JACC: CARDIOVASCULAR IMAGING
VOL. 7, NO. 3, 2014

ISSN 1936-878X/$36.00
PUBLISHED BY ELSEVIER INC.
http://dx.doi.org/10.1016/j.jcmg.2013.10.012

CME

iREVIEWS

STATE-OF-THE-ART PAPER

3D TEE During Catheter-Based Interventions

Francesco Fulvio Faletra, MD, Giovanni Pedrazzini, MD, Elena Pasotti, MD, Stefano Muzzarelli, MD, Maria Cristina Dequarti, MD, Romina Murzilli, MD, Susanne Anna Schlossbauer, MD, Iveta Petrova Slater, MD, Tiziano Moccetti, MD
Lugano, Switzerland

JACC: CARDIOVASCULAR IMAGING CME

CME Editor: Ragavendra R. Baliga, MD

This article has been selected as this issue's CME activity, available online at http://imaging.onlinejacc.org by selecting the CME tab on the top navigation bar.

Accreditation and Designation Statement

The American College of Cardiology Foundation (ACCF) is accredited by the Accreditation Council for Continuing Medical Education (ACCME) to provide continuing medical education for physicians.

The ACCF designates this Journal-based CME activity for a maximum of 1 *AMA PRA Category 1 Credit(s)*™. Physicians should only claim credit commensurate with the extent of their participation in the activity.

Method of Participation and Receipt of CME Certificate

To obtain credit for this CME activity, you must:

1. Be an ACC member or *JACC: Cardiovascular Imaging* subscriber.
2. Carefully read the CME-designated article available online and in this issue of the journal.
3. Answer the post-test questions. At least 2 out of the 3 questions provided must be answered correctly to obtain CME credit.
4. Complete a brief evaluation.
5. Claim your CME credit and receive your certificate electronically by following the instructions given at the conclusion of the activity.

CME Objective for This Article: At the end of this study the reader should be able to recognize structures on 3D imaging, steps of the procedures, and strength and limits of 3D TEE as imaging technique during percutaneous catheter-based edge-to-edge mitral valve repair.

CME Editor Disclosure: *JACC: Cardiovascular Imaging* CME Editor Ragavendra R. Baliga, MD, has reported that he has no relationships to disclose.

Author Disclosure: All authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Medium of Participation: Print (article only); online (article and quiz).

CME Term of Approval:

Issue Date: March 2014
Expiration Date: February 28, 2015

From the Division of Cardiology, Cardiocentro Ticino, Lugano, Switzerland. All authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Manuscript received June 27, 2013; revised manuscript received October 2, 2013, accepted October 3, 2013.

3D TEE During Catheter-Based Interventions

Guidance of catheter-based procedures is performed using fluoroscopy and 2-dimensional transesophageal echocardiography (TEE). Both of these imaging modalities have significant limitations. Because of its 3-dimensional (3D) nature, 3D TEE allows visualizing the entire scenario in which catheter-based procedures take place (including long segments of catheters, tips, and the devices) in a single 3D view. Despite these undeniable advantages, 3D TEE has not yet gained wide acceptance among most interventional cardiologists and echocardiographists. One reason for this reluctance is probably the absence of standardized approaches for obtaining 3D perspectives that provide the most comprehensive information for any single step of any specific procedure. Therefore, the purpose of this review is to describe what we believe to be the most useful 3D perspectives in the following catheter-based percutaneous interventions: transseptal puncture; patent foramen ovale/atrial septal defect closure; left atrial appendage occlusion; mitral valve repair; and closure of paravalvular leaks. (J Am Coll Cardiol Img 2014;7:292–308) © 2014 by the American College of Cardiology Foundation

Advances in technology and human skill have made possible the adoption of percutaneous catheter-based procedures in a wide spectrum of structural heart diseases that over the past 2 decades would have required open-heart surgery. Typically, guidance of these catheter-based procedures is performed using fluoroscopy and 2-dimensional (2D) transesophageal echocardiography (TEE). Both of these imaging modalities have significant limitations. Fluoroscopy is limited by its 2D projections of a complex 3-dimensional (3D) heart, and its inability to delineate soft structures precisely; 2D TEE, because of its tomographic nature, needs multiple planes and adjustments to visualize the course of intracardiac catheters and their complex relationship with cardiac structures.

3D TEE has the unique ability to depict cardiac structures as they are in reality (1,2). Moreover, because of its 3D nature, long segments of catheters, tips, and the devices can easily be intersected by the pyramidal ultrasound beam and displayed without excessive probe manipulations. Finally, the entire scenario in which most of the catheter-based procedures take place (i.e., atrial septum, left atrial appendage [LAA], left atrium, and mitral valve) can be shown in a single 3D view (3–5). Theoretically, 3D TEE should be the ideal guidance-imaging tool for catheter-based procedures. Despite its undeniable advantages, 3D TEE has not yet gained wide acceptance among most interventional cardiologists and among those echocardiographists involved in catheter-based procedures.

Several reasons may explain the reluctance to shift from 2D to 3D TEE. Historically, 2D TEE was used to guide these procedures, thus interventional cardiologists and echocardiographists became accustomed working with 2D TEE imaging. Because of its tomographic nature, 2D TEE needs multiple planes and adjustments to accurately track catheters moving in a 3D environment. For this reason, its use, especially during some complex catheter-based interventions, has been carefully standardized and both echocardiographists and interventional cardiologists have a clear notion of which plane(s) must be used for each step of the procedure (6).

The use of 3D TEE as guidance imaging modality during catheter-based procedures was first described by Perk et al. (3), who collected data from 5 institutions with great expertise with this new imaging tool. However, this first experience was not followed by an effort to select (and hence standardize) those 3D views that might provide the most useful data for each step of any specific procedure. Even when 3D TEE is described as a useful tool for guiding interventional procedures (4,7–10), there are no systematic descriptions of how to acquire those perspectives that can provide the best images of catheters, devices, and their relationships with target structures. The need to provide specific 3D views derives from the fact that the "volumetric" acquisition includes many cardiac structures that, in turn, can be imaged from countless perspectives. However, only a few of them are very innovative and useful, others are redundant and useless, and some are just confusing. Moreover, from some viewpoints, target structures may be covered by surrounding tissue that needs to be removed. Finally, reverberations (i.e., multiple reflections) and