4D Analysis of Ventricular Function: Is It Ready for Clinical Practice ?

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Recent emergence of 3D echocardiography (3DE) offered a non-invasive means to capture the complex 4D dynamics of the human heart. 3DE provides absolute value of ventricular volume without geometric and mathematical assumptions and resultant volume derived ventricular systolic function (ejection fraction: EF). The improvement in the accuracy of the evaluation of left ventricular (LV) volumes is one of the well established advantages of 3DE over 2D echocardiography (2DE). Many previous studies have validated the accuracy and reproducibility of 3DE for determining LV volumes and EF comparing with cardiac magnetic resonance (CMR) as a gold standard. The high accuracy and reproducibility of LV volume and EF estimation are of vital importance particularly in the candidates for valvular surgery, cardiac resynchronization therapy and coronary stem cell treatment, in which subtle changes in LV volumes should be detected by serial measurements. Moreover, 3DE has great advantage over 2DE in patients with LV aneurysm or regional wall motion abnormality in whom simple geometric assumption cannot take into account. 3DE can also eliminate the errors caused by foreshortened views even in symmetric LV. Therefore, 3DE is currently recommended as the standard in estimating LV volume and EF. On the other hand, right ventricular (RV) volume and EF are more challenging to assess with conventional 2DE. Because, RV overall shape, which can be described as a shell or a roughly triangular body covering part of the circumference of the LV, is inherently impossible to imply geometric assumption for volume calculation. Therefore, instead of RV volume and EF, other 2D parameters such as RV area on apical 4 chamber plane or measures of longitudinal function of RV wall (TAPSE and free wall velocity by tissue Doppler) have been used to estimate RV size and function. However, since they only consider a section of the RV and imply geometric assumptions, they are fundamentally problematic, and particularly so in pathologically remodeled ventricles. 3DE has made it possible to avoid those limitations of the 2DE in the assessment of RV volume and function. 3DE derived RV volumes and EF have showed reasonable limits of agreement with cardiac magnetic resonance imaging. However, 3DE derived RV volume measurement still has several issues limiting its implementation in clinical practice. Firstly, a lack of methodological standardization of several different methods (method of disks, surface modeling), secondly, limited visualization of some RV segments (RV anterior wall and RV outflow tract), thirdly, requirement of pretty long-time learning curve to achieve intra-observer reliability for novices, and finally, lack of large population-based normative values. Recently, 3DE technology including image resolution and software has greatly advanced and the further advancement is under way with the tremendous amount of data which has validated its clinical use in terms of accuracy, efficiency, and novelty. Therefore, in the near future, 3DE will determine its position as a new standard reference technique for accurate and repeatable measurement of both LV and RV volume and function.