Site-Specific Transseptal Puncture for Emerging Structural Heart Interventions

Imaging-assisted techniques for accurate access.

BY MICHAEL J. RINALDI, MD, FACC, FSCAI; MARKUS SCHERER, MD, FACC, FSCCT; WILLIAM DOWNNEY, MD, FACC, FSCAI; AND GEOFFREY ROSE, MD, FACC, FASE

Transseptal catheterization is an established interventional technique that was originally developed for hemodynamic evaluation of the left heart. Its use was then expanded to provide access for balloon mitral valvuloplasty (BMV). Although the most common use of transseptal catheterization during the past decade has been in the electrophysiology lab for atrial fibrillation ablation procedures, newer technologies that address a variety of unmet structural heart needs have led to a resurgence in the use of this technique in the interventional cardiology lab.

Historically, transseptal catheterization was performed using fluoroscopic guidance. The primary goal was simply to safely traverse the septum, preferably through the fossa ovalis, but with the development of a variety of structural heart interventions, the need has emerged for a site-specific approach to transseptal access. Intracardiac echocardiography (ICE) and transesophageal echocardiography (TEE) have become integral in this procedure, extending standard fluoroscopic approaches by providing a greater degree of anatomic orientation. In this article, we review the specific imaging guidance that is afforded by these modalities. We also provide CT image references for the anatomic relationships of intracardiac structures.

TEE FOR PROCEDURAL GUIDANCE

The esophagus lies adjacent to the posterior surface of the left atrium (LA). The proximity of the TEE imaging probe to the LA, intra-atrial septum (IAS), mitral valve (MV), and left atrial appendage (LAA) thus renders TEE ideal for guiding structural heart interventions. Simultaneous cross-sectional plane (x-plane) and three-dimensional (3D) imaging provides real-time, comprehensive anatomical assessment, allowing performance of the procedure with greater precision and safety.

SPATIAL ANATOMY

In patients with normal segmental anatomy, the right atrium (RA) is anterior, and the LA is posterior. The IAS lies in an oblique/off-axis coronal plane, with variable curvature depending on atrial size, pressure, and tissue redundancy (Figure 1). In reference to the body, the plane of the IAS is typically oriented left to right, but for the purposes of guiding cardiac interventions, describing its relationship to other cardiac structures is more relevant. By convention, the plane of the IAS is defined by two dimensions: anterior-posterior and superior-inferior. The superior vena cava (SVC) and inferior vena cava (IVC) lie adjacent to the superior-posterior and inferior-posterior aspects of the atrial septum, respectively. The aortic valve/root is adjacent to the anterior-superior portion of the atrial septum.

Various TEE imaging maneuvers will display IAS anatomy in detail. The standard bicaval view lays out the superior and inferior aspects of the more posterior portion of the septum and is typically obtained with the multiplane sector angled at 100° to 120°. A basal short-
axis view at the aortic valve level will demonstrate anterosuperior and inferoposterior septal landmarks and is typically obtained with the multiplane sector angled at 30° to 60°. Seeing both views simultaneously may also be achieved using the x-plane feature with a 3D TEE probe (Figure 2).

**TRANSSEPTAL PUNCTURE FOR PERCUTANEOUS MV REPAIR USING MITRACLIP**

MitraClip (Abbott Vascular, Santa Clara, CA) is now approved in the United States for percutaneous repair of symptomatic, severe degenerative mitral insufficiency in patients who are at high surgical risk. Precision in transseptal puncture is critical for procedural success. Three views are used to guide puncture for appropriate steerable guiding catheter placement: bicaval, short-axis at the base (SAX-B), and four-chamber views. X-plane can be used to simultaneously show the bicaval and short-axis views as the imager and implanter become more comfortable with the technique.

The bicaval view is used to follow the transseptal dilator as it moves down the septum from the SVC toward the IVC (Figure 3A). The position is confirmed by the typical tenting of the septum caused by the dilator. Simultaneously, clockwise torque is applied, which moves the dilator from anterior to posterior away from the aorta. This can be confirmed and adjusted by switching to the SAX-B view (Figure 3B). Stored torque in the catheter due to contact with the septum is compensated for by moving the catheter slightly inferiorly as posterior torque is applied. Therefore, it is best to start applying posterior torque while the dilator is somewhat superior to the desired position. Posterior orientation is essential to achieve adequate height above the MV annulus.

When a posterior and slightly superior position has been established, the echocardiographer then acquires the four-chamber view to measure height above the MV (Figure 3C). This view is adjusted to show tenting of the septum in the same view as the MV annulus. A measurement is then taken by drawing a line perpendicular to the valve plane from the point of tenting, and then a second line, 90° to the first, is extended down from that point to the valve. In order to have adequate height for the procedure, this line should be 3.5 to 4 cm from the valve annulus. Adequate height above the valve ensures that the MitraClip system has room to create a straight downward trajectory to the apex of the ventricle with a minimum of manipulations.

It is critical that this posterior position is achieved. An improper guide position can make the procedure difficult, if not impossible, to perform. An approach that is
too anterior (or even a midfossa stick) brings the guide closer to the valve plane, leaving inadequate distance to the valve. A puncture that is too superior delivers the guide closer to the aorta, placing the guide too anterior relative to the MV plane. When an acceptable position is confirmed, the echocardiographer returns to the SAX-B view. Transseptal puncture is executed in this view to ensure that the location is held as the implanter crosses into the LA (Figure 2).

A recent report on the use of MitraClip to treat non-central jets suggests a tailored approach to the transseptal puncture that is specific to the location of the jet. The authors illustrate that lateral jets may be better approached with a slightly lower puncture to compensate for the height gained by the deeper position of the system.4

**TRANSSEPTAL PUNCTURE FOR LAA OCCLUSION**

A number of techniques have been developed for percutaneous closure of the LAA for stroke prevention.5 These include implants such as the Watchman device (Boston Scientific Corporation, Natick, MA), the Amplatzer plug (St. Jude Medical, Inc., St. Paul, MN), and the WaveCrest occluder (Coherex Medical, Salt Lake City, UT), as well as the Lariat suture (SentreHEART, Inc., Redwood City, CA) ligation technique. As with other structural heart interventions, site-specific transseptal puncture is critical for a successful procedure. The main axis of the LAA is anteriorly oriented, and the plane of the LAA ostium is perpendicular to that axis. Successful coaxial device deployment depends on the ability to position the delivery sheath with as
much depth as possible into the LAA (Figure 4). This is most reliably accomplished with a posterior-to-anterior trajectory of the sheath. Thus, a transseptal puncture that is posterior and mid to slightly inferior in position provides the most favorable sheath orientation. Too superior a puncture can lead to a sheath orientation that is not coaxial with the LAA long axis or obstruction to the LAA ostium by the tissue that separates the left upper pulmonary vein from the LAA (“coumadin ridge”). Too anterior a puncture places the sheath out of the plane of the LAA.

TRANSSEPTAL PUNCTURE FOR PERCUTANEOUS CLOSURE OF MITRAL PARAVALVULAR LEAKS

Percutaneous closure of paravalvular leaks with Amplatzer plugs has become an effective procedure, particularly for patients at high risk for reoperation.6 As for MitraClip, the position of the transseptal puncture for repair of mitral paravalvular leak requires forethought in order to achieve the optimal position to approach the defect. For defects away from the septum, the location of the puncture is less critical. However, for medial defects near the IAS, a posterior and slightly superior puncture provides the appropriate working height within the LA (Figure 5). TEE guidance is critical.

A common issue in these cases is difficulty in puncturing a fibrotic septum that is scarred or patched from the atriotomy done during the MV replacement. Some physicians use the back end of a coronary guidewire through a transseptal needle or electrocautery to facilitate initial passage through the septum. We have found the NRG radiofrequency transseptal needle (Baylis Medical Company, Inc., Montreal, QC, Canada) to be invaluable in these cases. This device is blunt, but allows the targeted administration of radiofrequency energy to the IAS, safely burning a passage through the septum without the pressure often required on the Brockenbrough needle in these cases. Even after puncture is achieved, advancing the sheath over the system can still sometimes be difficult in the fibrotic septum. In these cases, balloon septostomy over a 0.014-inch wire introduced into the LA greatly facilitates passage. If difficulty is still encountered, the balloon itself can be used as a dilator positioned across the septum by deflating it while simultaneously advancing the sheath.

TRANSSEPTAL PUNCTURE FOR OTHER PROCEDURES

The TandemHeart percutaneous ventricular assist device (CardiacAssist, Inc., Pittsburgh, PA) requires placement of a 24-F LA inflow cannula through a transseptal puncture. Although the location of transseptal puncture is less critical for this procedure, in our experience, a fairly central transseptal catheter position allows more room in the LA. This reduces the likelihood of “chatter” through contact between the cannula and the LA wall while still permitting enough catheter length across the septum, reducing the chance that the cannula will inadvertently slip back into the RA.

BMV was the first indication for transseptal puncture for the treatment of valvular heart disease worldwide and remains the most common. Although countless BMV procedures have been performed with fluoroscopic imaging alone, it is possible that the procedure
could be performed with greater safety and efficiency with use of adjuvant imaging to guide site-specific transseptal puncture. As with MitraClip, a more posterior puncture would allow better height above the MV and a more coaxial plane; this would facilitate transit of the balloon across the valve. Although experienced operators clearly can perform BMV without such guidance, it is possible that, given the low volume of BMV in developed countries, less-experienced operators might benefit from such a targeted transseptal approach.

ICE GUIDANCE FOR TRANSSEPTAL PUNCTURE

In cases when TEE is not used, ICE guidance can be extremely useful in facilitating safe transseptal puncture. Operators primarily accustomed to TEE need to keep in mind that they are looking from the RA to the LA, the opposite view from TEE. The fossa ovalis is usually best identified by moving to a long-axis view of the aortic valve and then tilting the ICE catheter posteriorly. The ICE catheter can then be manipulated slightly to find the tenting. Puncture can then be completed under direct visualization by ICE. Although ICE is an invaluable tool and may be adequate to direct most left-sided electrophysiology procedures, it does not provide equivalent visualization to TEE and cannot be used as a substitute for TEE to guide most structural heart therapies.

CONCLUSION

Site-specific transseptal puncture is an essential skill to guide many interventional structural heart procedures. As with most interventional procedures, proper guide position is the foundation upon which the success of the procedure depends. Accomplishing this requires not only an understanding of intracardiac anatomy, but also seamless communication between the echocardiographer and the interventionist in the performance of the procedure. Although this technique requires a high-level skill set from the echocardiographer, it is eminently acquirable by dedicated teams.

Michael J. Rinaldi, MD, FACC, FSCAI, is Director, Clinical Research, at the Sanger Heart & Vascular Institute and Professor of Medicine, Carolinas HealthCare System, Carolinas Medical Center in Charlotte, North Carolina. He has disclosed that he is on the medical advisory board for Abbott Vascular and Boston Scientific. Dr. Rinaldi may be reached at (704) 446-2434; michael.rinaldi@carolinashealthcare.org.

Markus Scherer, MD, FACC, FSCT, is with the Sanger Heart & Vascular Institute, Carolinas HealthCare System, Carolinas Medical Center in Charlotte, North Carolina. He stated that he has no financial interests related to this article. Dr. Scherer may be reached at (704) 446-2434; markus.scherer@carolinashealthcare.org.

William Downey, MD, FACC, FSCAI, is Director, Cardiac Catheterization Laboratories, at the Sanger Heart & Vascular Institute and Associate Professor of Medicine, Carolinas HealthCare System, Carolinas Medical Center in Charlotte, North Carolina. He stated that he has no financial interests related to this article. Dr. Downey may be reached at (704) 446-2434; william.downey@carolinashealthcare.org.

Geoffrey Rose, MD, FACC, FASE, is Chief of Cardiology, the Sanger Heart & Vascular Institute and Professor of Medicine, Carolinas HealthCare System, Carolinas Medical Center in Charlotte, North Carolina. He stated that he has no financial interests related to this article. Dr. Rose may be reached at (704) 446-2434; geoffrey.rose@carolinashealthcare.org.