Ultrasound in the assessment of left ventricular performance

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Echocardiography provides a noninvasive technique to evaluate dynamic cardiac anatomy. Thus, echocardiography provides a method for obtaining standard measurements reflecting cardiac performances such as left ventricular cavitary size and wall motion, and additionally enables the evaluation of relatively unique data such as wall thickness and wall thickening during systole. Therefore, ultrasound has been used for the evaluation of left ventricular performance almost from the first introduction of M-mode echocardiography. The recent development of two-dimensional or cross-sectional echocardiography has overcome some of the limitations of M-mode echo in the evaluation of left ventricular performance and further expanded the role of ultrasound in this area.

Various measurements have been obtained from M-mode echocardiograms of the heart in the evaluation of left ventricular performance. The intracavitary dimension or diameter of the left ventricle may be readily recorded by ultrasound in both systole and diastole, and has been shown to be an accurate reflection of the ventricular area measured. Subsequently, one may utilize the single dimensional, left ventricular internal diameter measurement to extrapolate mathematically an estimation of left ventricular volume in either systole or diastole, thereby enabling deductions regarding stroke volume and ejection fraction of this chamber. Unfortunately, although such extrapolations have been shown to provide reasonable estimates of actual left ventricular volumes in the presence of ventricles of normal geometry, distortions of left ventricular shape by either coronary disease or ventricular dilation invalidate the estimation of ventricular volumes by M-mode. Further, the presence of segmental left ventricular disease may be missed by M-mode techniques and lead to inappropriate assumptions regarding the overall performance of the left ventricle. Such segmental disease of the left ventricle is frequently present at the left ventricular apex in patients with coronary disease. Therefore, at present, estimates of left ventricular volume do not appear to be warranted in most patients with cardiac disease by M-mode techniques. The addition of a measurement of the time required for dimensional shortening, such as the ejection time, enables an estimation of the velocity of myocardial contraction (referred to as velocity of circumferential shortening) as a reflection of left ventricular contractility. Unfortunately, such measurements are again susceptible to the same limitations in the assessment of left ventricular performance as the extrapolations of left ventricular volumes.

Echocardiography is relatively unique in its ability to provide accurate measurements of left ventricular wall thickness throughout the cardiac cycle. Thereby, the presence of left ventricular hypertrophy can be readily detected by M-mode echocardiography, and thinning of the left ventricle secondary to scar formation has also been reported. In addition, left ventricular wall thickening during systole may be quantified by echocardiography as a percentage of end-diastolic thickness. At present, these unique data regarding wall thickening during systole, which may be obtained from echocardiography, have not been exploited in the evaluation of cardiac function.

The pattern of left ventricular wall motion during systole may be reliably recorded by M-mode echocardiography for areas of the left ventricle that may be imaged by this technique. Accordingly, areas of hypokinesis, akinesis, or dyskinesis may be readily observed and measured by echocardiography in various areas including the interventricular septum and left ventricular posterobasal wall. The fidelity with which echocardiography can record patterns of wall motion is exemplified by the ability to record abnormalities in the presence of left bundle branch block and Wolff-Parkinson-White syndrome. Again, M-mode echocardiography is limited in this regard in that not all areas of the left ventricle may be visualized by M-mode techniques.

Due to the limitations inherent in the ability of M-mode echocardiography to evaluate left ventricular performance by means of imaging the ventricular chamber itself, numerous investigators have turned their attention to echocardiographic data independent of the ventricle itself in the assessment of cardiac function. Thus, it has been observed that an abnormal break or bump in the A-C interval of the M-mode echocardiogram of the mitral valve leaflets is a reliable indicator of the left ventricular end-diastolic pressure of 20 mm Hg or higher. In addition, a pattern of pulmonic valve leaflet motion consisting of a loss of the atrial dip, mid-systolic notching, and flattening of the diastolic slopes constitutes strong evidence indicative of pulmonary hypertension. An excessive degree of separation between the anterior mitral leaflet and interventricular septum in early diastole has been found to correlate well with reduced left ventricular ejection fraction. Thus, although all of these data provide evidence regarding left ventricular performance that is only inferential, such measurements have the decided advantage that they do not depend upon segmental left ventricular anatomy.

Recently, two-dimensional echocardiography has overcome many of the limitations associated with M-mode echocardiography. Cross-sectional echocardiography provides a 30° to 90° tomographic view of the left ventricle in a circular sector format. Tomographic views may be obtained through an infinite variety of planes, but several standardized views are applied routinely. Thus, the left ventricle is usually examined in its long axis, extending from aortic leaflets to ventricular apex, and along its short axis perpendicular to the longitudinal plane. The ultrasonic transducer may be positioned at the cardiac apex to obtain a tomogram of all four cardiac chambers simultaneously, or rotated about the long axis to image other ventricular surfaces.

There are advantages of cross-sectional echocardiography in the evaluation of the left ventricle. Thus, by providing the ability to obtain cross-sectional tomograms of the left ventricle through a variety of axes, two-dimensional echocardiography enables visualization of the entire circumferences of the left ventricle and obviates the difficulty associated with segmental dysfunction. Further, cross-sectional echocardiography provides special orientation so that the ultrasonic transducer may be positioned at the point of maximal cardiac impulse with the resultant effect that the area of the left ventricle may be accurately measured. Preliminary data have indicated that measurements of left ventricular volume based upon the circumference of this chamber obtained from two-dimensional cardiographic recordings exhibit a good correlation when compared to standard cineangiographic data. Thus, it would seem that two-dimensional echocardiography will provide reasonable measures of left ventricular volume, which may be utilized clinically.

The spacial orientation afforded by two-dimensional echocardiography has also been important in enabling visualization of areas of the ventricle hitherto unexamined by ultrasonic techniques. Thus, the free wall of the left ventricle as well as the cardiac apex may now be evaluated in great detail. Accordingly, preliminary studies have demonstrated that two-dimensional echocardiography provides information regarding the segmental left ventricular contractile pattern that is comparable to that obtained by standard cineangiographic techniques. In addition, echocardiography had been found to be of value in the detection of transient myocardial ischemia with dyssynergy, which reverts from abnormal to normal with the termination of such ischemia.

As is true with M-mode echocardiographic techniques, the unique ability of two-dimensional echocardiography to provide measurements of wall thickness has not yet been exploited in the evaluation of left ventricular performance. It would seem reasonable that cross-sectional echocardiography would provide the most accurate estimation of actual left ventricular mass. In addition, cross-sectional echocardiography is only now being applied to visualization of the coronary artery, with the left main coronary artery seemingly the most accessible to evaluation. The repeatability of ultrasonic studies combined with the fact that these studies may be performed without introducing foreign agents such as contrast materials would seem to hold the promise of greater utilization of echocardiography for the evaluation of left ventricular performance in the future.