Standardization in the Measurement of Left Ventricular Wall Mass
Two-Dimensional Echocardiography

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SUMMARY Two-dimensional echocardiography is superior to M-mode echocardiography for estimation of left ventricular mass when left ventricular shape is markedly abnormal. Left ventricular mass measurement by twodimensional echocardiography depends on careful experimental calibration of the echocardiographic instrument using either a standard phantom or actual heart slices, an appropriate geometric algorithm, and short axis images to determine myocardial cross-sectional area. Several well-validated algorithms are available, of which the short-axis area-length technique is the simplest. In hypertensive heart disease, in which left ventricular shape is usually close to normal, two-dimensional echocardiography may offer a smaller standard error than M-mode, but this issue requires further evaluation. Further, it is uncertain whether the incremental accuracy of two-dimensional echocardiography in hypertensive heart disease would offset its increased cost and complexity relative to M-mode echocardiography. (Hypertension 9 [Suppl II]: II-30-II-32, 1987)

KEY WORDS • two-dimensional echocardiography • left ventricular mass • left ventricular hypertrophy

ESTIMATION of left ventricular (LV) mass in vivo in humans was first performed with biplane, cut-film ventriculography. Subsequent studies demonstrated that M-mode echocardiographic mass estimates had comparable reliability, but both methods had relatively large standard errors (roughly 30 g). Thus, for individual subjects, a difference in serial change of roughly 60 g would be required to have 95% confidence that a real difference existed or that a real change had taken place. Since the normal mass range is 90 to 215 g, and severe hypertrophy produces masses of 300 to 400 g, both methods are sensitive only to large changes or differences between individuals. Further, in studies of patient groups, changes in LV mass with therapeutic interventions generally are less than 100 g. Thus, relatively large patient populations might be required to determine whether an apparent change is statistically significant.

For these reasons, the advent of two-dimensional (2D) echocardiography led to considerable interest in application for LV mass measurement. As with M-mode echocardiography, the most pressing issues have been selection of a geometric model and of a reliable method for determination of dimensions. Two approaches have been developed that have proven successful when compared to postmortem LV mass. At this time, neither approach has been shown to be superior to the other and both are appropriate for research and clinical application.

Our laboratory has applied the very simple area-length algorithm of Wyatt and co-workers, which uses a single papillary muscle level short-axis section for determination of myocardial area (Am) and minor axis cavity area (Ac), and uses the apical views only for determination of LV length (L). LV mass then equals $\frac{5}{6}AmL$. This simple geometric algorithm has worked remarkably well, even in hearts distorted by extensive ischemic damage or marked right heart dilatation. Based on in vitro imaging of short-axis sections of the left ventricle and comparison of results to photographic planimetry, we have concluded that application of 2D imaging requires a calibration method that corrects for the tendency of 2D images to exaggerate myocardial area and underestimate cavity area on short-axis images. We have observed that the appropriate correction factor is instrument-dependent. Thus, each type of instrument used and, preferably, each individual instrument of each type must be calibrated independently. We have used an in vitro heart slice calibration method, multiplying each in vivo image area by the regression describing the relationship between in vitro images and anatomic heart slice area. The technique is laborious, but the results have been excellent (Figure 1) and have surpassed M-mode results in the same hearts (Figure 2). Examination of the differences between 2D and M-mode data in the same hearts indicates that M-mode minor axis dimensions correlate well with 2D diameters, back-calculated from area planimetry. In contrast, M-mode mean wall thickness estimates and assumed LV length correlate weakly with 2D data when hearts with marked shape distortions are studied. Presumably, these apparent M-mode errors are less important when only symmetric hearts of normal shape are studied, such as those produced by hypertensive heart disease. Nonetheless, it seems likely that in symmetric hearts 2D can produce somewhat better correlations, with a smaller standard error than the M-mode technique. Further studies of this issue are warranted.
Byrd and co-workers have used a more complex apical geometric algorithm combined with short-axis imaging at midventricular level for mean myocardial thickness and have relied on calibration with a standard phantom. Results appear to be comparable in reliability to those obtained with our method. This method is simpler with respect to the calibration step, which does not require postmortem hearts, but requires a programmable calculator or microcomputer because of the complexity of the geometric algorithm. No direct comparison of the two methods has been performed.

These two approaches have in common rigorous calibration procedures and reliance on short-axis midventricular images for determination of mean myocardial thickness. Since studies lacking rigorous calibration methods have met with less success, instrument calibration may be a central issue in 2D determination of LV mass. Byrd et al. has also stressed meticulous attention to standardization of technique, which is clearly an essential point when serial studies are planned.

In summary, two satisfactory methods for 2D echocardiographic measurement of LV mass have been described. Each has certain advantages, but it is unclear whether either is clearly superior. Also unclear is whether 2D echocardiography has sufficient incremental value to warrant substitution of 2D for M-mode LV echocardiographic mass determination in all LV mass applications, or whether its advantages are restricted to settings where major LV shape deformities exist. Further studies to clarify these issues are required.

References

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