Clinical indications for echocardiography

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Echocardiography is the most widely used cardiac investigation, providing comprehensive information about the heart and great vessels, including valves, chamber size and function. It is an essential component of the diagnosis and management of patients with all types of cardiac disease.

Key points

- **Echocardiography is rapid, portable, safe and widely available.**
- **Guidelines exist regarding echocardiographic views, echocardiographic analysis and the use of echocardiography in patients with different cardiac conditions.**
- **Echocardiography is mostly a class 1 indication in patients with suspected or known cardiac diseases, including atrial fibrillation, heart failure and valvular heart disease.**
- **Echocardiography is useful in the intensive care unit, emergency department, catheterisation laboratory and cardiothoracic operating room.**
- **New developments in echocardiography include three-dimensional technologies and analysis of myocardial deformation.**

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The development of cardiac ultrasound, known as echocardiography, has revolutionised the diagnosis of cardiac conditions. It is the most widely used cardiac investigation, providing excellent visualisation of the heart and great vessels. The use of Doppler echocardiography to evaluate the instantaneous velocity of blood flow in any region of the heart allows the calculation of instantaneous pressure gradients across valve obstructions, meaning valve stenoses can be quantified accurately and noninvasively.

Echocardiography is usually readily available and portable, allowing imaging in the clinic, ward, operating room, intensive care unit and emergency department. Echocardiography can be repeated to allow the progress of cardiac conditions to be evaluated, and to assess the response to treatments or interventions. Echocardiography is used to guide invasive technologies in the catherisation laboratory, such as direct current cardioversion, pericardiocentesis, percutaneous ballooning of mitral stenosis, and implantation of septal occluder devices, left atrial appendage closure devices and percutaneously deployed aortic valve replacements. Echocardiography is also used intraoperatively by anaethestists during cardiac surgery. Echocardiography causes little or no patient discomfort, involves no radiation and presents no risk to the patient.

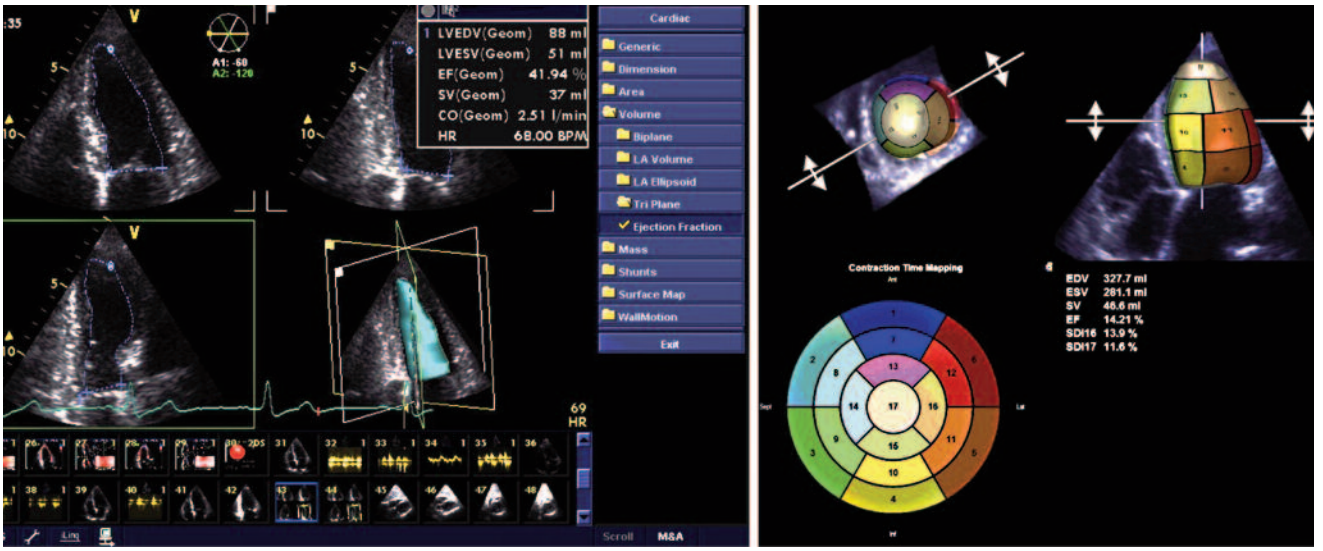
Echocardiography is a useful diagnostic test in all categories of cardiovascular disease; therefore, it should be considered in all patients with obvious or possible cardiac disease. The assessment of the structure of the chambers and valves in the heart is an essential component of diagnosis and management of all types of patients with cardiac disease.[1,2] Echocardiographic assessment is recommended by the American Heart Association and American College of Cardiology for most cardiac conditions, including heart failure,[3] ischaemic heart disease[1,2,4] arrhythmias including atrial fibrillation,[5] and valvular heart disease.[6-8]

Guidelines also delineate methods for acquisition of echocardiographic images, so that standard views are obtained worldwide, as well as describing the accepted methods for quantification of left ventricular (LV) size and function,[9,10] valve function,[11,12] prosthetic valve function[8] and many other aspects of echocardiography.

Drawbacks of echocardiography

Echocardiography requires satisfactory echocardiographic windows, which can be difficult to obtain in patients who are obese, have breast implants, are ventilated in intensive care units or have obstructive airways disease in whom the interposition of air-filled lung between the skin and the heart can limit imaging. However, the use of multiple echocardiographic windows to view the heart means, in most situations, at least some clinically useful information is obtained.

Similar to all diagnostic imaging tests, echocardiography should be used in conjunction with a careful history, examination, ECG and chest x-ray. Indiscriminate use of echocardiography is costly. Repeat studies that may be unnecessary increase costs; as echocardiography is very available, patients are often rescanned even if this test has been performed recently at another location. Finally, echocardiography cannot evaluate coronary artery anatomy and stenoses.



Figures 1a and b. Multiplane (also known as 4D) echocardiography imaging allows the quantification of LV volumes using different echocardiographic views acquired in the same cardiac cycle (a, left). The coloured views (b, right) show methods for mapping the motion of each individual LV segment.

Clinical indications for echocardiography

Dyspnoea, heart failure and cardiomyopathy

Of all indications for echocardiography, the assessment of LV dysfunction is the most common. Echocardiography is very useful in patients with oedema or shortness of breath to determine if there is myocardial, pericardial or valvular pathology present. Common causes of dyspnoea include ischaemic heart disease, valvular heart disease and cardiomyopathy. Echocardiography has been shown to frequently change the diagnosis in patients with dyspnoea.[13] Echocardiography is a class 1 indication in patients with symptoms or signs of heart failure.[3]

The main forms of cardiomyopathy are dilated, restrictive or hypertrophic. Echocardiography is the cornerstone investigation for the diagnosis of these conditions. In patients with dilated cardiomyopathy, echocardiography is used to measure LV size and function, concurrent valve lesions, and complications such as LV thrombus. It can noninvasively estimate LV filling pressures.[3] In patients with hypertrophic cardiomyopathy, echocardiography is the key in determining the risk of sudden cardiac death, which includes assessment of septal thickness, as well as assessing the mitral valve and the presence and severity of an LV outflow tract gradient. Echocardiography is also important when making decisions regarding treatments in all forms of cardiomyopathy. Echocardiography allows assessment of LV size, regional and global function, the presence and severity of pulmonary hypertension, LV diastolic dysfunction, and right ventricular size and function.

LV size is based on LV cavity measurements made at standardised times in the cardiac cycle. LV ejection fraction is the most familiar measurement of LV function. This derived measurement is calculated by using the diastolic and systolic volumes contained in the left ventricle, expressed as a percentage. A normal ejection fraction is above 55% whereas a severely impaired ejection fraction is less than 30%.[9,10] LV ejection fraction is commonly used to select patients for trials of cardiac drug treatments, and to follow LV function over time. Although this is a familiar and popular measurement, it has methodological limitations, such as the presence of regional wall motion abnormalities, which makes quantification of LV ejection fraction difficult. Three-dimensional (3D) echocardiography (also known as multiplane imaging or four-dimensional [4D] imaging as several planes are acquired in real time) may overcome some technical difficulties by making quantification of LV volumes at different phases of the cardiac cycle easier and more accurate (Figures 1a and b). One of the most accurate, reproducible and clinically useful measurements of LV systolic function is qualitative visual assessment by the physician reporting the echocardiogram on whether the LV systolic function is normal or mildly, moderately or severely impaired.[1,2,9]

Echocardiography is useful in establishing that LV function remains normal with use of drug therapies that are known to cause cardiomyopathy, most commonly clozapine (an atypical antipsychotic medication used in schizophrenia), herceptin (used in breast cancer) and some chemotherapy agents including doxorubicin and anthracyclines.

Murmurs and valvular heart disease

For patients with heart murmurs, echocardiography can define any valve pathology and judge its severity.[6,7] Echocardiography can evaluate the morphology of all four heart valves and is the primary diagnostic tool for valve stenosis and regurgitation.[1,2,6,7] In addition to identifying the valve lesion, echocardiography quantifies the degree of stenosis or regurgitation, assesses cardiac chamber size and function, and helps ascertain the cause of the valve problem. In patients with valvular heart disease, baseline echocardiography can

establish a reference point, with serial echocardiographies over time used to assess the progression of the valve lesion. Measurements of LV size are important because LV dilatation is part of the criteria for referral of patients with aortic regurgitation and mitral regurgitation for surgical valve repair or replacement.[6,7] Echocardiography is also used after percutaneous or surgical valve procedures, and to assess the response of valve lesions such as mitral regurgitation to treatment strategies such as medications and cardiac resynchronisation pacing.

In suspected or known valve endocarditis, both transthoracic and transoesophageal echocardiography are the cornerstone imaging tests for the diagnosis of vegetations, and for diagnosing complications of valve infection such as paravalvular abscess and valve regurgitation. Bioprosthetic and metallic valve replacements are assessed with echocardiography, both to assess normal function over time and for the diagnosis of prosthetic valve dysfunction if complications are suspected.[8] Transoesophageal echocardiography is often needed to complete the assessment of a prosthetic valve if complications, such as endocarditis, valve dysfunction or valve thrombosis, are suspected.[8] Figures 2 and 3a to c show the assessment of mitral valve pathology, specifically mitral stenosis and mitral valve prolapse, using a new echocardiographic modality 3D echocardiography.

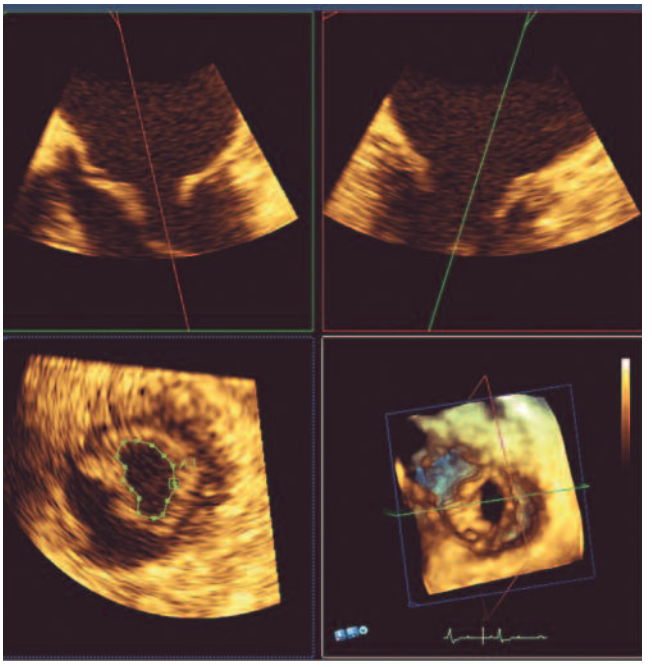


Figure 2. 3D echocardiographic view of valvular mitral stenosis. Views of the mitral valve leaflets are acquired at 90° perpendicular views from the same cardiac cycle, using a 3D echocardiography probe at mid-diastole when the mitral valve tips show maximal excursion (red and green lines). This is used to give a volume-rendered en-face view of the mitral valve, used to calculate mitral valve area by planimetry (tracing the orifice). This patient has moderate mitral stenosis with a valve area of 1.3 cm².

Coronary artery disease

Echocardiography is an important diagnostic tool in patients presenting with chest pain because it enables LV function to be assessed rapidly.[4] The presence of regional wall dysfunction at rest confirms the diagnosis of coronary artery disease, which is a useful adjunct to the assessment of coronary anatomy with coronary angiography. Echocardiography is useful in all common causes of cardiac chest pains, including coronary artery disease, valvular aortic stenosis, pericardial effusion, pericarditis, aortic dissection and pulmonary embolism. Echocardiography can be performed in the emergency department and can guide the physician to which is the next diagnostic test to perform.[4]

In acute coronary syndromes, the area and extent of regional wall dysfunction helps to stratify patients as low or high risk. Echocardiography can diagnose complications of acute myocardial infarction, such as ventricular septal defect, ventricular rupture, aneurysmal dilatation, acute mitral regurgitation and LV thrombus. The area of regional dysfunction suggests which coronary artery is likely to be involved. Echocardiography can be repeated after percutaneous intervention or surgical revascularisation to assess the regional dysfunction has responded to therapy, and to check for complications of these interventions such as pericardial effusion.[4]

Exercise stress echocardiography is a functional test to diagnose myocardial ischaemia using echocardiography imaging of LV wall regions at baseline and after exercise.[14-16] Dobutamine infusion is used instead of the treadmill exercise test if the patient is unable to walk. Stress echocardiography is superior to standard exercise testing because direct visualisation of the left ventricle allows localisation and assessment of the extent of myocardial ischaemia. It is also very useful in patients with baseline ST or T wave abnormalities on ECG that make standard treadmill testing unhelpful, including ventricularly paced rhythms, digoxin effects, LV hypertrophy or LV strain, and left bundle branch block.[15,16]

Palpitations, syncope and arrhythmias

Palpitations, dizziness and syncope are very common cardiac symptoms, and establishing that a patient has a structurally normal heart in this situation is reassuring and guides management. In atrial flutter and atrial fibrillation, an echocardiography to examine LV function, mitral valve function and left atrial size is a class 1 indication in current American Heart Association and American College of Cardiology guidelines.[5]

Other indications

Echocardiography is useful in assessing the pericardium in patients with pericarditis to diagnose and follow pericardial effusions, and for the diagnosis of rare pericardial conditions, such as pericardial tumours and pericardial constriction. It is also useful in assessing progression and guiding aspiration of pericardial effusions. Echocardiography is used to diagnose intracardiac masses, such as cardiac tumours, the most common being atrial myxoma, and LV thrombi. Echocardiography is used to examine the proximal

ascending aorta for aortic dissection (although transoesophageal echocardiography is often needed), aortic coarctation and ascending aortic aneurysms. The progression of aneurysmal dilatation of the ascending aorta over time can be assessed with echocardiography.

Echocardiography is useful in patients who are critically injured or severely unwell because it is portable and rapid. For example, in patients with penetrating injuries to the chest, out-of-hospital cardiac arrest, deceleration injuries and hypotension or hypoxia of uncertain cause, echocardiography can give valuable clues and even make the diagnosis.[13]

Echocardiography makes the diagnosis of congenital heart disease in patients of all age groups, from fetus to adult, and is useful in following progression after surgical repair of congenital defects.[2] Echocardiography assesses chamber size and function, valve morphology and function, the site and size of any systemic pulmonary shunts, and pressures in the cardiac chambers, all noninvasively.

Transoesophageal echocardiography

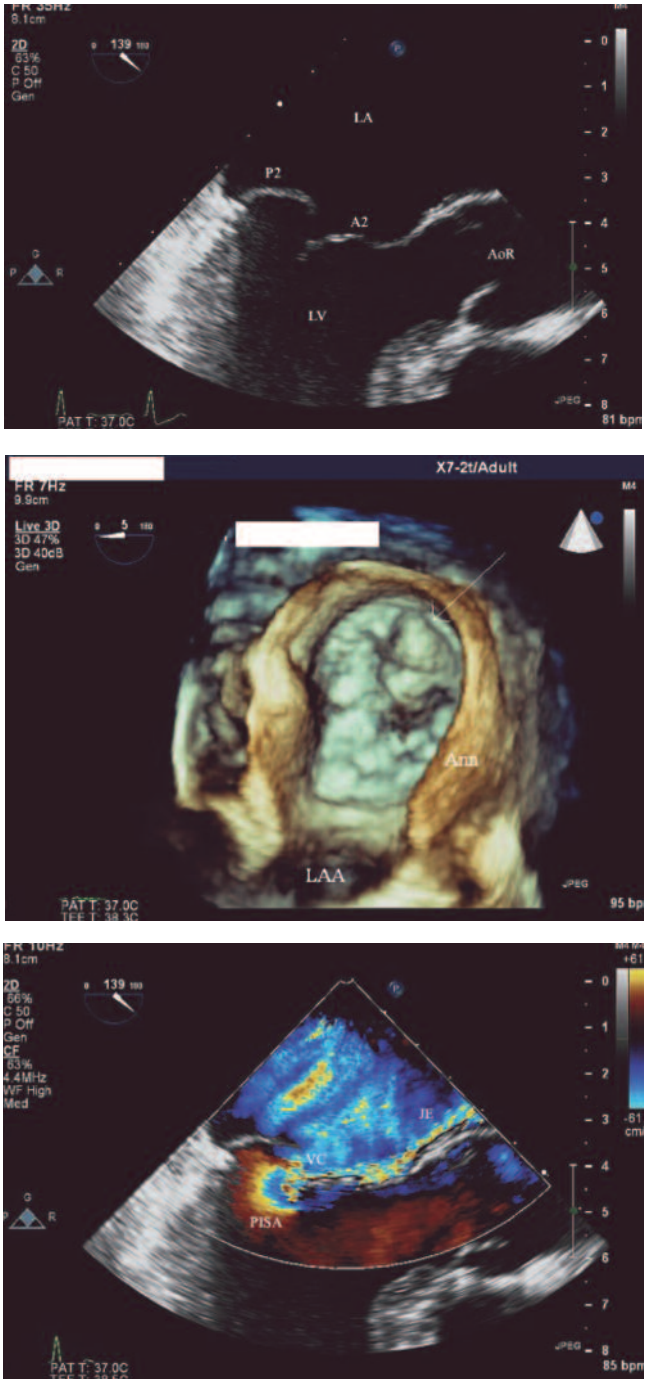
Transoesophageal echocardiography, known as TOE (or TEE in the USA), uses an echocardiography transducer mounted on a flexible endoscope, with ultrasound images of the heart obtained from the oesophagus and stomach.[17] This allows 'close up' imaging of the heart without interference from structures such as ribs. The aortic valve, mitral valve, left atrium, interatrial septum and aortic arch are seen particularly clearly using this technique. The main indications of transoesophageal echocardiography are:

- diagnosing endocarditis of native valves or prosthetic valves
- assessing the severity and cause of mitral regurgitation and deciding if leaking mitral valves are suitable for surgical mitral repair as opposed to full valve replacement
- finding intracardiac causes of proven or suspected cardioembolic stroke.

Transoesophageal echocardiography is invasive and causes some patient discomfort. Although it is largely a very safe procedure, it does present a small but definite risk of pharyngeal and oesophageal trauma (including oesophageal perforation) and aspiration.[1,17]

New developments in echocardiography

Echocardiography is a constantly developing field, with new developments in imaging rapidly incorporated into new echocardiography machines. Current echocardiography modalities of interest are 3D imaging, which allow 3D rendering of structures such as the mitral valve, aiding evaluation and decisions regarding treatment. 3D imaging is very useful in percutaneous deployment of intracardiac devices, such as percutaneous aortic valves.[17] Figure 2 shows the assessment of rheumatic mitral stenosis with 3D echocardiography. Figures 3a to c show the assessment of mitral valve prolapse using 3D transoesophageal echocardiography. 3D echocardiography is also used for the assessment of LV volumes, as shown in Figures 1a and b. Another recent development is strain-based technologies, which quantify myocardial deformation to aid evaluation of LV function.[18]



Figures 3a to c. Views from the oesophagus of the mitral valve using transoesopheal echocardiography, showing mitral regurgitation due to posterior mitral valve leaflet prolapse. (a, top). This image shows a standard 2D image of the valve. (b, middle). This image shows a multiplane volume-rendered 3D view of the valve. (c, bottom). This image shows the regurgitant jet on colour Doppler.

ABBREVIATIONS: A2 = middle scallop of anterior mitral valve leaflet; AoR = aortic root; LA = left atrium; LAA = left atrial appendage; LV = left ventricle; P2 = middle scallop of posterior mitral valve leaflet.

Summary

Echocardiography is a safe and useful tool that provides valuable clinical information for patients who have many different cardiac conditions. CT

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