Echocardiography

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Abstract

Echocardiography — the investigation of the heart with ultrasound — is the most frequently used cardiac imaging modality. Transthoracic echocardiography is a powerful tool to evaluate the structure and function of the heart. Further evaluation is possible with transoesophageal echocardiography. However, its higher resolution and image quality are accompanied by a small risk of complications. Stress echocardiography allows identification of patients with significant coronary artery disease with high sensitivity and specificity. The aim of this article is to outline the information that echocardiography can provide and the clinical situations where it is indicated. Further advanced applications such as contrast and three-dimensional echocardiography will also be discussed.

Keywords contrast echocardiography; coronary artery disease; Doppler; echocardiography; heart valve diseases; stress; three-dimensional; transoesophageal; ventricular function

Echocardiography provides a wealth of information, and importantly, is a non-invasive technique which does not involve radiation and is readily available at the bedside.

Basic ultrasound physics

Ultrasound waves transmitted into the body travel with a distinct velocity and are reflected at interfaces between tissues of different density (e.g. blood and myocardium). The time these echoes require to return to the transducer is analyzed and a two- or even three-dimensional image of a cross-section of the heart can be generated. Ultrasound waves reflected by moving structures such as red blood cells and myocardium cause a frequency shift of the ultrasound (=Doppler effect). This is the basis of Doppler-echocardiography (colour, continuous and pulsed-wave Doppler), which enables accurate measurements of blood flow and myocardial tissue velocities (Figures 1—3).

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What's new?

- More accurate assessment of left ventricular function is feasible with 3D-TTE.
- Guidance by 3D TOE is increasingly required for percutaneous (non-coronary) cardiac interventions (e.g. PFO-/ASD-closure, trans-catheter aortic valve implantation).

Transthoracic echocardiography (TTE)

A transthoracic study is usually performed by an experienced sonographer or a trained doctor and takes approximately 40 min for a full study. Optimal positioning of the patient is important since the bony thorax and the lungs represent obstacles to the ultrasound. While the patient is resting comfortably on his left side, a set of standard views is acquired from the left parasternal, apical, subcostal and suprasternal positions. Rotation and angulation of the transducer enable different planes of the heart to be visualized from a single position.

Left ventricular function

The commonest reason for requesting a TTE is evaluation of left ventricular function. By scanning the left ventricle from different views global systolic function can be qualitatively described as normal, mildly, moderately and severely impaired. In order to assess systolic function quantitatively, left ventricular area is measured in two planes at end-systole and end-diastole, and volumes and ejection fraction derived by applying Simpson's method. However, absolute numbers must be used carefully, as the method is based on a number of assumptions. 3D echocardiography is more accurate and reproducible[1,2] and may be considered in patients where serial comparison is necessary (e.g. during potentially cardiotoxic chemotherapy or in patients where

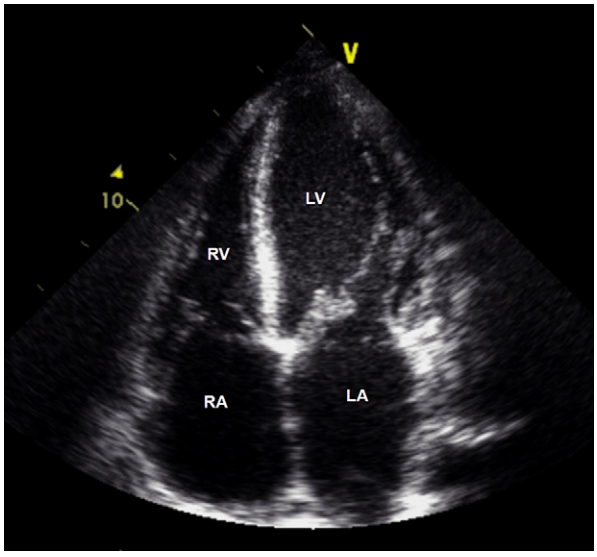

Figure 1 Transthoracic apical four chamber 2D image shows all the four chambers of the heart (RA = right atrium, RV = right ventricle, LA = left atrium, LV = left ventricle) and is therefore called 4-chamber view. The mitral valve appears thickened, the tricuspid valve looks normal.

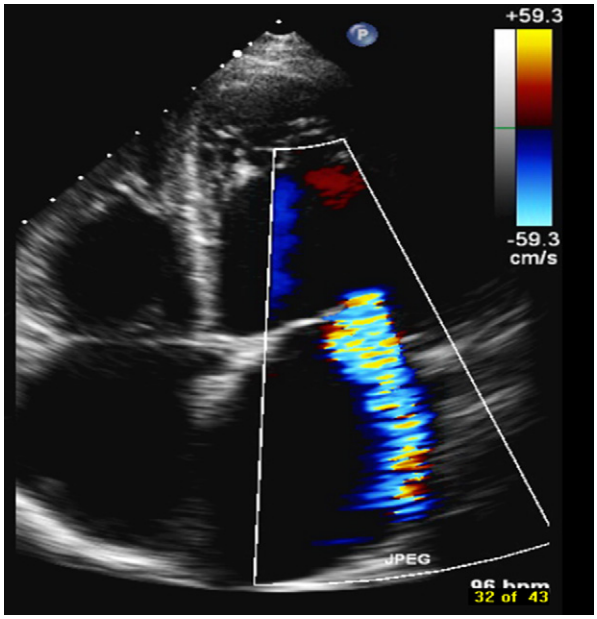

Figure 2 Mitral regurgitation visualized with colour Doppler. The coloured area represents the high velocity jet through the mitral valve moving towards the roof of the enlarged left atrium.

important clinical decisions are going to be based upon the parameters). Furthermore, regional left ventricular wall motion can be assessed and abnormalities suggesting ischaemic or scarred myocardial tissue detected. Diastolic function can also be determined helping to distinguish those patients with diastolic heart failure. However, although TTE is extremely valuable in patients with heart failure, a scan is not indicated if brain natriuretic peptide values are normal.[3]

Valve disease

TTE allows detailed evaluation of valvular anatomy and function and is therefore invaluable in the assessment of valve disease. Hence, one of the most frequent indications is a heart murmur. However, in the absence of symptoms, an innocent murmur (i.e. a soft ejection murmur and normal second heart sound) does not justify an echocardiographic assessment. In a febrile patient a systolic murmur can often be auscultated because the hyperdynamic physiology causes flow acceleration and turbulence. If there is a clinical suspicion of endocarditis, TTE may identify vegetations and is therefore indicated, but it is important to note that a normal TTE does not completely exclude endocarditis.[3] In patients with proven valvular disease, progression is monitored by TTE as indications for surgical intervention are mainly based on echocardiographic criteria and symptoms.[4]

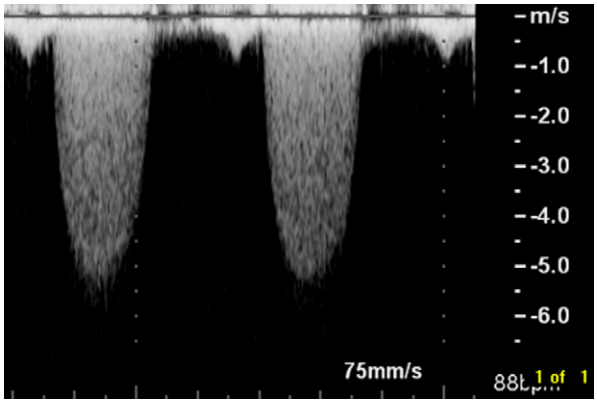

Figure 3 Continuous wave Doppler signal of severe aortic stenosis. Velocity of blood flow (*y*-axis) is recorded against time (*x*-axis). The peak velocity of about 5 m/s is consistent with severe aortic stenosis.

Cardiomyopathies

TTE is usually diagnostic for hypertrophic cardiomyopathy and plays an important role in identifying patients with other types of cardiomyopathies [i.e. dilated cardiomyopathy, arrhythmogenic right ventricular cardiomyopathy (ARVC) and infiltrative disease causing restrictive cardiomyopathy]. Further investigation with cardiovascular magnetic resonance may be necessary, particularly for ARVC and infiltrative disease.

Other indications

TTE also allows assessment of right ventricular function and estimation of systolic pulmonary artery pressure. Pericardial disease can be detected and the haemodynamic influence of pericardial effusion evaluated. Atrial and ventricular septal defects and other major congenital heart disease can be excluded, although agitated saline ('bubble') contrast may be needed for smaller atrial defects. And intracardiac masses such as tumours and thrombi may be identified; the use of a transpulmonary contrast agent may be helpful in these circumstances.

A comprehensive but not exhaustive list of indications can be found in Table 1.

In conclusion, TTE is a powerful tool to evaluate the structure and function of the heart. As with other diagnostic tests it should only be requested when the result will influence the management of the patient. To get the most out of a study adequate clinical information is vital and a specific question must be phrased. This allows the echocardiographer to look carefully for specific abnormalities and to decide whether additional techniques such as contrast echocardiography, or further investigations are indicated.

Transoesophageal echocardiography (TOE)

Insertion of the ultrasound transducer mounted on the tip of a probe similar to a gastroscope into the oesophagus and stomach enables the heart to be imaged from close proximity without obstruction by the bones and lungs. This results in higher resolution and better image quality and allows assessment of structures not well visualized by the transthoracic approach. However, the procedure is semi-invasive and therefore comes with a small risk of complications and may be uncomfortable for the patient. Serious complications, such as oesophageal perforation, laryngospasm, ventricular arrhythmia and severe hypoxia, are rare (<0.1%) but fatal incidents have been reported (<0.01%).[7,8]

Thus, a study should be performed only if:

- there are no contraindications (see Table 2);
- a transthoracic examination was inconclusive because of poor image quality;
- further evaluation of pathologic findings is necessary; or
- assessment of structures not well seen by TTE (i.e. left atrial appendage, descending aorta is required).