

Transseptal Basics

What you need to know to ensure safe puncture as this technique reemerges.

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Transseptal puncture of the atrial septum as a means to access the left atrium for diagnostic purposes was initially described in the late 1950s.^{1,2} With the emergence of balloon-tipped catheters facilitating indirect assessment of left atrial pressure through the measurement of pulmonary capillary wedge pressure, the need for higher-risk atrial septal puncture diminished. However, the rapid development of transcatheter therapies for atrial fibrillation and mitral valve disease has seen a reemergence in the importance of transseptal puncture as a route to the left heart.³ The presence of copathologies, including previous interventions on the atrial septum and the need for precise-site septal puncture to approach the mitral valve for device delivery, requires a thorough understanding of the variations in anatomy of the atrial septum and surrounding structures, the available equipment, and the techniques used to ensure safe puncture with confirmation of position with the left atrium.

Although commonly performed, transseptal atrial puncture is not without risk. This review is not intended to act as a step-by-step guide for those who are unaccustomed to performing this intervention.

THE ATRIAL SEPTUM

The interatrial septum, formed by fusion of the septum primum and secundum, divides the cavity of the left and right atrium and should be clearly differentiated from the septal wall of the right atrium, which extends both superiorly and inferiorly beyond the left atrial cavity. The interatrial septum represents the anatomical target for transseptal puncture and is anatomically represented by the fossa ovalis (FO) and its adjacent muscular margins. This muscular area, known as the *limbus*, is most pronounced superiorly and laterally, and forms the raised margin around the FO. The FO has an average vertical diameter of 18.5 mm and an average horizontal diameter of 10 mm,⁴ with a mean thickness of 1 to 2 mm. The surrounding limbus is thicker and may represent a greater challenge for puncture. Although the FO is generally depicted as lying in the middle of the septal wall, anatomical variation exists, particularly with a bulging atrial septum secondary to left atrial pressure or volume load. Superiorly, the ostium of the superior

vena cava (SVC) is formed by infolding of the right atrial wall between the SVC and the right-sided pulmonary veins. Anterosuperiorly, it overlies the aorta, hence a posterior orientation of the access needle is advised to avoid this area. The atrioventricular portion of the septal wall of the right atrium is surrounded anteroinferiorly by the coronary sinus, the septal leaflet of the tricuspid valve, and the atrioventricular node.

PATIENT AND PROCEDURE PREPARATION

Thorough appreciation of anatomical variations will ensure fewer surprises in the catheter laboratory. The presence of a prominent Eustachian valve, a dilated aorta, a prominent coronary sinus, or significant spinal scoliosis may all distort the usual anatomical landmarks of the atrial septum. Patients should be asked about previous surgery on the atrial septum or device closure of an atrial septal defect. Septal puncture may still be considered in this circumstance but may prove more challenging. Oral anticoagulation for comorbid conditions, such as atrial fibrillation, may exacerbate the risk of bleeding and, therefore, bridging to intravenous heparin is indicated. A decision regarding the need for general anesthesia versus conscious sedation should be made before the procedure, which may be influenced by the choice of intraprocedural imaging techniques used to guide atrial septal puncture.

THE PROCEDURE

Identification of the Atrial Septal Anatomy

The procedure is ideally performed from the right femoral vein. A neck approach is not advised because achieving a stable needle position from the SVC is challenging. In unusual circumstances, such as patients with an interrupted inferior vena cava, the transhepatic approach has been used and provides a favorable angle orientation for the needle to the FO.⁵ The initial goals in transseptal puncture should be optimal identification of surrounding anatomy and visualization of the interatrial septum. Various aids have been used to maximize fluoroscopic localization of the atrial septum, including biplane imaging, placing a pigtail catheter in the ascending aorta close to the aortic valve, and, in the case of ablation procedures, steerable catheters placed

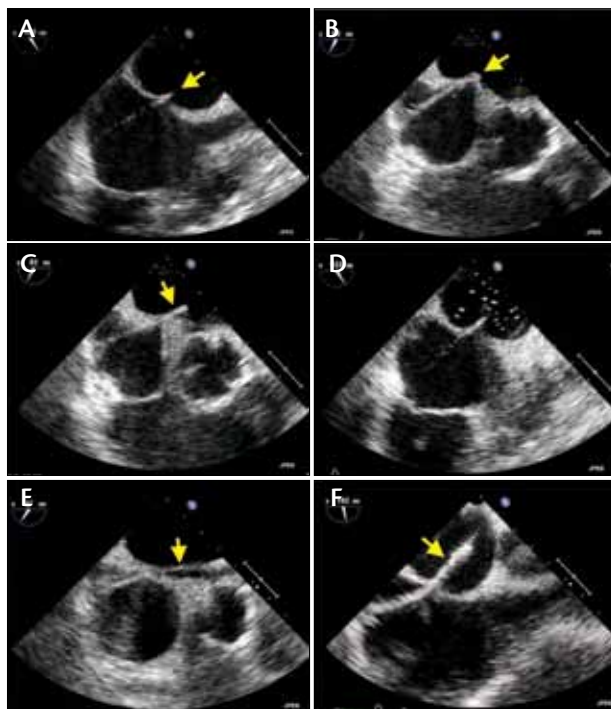


Figure 1. Series of images outlining TEE views during transseptal puncture for mitral valve intervention. Needle tenting of the atrial septum (yellow arrow) in orthogonal views (A, B). The needle (yellow arrow) has crossed the septum into the LA (C). Confirmation of left atrial positioning with bubbles seen in the LA (D). The sheath is seen across the septum (yellow arrow) (E) with device (yellow arrow) advancement within the sheath seen in (F).

in the coronary sinus to outline the anteroinferior septal wall of the right atrium. Although some operators may be comfortable using fluoroscopy alone, use of transesophageal echocardiography (TEE) (Figure 1) has been shown to reduce complication rates, particularly in higher-risk patients.⁶ Three-dimensional transesophageal imaging has evolved and demonstrated excellent correlation with septal

anatomy.⁷ Both approaches require heavy sedation or general anesthesia, unlike intracardiac echocardiography (ICE) performed from a femoral venous approach. ICE provides excellent imaging of the entire length of the atrial septum (Figure 2); however, it lacks multiplanar imaging capabilities. Recently, the use of a micro-TEE in nonsedated patients has been described during atrial fibrillation ablation and was judged to provide better imaging than ICE, with greater patient tolerability compared to standard TEE.⁸

Needle Preparation and Delivery

Although radiofrequency perforation of the septum has been described, this article concentrates on needle puncture of the atrial septum. The standard transseptal equipment in our laboratory is a 71-cm Brockenbrough needle (Medtronic, Inc., Minneapolis, MN) inserted through the dilator of an 8-F, 63-cm Mullins sheath (Medtronic, Inc.). The needle is available with a variety of curvatures to approach the atrial septum. Longer needles (89 and 98 cm) are also available, and consequently, a longer sheath is necessary. Because the dilator extends for approximately 6 cm beyond the distal end of the sheath, before delivery into the atrium it is advisable to ensure the needle extends for at least 1 cm from the end of the sheath dilator, as minor variations in dilator length may exist (Figure 3). This also allows the operator to evaluate how much the needle needs to be pulled back so that it is not protruding past the dilator until septal puncture is performed. A standard 0.032-inch wire is then placed in the SVC, and a long Mullins sheath/dilator assembly is advanced over the wire into the SVC. The wire is removed, and the sheath is flushed.

Heparin is held at this stage until after septal puncture. The needle is advanced until it is just (1–2 cm) proximal to the tip of the dilator (Figure 4). The needle stylet, if not previously withdrawn, is removed at this point, and the needle is connected to the pressure transducer with a three-way stopcock to allow blood sampling and injection of contrast or saline. The needle and dilator should be rotated posteriorly, with the arrow of the needle pointing to approxi-

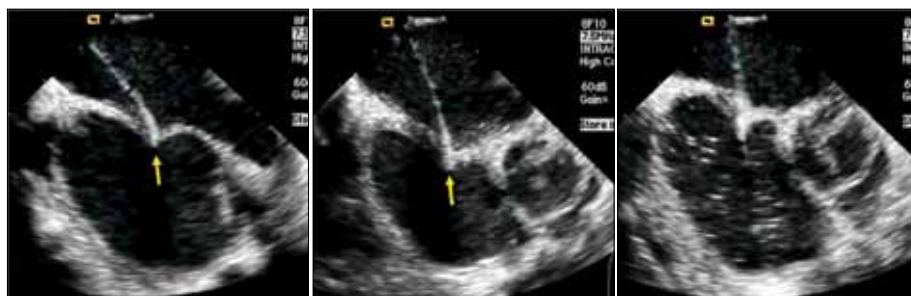


Figure 2. Series of ICE images indicating septal tenting in two different views (yellow arrow) followed by puncture of the septum with the needle in the left atrium (yellow arrow) confirmed by bubbles seen with the LA.

mately the 5-o'clock position. Clockwise rotation from this position usually results in more posterior movement of the needle with counter-clockwise rotation leading to anterior movement. The entire assembly is withdrawn, with the fluoroscopic projections dependent on whether single-plane or biplane imaging is available. With single-plane imaging, the left anterior



Figure 3. Transseptal needle seen extending beyond the sheath dilator sufficient for atrial puncture. This is evaluated before introduction into the body.

oblique view with cranial angulation profiles the plane of the atrial septum and may be useful.

Two distinct “jumps” or rightward movements of the system are seen with withdrawal. The first indicates the junction of the SVC and right atrium, with the second, more pronounced jump due to the assembly dropping underneath the superior muscular rim (limbus) of the FO. Verification of position within the FO can be achieved by ensuring the position is below and posterior to the pigtail catheter, near the center of the spine directed posteriorly (right anterior oblique position). The tip of the Mullins sheath/dilator assembly should be approximately halfway between the pigtail catheter and the right atrium free wall when viewed in the RAO projection. In addition, the catheter tip should be directed posteriorly when viewed in the LAO projection. Tenting of the FO seen on echocardiography provides further evidence of proper catheter positioning (Figures 1 and 2). Staining of the FO can be achieved by gentle injection of contrast through the needle (Figure 5).

Septal Puncture

Once an acceptable position has been confirmed, the needle is advanced aggressively out of the end of the dilator while holding the sheath/dilator assembly absolutely still. This action will actively puncture the atrial septum. The operator may feel a characteristic “pop” when puncture has occurred. Several diagnostic aids are available to confirm positioning in the left atrium. These include:

- Left atrial pressure waveform from the transducer attached to the needle
- Visualization of the needle in the left atrium on TEE/ICE with reduced tenting of the atrial septum (Figure 1)
- Oxygenated blood, as indicated by color or oxygen saturation on sample testing
- Bubble contrast seen in the left atrium on TEE/ICE with flushing saline through the needle (Figure 1)

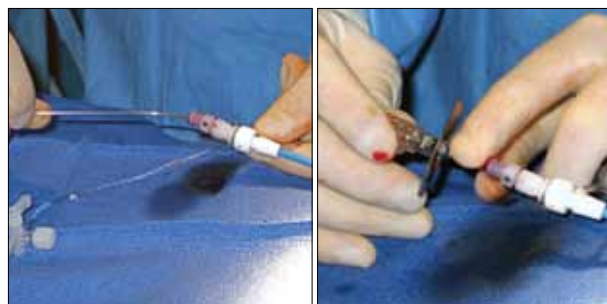


Figure 4. Advancement of the needle within the sheath to the SVC and rotation of the needle arrow to approximately 5 o'clock to maintain a posterior position for puncture.

- Contrast injection through the needle confirming LA filling by fluoroscopy
- Ability to advance the guidewire through the needle into the pulmonary veins (beyond border of heart silhouette).

Once the operator has confirmed the needle is in the LA, the dilator is carefully advanced under fluoroscopic guidance over the needle into the left atrium. Occasionally, it is difficult to advance the dilator across the septum. In this instance, a 0.014-inch guidewire may be advanced through the needle into the left atrium (ideally into the pulmonary vein), to provide more support for the dilator to cross the septum. This also predefines the trajectory of the needle and dilator while advancing into the left atrium to avoid inadvertent puncture of the left atrial free wall. Once the sheath is in the left atrium, it can be advanced further while holding the dilator and needle, avoiding overadvancement of these toward the appendage or left atrial free wall. The needle and dilator are then removed slowly to avoid air entry into the system. The sheath sideport may be left open momentarily at a level below the left atrium to allow “bleed-back” to ensure there is no thrombus within the system before flushing. Heparin can then be administered according to institutional preferences.

COMPLICATIONS

A structured approach with use of all possible diagnostic aids will help to limit adverse events. Complication rates of 1% have been reported consistently³ and relate predominantly to puncture of the aorta or perforation of the left or right atrial free wall. This may be associated with pericardial effusion. Care is always advised when in the left heart chambers to avoid the introduction of air or thrombus. The left atrial appendage should be evaluated for thrombus in high-risk patients before septal puncture, and if present, the procedure should not be performed. Recent availability of training simulators may help in reducing complication rates, and this approach may herald the future of training in interventional cardiology.⁹

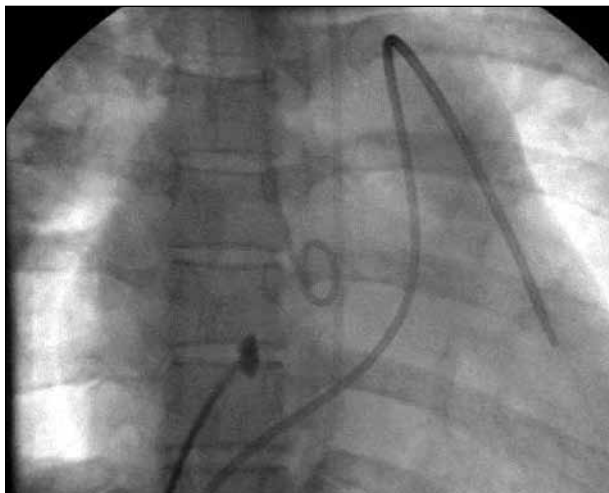


Figure 5. Fluoroscopic image in the frontal plane demonstrating a pigtail catheter in the ascending aorta with another catheter seen in the left pulmonary artery. There is staining of the FO with contrast injected through the needle confirming position just before puncture.

SPECIAL CONSIDERATIONS

Procedures requiring access to the left atrium include:

- Electrophysiology interventions, including pulmonary vein ablation: occasionally, two sheaths are required in the left atrium and can be achieved by two separate punctures or by advancing two sheaths through a single puncture. This involves withdrawing the initial sheath into the RA over a guidewire and then passing another wire through the pre-existing puncture site.
- Percutaneous mitral valve repair, the greatest reported clinical experience of which is with the MitraClip device (Abbott Vascular, Santa Clara, CA). Transseptal puncture requires a posterosuperior location to allow a more tangential approach to the mitral valve to facilitate device delivery.
- Left atrial appendage occlusion, irrespective of the device, is best facilitated with a puncture of the superior FO so that the delivery catheter is coaxial with the appendage.
- Balloon aortic valvuloplasty has been performed after transseptal puncture in a standard position with some suggestion of less aortic valve damage with the antegrade approach compared to the retrograde approach in patients with congenital aortic stenosis.
- Mitral paravalvular leaks along the medial annulus provide a significant challenge for device closure after transseptal puncture because the angle is often too acute to facilitate crossing of the defect. Transseptal puncture has also been used to create an arteriove-

nous loop to allow device delivery from the left ventricular aspect.

- Previous atrial septal defect/patent foramen ovale closure is not a contraindication to transseptal puncture and can be performed using a variety of maneuvers. In patients with previous device closure, puncture may be performed inferior and posterior to the device. In patients with previous surgical atrial septal defect closure, puncture through the patch itself has been successfully reported;¹⁰ however, this is somewhat dependent on the patch material, with polytetrafluoroethylene being more resistant to puncture.

CONCLUSION

Needle puncture of the atrial septum has extended its previous applications with increasing transcatheter procedures within the left atrium. A structured approach is key, with preprocedural identification of challenging anatomical substrates, and use of all available diagnostic tools to minimize complications. ■

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1. Cope C. Technique for transseptal catheterization of the left atrium: preliminary report. *J Thorac Surg.* 1959;37:482-486.
2. Ross J Jr, Braunwald E, Morrow AG. Transseptal left atrial puncture: new technique for the measurement of left atrial pressure in man. *Am J Cardiol.* 1959;3:653-655.
3. De Ponti R, Cappato R, Curnis A, et al. Trans-septal catheterization in the electrophysiology laboratory: data from a multicenter survey spanning 12 years. *J Am Coll Cardiol.* 2006;47:1037-1042.
4. Hanaoka T, Suyama K, Taguchi A, et al. Shifting of puncture site in the fossa ovalis during radiofrequency catheter ablation: intracardiac echocardiography-guided transseptal left heart catheterization. *Jpn Heart J.* 2003;44:673-680.
5. Singh SM, Neuzil P, Skoka J, et al. Percutaneous transhepatic venous access for catheter ablation procedures in patients with interruption of the inferior vena cava. *Circ Arrhythm Electrophysiol.* 2011;4:235-241.
6. Hahn K, Bajwa T, Samoski J, et al. Transseptal catheterization with transesophageal guidance in high risk patients. *Echocardiography.* 1997;14:475-480.
7. Faletra FF, Nucifora G, Ho SY. Imaging the atrial septum using real-time three-dimensional transesophageal echocardiography: technical tips, normal anatomy, and its role in transseptal puncture. *J Am Soc Echocardiogr.* 2011;24:593-599.
8. Stec S, Zaborska B, Sikora-Frac M, et al. First experience with microprobe transesophageal echocardiography in non-sedated adults undergoing atrial fibrillation ablation: feasibility study and comparison with intracardiac echocardiography. *Europace.* 2011;13:51-56.
9. De Ponti R, Marazzi R, Ghiringhelli S, et al. Superiority of simulator-based training compared with conventional training methodologies in the performance of transseptal catheterization. *J Am Coll Cardiol.* 2011;58:359-363.
10. El-Said HG, Ing FF, Grifka RG, et al. 18-year experience with transseptal procedures through baffles, conduits, and other intra-atrial patches. *Catheter Cardiovasc Interv.* 2000;50:434-439.