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3D Echocardiography: Towards a Better Understanding of Cardiac Anatomy and Function

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3D Echocardiography: Toward a Better Understanding of Cardiac Anatomy and Function

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ARTICLES DISCUSSED:

1. Ujvari, A. et al. Evaluation of left ventricular structure and function using 3D echocardiography. *Journal of Visualized Experiments.* (164), e61212 (2020).
2. Lakatos, B. K., Tokodi, M., Kispal, E., Merkely, B., Kovacs, A. Morphological and functional assessment of the right ventricle using 3D echocardiography. *Journal of Visualized Experiments*. (164), e61214 (2020).
3. Jenei, C., Nagy, L., Urbancsek, R., Czuriga, D., Csanadi, Z. Three-dimensional echocardiographic method for the visualization and assessment of specific parameters of the pulmonary veins. *Journal of Visualized Experiments*. (164), e61215 (2020).
4. Arbic, N., Dragulescu, A., Mertens, L., Villemain, O. The use of 3D echocardiography in surgical planning of the mitral valve in pediatric cardiology. *Journal of Visualized Experiments*. (172), e62574 (2021).
5. Molnár, A. Á., Ábrahám, P., Merkely, B., Nardai, S. Echocardiographic evaluation of atrial communications before transcatheter closure. *Journal of Visualized Experiments.* e61240 (2021).

EDITORIAL TEXT:

Advancements in ultrasound transducer and computer technology have permitted the visualization of cardiac structures with excellent spatial and temporal resolution in three dimensions. 3D echocardiography provided new insights into, among others, understanding cardiac mechanics and valvular heart diseases. From a fancy research tool, 3D echocardiography evolved into a robust clinical modality, and several 3D-derived measurements are now incorporated in current clinical guidelines. However, the widespread use of the technique is hindered by its learning curve. The current JoVE Methods Collection has aimed to bring together some cutting-edge protocols of 3D image acquisition and subsequent analysis to facilitate the use of 3D echocardiography in research and clinical practice. The contributors are experts and everyday users of the technique and cover the critical fields of assessing left and right ventricular morphology and function, the pulmonary veins, and the procedural planning of correcting atrial communications or the mitral valve.

In their article, Ujvari and coworkers aimed to provide a step-by-step acquisition and analysis protocol for the left ventricle's volumetric assessment and speckle-tracking analysis[1]. The protocol has been mainly focused on the practical aspects that can maximize the feasibility of 3D echocardiography-derived evaluation of the left ventricle. This protocol is particularly important as the left ventricular morphological and functional measurements represent the cornerstones of diagnosis, management, and follow-up of cardiac diseases[2]. Moreover, deformation imaging by speckle tracking proved to be a robust method to assess different myocardial strain directions, enabling a more granular quantification of wall motion abnormalities and a better correlation with myocardial contractility[3,4]. The authors concluded that 3D echocardiography-based measurements provide the most accurate echocardiographic results concerning LV morphology and function, and they are validated with gold standard cardiac magnetic resonance imaging. 3D echocardiography also proved to be more reproducible and even less time-consuming compared with conventional 2D techniques. Its application in everyday clinical practice will continue to rise, further facilitated by more automated methods applying artificial intelligence.

Similarly, Lakatos et al. aimed to obtain and analyze 3D echocardiographic data of the right ventricle using one of the leading commercially available software[5]. The third dimension's added value is even more significant concerning the right side of the heart. Compared to the relatively simple bullet-shaped left ventricle, the right ventricle bears a complex geometry that cannot be adequately quantified using linear diameters or other two-dimensional metrics[6]. Recently, 3D-derived right ventricular volumes and ejection fraction have been shown to have a significant prognostic value in various cardiovascular conditions, independent of left ventricular function[7]. Beyond the established clinical significance of these assessments, the protocols mentioned above have nicely discussed the potential pitfalls of the 3D technique.

In their beautifully illustrated protocol, Csaba Jenei and coworkers intended to appreciate the dimensions and anatomical variations of the pulmonary veins by transesophageal 3D echocardiography[8]. Such assessment is particularly useful before different electrophysiological procedures, like pulmonary vein isolation by the cryoballoon technique in patients with atrial fibrillation. However, adequate imaging of the pulmonary veins is rather challenging. The authors share their experience based on over 80 patients and nicely demonstrate the added value of 3D imaging as it may allow substituting cardiac magnetic resonance or computed tomography imaging before pulmonary vein isolation.

Arbic et al. provide a comprehensive protocol to assess mitral valve diseases in a technically difficult yet very important population: in pediatric cardiology patients[9]. Pediatric mitral valve disease consists of many morphological features associated with congenital or acquired cardiac abnormalities. The description of the valve morphology and underlying pathological mechanisms are critical parameters for surgical planning as well. The authors describe a transthoracic 3D echocardiographic workflow, which can be applied to any ultrasound system. Additionally, they discuss some clinical applications of 3D imaging in children and include great clinical examples. The authors emphasize that a proper 3D echocardiographic dataset allows for immediate review in the operating room with the surgeon, which provides the opportunity for a common pathophysiological understanding and planning of its surgical correction. Nevertheless, the

authors are also correct and transparent about the current limitations and shortcomings of 3D echocardiography in children.

Andrea Molnár and coworkers stress the importance of advanced echocardiographic techniques using 2D and 3D methods in diagnosis, clinical decision-making, therapeutic planning, intraoperative guiding, and a follow-up of patients undergoing transcatheter patent foramen ovale or atrial septal defect closure[10]. Stroke prevention justifies the clinical significance of this exceptionally illustrated and comprehensive echocardiographic protocol.

In the current Methods Collection, we aimed to provide a glimpse of the myriad of use cases where 3D echocardiography adds significant value on top of conventional echocardiographic assessment. Evaluation of chamber geometry and function, valvular heart diseases, and the proper understanding of cardiac anatomy and pathophysiology for adequate patient selection, procedural planning, and guidance are great clinical examples from various cardiovascular disease states. Constantly improving hardware and software technology, image quality, along more automation are all flattening the learning curve supporting the everyday use of 3D echocardiography. It is not too brave to envision that most clinical echocardiographic protocols will include 3D image acquisition and analysis within some years. Therefore, learning the basics of 3D echocardiography is a must not just for adult cardiologists but also pediatricians, anesthetists, and intensive care physicians.

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The author has nothing to disclose.

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