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Aortic Root Volume and Geometry: Ready for Clinical Application?

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Real-time 3-dimensional echocardiography (RT3DE) is a useful imaging modality that can be easily performed in the clinical practice, and has been proven to be applicable in measuring the real volumes of cardiac chambers such as left ventricle,[1-3] left atrium,[4][5] and right ventricle,[6][7] without geometric assumption. The volumes measured using RT3DE are well correlated with volumes assessed using other imaging tools such as cardiac magnetic resonance imaging (MRI) and multi-detector computed tomography (CT). However, volumes calculated using RT3DE tend to be smaller than those obtained using cardiac MRI, and this discrepancy might be attributed to a low spatial resolution of RT3DE. It was reported that minimal changes in endocardial surface position (1 mm) resulted in significant differences in measured volumes (11%) in measuring left ventricular volume using RT3DE.[1] Therefore, guidelines for measuring volumes using RT3DE is necessary to avoid volume underestimations and to reduce inter- and intra-observer variabilities.

The authors of the study titled "Validation of three-dimensional echocardiography for quantification of aortic root geometry; Comparison with multi-detector computed tomography" demonstrated 3-dimensional aortic root shape and excellent correlation between aortic root volumes measured using RT3DE and multi-detector CT.[8] This is another application of volume measurement using RT3DE. They found that aortic root volumes at end-diastole measured by RT3DE correlated well with those by multi-detector CT, and the agreement between the two was excellent. The results of this study showed feasibility and accuracy of RT3DE for clinical assessment of geometry and volume of aortic root. There are however several issues to resolve before applying these findings to clinical practice.

First, analyses of RT3DE images are time-consuming. Although authors of this study did not present the time duration required for the image analysis, 20-30 minutes would be necessary to analyze one image including time needed for manual border correction. Therefore, automatic border detection protocol with higher accuracy, which can obviate time-consuming process of manual correction, should be developed for more universal clinical usage.

Second, a low spatial resolution of RT3DE and tracing inner border of aortic wall might underestimate aortic root volume. Although there was no significant difference between aortic root volumes measured using RT3DE and multi-detector CT in this study, there was a tendency that the former is smaller than the latter. Therefore, tracing more outer dense line rather than tracing inner border of the aortic wall may be a better method.

Last but not least, how can we apply the findings revealed in this study using RT3DE images about aortic root volume and geometry into clinical practice? Since the study excluded patients who have any pathologic findings that could affect aortic root geometry, the results of this study cannot be extrapolated to the patients suffering from aortic root pathology. Further investigations should be necessary to verify whether this study result remains true in patients with aortic root pathology such as aortic annuloectasia and Marfan syndrome. RT3DE evaluation of aortic root volume may be useful in following up aortic root dilation in such patients as well as patients with aortic regurgitation.[9] The analyses using RT3DE of geometric components constituting entire aortic root may be of greater clinical use than simple measurement of aortic root volume. Although aortic annulus may not be a distinct anatomic structure,[10] evaluating annulus shape and diameters is essential to implement transcatheter aortic valve implantation. In the current study, aortic annulus appeared to be asymmetric triangular. Aortic annulus shape was reported to be oval rather than circular in previous reports.[11][12] Annulus shape and diameter can be evaluated in each patient and taken into consideration in determining prosthetic valve size.[13] The distance between aortic annulus and ostium of coronary arteries, which is critical in performing transcatheter aortic valve implanta-

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tion, can be measured from CT images.[12)14)] This parameter may be also measurable from the images of transesophageal RT3DE. Furthermore, aortic root dilation is not always uniform and symmetrical, but rather eccentric and asymmetrical. One coronary sinus may be substantially more enlarged than other two sinuses.[15)16)] The asymmetry of sinus dilation and individual variation may be visualized and quantified using RT3DE, and this geometric information may be useful to surgeon in planning aortic valve repair surgery or aortic root replacement with the use of stentless auto-, homo- and xenografts. The measurement of individual volumes of each sinus may provide more clinically relevant information.[16)] Finally, 3-dimensional deformations of aortic root during a cardiac cycle have been evaluated in several animal studies.[17-19)] Geometric analysis for 3-dimensional deformation of human aortic root may be possible using RT3DE, and it may provide physiologic information regarding aortic accommodation of ejected stroke volume and help to develop more ideal method for aortic root surgery.

The novel application of RT3DE for evaluating aortic root and measuring aortic root volume would be the first step to develop new dedicated software for this purpose and extend this technology to diagnose and evaluate aortic root diseases. The progression in the clinical application of this technology will help to provide tailored and appropriate management to patients with aortic root diseases.

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