Standardization in the Measurement of Left Ventricular Wall Mass
M-Mode Echocardiography

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SUMMARY A wide variety of approaches to M-mode echocardiographic methods for estimation of left ventricular mass have been proposed and employed in hypertensive heart disease. The cube function geometry, which assumes an ellipsoid of revolution with a length twice the minor axis, appears to be optimal provided left ventricular shape is relatively normal. The Penn measurement technique for wall thickness and diameter is best validated, but American Society of Echocardiography measurements can be used with appropriate regression correction. Changes in instrumentation may warrant reexamination of measurement techniques as well as the relative value of M-mode and two-dimensional echocardiographic techniques for estimation of left ventricular mass. (Hypertension 9 [Suppl II]: II-27–II-29 1987)

KEY WORDS • left ventricular mass • M-mode echocardiography • left ventricular hypertrophy

APPLICATION of M-mode echocardiographic estimates of left ventricular mass in suitable disease models, such as hypertensive heart disease, has been hampered by a lack of agreement among investigators on the most appropriate geometric model and the most reliable way of estimating wall thickness. This brief review addresses each of these issues and suggests approaches for the future.

With respect to geometric models, the most commonly utilized is the cube function model,1 which assumes that the M-mode left ventricular end-diastolic dimension is an accurate representation of the minor axis of the left ventricle at its base and that the left ventricle is an ellipsoid of revolution with a length that is twice its minor diameter. Alternative approaches have included alternative geometric models2 and empirical models.3 The latter have generally been validated by comparison to angiographic data. Existing data applying multiple models to identical sets of M-mode echocardiographic data and comparing results to postmortem left ventricular mass in humans have consistently shown that the cube function formula is more satisfactory than alternatives (Figure 1).4 It is important to recognize, however, that applicability of the cube model is inherently limited. It has not performed as well in ventricles with marked shape abnormalities. Further, if sufficiently large populations were compared, the method might tend to overestimate mass in more spherical ventricles, such as those produced by congestive cardiomyopathy.

A more difficult issue has been that of selecting appropriate approaches to sampling and measurement of left ventricular wall thickness. Left ventricular wall thickness shows considerable regional variation, with progressive thinning from base to apex and a tendency for the anterior wall to be thicker than the inferior wall.5 Thus, it is no surprise that, with the same data set, taking the mean of septal and posterior wall thicknesses tends to provide more reliable data than using posterior wall thickness alone.6

Three approaches to measurement of wall thickness have been utilized: the formerly common method (leading to trailing edge of septum, leading to leading edge of posterior wall), the so-called Penn convention (trailing to leading edge for both septum and posterior wall), and the American Society for Echocardiography (ASE) leading edge method.4,6 The formerly conventional method clearly overestimates left ventricular mass, as does the ASE method. Further, while the ASE method has been widely applied, it is based on theoretical considerations rather than empirical demonstration that the leading edge method gives the most satisfactory results. In contrast, the Penn convention gave more reliable mass estimates in a reported series (Figure 2), and these estimates appear to be insensitive to acute chamber volume changes and sensitive to real serial changes.7 However, it remains unknown whether this reflects better wall thickness estimates or an empirical correction for regional variations in wall thickness and errors of the echocardiographic method. Further, instrumentation has changed dramatically since the Penn convention was derived, and it is uncertain whether the Penn convention remains the optimal method of wall thickness measurement with all current two-dimensional guided digital M-mode methods. Finally, Devereux et al.8 have noted that, at least with some instruments, ASE-based results correlate quite well with Penn results. Thus a need exists to reexamine the method of M-mode echocardiographic determination of left ventricular mass. Furthermore, in view of the

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FIGURE 1. Echocardiographic left ventricular mass estimates (LVM<sub>e</sub>) are compared to postmortem left ventricular mass (LVM<sub>p</sub>) using three geometric approaches and identical echocardiographic data. Better results are obtained with the cube method (C), while alternative geometric approaches (A, B) give weaker correlations. (Reprinted from Devereux and Reichek<sup>4</sup> with permission of the American Heart Association.)

FIGURE 2. Relationship between postmortem left ventricular weight (LVM<sub>p</sub>) and echocardiographic estimate (LVM<sub>e</sub>) by two different methods. A. LVM<sub>e</sub> is based on standard measurement convention, cube function geometry, and mean muscle thickness (MMT) taken as the average of interventricular septal thickness (IVST) and posterior wall thickness (PWT). Note the wide scatter, particularly in hypertrophied ventricles. B. This plot differs from Panel A only in using the Penn convention for measurement of wall thickness. Note the excellent linear relationship with a higher correlation coefficient (r) and smaller standard deviation (SD). The dashed line indicates the line of identity. (Reprinted from Devereux and Reichek<sup>4</sup> with permission of the American Heart Association.)

promising recent applications of two-dimensional echocardiography for this purpose, such a reevaluation should also address the relative utility of M-mode and two-dimensional mass measurements, with particular attention to the role of left ventricular shape in determining their relative accuracy.

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