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EDITORIAL COMMENT

Application of 3D Echocardiography to Everyday Practice

Development of Normal Ranges Is Step 1*

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The development of the matrix transducer, more than a decade ago, introduced a new era of 3-dimensional (3D) echocardiography (1). This field has been widely reviewed, but although the most exciting illustrations from this new technique have been derived using rendered images, the greatest promise for routine echocardiography may well be from the application of 3D imaging to left ventricular (LV) measurement. A number of validation studies have now been reported that have emphasized the superior accuracy of volumetric assessment using 3D echocardiography in comparison with a reference standard such as magnetic resonance imaging or phantoms (2,3). Paradoxically, one of the barriers to the application of 3D LV assessment in clinical practice has been the lack of defined normal ranges.

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In this issue of *iJACC*, Chahal et al. (4) report their experience with the application of 3D echocardiography in a large epidemiological cohort. In this group of subjects, free of overt cardiovascular disease, hypertension, and type 2 diabetes, images were considered to be feasible for measurement in 89% of individuals. Normal ranges for LV volumes were recorded for subgroups according to race and sex. Table 1 compares these findings with the limited previous literature on 3D normal ranges (5,6).

The results of this study are important on several levels. First, the applicability of the 3D technique in ~90% of individuals has been confirmed. Second, the feasibility of gathering this information using nonexpert readers has been documented. Third, normal values of ejection fraction are similar between 2-dimensional (2D) and 3D techniques, with a lower cutoff of 52%, which is similar to the normal range of >55% in the American Society for Echocardiography guidelines (1). Fourth, normal values of 3D volumes have been confirmed to be greater than that measured using 2D techniques, although, as we also know, 3D volumes are still slightly underestimated compared with cardiac magnetic resonance (7). Finally, the importance of sex and race in normal ranges is confirmed, but this granularity of the data reveals an ongoing heterogeneity between studies, even within sex and racial group.

What can we learn from this heterogeneity? As always, ejection-phase indexes are sensitive to loading conditions (especially afterload) and heart rate, although it seems reasonable to expect that normal subjects in the community would not have disturbances in either of these parameters. Technical contributors could be important. The details of how the endocardium is traced is important; the spatial resolution of 3D echocardiography is still limited, and trabeculae may be attributed to the LV wall (7). The reliability of automated correction methods that can be used to track the compacted myocardium seems encouraging (8) but warrants further study. The application of contrast during 3D imaging may improve some of these problems (9) but continues to pose challenges that relate to the definition of the mitral annular plane. The optimal balance between multibeat imaging, which offers better spatial resolution but the risk of stitching

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Table 1. Comparison With Normal Ranges in Different Studies by Race and Sex

Study (Ref. #) Parameter	3D European (4) Philips	3D European (5) Philips	3D Indian (4) Philips	3D Japan (6) Mixed	2D (4) Mixed	2D (1) Mixed
Men						
ESVI	19 ± 5	29 ± 6	16 ± 5	19 ± 5	17 ± 5	12–30
EDVI	49 ± 9	66 ± 10	41 ± 9	50 ± 12	44 ± 9	35–75
EF	61 ± 6	57 ± 4	62 ± 5	61 ± 4	61 ± 4	>55
Women						
ESVI	16 ± 4	23 ± 5	15 ± 4	17 ± 4	14 ± 4	12–30
EDVI	42 ± 8	58 ± 8	39 ± 8	46 ± 9	38 ± 9	35–75
EF	62 ± 5	61 ± 6	62 ± 5	63 ± 4	63 ± 5	>55

Values are mean ± SD.
3D = 3-dimensional; EDVI = end-diastolic volume index; EF = ejection fraction; ESVI = end-systolic volume index.

artifact, compared with single-beat acquisitions remains to be elucidated. Finally, previous investigations have demonstrated differences between online and offline measurement of LV volumes (5), possibly related to differences in the automated detection algorithms (Fig. 1), and although software is continually being improved, caution should be added that these results pertain to a single platform and should be considered indicative but not definitive guides to volume measurements on other platforms.

The development of normal ranges for 3D echocardiography in the assessment of LV volumes is a major step forward. The application of these findings to the assessment of ventricular size, for example, including patients with regurgitant valves may

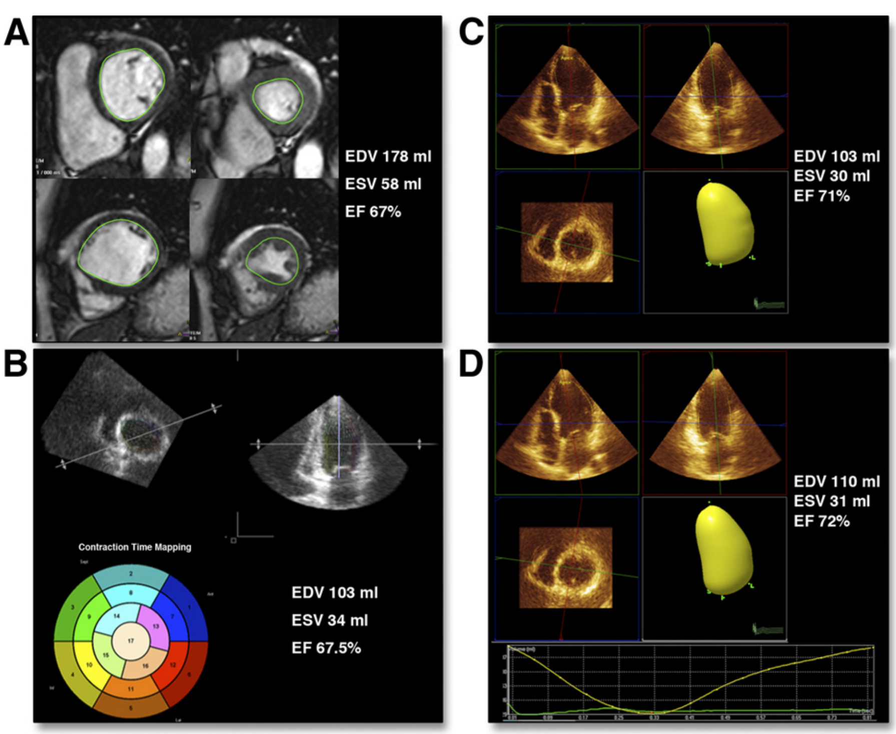

Figure 1. Measurements of 3-Dimensional Left Ventricular Volumes Using Multiple Techniques on the Same Day

(A) Cardiac magnetic resonance–measured end-diastolic volume (EDV) and end-systolic volume (EDV) of 178 and 58 ml, respectively, and ejection fraction (EF) of 67%. **(B)** An offline system measured EDV and ESV 103 and 34 ml, respectively, and EF of 67.5%. **(C, D)** An online system gave sequential measures of EDV and ESV 103 and 30 ml, respectively, and EF of 71%, and 110 and 31 ml, EF of 72%. The challenges of endocardial tracing are readily apparent in the offline images.

have an important impact on practice. It is incredible that in the era of 3D imaging, the guidelines for intervention with regurgitant valves are based on LV dimensions (11). Nonetheless, the spatial and temporal resolution of 3D images is still not as high as desirable, and this is a contributor to the underestimation of volumes, arising from difficulties in resolving trabeculations. Although the substitution of 2D by 3D echocardiography would enable a reduction of scanning time (with commensurate reduction of costs and workplace injury), these technical limitations (12) remain a barrier to uniform adoption of 3D echocardiography.

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Key Words: ejection fraction ■ LV volumes ■ 3-dimensional echocardiography.