Left Atrium Reclassified: Application of the American Society of Echocardiography/European Society of Cardiology Cutoffs to Unselected Outpatients Referred to the Echocardiography Laboratory

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Objectives: We sought to determine whether categorization of abnormal left atrial (LA) size based on volumes indexed to body surface area (LAVi) results in reclassification of LA dilatation if the classic antero-posterior diameter (LAd) was measured. The American Society of Echocardiography/European Society of Cardiology recommended LAVi over linear measurements and recently published cutoffs to qualify LA dilatation. However, many laboratories continue to use the LAd because it appears easier to measure.

Methods: Unselected adult outpatients referred to the echocardiography laboratory for any indication in the period March 2005 to January 2006 prospectively underwent standard Doppler echocardiography, including real-time measurement of LAd and LAVi.

Results: We enrolled 578 patients (mean age 66 ± 14 years, 56% women). There was a good positive linear correlation between LAd and LAVi ($r = 0.686$, $P < .0001$). When the published cutoffs for LA enlargement were used, 49.0% of patients were classified as having abnormal LA by LAd and 76.3% by LAVi ($P < .001$). Of the 295 who had normal LA by LAd, 58.6% patients had abnormal LAVi. Conversely, of the 283 with abnormal LAd, almost all patients (94.7%) had abnormal LAVi. The proportion of overall agreement was 67.5% (kappa = 0.357, $P < .001$).

Conclusion: Assessment of LA size by LAVi allows identification of patients with enlarged atria that would have been missed if classified by antero-posterior diameters, especially when cutoffs are applied.

Left atrial (LA) size measured by echocardiography has been shown to be a marker of cardiovascular risk especially among patients in sinus rhythm.[1] In the general population and in high-risk groups, LA enlargement represents an independent and powerful risk marker of cardiovascular events.[2-6]

To date, the most worldwide-used parameter to assess LA size was the antero-posterior diameter (LAd) by 2-dimensional (2D) echocardiography. However, there is emerging evidence that the best method to describe the degree of LA enlargement is the measurement of its volume rather than the diameter, without excessively prolonging the duration of the examination.[7]

Echocardiographic measurement of LA volume indexed to body surface area (LAVi) provides a more accurate estimation of LA size compared with the use of the unidimensional antero-posterior LAd as shown by magnetic resonance imaging studies because of fewer geometric assumptions.[8] Furthermore, LAVi was a better predictor of adverse outcomes than linear measurements.[1]

Therefore, the recently released American Society of Echocardiography (ASE)/European Society of Cardiology (ESC) recommendations concluded that LAVi is preferred over linear measurements to determine LA size and published cutoffs to qualify LA dilatation.[9]

In addition, a standardization of the approach for LA assessment has been warranted essential for communication of LA size among laboratories.[2] However, several laboratories continue to use the antero-posterior LAd because it appears easier to measure.

To the best of our knowledge, there are no large echocardiographic studies concurrently assessing the traditionally used antero-posterior LAd and the LAVi and no study has applied the recently published cutoffs. For these reasons, we sought to determine whether categorization of abnormal LA based on LAVi results in reclassification of LA dilatation if the classic antero-posterior LAd is measured.

METHODS

Echocardiographic Data

Unselected elective adult outpatients referred to the echocardiography laboratory for any indication in the period of March 2005 to January 2006 underwent standard Doppler echocardiography, including prospective real-time measurement of LAd and LAVi. Antero-posterior linear LAd was measured with M-mode from the

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parasternal long-axis view at end systole before the opening of the mitral valve using 2D guidance to position the cursor. LAV was assessed by the modified biplane Simpson method from apical 4- and 2-chamber views. Measurements were obtained in end systole from the frame preceding mitral valve opening. The LA planimetry was traced and the volume was computed by the online software package. While tracing the endocardium, care was taken to exclude LA appendage and ostia of pulmonary veins. Both the linear dimension and the volume of the LA were indexed to body surface area.[10]

The left ventricular (LV) diameters were measured from 2D-guided M-mode method in the short-axis view. LV end-diastolic dimensions were measured at the onset of the QRS complex. LV systolic function was assessed with Simpson-derived LV ejection fraction (EF).[11] LV mass was obtained with the ASE-recommended formula for estimation of LV mass from LV linear dimensions based on modeling the LV as a prolate ellipse of revolution.[12]

Pulsed Doppler measurements were obtained with the transducer in the apical 4-chamber view, with the Doppler sample volume parallel to the flow placed between the tips of the mitral leaflets during diastole. Early mitral inflow velocity (E wave), E-wave deceleration time, late mitral inflow velocity (A wave), and E/A ratio were calculated.[13]

Doppler tissue imaging of the mitral annulus was obtained from the apical 4-chamber view, using a 1- to 2-mm sample volume placed in both corners of the mitral valve annulus. Early velocities (Em) were measured and E wave to Em were calculated. Average of both corner velocities was obtained.[14] Color M-mode was obtained from the apical 4-chamber view with the cursor aligned parallel with LV inflow as previously described.[15,16] Individual echocardiographic parameters (mitral inflow pattern, tissue Doppler, color M-mode, and Valsalva maneuver where necessary) were integrated to grade diastolic function in 4 stages: normal diastolic function; impaired relaxation with normal or near-normal filling pressures (grade I/IV); impaired relaxation with moderate elevation of filling pressures, pseudonormal filling (grade II/IV); and impaired relaxation with marked elevation of filling pressures, restrictive filling (grades III-IV/IV) as previously described.[17]

Mitral regurgitation severity (none, mild, moderate, or severe) was graded using an integrative approach of clues, signs, and measurement obtained by Doppler echocardiography.[18]

Each value represents the average of 3 consecutive beats. All measurements were performed online and entered in an electronic database at the time of the echocardiogram.

To evaluate interobserver variability, two independent observers measured LAd and LAV in 10 randomly selected outpatients without knowledge of the results obtained by the other observer.

LA Size Cut-off Limits

The ASE/ESC guidelines suggest using the following cutoffs [9]: LAd greater than 39 mm for women and LAd greater than 41 mm for men to identify patients with abnormal LAd; LAd greater than 47 mm for women and LAd greater than 52 mm for men to identify patients with severely abnormal LAd; left atrial diameter index (LAdi) greater than 23 mm/m^2 for both sexes to identify abnormal LAdi; LAdi greater than 30 mm/m^2 to identify patients with severely abnormal LAd; LAVi greater than 29 mL/m^2 for both sexes to identify abnormal LAVi; and LAVi greater than 40 mL/m^2 to identify patients with severely abnormal LAVi.

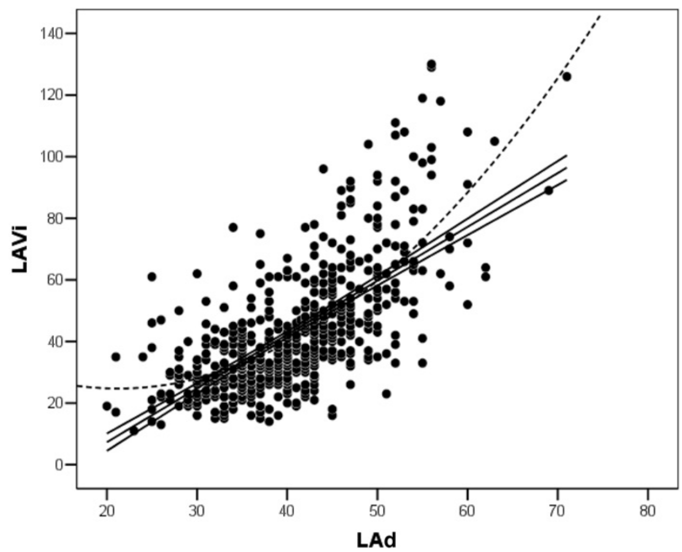

Figure 1 Linear correlation between left atrial (LA) diameter (*LAd*) and LA volume indexed to body surface area (*LAVi*). Regression line and its 95% confidence interval are shown as *solid lines*. Linear $R^2 = 0.47$, $P < .001$. *Dashed line* represents quadratic fitting curve.

Clinical Data

Age, sex, height, weight, cardiac rhythm, and comorbidity were recorded at the time of the echocardiogram.

Statistical Analysis

Results are expressed as count (percentages) or mean ± SD. To measure the strength of the relation between the M-mode LAd and 2D-derived LAV the Pearson correlation coefficients (r) were calculated. The kappa statistics was used to calculate the strength of the accord in categorizing LA as enlarged or severely enlarged. The percent of agreement was calculated as the ratio between agreed-on measures and the total. χ^2 Test or t test statistics were used to compare characteristics across groups. Interobserver reliability was expressed as mean ± SD of the absolute difference between the sets of measurements by two investigators and as interclass correlation coefficient. All tests were two-tailed. P less than .05 was considered statistically significant. All analyses were performed with software (SPSS, Version 13.0 for Windows, Chicago, IL).

RESULTS

Correlations Between LAd and LAV

We enrolled 578 unselected patients; mean age was 66 ± 14 years and 56% were women. There was a good positive linear correlation between LAd and LAVi (the slope was 1.75 [95% confidence interval 1.60-1.90], the y intercept was −27.66, $r = 0.686$, $r^2 = 0.47$, $P < .0001$) (Figure 1) and between LAdi and LAVi (the slope was 3.03 [95% confidence interval 2.78-3.28], the y intercept was −26.06, $r = 0.710$, $r^2 = 0.50$, $P < .0001$) (Figure 2). The correlation between antero-posterior LAd and LAVi was stronger for values of LAd less than 50 mm, whereas in the rest of the curve there was a larger degree of scatter of the data. Similarly the correlation between LAdi and LAVi was tighter for values of LAdi below 29 mm/m^2.