When to order an echocardiogram

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The past decade has seen dramatic advances in noninvasive cardiac imaging technologies. However, echocardiography remains the single most important and relevant diagnostic imaging tool in everyday general and cardiology practice. This article discusses the appropriate clinical application of this modality.

A comprehensive patient history and physical examination will always be the fundamental basis for the diagnosis and management of patients with cardiovascular disease. However, since its development almost six decades ago, echocardiography has evolved into a powerful and practical addition to these cornerstones of bedside cardiac assessment.

The ability of echocardiography to provide unique noninvasive information with minimal discomfort or risk, without the use of contrast material or ionising radiation, coupled with its portability, availability and repeatability, accounts for its use in virtually all categories of cardiovascular disease. However, the technique is best utilised following history taking, physical examination and relevant investigations, including ECG, with or without chest x-ray, so that appropriate clinical questions can be asked to guide the study. Indiscriminate or 'screening' use of echocardiography should be discouraged because of the high healthcare cost implications and the potential for inappropriate further testing and intervention.

This article reviews the evidence and guidelines supporting the use of echocardiography in common clinical scenarios encountered in general practice.

Murmurs and valvular heart disease

A murmur is a sound caused by turbulent blood flow as a consequence of high volume flow across a normal valve or flow across a valve affected by stenotic or regurgitant valvular disease or other cardiac defects, either congenital (e.g. atrial and ventricular septal defects) or acquired. Echocardiography can show the aetiology of valvular disease (e.g. degenerative calcification, mitral valve prolapse), quantify its severity at rest and with stress, and assess any effect on chamber dimensions, intracardiac pressures and ventricular function. Although a murmur may be the major manifestation of underlying valvular or congenital heart disease, many murmurs in people without symptoms of heart disease have no clinical significance.

Murmurs can be classified as systolic, diastolic or continuous. Diastolic and continuous murmurs are always pathological and require echocardiographic assessment. Systolic murmurs can be either functional or pathological. Functional murmurs are common in high-output or

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Key points

- **Evaluation of ventricular function is the most common indication for echocardiography.**
- **Echocardiography is useful for the evaluation of a cardiac basis for oedema and/or dyspnoea.**
- **Echocardiography is used to identify the cause and severity of cardiac murmurs and monitor progression in established valvular disease.**
- **Echocardiography is more sensitive than ECG for the assessment of left ventricular hypertrophy in systemic hypertension.**
- **In patients with arrhythmia, echocardiography is used to assess for the presence of structural heart disease.**
- **Echocardiography is useful in the initial evaluation of cardiovascular causes of chest pain.**

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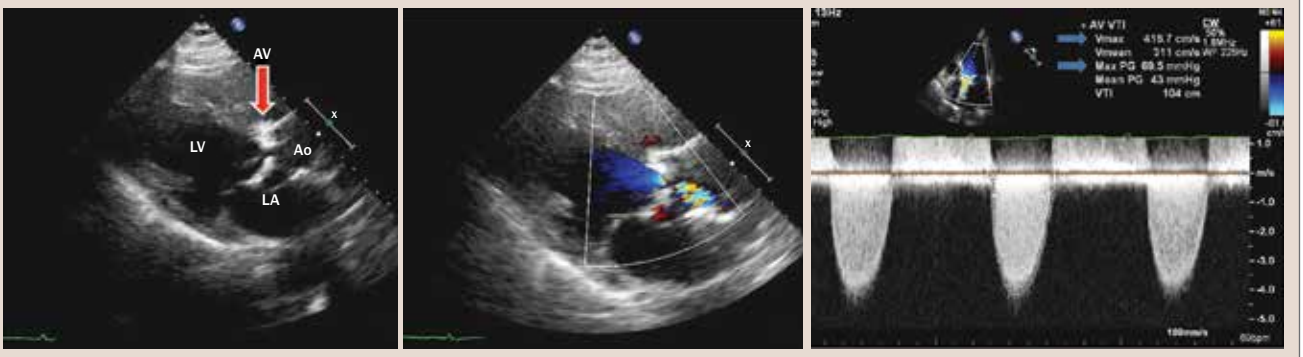
1. Aortic stenosis: case 1, Mr DB

Mr DB is a 70-year-old man who presented with increasing shortness of breath and intermittent chest pain on exertion. On auscultation of his chest, a loud ejection systolic murmur was heard radiating to the carotid arteries bilaterally. ECG showed left ventricular hypertrophy. He was referred for echocardiography, which showed a severely calcified aortic valve with severe aortic stenosis, with associated left ventricular hypertrophy and preserved left ventricular systolic function (Figures 1a to c).



Figures 1a to c. Severe aortic stenosis. a (left). Heavily calcified aortic valve with restricted leaflet excursion (red arrow). Parasternal long axis view. b (centre). Turbulent blood flow across the severely stenotic aortic valve. Parasternal long axis view with colour Doppler analysis. c (right). Severely increased aortic valve gradients confirming severe stenosis (peak AV velocity 4.2 m/s and peak gradient 69.5 mmHg; blue arrows). Spectral Doppler analysis derived aortic valve velocities with gradients calculated using the Bernoulli equation ($P = 4v^2$ where P = pressure and v = velocity).

Abbreviations: Ao = aorta; AV = aortic valve; LA = left atrium; LV = left ventricle.

hyperdynamic states such as pregnancy, anaemia, infection and thyrotoxicosis.

The American College of Cardiology/American Heart Association (ACC/AHA) guidelines for the clinical application of echocardiography recommend that echocardiography should not replace clinical evaluation as a screen for valvular heart disease.[1] Referral for echocardiography is warranted in symptomatic patients or in asymptomatic patients in whom there is sufficient concern that the murmur is probably pathological rather than functional (see case 1 and Figures 1a to c in Box 1).

In patients with established valvular heart disease, repeated echocardiography should be performed with a frequency interval determined by the haemodynamic severity of the lesion. As recommended in the ACC/AHA guidelines for the management of patients with valvular heart disease, serial studies should be considered every three to five years for mild lesions, every one to two years for moderate lesions and every six to 12 months for severe lesions; however, any change in signs or symptoms warrants earlier repeat assessment.[2]

Symptoms of oedema and/or breathlessness of possible cardiac origin

There are numerous causes of peripheral oedema, both cardiac and noncardiac. Cardiac pathologies cause oedema via an increase in central venous pressure and include the full spectrum of myocardial, valvular and pericardial disease. Echocardiography is able to reliably exclude a major cardiac cause of oedema in the vast majority of cases.

Dyspnoea, either at rest or on exertion, is a hallmark of cardiac disease. It can be difficult in certain patients to distinguish primary cardiac or respiratory causes of dyspnoea from other causes, including deconditioning and anxiety. Cardiac dyspnoea results from pulmonary congestion and when the aetiology of dyspnoea is in doubt, echocardiography can exclude relevant cardiac pathology, including left-sided valvular disease and left ventricular (LV) systolic or diastolic dysfunction/cardiomyopathy. Of all the major indications for echocardiography, evaluation of ventricular function is the most common; for this purpose, it can be performed using qualitative and semiquantitative two- and three-dimensional assessments. A common method used in clinical cardiology, known as Simpson's biplane method, is described in Box 2 (with Figures 2 and 3).[3]

Current definitions of congestive heart failure (CHF) include two distinct clinical categories that can be difficult to distinguish on clinical grounds alone. These are heart failure with reduced ejection fraction (HF-REF) and heart failure with preserved ejection fraction (HF-PEF).

Impaired LV systolic function (i.e. HF-REF) is well established as a poor prognostic marker. The vast majority of cases are due to ischaemic heart disease, valvular pathology, hypertensive heart disease and cardiomyopathy (see case 2 and Figure 4 in Box 3). HF-PEF (formerly known as diastolic dysfunction) refers to impaired diastolic filling of the left ventricle due to slow early relaxation or increased myocardial stiffness.

As recommended in the Cardiac Society of Australia and New Zealand and National Heart Foundation guidelines for the prevention, detection and management of CHF, all patients with suspected CHF should have an echocardiogram.[4] Echocardiography can readily identify systolic dysfunction (generally defined as a LV ejection fraction [LVEF] below

50 to 55%) and evaluate LV diastolic filling parameters while also excluding other causes of CHF (e.g. valvular disease).[1]

The guidelines also apply to patients with established cardiomyopathy who require re-evaluation of ventricular function because of a change in clinical status or to guide medical therapy.

Systemic hypertension

Echocardiography is the noninvasive investigation of choice to assess end-organ cardiac consequences of systemic hypertension, the most common cause of LV hypertrophy (LVH) and CHF in adults. Echocardiography is more sensitive than electrocardiography in establishing the presence and severity of LVH.[5] Assessment of LVH is relevant because several studies have correlated the presence of echocardiographic evidence of hypertrophy in hypertensive patients with increased risk of cardiac morbidity and mortality that is independent of other traditional cardiovascular risk factors. Hence, in patients with borderline hypertension, echocardiographic evidence of LVH may help with the decision to initiate treatment.

In patients with established hypertension who are already being treated, the utility of echocardiography depends on the clinical relevance of LV structural and functional assessment. Accordingly, the ACC/AHA guidelines do not recommend routine resting echocardiographic screening in such patients. Rather, it should be reserved for those in whom concurrent cardiac disease is suspected and it is likely to result in a change in clinical management.

Palpitations and arrhythmias: looking for structural heart disease

Arrhythmias can occur due to primary electrical defects or in association with structural heart disease. Echocardiography is used to define any structural heart disease, which may then influence treatment and/or provide prognostic information.

Atrial fibrillation (AF) is the most common arrhythmia, with a prevalence that rises dramatically with increasing age (a prevalence of over 10% in patients older than 80 years) and is an independent risk factor for thromboembolic stroke.[6] Transthoracic echocardiography is unable to adequately image the left atrial appendage, the most common site for the formation of thrombus in patients with AF. Transoesophageal echocardiography has greater sensitivity and is the investigation of choice in this clinical context. Although insensitive for the detection of left atrial thrombi, transthoracic echocardiography is recommended in the initial assessment of patients presenting with newly diagnosed AF and is used to assess atrial size (Box 4, with Figure 5).

The presence of atrial dilatation, which can be seen in a variety of pathologies (e.g. hypertension, mitral valve disease), helps guide therapy, including the decision to attempt cardioversion and, in association with clinical guidelines such as the CHA_2DS_2-VASc score, anticoagulation choices.[7]

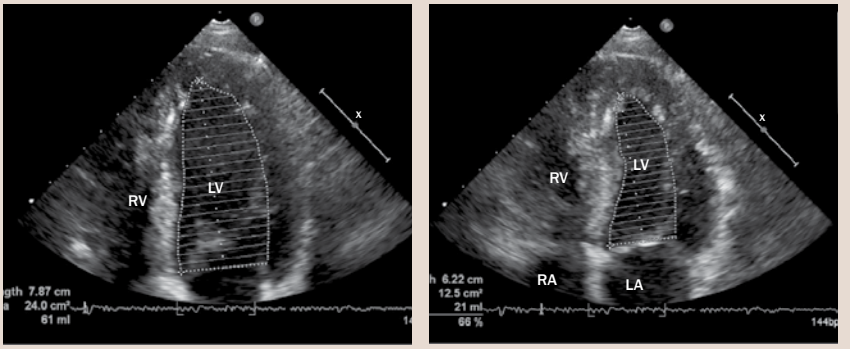
Evaluation of chest pain

Chest pain is a common presentation in both general practice and emergency departments, and may be cardiac or noncardiac in origin. Coronary artery disease is by far the most common cardiac aetiology of chest pain. Echocardiography can define segmental changes in LV function that may reflect underlying coronary disease or prior infarction. It

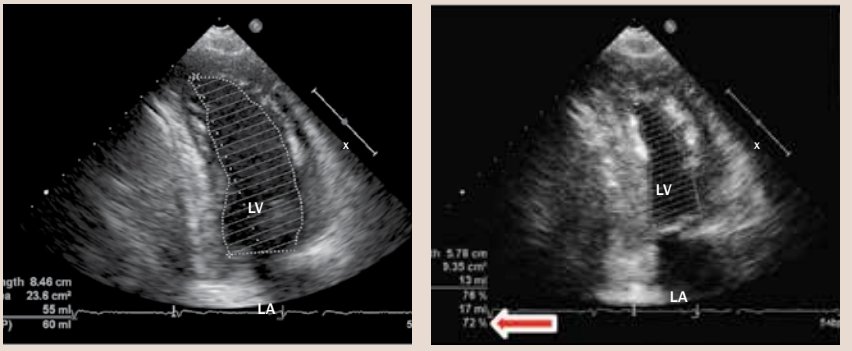
2. Evaluation of left ventricular ejection fraction[3]

The left ventricular ejection fraction (LVEF) can be quantified using Simpson's biplane method.[3] Left ventricle (LV) end-diastolic volume (EDV) and end-systolic volume (ESV) are traced in both the apical four-chamber and apical two-chamber views (Figures 2 and 3), providing a stroke volume estimate from which the LVEF is then derived as a percentage of the LV EDV:

LVEF = (LV EDV – LV ESV) / LV EDV x 100%.



Figures 2a and b. LV end-diastolic volume (a, left) and LV end-systolic volume (b, right) derived from tracings in the apical four-chamber view.



Figures 3a and b. LV end-diastolic volume (a, left) and LV end-systolic volume (b, right) derived from tracings in the apical two-chamber view. The final calculated ejection fraction of 72% is shown at the bottom of the systolic frame (red arrow).

Abbreviations: LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle.

3. Left ventricular cavity dilatation: case 2, Mrs CS

Mrs CS is a 56-year-old woman who presented with increasing shortness of breath, orthopnoea, marked lethargy, fatigue and bilateral ankle oedema. Cardiac auscultation showed a third heart sound with a pansystolic murmur radiating to the axilla. Lung auscultation showed bibasal crepitations. A subsequent echocardiogram showed a moderately dilated left ventricle with severely impaired left ventricular systolic function consistent with dilated cardiomyopathy.

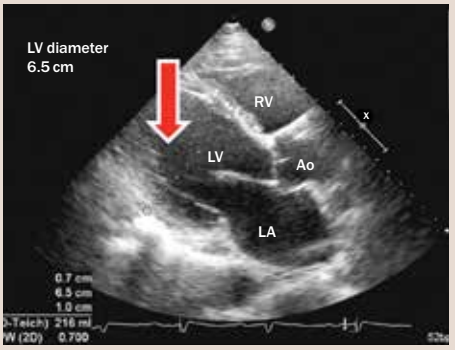


Figure 4. Moderate LV cavity dilatation. Parasternal long axis view with standard two-dimensional measurements demonstrating a moderately dilated LV cavity in diastole of 6.5 cm (red arrow; upper limit of normal 5.6 cm).

Abbreviations: Ao = aorta; LA = left atrium; LV = left ventricle; RV = right ventricle.

is also widely used to evaluate chest pain syndromes, stress echocardiography being used to exclude flow-limiting coronary stenoses. Stress echocardiography is more sensitive than stress electrocardigraphy alone (mean sensitivities 88% and 67%, respectively) and is also helpful when there are baseline ECG abnormalities.[8,9] It also provides valuable information on the location and extent of any ischaemia, and is cost-effective and free from radiation. Nuclear stress testing involves exposure to radiation and has similar sensitivity but inferior specificity for the detection of ischaemia compared with stress echocardiography, accounting for the recent increased use of stress echocardiography.[10]

Other noncoronary cardiovascular causes of chest pain can also be assessed by echocardiography, including pericarditis, aortic dissection, acute pulmonary embolism and, as discussed earlier, valvular pathology (e.g. aortic stenosis).

Conclusion

Echocardiography has become an indispensable diagnostic and prognostic addition to basic clinical assessment in modern cardiology practice. Although the full list of indications for echocardiography extends beyond the scope of this article, we have summarised the appropriate use of the method in commonly encountered clinical scenarios in general practice, with the aim of promoting optimal and cost-effective use of this valuable clinical resource. **CT**

4. Assessment of atrial dilatation

Transthoracic echocardiography is used to assess atrial size and is recommended in the initial assessment of patients presenting with newly diagnosed atrial fibrillation.

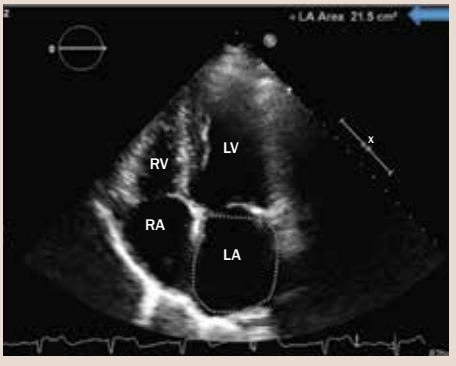


Figure 5. Mild left atrial dilatation. Apical four-chamber view showing mild left atrial dilatation measured on planimetry (LA area 21.5 cm² [blue arrow] compared with upper limit of normal 20 cm²).

Abbreviations: LA = left atrium; LV = left ventricle; RA = right atrium; RV = right ventricle.

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