



Diagnostic tests

Echocardiography

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Summary

Technological advances have led to a broader range of indications for echocardiography. For some conditions such as endocarditis, echocardiography has a key role, while in others such as hypertension it provides useful supporting information. Although most conditions can be assessed with transthoracic ultrasound, a transoesophageal approach under anaesthetic may be more useful for conditions such as aortic dissection. Stress echocardiography, using exercise or pharmacological stress, can help in the investigation of coronary artery disease and the assessment of patients following myocardial infarction.

Key words: cardiovascular disease, ultrasound.

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Introduction

We have come to enjoy the convenience and accuracy of echocardiography to diagnose and monitor a wide variety of cardiac conditions with safety and at a relatively low cost. The indications are now broad. In some cases echocardiography is the investigation of first choice, while in others it provides important supplementary data. By selecting the most appropriate form of echocardiographic imaging we can obtain the greatest benefit for our patients with minimum adverse effects.

It is important to remember that the quality of information may be influenced by the technician's skill, the standard of equipment used and the interpretation of the reporting doctor. As with any imaging modality, the report should be considered in the context of the clinical setting.

Indications

The patient's condition and the clinical question determine whether a transthoracic or a transoesophageal approach under anaesthetic is used.

Heart failure

All patients with suspected heart failure should have echocardiography for the assessment of left ventricular

function and its aetiology. Ejection fraction may be estimated qualitatively or quantitatively. Regardless of the method there are limitations of the ejection fraction as a reflection of myocardial performance as it is load-dependent, and this should be considered when interpreting the results. Rhythm disturbances such as atrial fibrillation can make the image difficult to interpret.

Oedema and dyspnoea are common indications for echocardiography. Cardiac aetiologies such as myocardial dysfunction, valvular disease and pericardial abnormalities can usually be readily diagnosed. Significantly, echocardiography can play an important role in excluding left ventricular dysfunction in those previously diagnosed with heart failure. It also has a role in following patients' responses to the treatment of heart failure.

Diastolic dysfunction is another important cause of heart failure. It can be diagnosed non-invasively by measurements performed in a standard transthoracic echocardiogram. There are some recognised limitations including a broad overlap between normal and abnormal filling parameters, and a dependence on load, heart rate and rhythm.

Murmurs

Murmurs caused by valvular disease and other aetiologies can be readily differentiated from benign flow murmurs (Table 1). Incompetence and stenosis of each of the four cardiac valves can be diagnosed by the transthoracic approach. This provides qualitative and quantitative data which can help in determining prognosis, disease progression and guidance for treatment.

Septal defects

Septal defects may be diagnosed by echocardiography. Not uncommonly, the septal defect is an incidental finding and, particularly in the case of an asymptomatic patent foramen ovale, no further action may be required. As always, the patient's clinical condition is important when interpreting such incidental findings.

Transoesophageal echocardiography has a vital role in the selection of patients for the percutaneous occlusion of septal defects, the sizing and deployment of the devices and in follow-up.

Ischaemic heart disease

Abnormalities in the motion of the cardiac wall are characteristic of myocardial ischaemia and correlate with coronary

Table 1

Quantitative echocardiographic parameters of valvular lesions

Mitral regurgitation			
	Regurgitant fraction (%)	Effective regurgitant orifice (mm ²)	
Mild	<30	<20	
Moderate	30–39	20–29	
Moderately severe	40–49	30–39	
Severe	≥50	≥40	

Aortic stenosis *			
	Mean gradient (mmHg)	Peak velocity (m/sec)	Area (cm ²)
Mild	<25	<3.5	>1.0
Moderate	25–50	3.5–4.5	0.76–1.0
Severe	>50	>4.5	<0.76

Mitral stenosis		
	Mean gradient (mmHg)	Area (cm ²)
Mild	<5	>1.5
Moderate	5–10	1.0–1.5
Severe	>10	<1.0

* good ventricular function is needed to get an accurate assessment

distribution. Following a known ischaemic event, transthoracic echocardiography can detect complications such as pump failure, acute mitral regurgitation, septal defects or free wall rupture, intracardiac thrombus (Fig. 1), right ventricular involvement and pericardial effusion. Later, echocardiography can provide important prognostic information regarding remodelling.

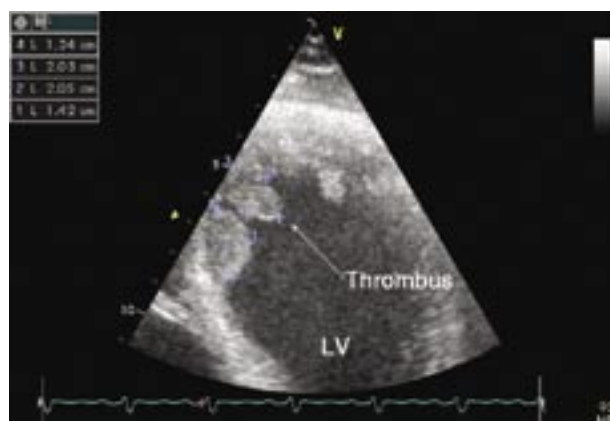
Stress echocardiography

Stress echocardiography is an important tool in the evaluation of known or suspected coronary artery disease.¹ It can also be used in valvular heart disease, hypertrophic cardiomyopathy and pulmonary hypertension. Physical stress is preferred (either treadmill or bicycle) for the assessment of chest pain, dyspnoea, valvular disease or post-myocardial infarction risk. Pharmacological stress testing with dobutamine is the method of choice for studies of myocardial viability, and preoperative risk assessment before non-cardiac surgery (usually because the patient is not well enough or able to exercise before the surgery) or if the patient cannot exercise.

The sensitivity of exercise echocardiography ranges from 71%⁶ to 97%.² The accuracy of dobutamine echocardiography is similar. Due to its availability, convenience, versatility and ability to evaluate other forms of cardiac disease simultaneously, it is preferred to radionuclide scintigraphy in some centres. It is also cheaper and avoids a dose of radiation. Compared to stress ECG

Fig. 1

Transthoracic image of left ventricular apical thrombus



LV left ventricular cavity

alone, echocardiography is more specific for detecting stress-induced ischaemia or left ventricular dysfunction.

Systemic hypertension

The cardiac effects of hypertension can be evaluated by echocardiography. Left ventricular hypertrophy can be more accurately diagnosed than by ECG and echocardiography is less expensive and more accessible than magnetic resonance imaging. The presence of increased mass or even increased wall thickness impacts adversely on morbidity and mortality.

Arrhythmias and palpitations

Arrhythmias may be the manifestation of a variety of cardiac abnormalities including congenital defects, acquired valvular lesions, pericardial disease and ischaemia. Conversely, arrhythmias may be the cause of cardiac pathology such as atrial thrombus or dilated cardiomyopathy. In patients with atrial fibrillation echocardiography can unmask otherwise unsuspected cardiac disease in 10% of cases and can help predict which patients are more likely to remain in sinus rhythm post-cardioversion. Before cardioversion, transoesophageal echocardiography has a vital role in excluding intra-atrial thrombus in patients who have had atrial fibrillation for more than 48 hours without anticoagulation.

Although not an absolute indication, an echocardiogram showing a structurally normal heart in a patient troubled by isolated ectopic beats can be very reassuring for both physician and patient. Similarly, echocardiography is useful in the evaluation of patients with an abnormal ECG.

Endocarditis

Echocardiography is vital in the workup of a patient with suspected endocarditis particularly for the diagnosis of

Fig. 2

Transthoracic image of vegetation on the anterior leaflet of the mitral valve



AMVL anterior mitral valve leaflet

vegetations (Fig. 2). Transoesophageal echocardiography is more sensitive than transthoracic imaging for detecting small vegetations, abscess cavities and leaflet perforation, and is superior for the imaging of prosthetic valves.³ Indications for transoesophageal echocardiography include a diagnostically inadequate transthoracic echocardiogram, a negative transthoracic echocardiogram despite ongoing high clinical suspicion of endocarditis, prosthetic valve involvement and staphylococcal (or suspected) bacteraemia.

Prosthetic valves

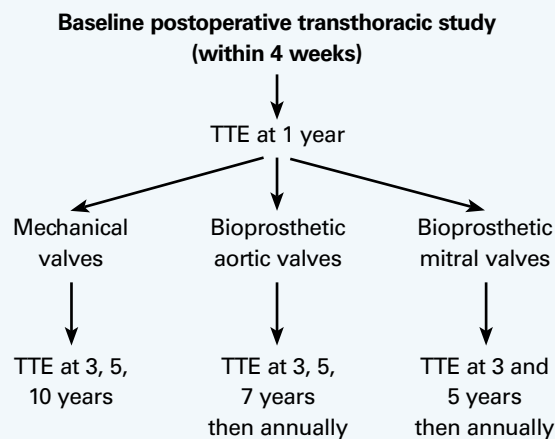
Prosthetic valves are susceptible to infection, degeneration, stenosis and thrombosis. They are routinely checked with transthoracic echocardiography (see box). Transoesophageal echocardiography is indicated when the assessment of prosthetic valve function is hampered by acoustic shadowing, or the detection of vegetations is made difficult by other artifacts. It is essential when evaluating complicated endocarditis in patients with prosthetic valves.

Embolic disease

Echocardiography plays a very important role in finding the source of an embolus following a stroke or peripheral embolic event. Younger patients or those who have suffered occlusion of a large peripheral vessel are more likely to have suffered a purely cardiac embolic event. Older patients are more likely to have intrinsic cerebrovascular disease or atrial fibrillation.

Transthoracic echocardiography is easier, carries negligible risk and is less expensive, but has a lower yield than transoesophageal echocardiography. Sources of emboli that are usually better defined by transoesophageal echocardiography include left atrial appendage thrombus, small vegetations, septal defects or aneurysm and aortic arch atheroma.

Follow-up of patients with prosthetic valves



TTE transthoracic echocardiography

From: Guidelines of the Prince Charles Hospital Echocardiography Laboratory, Brisbane

Cardiac masses and tumour

Patients in whom the diagnosis of an intracardiac mass should be considered are those with cryptogenic stroke or other embolic events, those with atrial fibrillation, dilated cardiomyopathy, anteroapical infarction, bacteraemia or fever of unknown origin. Echocardiography can accurately diagnose primary and secondary cardiac tumours, thrombi and vegetations.

Pericardial disease

Echocardiography is the investigation of choice for the diagnosis and evaluation of a pericardial effusion (Fig. 3). The effusion's presence, size, haemodynamic significance and response to therapy are well demonstrated. Echocardiographic signs in keeping with tamponade include right atrial invagination at the onset of systole (sensitive), right ventricular collapse in diastole (specific) and marked respiratory variation in transvalvular inflow velocities. Transthoracic echocardiography assists in the planning and the execution of pericardiocentesis.

Constrictive pericarditis may be diagnosed on echocardiography, however the assessment of the pericardium can be difficult and investigation such as magnetic resonance imaging may be more helpful.

Diseases of the great vessels

Transthoracic echocardiography shows the main pulmonary arteries as far as the proximal main branches, the hepatic veins as they drain into the inferior vena cava, and the inferior vena cava as it emerges from the liver and enters the right atrium. Three of the four pulmonary veins can usually be seen transthoracically where they connect with the left atrium, but for a complete examination of pulmonary venous drainage, transoesophageal echocardiography is usually required. The

Fig. 3

Transthoracic image of pericardial effusion



arrow pericardial fluid

superior vena cava can occasionally be seen as it enters the right atrium, but this vessel is best seen by transoesophageal echocardiography.

Transoesophageal echocardiography, magnetic resonance imaging and CT scanning have similar sensitivity and specificity for the detection of aortic dissection. With the exception of a sometimes encountered blind spot at the upper ascending aorta, the remaining thoracic aorta can be accurately visualised by transoesophageal echocardiography.

Pulmonary disease

Although pulmonary disease often contributes to poor image quality, echocardiography can be useful in the non-invasive evaluation of pulmonary pressures, right heart size and function and in the exclusion of a cardiac cause for dyspnoea. Echocardiography is not the investigation of choice for pulmonary emboli. However, it can provide indirect evidence such as elevated right heart pressures or right ventricular dilatation and dysfunction. Large proximal pulmonary emboli (for example, saddle embolus) can be diagnosed by transoesophageal imaging.

Syncope

Transthoracic echocardiography can be considered if there is syncope in the presence of an abnormal ECG or cardiovascular disease. Some common cardiac aetiologies that can be excluded are obstructive lesions such as hypertrophic cardiomyopathy or significant aortic stenosis, and conditions providing a substrate for malignant arrhythmias such as left ventricular dysfunction or right ventricular dysplasia.

Screening

Echocardiography can screen for abnormalities in the relatives of patients with familial cardiomyopathies (dilated and hypertrophic) and Marfan's syndrome.

Technological advances

Intravascular imaging has given greater insights into coronary atherosclerotic disease. While the applications of intracardiac echocardiography are still emerging, this technology has proved useful in percutaneous closure of cardiac defects, the evaluation of double prosthetic valves and the exclusion of pacing lead endocarditis.

Three-dimensional imaging can provide accurate anatomic information. There has been preliminary work on three-dimensional imaging during pharmacological stress.⁴

Doppler tissue imaging examines the velocity of the systolic and diastolic motion of the myocardium at various sites. It provides insight into diastolic function and has become a routine part of the standard transthoracic imaging. Recently, Doppler tissue imaging has been used in stress-testing to improve sensitivity compared with visual analysis alone.⁵ Strain rate imaging is a promising application of Doppler tissue imaging in the assessment of ischaemia and viability via detection of subtle alterations in myocardial contractility.⁶

Lightweight and less expensive hand-held devices are now available. Their image quality is sufficient to make basic diagnostic assessments.

Conclusion

Echocardiography is widely available in Australia. Its use is likely to increase as technological developments increase its accuracy and portability. While echocardiography has many potential indications, it is best used when it will provide information that will add to the clinical findings and help to guide treatment. This principle is particularly important when considering the need for the more invasive transoesophageal echocardiography.

References

1. Marwick TH, Torelli J, Harjai K, Haluska B, Pashkow FJ, Stewart WJ, et al. Influence of left ventricular hypertrophy on detection of coronary artery disease using exercise echocardiography. *J Am Coll Cardiol* 1995;26:1180-6.
2. Crouse LJ, Harbrecht JJ, Vacek JL, Rosamond TL, Kramer PH. Exercise echocardiography as a screening test for coronary artery disease and correlation with coronary arteriography. *Am J Cardiol* 1991;67:1213-8.
3. Erberl R, Rohmann S, Drexler M, Mohr-Kahaly S, Gerharz CD, Iversen S, et al. Improved diagnostic value of echocardiography in patients with infective endocarditis by transoesophageal approach: a prospective study. *Eur Heart J* 1988;9:43-53.
4. Ahmad M, Xie T, McCulloch M, Abreo G, Runge M. Real-time three-dimensional dobutamine stress echocardiography in assessment of ischemia: comparison with two-dimensional dobutamine stress echocardiography. *J Am Coll Cardiol* 2001;37:1303-9.
5. Pasquet A, Yamada E, Armstrong G, Beachler L, Marwick TH. Influence of dobutamine or exercise stress on the results of pulsed-wave Doppler assessment of myocardial velocity. *Am Heart J* 1999;138:753-8.

- Voigt JU, Exner B, Schmiedehausen K, Huchzermeyer C, Reulbach U, Nixdorff U, et al. Strain-rate imaging during dobutamine stress echocardiography provides objective evidence of inducible ischemia. *Circulation* 2003;107:2120-6.

Further reading

ACC/AHA/ASE 2003 Guideline update for the clinical application of echocardiography. American College of Cardiology/American Heart Association Task Force on Practice Guidelines.

http://guideline.gov/summary/summary.aspx?doc_id=4020 [cited 2006 Sep 12]

Conflict of interest: none declared

Self-test questions

The following statements are either true or false (answers on page 143)

- Arrhythmias limit the usefulness of echocardiography in the diagnosis of diastolic heart failure.
- Echocardiography is useful for detecting small pulmonary emboli.

New drugs

Some of the views expressed in the following notes on newly approved products should be regarded as tentative, as there may have been little experience in Australia of their safety or efficacy. However, the Editorial Executive Committee believes that comments made in good faith at an early stage may still be of value. As a result of fuller experience, initial comments may need to be modified. The Committee is prepared to do this. Before new drugs are prescribed, the Committee believes it is important that full information is obtained either from the manufacturer's approved product information, a drug information centre or some other appropriate source.

Butoconazole nitrate 2%

Gynazole-1 (Arrow Pharmaceuticals)

single dose applicator containing 5 g of cream

Approved indication: local treatment of candidal vulvovaginitis

Australian Medicines Handbook section 17.11.1

Candida albicans is a common cause of vulvovaginitis.^{1,2} These infections are usually treated with imidazole antifungal drugs. Butoconazole nitrate is the fifth imidazole agent to be registered in Australia, after clotrimazole, ketoconazole, miconazole and econazole. These drugs come in a number of different formulations (including cream, pessaries and oral tablets) and dosing regimens. Although butoconazole nitrate 2% cream is a new product in Australia, it was first introduced in the USA as a prescription drug in 1986 and is currently marketed there as an over-the-counter product.

Depending on the formulation, up to 6% of an intravaginal dose is absorbed, with peak plasma levels being reached 12–24 hours after administration. The drug is excreted mainly as metabolites in the urine and faeces.

The Australian butoconazole cream has been formulated to adhere to the vaginal wall for longer than the standard butoconazole cream.³ The prolonged retention time means that this formulation can be given as a single-dose application rather than a three-day course.

In a randomised open-label trial of 181 American women with vulvovaginal candidiasis, a single application of butoconazole cream was compared to a single 150 mg oral tablet of fluconazole. Twelve hours after treatment, 44.4% of women given topical butoconazole experienced first relief of symptoms

compared with 29% of women given oral fluconazole. The time to complete relief of symptoms was similar in both treatment groups. Yeast cultures to confirm the presence or absence of candida were not performed in this study so the true microbiological cure rates could not be assessed. The most common butoconazole-related adverse events were vulvovaginal pruritis (3 events) and vulvovaginal burning (3 events). In the fluconazole group, headache (6 events), diarrhoea, nausea, skin sensitivity and upset stomach were the most common drug-related adverse events.⁴

In another trial, a single-dose butoconazole cream was compared to a seven-day miconazole cream. Similar levels of drug efficacy in both treatment groups were observed with regard to clinical symptoms and microbiological cultures.⁵

Two unpublished studies compared butoconazole nitrate 2% cream with a clotrimazole pessary (500 mg) in women with confirmed vulvovaginal *Candida albicans* infection. Microbiological and symptomatic signs of candidiasis were resolved 30 days after treatment in 79 of 118 (67%) women treated with butoconazole compared with 71 of 116 (61%) given clotrimazole.

In trials comparing butoconazole and clotrimazole vaginal treatments, irritation of the vulva, vagina or urethra were the most common drug-related adverse event. These were reported by approximately 1% of patients receiving either treatment.

The use of latex or rubber products such as condoms or contraceptive diaphragms is not recommended within 72 hours of butoconazole application. Additional topical antifungal cream may be required for the treatment of external vulval or perianal areas.

In Australia, 10% clotrimazole is the only single-dose cream