Journal of Cardiothoracic and Vascular Anesthesia 000 (2023) 1−2

Contents lists available at ScienceDirect

Journal of Cardiothoracic and Vascular Anesthesia

journal homepage: www.jcvaonline.com

Editorial

Real-Time Multiplanar Reconstruction As a Standard Imaging Modality for Structural Heart Procedural Guidance

THE NUMBER OF TRANSCATHETER procedures for structural heart disease has increased dramatically over the past 10 years. According to the Society of Thoracic Surgeons-American College of Cardiology Transcatheter Valve Registry, in 2014, slightly more than 1,100 mitral valve transcatheter edge-to-edge repairs (MV TEER) and 84 transcatheter mitral valve replacements were performed. Data from 2019 estimate these numbers to be approximately 10,400 and 1,100, respectively, demonstrating a substantial increase in these types of cases.[1] With technologic advances in both devices and delivery systems, the spectrum of disease states and patients who can be treated with structural heart procedures has expanded widely. As such, there is an increased need for standardizing optimal imaging techniques to facilitate safe and accurate echocardiographic guidance for these complex procedures.

Biplane imaging, which allows for simultaneous visualization of 2 imaging planes (typically orthogonal to one another), was described in the literature as early as 1990 in reference to its clinical application to transesophageal echocardiography (TEE).[2] This imaging modality has been fundamental to the assessment of cardiac structures during both the planning and implementation stages of transcatheter procedures for many years. In the American Society of Echocardiography's Recommended Standards for the Performance of Transesophageal Echocardiographic Screening for Structural Heart Intervention, Hahn et al. demonstrated the ubiquitous applications of biplane imaging with respect to the assessment of various cardiac structures.[3]

As echocardiographic imaging techniques such as 3-dimensional (3D) data acquisition and software imaging packages that enable live manipulation of a dataset have developed, echocardiographers are less and less reliant on biplane imaging to interrogate cardiac structures. One such example of this software is multiplanar reconstruction (MPR), in which a 3D volume enables simultaneous visualization of axial, coronal, and sagittal projections that can be adjusted within the dataset.

In their recent publication, "Real-Time Multiplanar Reconstruction Imaging Using 3D Transesophageal Echocardiography in Structural Heart Interventions," Wollborn et al. described the advantages of this technique's application to guiding transcatheter structural heart procedures, including MV TEER, tricuspid valve TEER, left atrial appendage (LAA) occlusion device implantation, and laceration of the anterior mitral leaflet to prevent outflow obstruction.[4]

One of the main advantages of using live 3D MPR, as discussed by Wollborn et al., is the ability to view structures in the axial, coronal, and sagittal planes simultaneously, which may allow for a more detailed assessment of cardiac structures compared to biplane alone. The MPR allows the echocardiographer to visualize 3 distinct 2-dimensional (2D) slices of a 3D volume and actively manipulate them to optimize a region of interest. One example of where this technique is especially useful is for patients undergoing MV TEER who do not have a classic A2-P2 regurgitant lesion. When the regurgitant jet arises more from the anterior-lateral or posterior-medial segment of the valve, a standard 2D biplane across the mitral valve commissural axis will not be helpful, as the device clip arms will be out of plane.[4] In 3D MPR, the 2D projections can be adjusted to better visualize the clip and direct the interventionalist to not only ensure it is placed over the pathologic segment of the valve but also that it is perpendicular to the line of coaptation. Additionally, simultaneous visualization of the 3D volume with the 2D slices is also advantageous during MV TEER multiclip procedures when it is critical to see the spatial relationship between the first clip during the placement of the second.[4]

Real-time MPR also has several advantages over biplane imaging with respect to examining the LAA for occlusion device placement. Using conventional 2D methods, landing zone and depth measurements are obtained at a set of sequential angles to ensure appropriate device sizing in all dimensions, although foreshortening or inappropriate angulation can yield inaccurate measurements. Using real-time 3D MPR, the echocardiographer can align the MPR axes to display not only

DOI of original article: http://dx.doi.org/10.1053/j.jvca.2022.11.011.

https://doi.org/10.1053/j.jvca.2022.12.035
1053-0770/© 2023 Elsevier Inc. All rights reserved.

the septal-lateral and anteroposterior dimensions of the LAA, but also the landing zone simultaneously, which can be especially helpful in appendages with an ovoid ostium.[4] Additionally, the same technical principles can be applied to a post-deployment assessment of LAA occlusion device implantation, such that the MPR axes traverse the device's central pin to display accurate dimensions for compression measurements without the risk of foreshortening.

Using live 3D MPR also may provide a safety advantage compared to conventional 2D biplane imaging methods. It has been demonstrated that increased TEE probe manipulation times correlate well with increased risk for major gastrointestinal complications, including gastroesophageal bleeding or perforation.[5] Wollborn et al. proposed that using live 3D MPR reduces the need to continuously and repeatedly maneuver the TEE probe between the esophageal and gastric windows due to the ability to manipulate the 2D projections within the 3D volume dataset. This is especially true with regard to the tricuspid valve TEER procedures, during which it is recommended to use multiple transgastric and mid- and/or deep esophageal views for evaluation of leaflet morphology, valvular apparatus assessment, and procedural guidance.[3]

Although the use of live 3D MPR offers several advantages over conventional biplane imaging, its use also has several limitations. Temporal and spatial resolution are both significantly reduced with 3D imaging compared to 2D. As a result, regulating sector size for optimal image acquisition must be considered to obtain reliable qualitative and quantitative information. Similarly, the image window size is significantly reduced when using 3D MPR as compared to 2D, due to a 4-pane layout required to visualize each plane simultaneously, which may affect image interpretation. Lastly, there is a steep learning curve with respect to the use of this technology, not only for echocardiographers but also for interventionalists who will be relying on potentially nonstandard views for procedural guidance. It is, therefore, important to ensure familiarity with this imaging modality among the entire team prior to incorporating it into practice.

In their detailed discussion of live 3D MPR's application to various structural heart procedures, Wollborn et al. effectively described the benefits of this imaging modality over conventional 2D imaging. Although the most recent American Society of Echocardiography guidelines published by Hahn et al. provide echocardiographers with a framework to perform a comprehensive preprocedural structural assessment, it, unfortunately, does not discuss in detail the optimal intraprocedural imaging techniques that may facilitate these procedures.[3] With the growing number and complexity of both procedures and patients, there is an emerging need for creating a standardized intraoperative imaging approach using techniques such as 3D MPR to provide safe, reliable, and easy-to-replicate ultrasound-based procedural guidance.

Declaration of competing interest

None.

Charles H. Gartman, DO[1]
Jared Feinman, MD, FASE
Hospital of the University of Pennsylvania, Philadelphia, PA

References

1 Mack M, Carroll JD, Thourani V, et al. Transcatheter mitral valve therapy in the United States: A report from the STS-ACC TVT Registry. J Am Coll Cardiol 2021;78:2326–53.
2 Nanda NC, Pinheiro L, Sanyal RS, et al. Transesophageal biplane echocardiographic imaging: Technique, planes, and clinical usefulness. Echocardiography 1990;7:771–88.
3 Hahn RT, Saric M, Faletra FF, et al. Recommended standards for the performance of transesophageal echocardiographic screening for structural heart intervention: From the American Society of Echocardiography. J Am Soc Echocardiogr 2022;35:1–76;Erratum in: J Am Soc Echocardiogr 2022;35:447.
4 Wollborn J, Schuler A, Sheu RD, et al. Real-time multiplanar reconstruction imaging using 3-dimensional transesophageal echocardiography in structural heart interventions [e-pub ahead of print]. J Cardiothorac Vasc Anesth. https://doi.org/10.1053/j.jvca.2022.11.011. Accessed December 10, 2022.
5 Patel KM, Desai RG, Trivedi K, et al. Complications of transesophageal echocardiography: A review of injuries, risk factors, and management. J Cardiothorac Vasc Anesth 2022;36:3292–302.