubs are sometimes difficult to hear it may help to confirm a diagnosis of pericarditis. Its presence in some patients with hypothyroidism may possibly indicate those prone to the adverse cardiac effects of thyroxine.

In patients with known or suspected mitral stenosis the diagnosis is confirmed and a study of the anatomy of the valve is obtained which may be a guide to the type of operation to be recommended.

The group in which systolic murmurs (both mitral and aortic) were investigated has probably yielded the least beneficial information. It is recognized that study of the aortic valve in aortic stenosis, and the mitral valve in mitral regurgitation, yields less useful information than study of the mitral valve in mitral stenosis. Nevertheless enhanced diagnosis was obtained in one patient (case no. 1) thought to have lone mitral regurgitation, who was shown to have the appearances of mitral stenosis.

Patients with idiopathic atrial fibrillation were investigated in order to detect those with silent mitral stenosis, but none was found. One possible cause of the reversal and immobility of septal movement which was an unexpected finding, is left anterior descending coronary artery disease, and the label 'idiopathic' is therefore probably incorrect. This may have prognostic implications.

This study was not aimed at evaluating cost effectiveness. Nevertheless there are some obvious savings. A quicker diagnosis may be achieved, so reducing hospital stay, and a more informative referral to a cardiac centre may speed up transfer (if indicated) and again reduce total hospital admission time. A more rational approach to drug therapy may further reduce cost. A particular example may be the use of long-term anticoagulation. Whilst this may prevent emboli so reducing morbidity and therefore costly hospital admission time, it may itself cause an increased morbidity (because of the risks of haemorrhage) and increase expense. The echocardiogram can help define those patients in whom anticoagulation should and should not be used. For instance, the patient with unsuspected mitral stenosis may benefit from anticoagulation, whereas those patients in whom the diagnosis of mitral stenosis is excluded are saved from its risks.

From the foregoing the groups of patients likely to benefit from echocardiography are described. In establishing a referral service, some idea of the number of patients requiring investigation is clearly desirable. There are approximately 300 chest X-rays performed in this hospital every week, of whom 5% may fulfil the criteria of a radiologically enlarged heart. These patients should be referred for echocardiography.

There are approximately seventy-five to 100 patients with mixed rheumatic mitral valve disease, either operated or not, who attend regular follow-up clinics each year, and these probably warrant a yearly echocardiogram. Systolic murmurs may occur in 50–60% of the elderly (Pomerance, 1968). There are approximately 3000 medical in-patients in this hospital in one year, of whom at least 75% are over the age of 65 years, making routine referral impossible. In any case, as can be seen in this study, the existence of a murmur does not imply the demonstration of an abnormal valve, so that the echocardiogram will not help in assessing the origin of the murmur. Patients with aortic systolic murmurs are probably least benefited, whereas the calculation of stroke volume in a patient with mitral regurgitation may help to assess the haemodynamic significance of the murmur. Aortic diastolic murmurs may occur in 3% of the elderly (Nejat and Grief, 1976) and a referral is therefore feasible.

The miscellaneous group examined in this study probably gives some clue to the number of patients with these varied conditions which may be referred (perhaps 15% of the whole). Thus up to fifteen patients with a radiologically enlarged heart, perhaps five with valvular disease, and a few more miscellaneous patients could be referred with benefit for echocardiography in a hospital of this size each week. This proportion is different from this study in which patients with cardiac murmurs formed the largest group of referral. However, as stated above, although patients with systolic murmurs are very common, they seem the least to benefit from echocardiography.

This estimate has not directly included those patients with the two most numerically important cardiac diseases in a general hospital, namely ischaemic heart disease and hypertension. At present the benefit to patients with myocardial infarction is still being evaluated, nevertheless it may prove to be a useful indicator of prognosis (Feigenbaum, 1976), and computerized digitization may provide an early sign of myocardial ischaemia (Venco, Gibson and Brown, 1977). Two-dimensional echocardiography has the ability to visualize the origins of the coronary arteries and give a more comprehensive picture of LV function. In hypertension, the ECG
and the blood pressure are still the main guides to management but with more use of the left ventricular cavity size and wall thickness may prove to be as or even more valuable in at least assessing prognosis.

To conclude, this study shows that the introduction of echocardiography into a district general hospital will be of benefit to many patients with cardiac disease. There should be few difficulties in establishing such a service. The cost is low, a basic machine costs about £6000, and the cost of photographic paper is perhaps £1–2/patient. Whilst the echocardiogram is not as easy to obtain as an ECG, and this has been referred to in this paper (see ‘Success rate’), the technique can be learnt within 3–6 months (Gramiak et al., 1975).

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References


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