Three-Dimensional Transesophageal Echocardiography: Pretty Pictures or an Advance in Technology

Stanton K. Shernan, MD, FAHA, FASE
Associate Professor of Anesthesiam, Chief, Division of Cardiac Anesthesia
Department of Anesthesiology, Brigham and Women’s Hospital, Harvard School of Medicine

OBJECTIVES:
After attending this lecture, participants will understand:
1. the evolution of three-dimensional transesophageal echocardiography technology
2. current and future clinical applications of perioperative three-dimensional transesophageal echocardiography

Although the concept of three-dimensional (3-D) echocardiography was first introduced in the early 1970s, its utility in the perioperative environment has only recently acquired appropriate recognition.1 Advantages of both conventional 3-D reconstruction and real-time 3-D imaging (RT3-DE) techniques for enhancing the diagnostic confidence of conventional echocardiography in the perioperative period have begun to emerge in the literature.2 Primary areas of interest have included the utility of 3-D echocardiography in preoperative surgical planning, intraoperative assessment of the surgical procedure, and postoperative early and long-term follow up to determine the need for further intervention.3

The utility of 3-D echocardiographic techniques in providing preoperative, noninvasive imaging of intracardiac lesions from the surgeon’s visual perspective, has been demonstrated in patients with congenital heart and valvular lesions. Lange et al compared preoperative 2-D and 3-D TTE evaluations with intraoperative findings in 15 patients with atrioventricular septal defect morphology.4 In comparison with preoperative 2-D echocardiography, 3-D TTE reconstruction provided superior imaging of the mitral valve (MV) and tricuspid valve function. In addition, 3-D TTE provided a more precise description of primum atrial septal defect (ASD) size, secundum ASD fenestrations and ventricular septal defect (VSD) size. Acar et al also performed pre-procedural 3-D TTE in 62 consecutive patients aged 2 to 18 years with ASDs scheduled for either transcatheter (n= 42) or surgical (n=20) closure.5 Pre-procedural 3-D TTE measurement of ASD size correlated well with findings obtained intraoperatively and during transcatheter closure. A similar degree of accuracy for 3-D TTE evaluation of VSD size prior to closure has also been demonstrated.6 Additional reported applications for preoperative 3-D echocardiography have included a complimentary role to conventional echocardiographic techniques in facilitating surgical planning for defining the shape, dimensions, location, origin, mobility and valve involvement of cardiac tumors.7

The accuracy, feasibility and value of 3-D echocardiography has also been demonstrated in the intraoperative environment.8 Abraham et al performed intraoperative 2-D and 3-D reconstruction TEE examinations on 60 patients undergoing valve surgery.9 In this study, 3-D acquisitions were completed in 87% of the patients within a mean acquisition time of 2.8 ± 0.2 minutes and reconstruction time within 8.6 ± 0.7 minutes. Three-D echocardiography detected all salient valve morphological pathology (leaflet perforations, fenestrations and masses) which was subsequently confirmed on pathological examination in 84% of the patients. In addition, intraoperative 3-D TEE provided new additional information not obtained by 2-D TEE in 15 patients (25%), and in 1 case influenced the surgeon’s decision to perform a valve repair rather than a replacement. Furthermore, intraoperative 3-D reconstruction TEE provided worthwhile and complimentary anatomic information that explained the mechanism of valve dysfunction demonstrated by 2-D imaging and color flow Doppler. Ahmed et al evaluated the potential utility of 3-D TEE in identifying individual MV scallop prolapse in 36 adult patients with undergoing surgical correction.10 Perfect correlation between 3-D TEE and surgical findings was noted in 78% of the patients. Similarly, De Castro et al demonstrated superior concordance between intraoperative 3-D TEE surgical identification of prolapsing anterior and posterior MV scallops compared to 2-D TEE.11 Intraoperative 3-D TEE has also been used to identify distortion and folding of the mitral annulus as a cause of functional mitral stenosis or worsening mitral regurgitation during beating heart surgery while positioning to access the back of the heart.12 For example, the superiority of intraoperative 3-D TEE compared to 2-D has been demonstrated in providing “en face” and oblique views of left atrioventricular (AV) valve septal malformations in patients undergoing reoperation for persistent regurgitant lesions after previous repair of partial AV septal defects.

The recent development and availability of RT3-DE has introduced additional opportunities for noninvasive diagnostic imaging to influence perioperative decision-making. Compared with conventional 3-D reconstruction, RT3-DE permits faster acquisition without a dependency on the electrocardiogram or respiratory gating, and allows simultaneous visualization of orthogonal planes with 2-D resolution. Disadvantages compared to conventional 2-D imaging include decreased line density in the acquired volume and slower frame rates. In addition, compared to conventional TEE probes, the larger dimensions of
RT3-DE transducers currently available for clinical utilization have limited their utilization to TTE or intraoperative epicardial viewing planes. Recently the introduction of more sophisticated miniaturized ultrasound transducers with real-time volume rendering capabilities has permitted the development of RT3-DE TEE which may be used intraoperatively to permit a more comprehensive evaluation to facilitate perioperative surgical planning.13–26

REFERENCES