D. Balzer, M.D.

INTRACARDIAC ECHOCARDIOGRAPHIC ATRIAL SEPTAL DEFECT CLOSURE

David Balzer, M.D.

Washington University School of Medicine, St. Louis, Missouri

Abstract

Intracardiac echocardiography (ICE) is an excellent ultrasound modality that can be used to guide atrial septal defect (ASD) closure. Compared with transesophageal echocardiography, ICE offers better imaging of the posterior inferior septum, it does not require deep or general anesthesia, and it allows the operator total control over image acquisition. This latter advantage requires that the operator become an expert in image acquisition and interpretation. The following is intended to serve as a primer on performance and interpretation of ICE to guide ASD closure.

Intracardiac Echocardiographic Guidance for Atrial Septal Defect Closure

Multiple imaging modalities have been used to guide transcatheter closure of the ASD and patent foramen ovale (PFO), including fluoroscopy, transthoracic (TTE) and transesophageal (TEE) echocardiography, and ICE. Compared to the first two modalities, ICE allows excellent visualization of the atrial septum and surrounding structures and has the advantages of better visualization of the posterior/inferior atrial septum, not requiring general anesthesia or deep sedation, and allowing the operator complete control over image acquisition. There is, however, a learning curve in the performance and interpretation of ICE images. The purpose of this review is therefore to give a primer on ICE imaging using the AcuNav catheter, emphasizing the practical aspects of image acquisition.

The AcuNav ICE catheter (Biosense Webster, Inc., Diamond Bar, CA) is a 64-element phase array catheter available in 8 and 10 French (Figure 1) that delivers frequencies between 5.0 and 10.0 MHz depending on the imaging console. There are three knobs on the handle of the catheter: the top knob controls anterior (clockwise) or posterior (counterclockwise) tilt; the middle knob controls left (counterclockwise) and right (clockwise) tilt; and the bottom knob locks the tilt on the catheter. When all the notches on the knobs are lined up, the catheter is in a neutral (straight) position. Rotation of the catheter along with rotation of the knobs allows an infinite variety of imaging planes to be achieved. The directionality listed on the handle (i.e., anterior, posterior, left, or right) only applies when the catheter is in a neutral position with all the notches pointing straight anteriorly. Once the catheter is rotated it is nonsensical to refer to these positions; therefore, for the remainder of this paper I will refer to either clockwise or counterclockwise knob rotation. With the patient supine on the table and viewed from the feet looking upward toward the head, imagine a clock face centered on the patient; 12 o'clock is straight anterior, 6 o'clock is straight posterior, 3 o'clock is straight left, and 9 o'clock is straight right (Figure 2). This clock face will be used to discuss catheter rotation when all the notches are in the neutral

Figure 1. AcuNav catheter showing handle with locking knob, top knob (anterior, posterior), and middle knob (left, right).

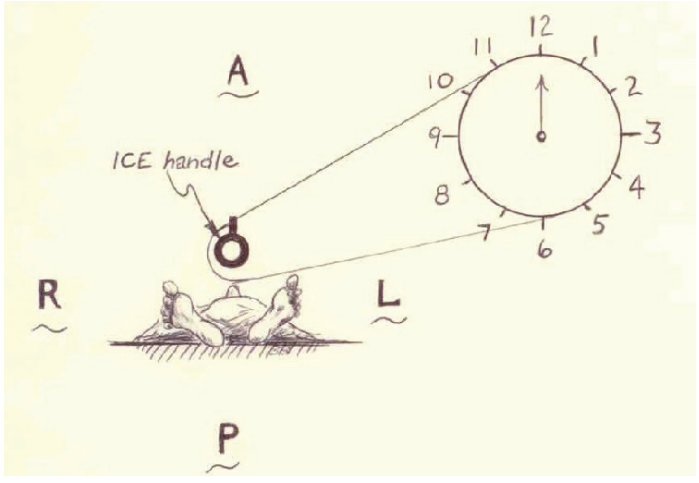

Figure 2. Patient representation as viewed from foot of bed. ICE handle demonstrated with notches on handle pointing anteriorly. Rotation of catheter is referenced to clock face.

View	Rims visualized	Clock	Top knob	Middle knob	Lock knob
Home	N/A	1:00-2:00	N	N	N
Outflow view	N/A	2:30-3:00	N	N	N
CS/MV	AV valve	4:00	N	N	N
LPVs/DAO	N/A	4:30-5:00	N	N	N
SAX	Aortic, post, IVC	4:30-5:00	CC	N	L
Superior rim	Superior	4:30-5:00	CC	CW	L
RSVC	SVC, IVC	4:30-5:00	CC	CW	L
MV/LV	AV valve	7:00-8:00	CC	N	L

Table 1. Quick summary guide for ICE imaging. Views: CS/MV: coronary sinus/mitral valve; LPVs/DAO: left pulmonary veins/descending aorta; SAX: short axis aorta and atrial septum, superior rim obtained as middle knob is swept from SAX to RSVC views; RSVC: right superior vena cava; MV/LV: mitral valve/left ventricle. Knob: N: neutral; CC: counterclockwise; CW: clockwise; L: locked.

position. These clock positions are approximate and will vary slightly depending upon the individual patient's anatomy.

Catheter manipulation is best performed with the catheter kept as straight as possible and the operator's right hand on the handle and left hand on the shaft of the catheter next to the venous sheath. Rotation of the catheter is performed simultaneously with both hands. This assures that there is no lag in catheter rotation from friction at the level of the sheath diaphragm.

When performing ASD device closure, I recommend four full sweeps using the following protocol: the first before crossing the defect to fully interrogate the septum and surrounding structures in order to understand rim anatomy and assess for secondary defects; the second during balloon sizing (stop flow) to ensure that the primary defect is crossed and to rule out secondary defects; the third once a device is deployed across the septum but not yet released from the delivery system to ensure that all rims are captured and to rule out secondary defects; and the fourth once the device is released from the delivery system to assess for proper device placement, rule out secondary defects, and make certain the device is not impinging upon adjacent structures. Once an operator is proficient with catheter manipulation and image interpretation, a full sweep should only take a few minutes to perform.

Various authors have used different terminology when describing the atrial septal rims. For the purpose of this paper, I will use the nomenclature proposed by Amin et al.[1]

Home View (Figures 3, 4 and Video 1)

The catheter is advanced from a femoral venous approach into the low right atrium. The notches are neutral with the catheter at the 1 o'clock to 2 o'clock position. The home view visualizes the Eustachian valve, tricuspid valve (TV), and right ventricular inflow. Slight cephalad advancement of the catheter will center the TV if necessary, and color flow can be added to visualize TV regurgitation. This view is easy to obtain and should be the starting point for the imaging study. If during subsequent evaluation the operator becomes disoriented, return to the home view and start over.

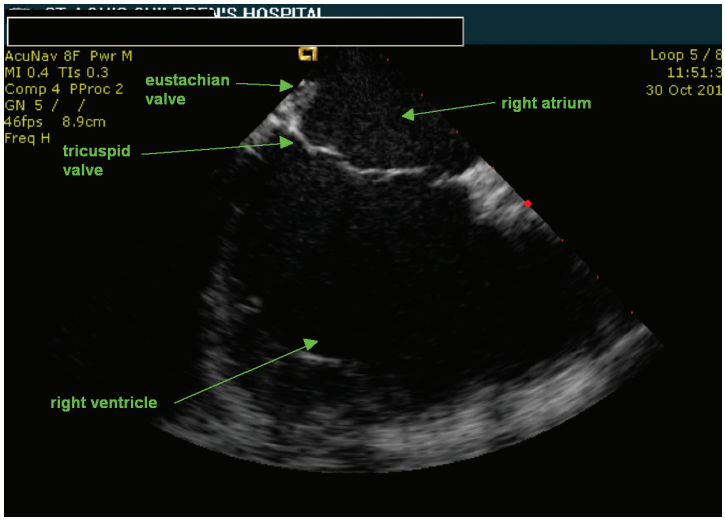

Figure 3. Home view demonstrating Eustachian ridge, right atrium, tricuspid valve, and right ventricle.

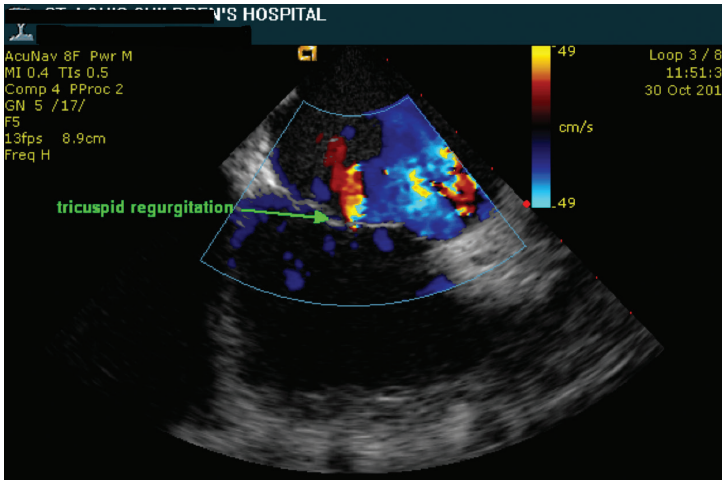

Figure 4. Home view with color flow demonstrating mild tricuspid regurgitation.

Biventricular Outflow View (Figure 5, Video 2)

From the home view, rotate the catheter slightly clockwise to approximately half past 2 o'clock to 3 o'clock. The catheter remains neutral. The left ventricle long axis, aorta, and pulmonary artery will be visible in this view.

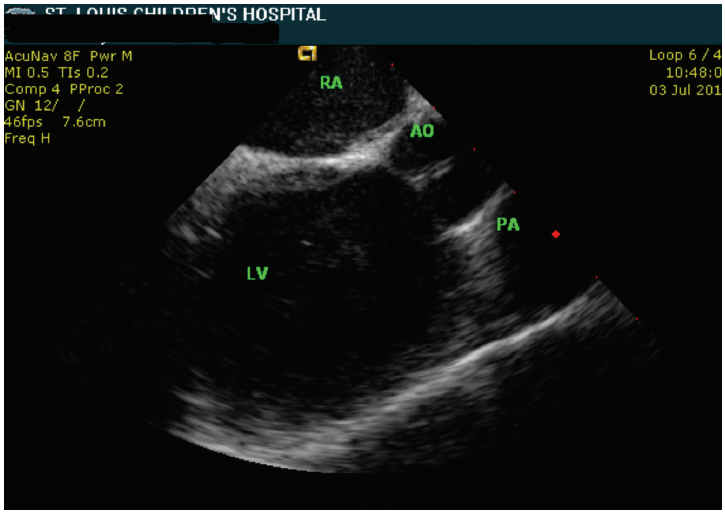

Figure 5. Biventricular outflow view showing right atrium, left ventricle, aorta, and pulmonary artery.

Coronary Sinus and Mitral Valve (Figures 6, 7 and Video 3)

From the outflow view, continue to rotate the catheter clockwise a few degrees to approximately 4 o'clock. The catheter remains in the neutral position. The coronary sinus is usually seen in cross section entering the right atrium. The atrial septum, just above the coronary sinus, can be visualized easily. The mitral valve is also visible as is the left atrial appendage. Once a device has been deployed within the atrial septum, there may be artifact created that can make it difficult to visualize the mitral valve. It may then be necessary to use an alternative view as described below to ascertain whether the device is contacting the mitral valve.

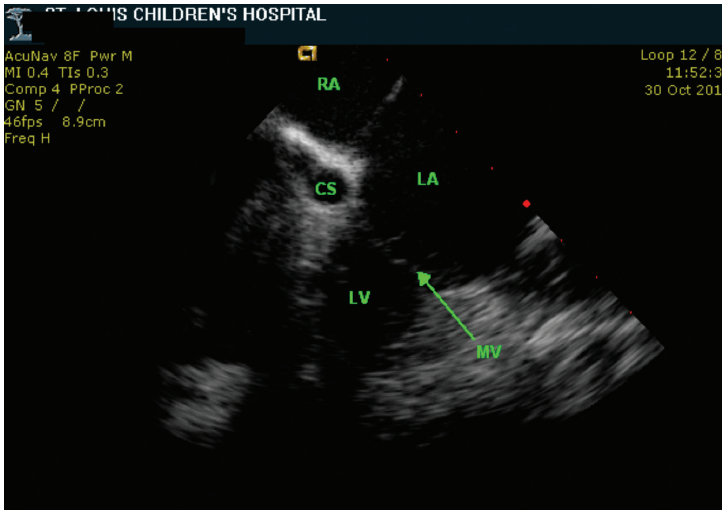

Figure 6. Coronary sinus/mitral valve view showing cross section of coronary sinus (CS), right atrium (RA), left atrium (LA), and mitral valve. The atrioventricular valve rim of the atrial septum can be seen between the RA and LA, just above the CS.

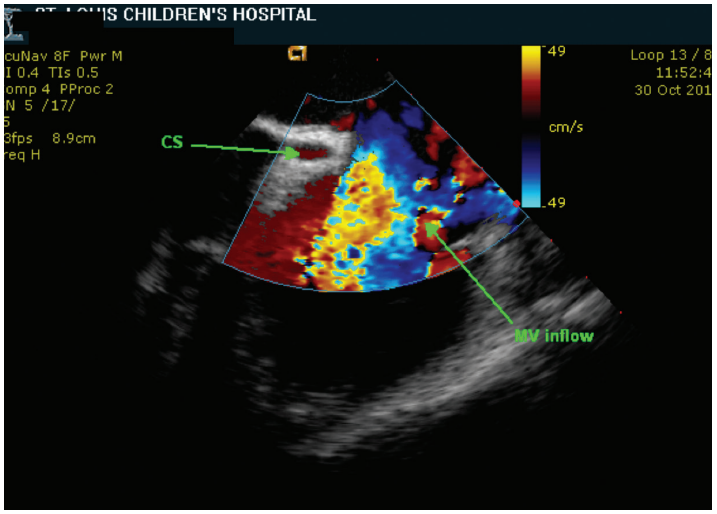

Figure 7. Coronary sinus/mitral valve view with color flow assessing for mitral regurgitation

Left Pulmonary Veins (Figure 8, Video 4)

Continue to rotate the catheter clockwise in the neutral position to half past 4 o'clock to 5 o'clock. The descending aorta will be seen in long axis horizontally, and the left superior and inferior pulmonary veins will be visible entering the back of the left atrium. The atrial septum will be near the apex of the imaging pie. Color flow can be added to fully assess the pulmonary veins.

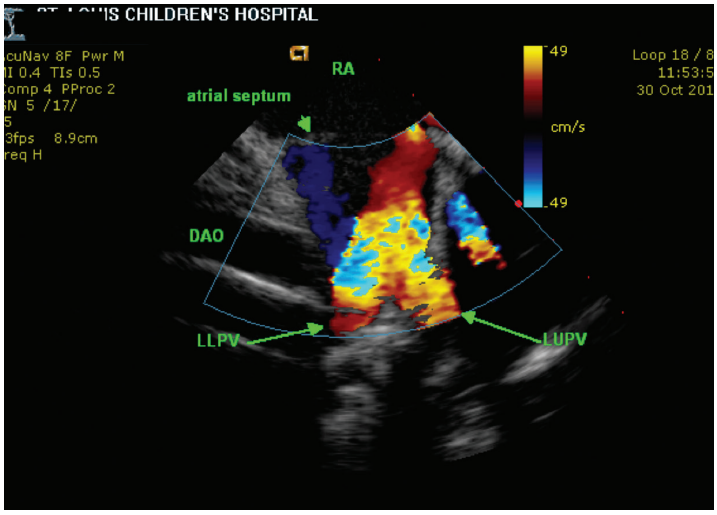

Figure 8. Left pulmonary vein view. Image of left upper and left lower pulmonary veins entering posterior aspect of left atrium as they drape over aorta.

Atrial Septum and Short Axis Aortic View (Figure 9, Video 5)

Keep the catheter neutral in the left pulmonary vein view. Lock the catheter by rotating the locking (bottom) knob clockwise. Take the top knob and slowly rotate it counterclockwise. This will tilt the catheter away from the atrial septum and allow better visualization of the septum and any defects. The aorta is usually seen in short axis once this view is attained, allowing interrogation of the aortic (retro-aortic) rim. This rim is very

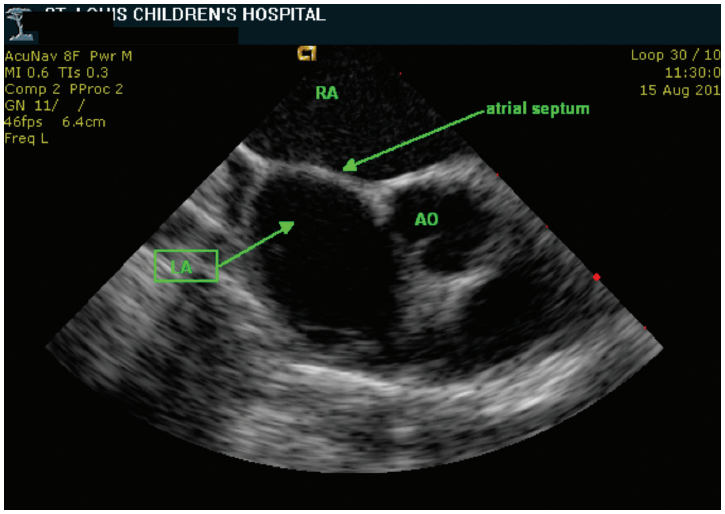

Figure 9. Atrial septum/short axis aorta view. This view demonstrates the aorta and allows assessment of the aortic rim of an atrial septal defect. It also allows assessment of the rims opposite the aorta, the posterior and inferior rims.

frequently deficient in patients with ASD. The entire catheter can be pulled inferiorly to better visualize the posterior inferior portion of the atrial septum opposite the aorta. Occasionally, a good short-axis view of the aorta is not attained initially and slight clockwise rotation of the entire catheter may be required.

Superior Septum (Figure 10, Video 6)

Once the short-axis aortic view is obtained, keep the handle fixed in position and slowly rotate the middle knob clockwise. This will sweep the catheter from the short-axis aorta toward the right superior vena cava (SVC). As the imaging plane advances toward the SVC, a view of the superior portion of the atrial septum will be obtained. Many large secundum ASDs have deficient superior rims in addition to deficient anterior superior rims, and it is therefore important to fully interrogate this portion of the septum.

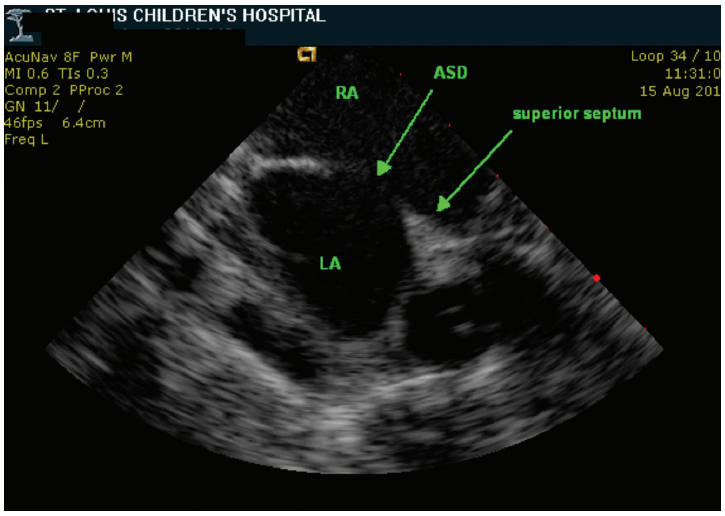

Figure 10. Superior septum. This view is obtained as the transducer is swept from the short axis aortic view toward the right superior vena cava by rotating the middle knob clockwise. A moderate-sized secundum atrial septal defect can be seen in this example.

Right SVC (Figure 11, Video 7)

Continued clockwise rotation of the middle knob will continue to sweep the catheter past the view of the superior portion of the septum and bring the right SVC into view. This allows visualization of the SVC rim of the atrial septum. The inferior vena cava and posterior portion of the septum can also be seen in this view as well as a portion of the right pulmonary veins.

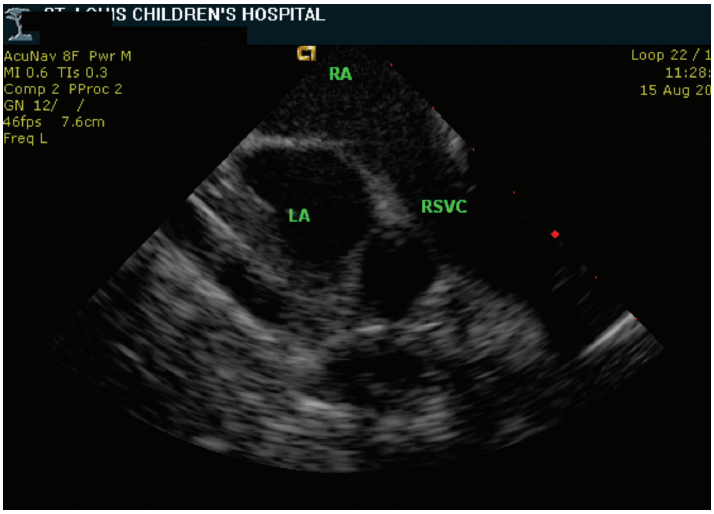

Figure 11. Right superior vena cava (SVC). This view demonstrates the SVC rim of an atrial septal defect.

Mitral Valve/Left Ventricular View (Figure 12, Video 8)

Occasionally, once a device has been deployed within the atrial septum but not yet released, there may be significant artifact from the delivery cable or the device itself that impairs the ability to assess the relationship between the device and the mitral valve. In these circumstances, the coronary sinus/mitral valve view (Figures 6, 7) as described above may not be sufficient to fully assess the device/mitral valve relationship. It is then necessary to advance the ICE imaging probe adjacent to or through the tricuspid valve to view the anterior mitral leaflet. This can be achieved by returning the catheter to the home view so that the TV is visualized. Lock the locking knob and rotate the top knob clockwise. This will bend the catheter anteriorly and allow you to advance the catheter adjacent to or through the TV. Slight clockwise rotation should allow visualization of the anterior mitral leaflet. Adjustments of the middle knob may be required to fine-tune the image. An alternative approach, and the one that I favor, is to return to the home view and rotate the entire catheter clockwise to approximately 7 o'clock to 8 o'clock. At this point the imaging plane will be pointing posteriorly and slightly to the patient's right. Lock the locking knob and turn the top knob counterclockwise. This will actually bend the catheter anteriorly and allow the operator to advance the probe through the TV as described above. Slight rotational adjustments of the entire catheter or the middle knob may be required to visualize the anterior mitral leaflet.

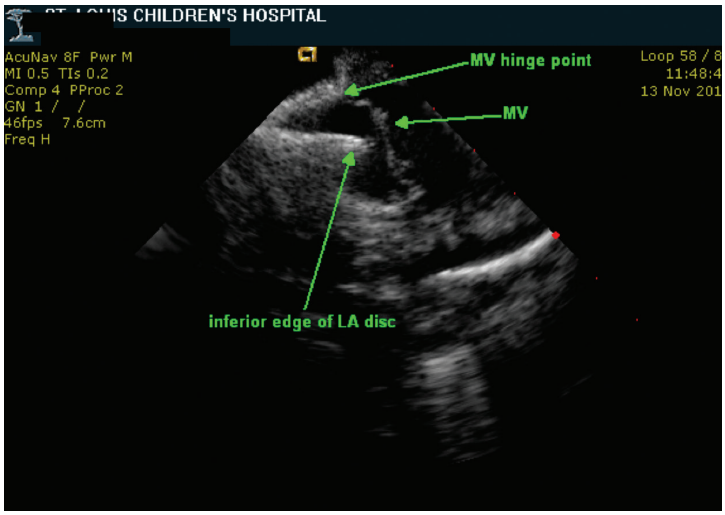

Figure 12. Mitral valve/left ventricular view. This view is useful to assess the mitral valve if the device causes artifact prior to release. It demonstrates the mitral hinge point very well.

Once this view is achieved, the relationship between the device and the anterior mitral leaflet can be fully appreciated. The left atrial disk of a device can often be seen to extend very close to the anterior mitral leaflet. If a device extends beyond the hinge point of the mitral valve, it should be removed and a smaller device deployed or the patient referred for surgical closure.

Conclusion

ICE guidance for ASD device closure is a simple, rapid technique that allows the operator complete control over image acquisition. Compared with TEE, it offers better visualization of the posterior and inferior rims of the defect. In addition, it can be performed with minimal sedation. There is a learning curve associated with image acquisition and interpretation that requires a systematic approach such as the one outlined above. Application of such an approach will minimize the chance of device malpositioning or missed secondary defects. Intracardiac echocardiography is an excellent complement to fluoroscopy and is an invaluable guide to successful device closure of atrial-level shunts.

Conflict of Interest Disclosure: Dr. Balzer is a proctor for both St. Jude Medical and Medtronic, Inc

Funding/Support: The author has no funding disclosures.

Keywords: atrial septal defect, ASD, intracardiac echocardiography

References

1. Amin Z. Transcatheter closure of secundum atrial septal defects. Catheter Cardiovasc Interv. 2006 Nov;68(5):778-87.