Assessment of left ventricular systolic function in research and in clinical practice

Left ventricular (LV) systolic function is a major prognostic factor in cardiac disease; the serial reliable assessment of LV function is therefore essential. Since its development, echocardiography has played a major role in non-invasive evaluation.

M mode echocardiography
With the increasing sophistication of two dimensional echocardiography, it is notable that two groups with papers in this issue have used the very basic technique of M mode (one dimensional) echocardiography in the assessment of LV function. M mode measurements allow excellent resolution in measurement of LV diameters and wall thickness. Mahon and colleagues have taken advantage of this to identify LV enlargement in relatives of patients with dilated cardiomyopathy and then elegantly demonstrated metabolic abnormalities in these patients.

The population based heart failure study by Cowie and colleagues illustrates the limitations of M mode. It should be noted that echocardiography was not a primary focus of this study. Qualitative two dimensional and M mode echocardiographic findings were not significantly associated with outcome. In this heterogeneous group, M mode was likely inadequate for assessment of LV function. Data were missing in over 50% of patients, possibly because of the technical limitations of M mode.

M mode has shown little evolution until the relatively recent development of anatomic M mode, which allows independent positioning of M mode cursors on cine loops. This technique may have a role for patients with unusual imaging planes and in stress echocardiography.

Two dimensional quantitative assessment of LV function
While M mode echocardiography still has applications, two dimensional imaging is critical for assessment of LV function in most patients.

LV systolic function is frequently assessed visually. The general validity of this has been shown, although wide ranges of interobserver variability have been reported. Visual estimation is clinically useful, but unreliable for patients with very poor images, of limited value in serial evaluation, and inadequate for patients in whom LV volumes critically affect timing of intervention.

M mode measurements can be converted to LV volumes, but compounds errors and is inaccurate in regional LV dysfunction and spherical ventricles. Multiple algorithms may be used to calculate LV volumes from two dimensional traces; all involve some geometric assumptions. The area–length method (symmetrical ventricles) and the apical biplane summation of discs method (asymmetrical ventricles) are validated and normal values are available. Opinions for and against the use of quantitative two dimensional echocardiography largely revolve around issues of comparability to gold standards and reproducibility. There are multiple potential problems in deriving LV volumes from two dimensional traces, but the major technical difficulty is in accurate endocardial tracing. Ultrasound technology has continued to improve, and it is our experience and that of others that acceptable reproducibility can be obtained, particularly with the recently introduced technique of second harmonic imaging, which can dramatically improve endocardial definition.

Contrast echo may allow quantitative measurements in patients with poor images, although normal values may need to be defined for this technique. Automated endocardial border detection systems are commercially available. This technique identifies the blood–tissue interface by acoustic quantification of the ultrasonic back scatter signal and may allow rapid on-line assessment but remains dependent on endocardial definition and underestimates LV volumes.

Clinical use of quantitative two dimensional echocardiography requires a significant commitment in time and learning. In clinical practice, no less than in research, minimisation of errors is critical and a lab committed to quantitative two dimensional echo must maintain a rigorous approach to quality control. Where possible, serial quantitative measurements should be performed by the same individual. We believe this time investment is worthwhile, as quantitative measurements have substantially greater prognostic value than visual assessment. Left ventricular end systolic volume index is a powerful prognostic factor in coronary and valvular disease; LV end diastolic volume index and ejection fraction are also important. The value of quantitative echocardiography is reflected in the enormous contribution it has made to the literature on LV remodelling postinfarction and valvular heart disease.

Measurements of LV shape are an important aspect of remodelling which are underutilised. Increasing LV sphericity has prognostic importance; loss of the normal LV shape may be an early indicator of LV dysfunction. Two dimensional imaging allows a simple assessment of LV shape by measurement of the ratio of mid-cavity diameter to long axis length.

The location and extent of wall motion abnormality in postinfarction patients correlates with LV ejection fraction and has prognostic value. Velocity of myocardial contraction is an index of function previously obtained by M mode digitisation; this can now be measured with tissue Doppler imaging, a modified Doppler technique allowing colour coded endocardial velocity calculations. It has some limitations (for example, it may be affected by cardiac translation) but may have important applications, particularly in stress echocardiography and in evaluation of mild degrees of hypokinesia.

Three dimensional echocardiography
Three dimensional echocardiography avoids geometric assumptions and may reduce the experience required for two dimensional assessment. Development of three dimensional systems has been hindered by the analysis time required, but rapid progress is being made towards routine clinical use. This technique is now well validated and accepted as a gold standard for research; its high reproducibility will increase power in clinical trials compared with two dimensional echocardiography. The major clinical roles of three dimensional echocardiography in LV function assessment are likely to be infarct size measurement, evaluation of distorted ventricles, and serial LV volume measurement in patients with valvular regurgitation.
Load independent indices
A limitation of all common measures of LV systolic function is their dependence on preload and/or afterload. The relation between LV wall stress and rate corrected velocity of fibre shortening is a load independent index of contractility. Other groups are developing alternative non-invasive indices of LV contractility. These sophisticated measurements provide insight into LV mechanics but have limited clinical applicability presently; they are likely to be of most value in serial follow up of patients with major abnormalities of loading conditions, particularly aortic and mitral valve disease.

Assessment of LV function in clinical practice: present and future
Progress towards quantitative two dimensional echocardiography in the assessment of LV function has paralleled advances in ultrasound technology. Three dimensional echocardiography has become a gold standard in research; affordable and reliable real time three dimensional imaging will dramatically impact clinical cardiology.

Currently, assessment of LV function should include those factors providing prognostic information. Our practice is generally to combine M mode measurements, which have value in the serial assessment of LV diameters, with a qualitative assessment of LV ejection fraction, calculated LV volumes from two dimensional traces, and wall motion scoring. It is critical to recognise technical errors and limitations of image quality; subjective assessment of LV function has clinical value in patients with suboptimal endocardial definition. Indices of LV shape are underutilised in clinical practice.

Load independent measures of LV function are ideal and are providing insight into LV mechanics; their clinical applicability to date has been relatively limited but is likely to increase.

Electronic pages

eHEART: www.heartjnl.com
The following electronic only articles are published in conjunction with this issue of Heart.

Transient appearance of antegrade conduction via an AV accessory pathway caused by atrial fibrillation in a patient with intermittent Wolff-Parkinson-White syndrome
S Nishino, Y Kitano, M Moriguichi, T Izumi
A 55 year old man with intermittent Wolff-Parkinson-White syndrome had an episode of atrial fibrillation (AF) that lasted for 117 days. After interruption of the AF a Δwave appeared that lasted for two days and then disappeared. Exercise stress and isoprenaline infusion could not reproduce the Δwave, but after another episode of AF which lasted for seven days a persistent Δwave appeared that lasted for six hours. In an electrophysiological study performed on a day without a Δwave, neither antegrade nor retrograde conduction via an accessory pathway was seen, but after atrial burst pacing (at 250 ms cycle length) for 10 minutes, a Δwave appeared lasting for 16 seconds. The atrial electrical remodelling—that is, the shortening of the atrial effective refractory period caused by AF, is a possible mechanism of the appearance of the Δwave.

Coronary arteries from a single coronary ostium in the right coronary sinus: a previously unreported anatomy
D A H Neil, R S Bonser, J N Townend
The coronary circulation originating from a single coronary ostium is rare. All possible anatomical variations were the basis of a recent classification. This report describes a previously unreported IID, pattern, comprising a solitary coronary ostium in the right coronary sinus with an anatomical course of the right coronary artery. The left circumflex coronary artery arises from the proximal right coronary artery coursing to the left side anterior to the right ventricle.