INTRODUCTION

Hypertension Research

Echocardiography in the Measurement of Left Ventricular Wall Mass

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KEY WORDS • hypertension • left ventricular hypertrophy • echocardiography

THE purpose of this supplement is to define the current status and future applications of echocardiography in hypertension research. Electrocardiography has long been used in epidemiologic studies of hypertension and its regression.1-4 More recently, however, mounting evidence of the superior precision, reproducibility, sensitivity, and specificity of echocardiography as a noninvasive tool for measuring left ventricular dimensions and muscle mass has led to its use in the clinical assessment of hypertension.

This series of papers focuses on several topics related to the use of echocardiography in hypertension research and in population studies. The techniques of echocardiographic measurement are varied. A consensus has yet to be developed concerning whether to use either M-mode or two-dimensional techniques or both, the appropriate temporal points for end diastole and end systole, the definition of septal and posterior left ventricular wall limits for M-mode and two-dimensional studies, the appropriate views and measurement criteria for two-dimensional studies, and the choice of formulas for calculation of left ventricular wall mass.5-16

Factors that systematically affect heart size must be considered in the evaluation of left ventricular wall mass. In normal populations, wall thickness and calculated wall mass have been shown to vary with the age, sex, and body surface area of the individual, aside from independent contributions of blood pressure and possibly other hereditary or environmental factors.17-29 Regression equations have been developed to define confidence limits of normal left ventricular dimensions and mass based on these variables.20, 22, 24, 25 Agreement on appropriate calculations and limits for normal mass would permit detection of individuals with abnormal left ventricular mass, whose prognosis is expected to be adversely affected. Since precise separation of "normal" from "abnormal" is difficult, using indices of left ventricular mass as continuous variables may be more valuable in understanding the significance of hypertensive cardiac hypertrophy than "yes" or "no" decisions about the presence of left ventricular hypertrophy. Thus, clinical risk might turn out to be discernibly greater among hypertensive patients whose left ventricular mass falls above the 90th percentile than among those whose values fall lower, within a stringently defined normal range.

Echocardiographic measurements are also subject to errors in sampling and reproducibility.30-38 The number of cardiac cycles, the number of dimensions that need to be measured to calculate wall mass, the number of readers, the types of equipment, and the possible need for duplicate recordings or readings must all be considered in determining an optimal approach. Technique must be specified as must standardization of patient positioning and precautions to minimize variation introduced by respiration. Angulation of the transducer beam with respect to the minor axis of the left ventricle is also important since wall mass measurements presuppose a beam angled along the chamber's minor axis.31, 35-39 Little information in the methods described in published M-mode studies of myocardial hypertrophy and its regression in hypertensive patients bear specifically upon the relationship of beam angle to true minor axis. Agreement upon acceptable limits of angle variation is desirable, but achieving this goal depends on solving problems in the three-dimensional orientation of two-dimensional imaging planes as well as of the one-dimensional M-mode beam. Development of practical methods for three-dimensional echocardiographic reconstruction may be needed to resolve this problem.

Echocardiography has been extremely useful in evaluating the relationship between the presence and degree of left ventricular hypertrophy and the level of blood pressure, its variation during normal activity, and differences in physiologic factors in hypertension.39-59 Aside from use in anatomic measurements of wall mass and relative wall thickness or radius/thickness ratios, echocardiography has also been demonstrated to be of value in evaluating left ventricular function in both systole and diastole in hypertensive patients. Measurement by echocardiography of the degree and rate of left ventricular systolic contraction, end-systolic wall stress,57, 50-57 and the timing and rate of the chamber's diastolic relaxation58, 60 allows relatively complete characterization of cardiac pathophysiology. The recent recognition that left ventricular systolic function is closely and inversely related to end-systolic stress58-57 makes it possible to determine

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whether changes in cardiac function reflect altered loading conditions or myocardial changes. The prognostic significance of these measurements, the ultimate test of their usefulness, remains to be determined, both in patients with hypertension and in unselected populations.

The cost-effectiveness of echocardiography is particularly important in planning clinical trials. Initial costs of echocardiographic equipment, the time needed by both the technician and reader to obtain adequate echocardiographic studies, and the number of echocardiograms required need to be considered. Recent studies have consistently revealed that echocardiography is superior to electrocardiography in sensitivity, specificity, and predictive accuracy for detection of left ventricular hypertrophy.6-8 While these studies have clearly shown that left ventricular mass may be reduced, the data obtained have focused attention on several still unanswered questions9-10: 1) What accounts for the commonly observed disparity between changes in blood pressure and development of hypertrophy? 2) How important are changes in the balance between blood pressure and reduced left ventricular size or radius/thickness ratio as consequences of hypertrophy regression, as potential causes of increased left ventricular wall stress and hence greater vulnerability to myocardial ischemia? 3) How long an interval between echocardiographic studies is required to demonstrate changes in wall mass if such changes ultimately occur? 4) What is the value of or need for ancillary techniques such as radioisotope ventriculography for analysis of left ventricular function and functional reserve?

Echocardiographic methods of measuring left ventricular mass have been used in numerous studies over the past several years to determine the reversibility of hypertensive cardiac hypertrophy.6,8-10 While these studies have clearly shown that left ventricular mass may be reduced, the data obtained have focused attention on several still unanswered questions9-10:

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These considerations have not previously been approached by a task force of researchers in the area of echocardiography as applied either to cardiac consequences of hypertension or the study of unselected populations. This supplement is designed to assess critically the strengths and limitations of currently standardized echocardiographic methods for evaluating the heart in hypertension as well as promising techniques currently under development. An important result of this supplement should be performed in clinical trials in order to utilize its versatility optimally for data collection while containing costs. Analysis of the cost-effectiveness of echocardiographic methods must be performed with regard to the specific intended uses.

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(Hypertension 9 [Suppl II]: II-2-II-5, 1987)
Hypertension research. Echocardiography in the measurement of left ventricular wall mass.

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*Hypertension*. 1987;9:II2
doi: 10.1161/01.HYP.9.2_Pt_2.II2

*Hypertension* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0194-911X. Online ISSN: 1524-4563

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