Introduction

Atrial fibrillation (AF) is a common cardiac arrhythmia, affecting about 2.6 million people in the United States. Cryoballoon ablation of the pulmonary veins (PVs) has become a well-established therapeutic option for patients experiencing paroxysmal AF. Right phrenic nerve (PN) pacing is recommended when applying cryoballoon applications to the right PVs owing to their close proximity to this nerve. This may be difficult in patients with atresia of the right superior vena cava (SVC). We propose an alternative option to accessing the right PN via access through the coronary sinus (CS) and right subclavian vein.

Case report

The patient was a 48-year-old man experiencing symptomatic, drug-refractory, paroxysmal AF. The patient discontinued Tikosyn 48 hours prior to the procedure.

Routine evaluation was performed, including a prior cardiac computed tomography (CT) scan. Careful review of the cardiac CT revealed a persistent left SVC with possible atresia of the SVC.

The patient was brought to the electrophysiology laboratory in the fasting state, sedated and intubated. A transesophageal echocardiogram was performed prior to the procedure and revealed no left atrial thrombus. No significant valvular regurgitation was noted. Left atrial size was not noticeably enlarged. There was significant enlargement of the CS. Prior to the procedure, confirmation of SVC atresia was noted via CT (Figure 1).

Access was obtained into the right and left femoral veins via the modified Seldinger technique. A CS and lateral right atrium (RA) catheter, duodecapolar Livewire (St Jude Medical), was advanced through an 8F sheath in the left femoral vein. Another 10F sheath was inserted into the left femoral vein for the intracardiac echocardiography (ICE) catheter. A HIS CRD2 Supreme (St Jude Medical, St. Paul, MN) was advanced via a 5F catheter in the right femoral vein. Wires could not be advanced into the SVC owing to the lack of a rightward SVC. Atresia of the right SVC was confirmed via ICE, as well as a 15 mL intravenous contrast injection through the right antecubital IV and subsequent fluoroscopy confirming entry into the RA via the CS. A radiofrequency approach was briefly considered owing to the assumed inability to pace the diaphragm and confirm PN capture. Prior to swapping ablation technology, an additional decapolar catheter, Dynamic Tip (Bard), was advanced through the CS and into the right subclavian vein using fluoroscopy and EnSite Velocity (St Jude Medical) (Figure 2). Using the created geometry on EnSite, this catheter position in the right subclavian was reproducibly accessed. High output pacing (15 mA, 2.0 ms) from this distal pair of electrodes on this catheter was sufficient to capture the right PN, causing diaphragmatic movement and thus the ability to assess potential PN damage during cryoablation.

A 9F ViewFlex PLUS ICE catheter (St Jude Medical) was inserted through the 10F femoral sheath and advanced with careful manipulation via fluoroscopic guidance. The transseptal puncture was completed using an SL1 sheath (St Jude Medical) in the right femoral vein and a BRK 71 cm needle (St Jude Medical), in combination with fluoroscopy guidance, ICE catheter with agitated saline, and pressure monitoring. Once in the left atrium, this SL1 sheath was directed toward the left superior PV and then swapped out for the 15F FlexCath sheath, Arctic Front balloon, and Achieve catheter (Medtronic, Minneapolis, MN). The patient was administered a bolus of heparin intravenously with a target activated clotting time of 300–350 seconds. Activated clotting times were obtained every 30 minutes.
Prevoltage mapping was completed in normal sinus rhythm (Figure 3). Each vein was ablated using a double-frost method with each application lasting 240 seconds. When freezing in the right PVs, PN pacing was achieved via the catheter position, as discussed earlier. No loss of capture was noted and diaphragmatic stimulation remained constant throughout each freeze. Postvoltage mapping was then completed, as seen in Figure 3.

All endpoints were met. The patient did not experience any major complications, did well post procedure, and was subsequently discharged the next day.

Discussion
The presence of left SVC occurs in approximately 0.3%–0.5% of the general population. During normal cardiac development the left-sided anterior venous cardinal system involutes, leaving the CS and a remnant known as the ligament of Marshall. Failure of closure of the left anterior cardinal vein results in persistent left SVC. Very rarely is persistent left SVC associated with absent right SVC (0.07%–0.13% of congenital cardiovascular malformations). Congenital anomalies of the SVC often coexist with other congenital cardiac anomalies, including atrial septal defect, double aortic arch, dextrocardia, and asplenia. These SVC anomalies are most often asymptomatic and are found incidentally. These anomalies may complicate invasive cardiac procedures such as cardiac implantable electrical device implantation and/or cardiac ablation. As in this case, the contrast given into the right antecubital vein will first appear in the dilated CS and then in the RA.

An additional alternative approach could be a direct right subclavian catheterization to access the right PN. However, this approach would require a separate venous access point with a number of potential complications, including pneumothorax, discomfort, and bleeding.

Conclusion
To our knowledge, this is the first case study reported of pacing the PN in such a way while performing cryoballoon ablation of the PVs. This report illustrates that in the face of the anatomic absence of a right SVC, transfemoral access to the right subclavian vein for the purpose of right PN stimulation may still be possible via the CS and a persistent left SVC.
Figure 2  EnSite geometry and radiograph showing access into the right subclavicular region via access through the persistent left superior vena cava.

Figure 3  Pre- and postcryoablation voltage maps of the left atrium. High voltage (0.5 mV) displayed as purple and low voltage (0.2 mV) displayed as gray.

References
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