IMAGING VIGNETTE

Transesophageal Echocardiography for Device Closure of Atrial Septal Defects
Case Selection, Planning, and Procedural Guidance

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TRANSCATHETER CLOSURE IS AN EFFECTIVE ALTERNATIVE TO SURGERY in most patients with atrial septal defects (ASDs) of the secundum type (1,2). Factors that decide suitability for transcatheter closure include size of the defect and presence of adequate tissue rims around the defect (3). Accurate imaging of the anatomic features of the ASD is critical for case selection, planning, and guidance during the procedure. This is accomplished using 2-dimensional (2D) and 3-dimensional (3D) echocardiography and of late, intracardiac echocardiography (ICE). This review focuses on comprehensive imaging through transesophageal echocardiography (TEE) for transcatheter closure of ASDs.

ANATOMY OF THE ASD: NOMENCLATURE OF THE RIMS/MARGINS

Conventionally, the rims of a secundum ASD are labeled as aortic (superoanterior), atrioventricular (AV) valve (mitral or inferoanterior), superior venacaval (SVC or superoposterior), inferior venacaval (IVC or inferoposterior), and posterior (from the posterior free wall of the atria). By conventional definition, a margin >= 5 mm is considered to be adequate (3). Podnar et al. (4) defined 10 morphological variations of defects, the most common type being the defect with deficient aortic rim (42.1%). The other variants included central defects (24.2%), deficient inferoposterior rim (12.1%), perforated aneurysm of the septum (7.9%), multiple defects (7.3%), combined deficiency of mitral and aortic rims (4.1%), deficient SVC rim (1%), and deficient coronary sinus rim (1%).

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2D TEE

For a comprehensive evaluation of the ASD, TEE is performed in 3 different planes: transverse (0°), longitudinal (90°), and at 45°.

**Figure 1. TEE at 0° to Evaluate the Posterior and Anterior Rims of the Defect**

The transesophageal echocardiography (TEE) probe is at the mid-lower esophageal level. The posterior and the mitral rims are best evaluated in this view. Rotating the probe to 30° to 40° towards the left will best profile the aortic (Ao) rim. The margins are evaluated by carefully moving the probe in and out and obtaining sections at various levels. In the highest plane (A), the superior venacaval (SVC)-right atrial junction and the ascending (Asc) aorta are seen; the atrial septum is visualized as intact. At the mid-level (B), the septum breaks and the margins of the atrial septal defects (ASD) (arrows) are clearly seen. At the level of the atrioventricular valves (C), the septum forms once again. This suggests that the ASD is likely to have adequate margins for catheter closure. CS — coronary sinus; IVC — inferior venacaval; Jn — junction; LA — left atrium; RA — right atrium; RAA — right atrial appendage; TV — tricuspid valve.

**Figure 2. TEE at 90° to Evaluate the SVC and IVC Rims**

This view is best for evaluating the SVC and IVC rims. The margins are evaluated by rotating the probe while keeping it at more or less the same level. Here the defect is seen with the probe rotated leftward (B, margins of the ASD shown by the arrows), while septum is seen to form when the probe is rotated to the right (A). The 45°-view is helpful in assessing the posterior and the aortic rims and often helps to determine the maximum size of the defect. Abbreviations as in Figure 1.
Figure 3. Different Morphological Variations of ASD as Demonstrated Using TEE

Panel A shows a centrally located ASD imaged at 0°; the posterior (Post) and the anterior (Ant) margins are clearly demonstrated (arrows). Panel B (Online Video 1) shows an ASD with deficient Ao margin (arrow). Both of these types of ASDs can be easily closed using the transcatheter technique (4). Panel C shows a large ASD with deficient posterior and Ao margins (arrows). This type of ASD is technically challenging for device closure and requires specialized imaging and deployment techniques (5). Panel D (Online Video 2) shows multiple ASDs; there is a larger anterior defect (block arrow) and a smaller posterior defect (thin arrow). This type of ASD is amenable for device closure, often with a single device. Abbreviations as in Figure 1.

SPECIAL TEE VIEWS FOR IMAGING THE INFEROPOSTERIOR RIM

Figure 4. Retroflexed TEE View for Imaging the Inferoposterior Rim

The IVC rim cannot be profiled well through conventional TEE techniques because of the proximity of the IVC to the lower esophagus. Panel A demonstrates the fluoroscopic image of the TEE probe by using the conventional method; panel B depicts the TEE images thus obtained. The inferoposterior rim (arrow) is not clearly profiled. Panel C demonstrates the retroflexed TEE probe position on fluoroscopy. The TEE probe is advanced into the stomach, retroflexed, and slowly withdrawn to lower esophagus. Imaging is performed in the long axis at 70° to 90°. The probe along with the lower esophagus moves away from the IVC-right atrial junction and the ultrasound beam is directed perpendicular to the IVC rim thus profiling the IVC rim (arrow) clearly (D) (5). Abbreviations as in Figure 1.
3D ECHOCARDIOGRAPHY

**Figure 5. 3D Echocardiography for Evaluation of ASD Size and Margins**

This is performed using "matrix" transducers which allow acquisition of a pyramid-shaped volume of echocardiographic data. To achieve the highest resolution of the atrial septum and adjacent structures, a “full-volume” 3 dimensional (3D) dataset is obtained over 4 to 7 cardiac cycles. For transthoracic 3D images, the subcostal view is the preferred view because its projection is en face to the atrial septum; in patients with suboptimal windows the low parasternal 4-chamber view may be used. 3D TEE overcomes the limitation of poor acoustic windows in adult patients (>25 kg) (A and B). Real-time 3D imaging demonstrates the changing shape of the ASD (Online Video 3) during a cardiac cycle, with maximum size in diastole (6). Panel A shows an en face 3D reconstruction of a secundum ASD with a relatively deficient IVC and posterior rim (arrow). Panel B demonstrates multiple ASDs with the thin atrial septum (*) separating the 2 defects. Abbreviations as in Figure 1.

**Figure 6. 3D TEE to Guide Deployment and Assess Device Position**

During the procedure, “live 3D” or a “3D zoom” mode is used to observe the position of guidewires, sheaths, and devices in real time (Online Video 4). Panel A depicts a 3D image of the ASD from the right atrial side demonstrating the delivery sheath being positioned through the defect. 3D echocardiography is particularly helpful in patients with multiple ASDs to ensure placement of the delivery sheath through the bigger defect. 3D echocardiography can be potentially helpful in patients with difficult ASDs by demonstrating the alignment of the discs against the septum during deployment (Online Video 5) (7). Panel B demonstrates the deployment of the LA disc which is still attached to the deployment catheter. The LA disc is fully expanded and is seen to align well against the atrial septum. Panel C demonstrates the ASD device post-deployment; the device is well aligned against the septum and both the discs are well visualized on either side. Panel D illustrates an en face reconstruction of the Amplatzer device from the LA side post-deployment. The device is seen snugly fitting to the ASD margins (Online Video 6). MV = mitral valve; other abbreviations as in Figures 1 and 5.
Echocardiography plays a critical role for patient selection, guidance, and post-deployment evaluation for transcatheter closure of ASDs. Understanding the echoanatomic correlation by transesophageal echocardiography is perhaps the most essential requisite to ensure a successful procedure. 3D echocardiography is likely to further this understanding in the future especially in difficult cases like multiple defects and defects with deficient margins.

REFERENCES