Percutaneous transhepatic approach for cryoballoon pulmonary vein isolation in a patient with persistent atrial fibrillation and interruption of the inferior vena cava

G. Joseph Orme, DO, MPH,* Cole Mendenhall, MD,† Foreman Blair, MD, FACC,‡ Steve Yu Wen Chen, MD,† Edward Rhee, MD, FACC,§ Wilber Su, MD, FHRS*

*From the *Department of Cardiology, Banner University Medical Center, Phoenix, Arizona, †Department of Interventional Radiology, Banner University Medical Center, Phoenix, Arizona, ‡Department of Cardiology, Genesis Medical Center, Davenport, Iowa, and §Department of Cardiology, Phoenix Children's Heart Center, Phoenix, Arizona.*

Introduction

Pulmonary vein isolation (PVI) with Arctic Front cryoballoon has been an effective treatment for paroxysmal atrial fibrillation.[1] The recent 2016 European Society of Cardiology guidelines and Heart Rhythm Society Guideline on the management of atrial fibrillation have established PVI as a cornerstone catheter ablation strategy during the primary index ablation for patients with symptomatic and drug-refractory atrial fibrillation.[2] Furthermore, these guidelines recognized that cryoballoon catheter ablation can be an effective alternative to the traditional radiofrequency ablation catheters that have been historically used.[2] The performance of PVI is typically achieved via the inferior vena cava (IVC) through the access of the femoral veins; however, congenital anomalies or venous occlusion may inhibit the use of this approach. In these rare circumstances, access to the cardiac chambers may be achieved via the superior vena cava or via retrograde aortic approaches. Unfortunately, these approaches are less favorable owing to reduced catheter control, manipulation, and stability.[3–5] The purpose of this case report is to illustrate the safety and efficacy of performing PVI with the Arctic Front cryoballoon catheter via the transhepatic approach among patients with congenital anomalies.

Access to the right atrium via the percutaneous transhepatic approach is an alternative method when traditional means are not feasible. The percutaneous transhepatic approach has been shown to be effective, with a complication rate of <5%.[6] Although percutaneous transhepatic approach in performing cardiac ablation procedures is traditionally utilized in pediatric cases,[6–9] there is limited data on the transhepatic approach in the adult population.[3]

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Dr Su receives significant research and honorarium fees from Medtronic Corp. **Address reprint requests and correspondence:** Dr Wilber Su, Banner University Medical Center, Heart Institute, 755 E McDowell Rd, 4th Floor, Phoenix, AZ 85006. E-mail address: Wilber.su@bannerhealth.com.

Case report

The patient is a 33-year-old man with a past medical history significant for sick sinus syndrome, requiring a dual-chamber pacemaker at 21 years of age, and symptomatic persistent atrial fibrillation with associated interruption of the IVC (Supplemental Figure S1). The patient is a healthy, physically active, man who requires strict health maintenance owing to his professional occupation as a pilot and required long-term rhythm control, and potential cure, for his cardiac arrhythmia. Despite 2 separate attempts to maintain sinus rhythm by direct current cardioverison, atrial fibrillation recurred. The patient therefore underwent an attempted percutaneous transfemoral atrial fibrillation ablation at a different institution. However, the procedure was unsuccessful owing to a previously unidentified interruption of the IVC. The patient was then referred for a potential transhepatic versus transjugular approach for PVI. Owing to his congenital anatomic anomalies, a transhepatic venous approach was carefully planned and performed with a multidisciplinary team approach and interruption of his anticoagulation for 48 hours prior to the procedure. A percutaneous approach via the internal jugular veins was considered, but because of the increased difficulty of catheter manipulation with this approach, we elected to perform a transhepatic approach under general anesthesia.

The left internal jugular vein was used to insert a 7F sheath duodecapolar catheter for right and left atrioventricular groove pacing recording. The right internal jugular vein was used to insert a 9F sheath to utilize comprehensive intracardiac echocardiography and exchanged for a deflatable

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KEY TEACHING POINTS

- This is the first-ever documented case in which the cryoballoon catheter was used to perform pulmonary vein isolation via the percutaneous transhepatic venous approach.
- The Avitene collagen plug closure device is a safe and effective closure method of the transhepatic parenchyma tract when used with fluoroscopy and ultrasonography.
- A multidisciplinary team approach (congenital cardiologist, interventional radiologist) is useful when performing procedures in adults with congenital heart disease.

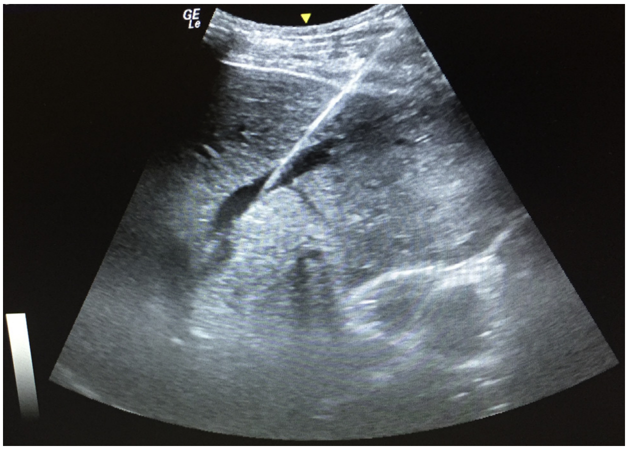

Figure 1 Ultrasound visualization of access into the hepatic vein using an AccuStick needle.

quadripolar catheter for atrial His ventricular pacing recording and phrenic nerve stimulation during the right PVI.

Interventional radiology gained access to the middle hepatic vein via ultrasound guidance using an Accustick needle and 5F sheath (Figure 1). The 5F sheath was removed over a 180-cm wire and an 8.5F Agilis catheter was inserted into the right atrium. The intra-atrial septum was crossed with a 98-cm BRK needle with appropriate heparin bolus to maintain activated clotting time > 300 seconds. Once access into the left atrium was obtained, the wire was advanced into the left atrial chamber and the BRK needle and Agilis catheter were removed. A 14F dilator was inserted over the wire to allow access for the 15F FlexCath Advanced Steerable Sheath (Medtronic, Minneapolis, MN). The 15F FlexCath was then inserted into the left atrium and the Arctic Front Advance Cardiac Cryoballoon catheter (Medtronic) was inserted over the long wire through the FlexCath sheath. Imaging of placement of the FlexCath sheath and cryoballoon catheter via the transhepatic approach along with intracardiac echocardiography via the right internal jugular vein can be seen in Figure 2A. A 3-dimensional mapping was performed using the EnSite Precision cardiac mapping system (Abbott, Lake Bluff, IL).

The left superior and inferior pulmonary veins were isolated using a freeze/thaw/freeze cycle at 2-minute intervals with good time-to-effect of isolation. During the right-sided PVIs, the phrenic nerve was paced every 30 seconds to avoid excessive hepatic parenchymal disruption and was also ablated with the freeze/thaw/freeze technique at 2-minute intervals. Right and left atrial pacing decrementally revealed no evidence of antegrade accessory pathway. Furthermore, right ventricular pacing revealed no evidence of retrograde accessory pathway, or concentric or decremental retrograde conduction.

After completion of the ablation procedure, the 15F FlexCath sheath was exchanged for a 15F 10-cm sheath. Contrast was injected through the dilator of the 15F short sheath and slowly pulled back until contrast no longer visualized the middle hepatic vein and the hepatic vein/liver parenchyma junction was located. At this time, 1 g of Avitene (Figure 3A) was mixed with 4 mL of contrast and 2 mL of saline until a thick paste was formed. Under fluoroscopic guidance, the transhepatic parenchyma tract was embolized with an Avitene plug and the sheath was removed. Hemostasis was achieved immediately and confirmed under ultrasound (Figure 3B) and fluoroscopic imaging (Figure 3C), revealing the hyperdense Avitene plug in the peripheral liver parenchyma and no perihepatic hematoma. Removal of all catheters and completion of the closure device in the hepatic tract can be seen in Figure 2B.

The patient tolerated the procedure well and started on apixaban 5 mg oral twice daily, 36 hours after completion of the procedure, with no heparin infusion in the interim.

Interestingly, 16 days after completion of the procedure, the patient developed bilateral knee and bilateral elbow swelling, joint stiffness, reduced range of motion, and pain. The patient was diagnosed with reactive arthritis with peripheral eosinophilia requiring arthrocentesis of bilateral knees, with straw-colored clear fluid removed. Markers for inflammation were elevated, including C-reactive protein. The patient's apixaban was discontinued out of concern of hemarthrosis development. The patient was treated conservatively with prednisone, and symptoms and inflammation dissipated. Furthermore, the patient has since completed a 90-day postprocedural stress echocardiogram and 24-hour Holter monitor without any complications or evidence of atrial arrhythmias as per his professional career medical recommendations and guidelines. The patient continues to run and cycle long distances and is back to his regular routine.

Discussion

Congenital anomalies of the venous system are rare but are becoming more widely described and understood. Interruption of the IVC occurs in approximately 0.15% of the general population. The most common variant of interruption of the IVC is absence of the segment of the IVC between the hepatic

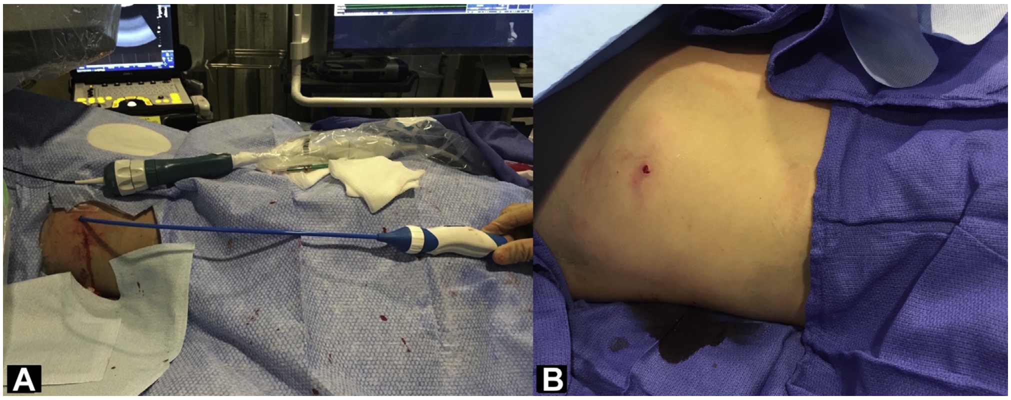

Figure 2 **A:** FlexCath and cryoballoon visualization along with intracardiac echocardiography via the right internal jugular vein. **B:** Removal of all sheaths and completion of procedure.

and renal veins, with blood from the liver draining directly into the right atrium through hepatic veins and from the lower extremities draining in the right atrium through the azygos system.[3]

There are several approaches to the right atrium that can be performed to successfully complete percutaneous ablation; however, transjugular and retrograde aortic approaches may be suboptimal owing to the difficulty of catheter manipulation and increased thrombotic risk. If performed through a transjugular approach, transseptal access is difficult because the curvature of the catheters and sheaths and angulation of the pulmonary veins may make it difficult to achieve good contact, with sharp curvatures of the devices needed to perform such ablations.

Transhepatic approach for cardiac ablations has been well described in pediatric literature.[3,6,10,11] The large-caliber size of the hepatic vein allows for use of larger sheath sizes for percutaneous catheter ablation procedures. Furthermore, Shim and colleagues[6] reported a complication rate of approximately 5% when transhepatic access was obtained for invasive cardiac procedures in a pediatric population.

A main source of complications occurs during the closure of the hepatic tract during transhepatic percutaneous procedures. Although there is no consensus on how to close the

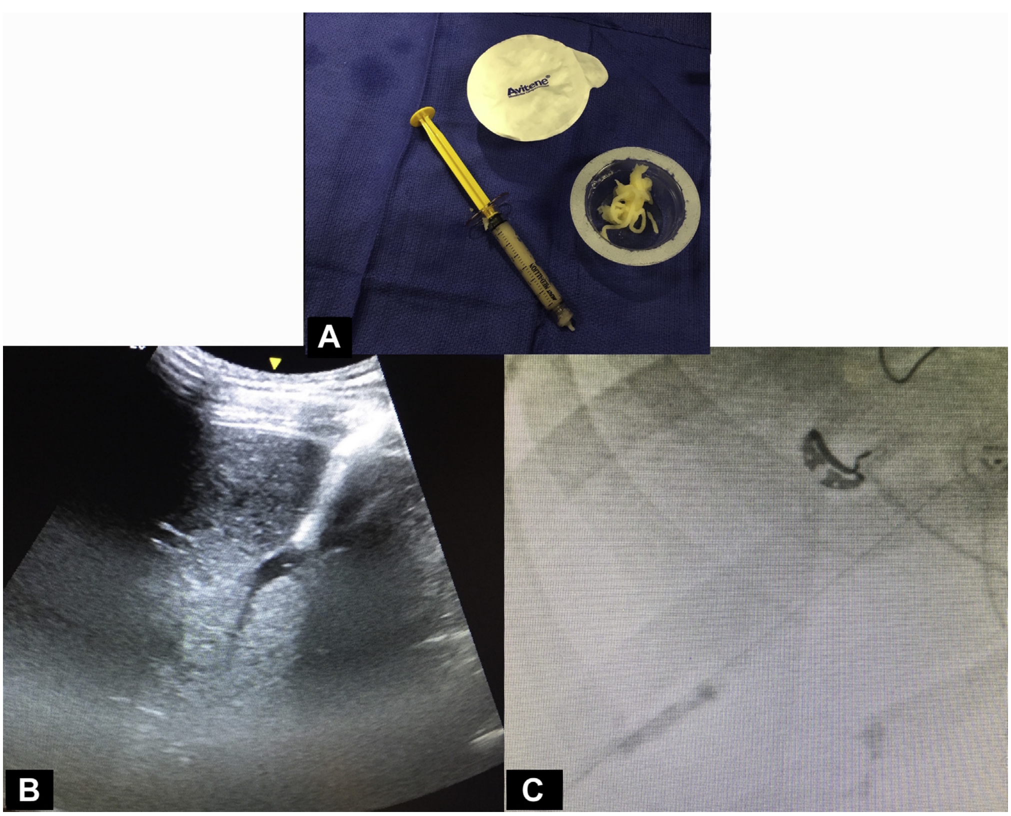

Figure 3 **A:** Avitene collagen plug used to embolize the hepatic tract. **B:** Avitene collagen plug visualized under ultrasonography. **C:** Avitene collagen plug visualized under fluoroscopy.

hepatic parenchymal tract, few cases have documented how hemostasis was achieved. Some cases have used manual pressure or placed patients in the right lateral decubitus position,[8,12] while others have achieved hemostasis with the placement of intrahepatic coils[10,13] or Gelfoam[14] or bipolar radiofrequency energy to cauterize/coagulate the adjacent hepatic parenchymal tissue.[3] When hepatic parenchymal plugs are used, it is imperative to ensure no embolization or migration into the hepatic vein itself, as it could be a nidus of infection or result in venous occlusion. We decided to use the Avitene collagen plug, as it is more viscous and dense than the Gelfoam and less likely to migrate. The Avitene plug can be echodense when mixed with contrast and yet is absorbed rather quickly, as it was not visualized on the computed tomography (CT) image the following day, so as to avoid a foreign body such as with coiling.

Once hemostasis is obtained, we recommend monitoring for transaminitis, hemorrhage, cholangitis, liver abscess, sepsis, hepatic vein thrombosis, gallbladder perforation, and pneumothorax, which can all occur during such a procedure. It is recommended that imaging and landmark guidance be used when gaining access during transhepatic percutaneous procedures to minimize and reduce complication rate. Furthermore, imaging after such a procedure such as hepatic ultrasonography or CT imaging modalities may be warranted to ensure that no complication has occurred or is evolving. During our case, ultrasound guidance was performed at the time of venous access and during venous closure with the Avitene collagen plug so as to avoid disruption of the collagen plug into the vascular system. In addition, CT angiography was performed the morning after the procedure to ensure no migration of the collagen plug and no complication around the hepatic architecture.

It is interesting to note that the patient developed a reactive arthritis syndrome requiring arthrocentesis and temporary discontinuation of anticoagulation 2 weeks after the procedure. It is unknown if the reactive arthritis was a result of the procedure itself or was owing to a reaction with the Avitene collagen plug. There have been no documented cases of reactive arthritis with the use of the Avitene plug, but that does not exclude this possibility.

The patient presented to the outpatient procedure suite in sinus rhythm and electrical cardioversion was not necessary during PVI. However, in patients undergoing transhepatic access for cardiac ablations requiring elective cardioversion, it is reasonable to attempt medical cardioversion prior to electrical cardioversion so as to avoid hepatic trauma. If medical cardioversion fails, perhaps electrical cardioversion after procedure recovery would be a suitable alternative.

Conclusion

With newer advances in ablation techniques, for patients with left-sided isomerism with associated interrupted IVC, the cryoballoon catheter via percutaneous transhepatic venous approach may be an option for those with favorable anatomic anomalies. This is the first-ever documented case in which the cryoballoon catheter was used to perform PVI via the percutaneous transhepatic venous approach. Furthermore, a multidisciplinary team approach (congenital cardiologist, interventional radiologist) is useful when performing procedures in adults with congenital heart disease.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2018.01.012.

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