Atrial balloon septoplasty facilitates trans-subclavian approach for left atrial tachycardia in a patient with hemiazygos continuation of inferior vena cava

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Introduction

Pulmonary vein isolation (PVI) stands as a cornerstone in the treatment of atrial fibrillation (AF). However, the emergence of atrial tachycardia (AT) following PVI is widely recognized as an adverse effect of left atrial intervention.[1,2] When tachycardia occurs, antiarrhythmic drug therapy alone is often ineffective, while radiofrequency (RF) ablation procedures have shown greater success. Access to the left atrium (LA) via transseptal puncture (TSP) is essential for performing LA ablation. TSP is commonly carried out through the femoral venous route; however, anatomical abnormalities may necessitate alternative access routes, making TSP challenging. Atrial balloon septoplasty (ABS) has been reported as a bailout method to overcome difficult LA access during catheter ablation.[3] In this report, we describe the first successful case of AT ablation in the LA using ABS via the right subclavian vein, necessitated by anatomical anomalies of inferior vena cava (IVC).

KEY TEACHING POINTS

- The subclavian approach offers a viable alternative for ablations when the inferior vena cava approach is challenging.
- Atrial balloon septoplasty (ABS) is an effective solution for cases in which transseptal puncture (TSP) is difficult, although it has not been commonly reported for the superior approach.
- In instances where TSP proves challenging even with the superior approach, ABS remains a safe and effective option for achieving TSP.

Case report

A 71-year-old male patient diagnosed with polysplenia syndrome presented with an interrupted infrahepatic IVC with hemiazygos continuation, and a permanent left superior vena cava (PLSVC) connected to the coronary sinus (Figure 1). He had previously undergone surgical excision of the left atrial appendage and PVI for paroxysmal AF. Approximately 1 month after the surgery, he developed drug-refractory AT, necessitating referral for catheter ablation.

Owing to IVC anomalies, TSP was performed through the right subclavian vein using a SureFlex® Steerable Guiding Sheath (Baylis Medical, Montreal, Canada) and Supra-Cross® RF wire (Baylis Medical) under the guidance of fluoroscopy and intracardiac echocardiography (ICE). The RF wire served a dual purpose: as a guidewire and as a needle that connected to the RF generator at the wire's end, conducting RF current from the tip. Tenting of the atrial septum was confirmed using ICE, and RF energy was delivered to the RF wire's tip. Following RF ablation, the RF wire was advanced into the LA, positioning the wire tip in the left superior pulmonary vein. Nevertheless, the sheath insertion remained challenging owing to the steep slope of the atrial septum from the superior vena cava (Figure 2A). Subsequently, the sheath was replaced with an Agilis™ NxT steerable transseptal sheath (St. Jude Medical, St. Paul, MN) for a second attempt, but this also failed to pass through the atrial septum. Reverting to the SureFlex sheath, a noncompliant 0.035-inch Mustang™ balloon dilation catheter (with a diameter of 7 mm and a length of 40 mm; Boston Scientific, Marlborough, MA) was advanced over the RF wire and positioned across the septum. The balloon was inflated to 10 atm nominal pressure, and ABS was performed (Figure 2B). Following ABS, the SureFlex sheath smoothly introduced to the LA (Figure 2C). In terms of anticoagulation, the patient received a daily dosage of 220 mg of dabigatran. During the procedure, anticoagulation was managed by administering an initial heparin dose of 5000 units immediately after the RF

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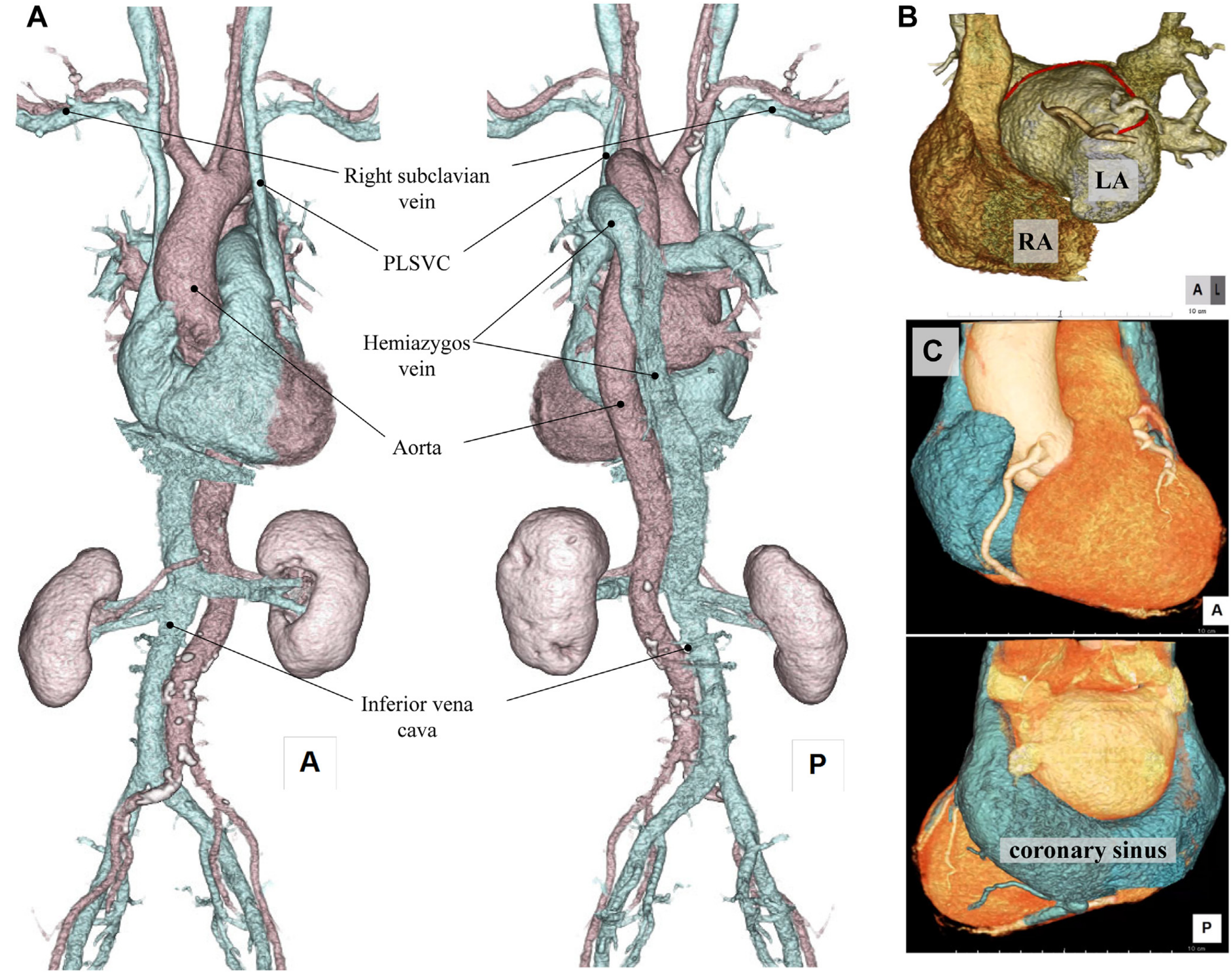

Figure 1 **A:** Three-dimensional computed tomography (3D-CT) reconstructions of arteriovenous anatomy, with the left panel displaying an anterior-posterior (AP) view and the right panel a posterior-anterior (PA) view. **B:** A 3D-CT image of both atria with the red curve highlighting the sinus node artery. **C:** 3D-CT images of the entire heart, with the top panel in AP view and the bottom panel in PA view, illustrating the coronary sinus connection to permanent left superior vena cava.

wire was inserted into the LA. Additional doses of heparin were adjusted to maintain an activated clotting time of at least 300 seconds.

The procedure employed the remote magnetic navigation system (Niobe™ ES; Stereotaxis, St. Louis, MO) combined with the CARTO®3 mapping system (Biosense Webster, Irvine, CA).[4–6] LA burst pacing was conducted using a magnetically navigated THERMOCOOL® RMT Catheter (Biosense Webster), which triggered AT1 with a cycle length of 266 ms. Mapping of the LA was conducted point by point with a single catheter. No reconnection was observed in the pulmonary veins, and the local activation time isochronal map indicated that AT1 manifested as a counterclockwise rotation of the mitral valve annulus. The anterior LA wall exhibited slow conduction and fragmented potential. RF ablation (30–40 W, 20–70 s) there changed AT1 to AT2 with a cycle length of 272 ms (Figure 3A).

The LA was remapped in a similar manner, revealing that AT2 was a roof-dependent AT, conducting from the roof to the floor of the LA anterior wall. Roofline ablation (30–40 W, 20–70 s) was started from the roof of the right superior pulmonary vein to the left superior pulmonary vein. During the middle of the roofline ablation, AT2 ceased and the block line was completed (Figure 3B). Bidirectional block across the roofline was confirmed through a differential pacing maneuver. Following the ablation, AT was no longer induced by LA burst pacing, isoproterenol administration 10 μg/min for 5 minutes, and adenosine 20 mg bolus application.[7] The patient was discharged 2 days after the procedure without any major complications. One month later, during our outpatient follow-up, no AT incidents were detected. A subsequent transthoracic echocardiogram showed a minor iatrogenic atrial septal defect with a trivial left-to-right shunt. The pulmonary-to-systemic blood flow ratio (Qp/Qs) measured

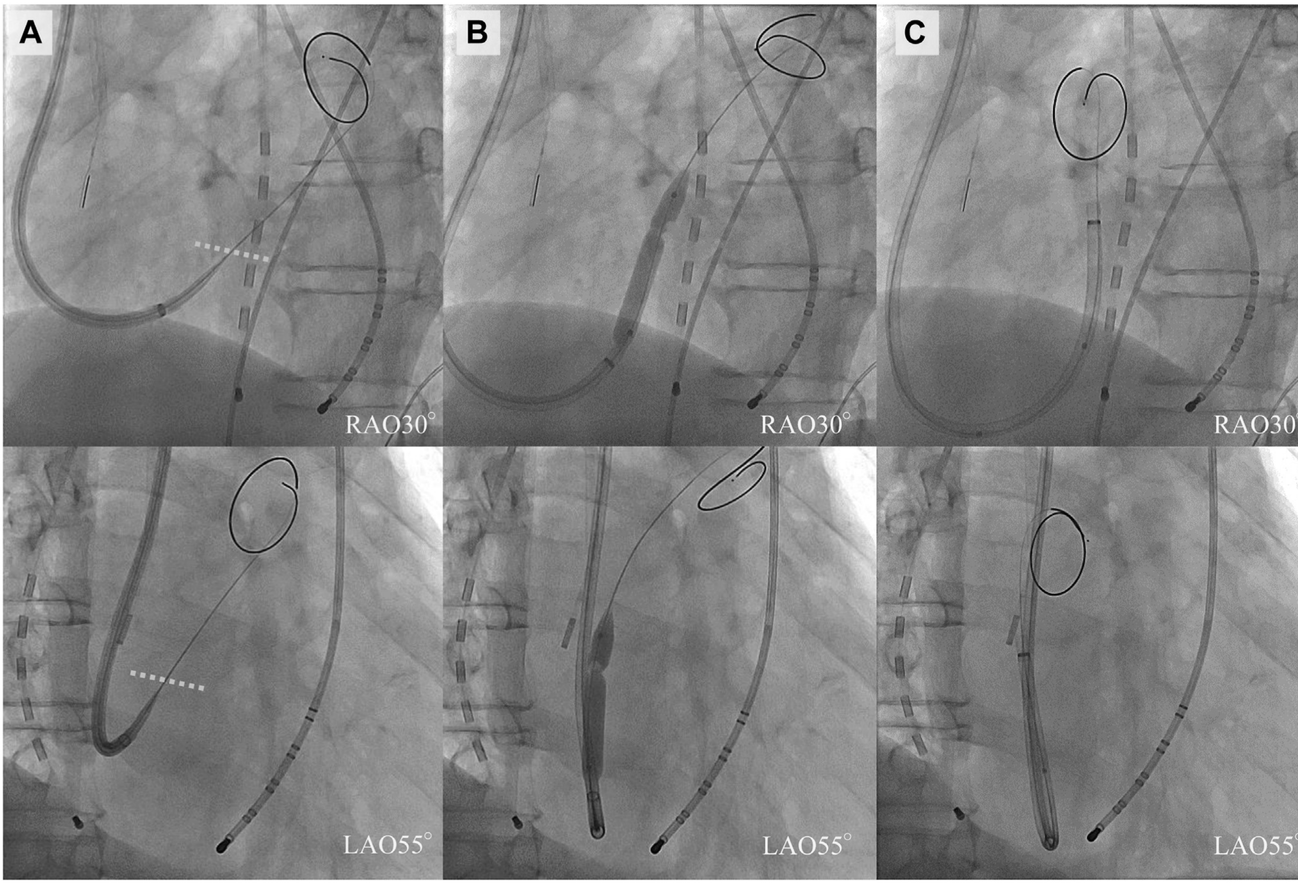

Figure 2 Fluoroscopic images of the transseptal puncture (TSP) procedure from the right subclavian vein. The top panels show the right anterior oblique 30° (RAO30°) view, and the bottom panels show the left anterior oblique 55° (LAO55°) view. TSP was performed with intracardiac echocardiography imaging to confirm atrial septal tenting. **A:** Images of the SupraCross wire (Baylis Medical, Montreal, Canada) crossing the atrial septum and into the left superior pulmonary vein. The dashed line indicates the atrial septal plane where the SureFlex sheath (Baylis Medical) faced difficulty passing. **B:** Atrial balloon septoplasty (ABS) using a Mustang balloon (Boston Scientific, Marlborough, MA). **C:** Images of the successful insertion of the SureFlex sheath into the left atrium after ABS, demonstrating a successful TSP.

1.1, and no additional cardiac complications associated with the procedure were identified. The patient's clinical cardiologic condition remained stable. However, the patient later sought care at a nearby hospital, leading to the discontinuation of our follow-up.

Discussion

Polysplenia is a rare heterotaxy disorder with a reported incidence of 1 per 250,000 live births.[8] Common abnormalities associated with polysplenia syndrome include the absence of the intrahepatic portion of the IVC with azygos or hemiazygos continuation (58%–100%) and a PLSVC (33%–50%).[9] In cases of congenital infrahepatic IVC interruption, transseptal catheterization of the LA through the femoral veins becomes unfeasible. Alternative approaches to access the LA include the retrograde aortic approach, the transhepatic approach, and the superior approach. The retrograde aortic approach can be used for LA ablation with the assistance of a magnetic navigation system.[10] However, it is not considered ideal owing to catheter instability resulting from the lack of support from the fossa ovalis and interference from left ventricular wall motion. The transhepatic approach, providing an inferior access route, is favored by cardiac electrophysiologists who are more accustomed to this method, offering greater ease in catheter manipulation compared to the superior approach. Nevertheless, it carries the risk of intraperitoneal hemorrhage and should be reserved for centers experienced in this approach.[11] In our institution, we lacked experience with the transhepatic approach, prompting us to consider alternative options. Considering these factors, catheter ablation via the superior approach was deemed optimal in our case. This approach involves access through the internal jugular vein or the subclavian vein, with the choice available on both the left and right sides. When determining the access route, it is crucial to ensure that the vessel diameter is sufficient to accommodate device insertion and that there are no complications such as severe tortuosity, stenoses, or obstructions in the vessel. The right-sided vein is typically preferred owing to its shorter distance from the atrial septum and reduced curvature compared to the left-sided vein. In this case, the left-sided vein was considered inappropriate as an access vein because the innominate vein is absent, and the left-sided vein is connected to the right

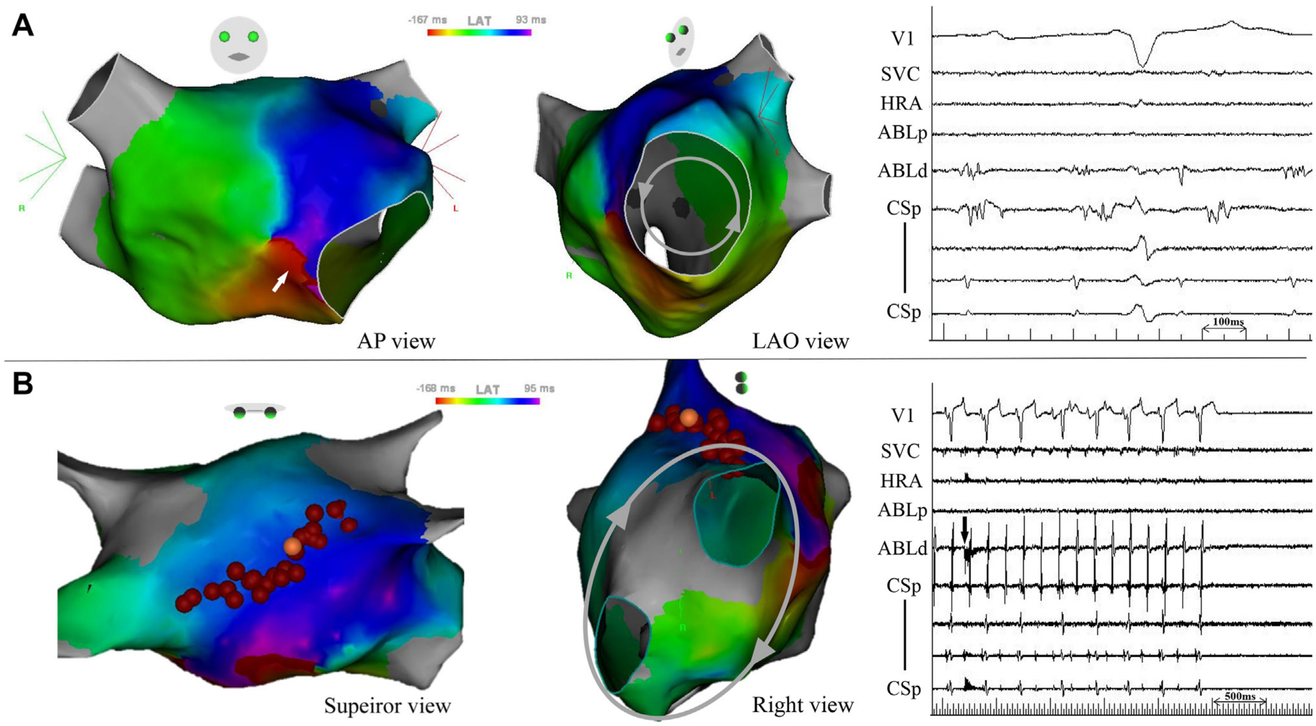

Figure 3 **A:** The left and middle panels show the local activation time (LAT) map of AT1, depicting its counterclockwise rotation around the mitral valve annulus. The right panel exhibits electrophysiological findings at the site of fragmented potential recording in the anterior left atrial wall, where the distal ablation catheter (ABLd) is marked by a white arrow and the proximal coronary sinus (CSp) electrodes are located. **B:** The left and middle panels present the LAT map of AT2, revealing its roof-dependent nature. The right panel shows electrophysiological findings during roofline ablation at the site of the orange tag. AT2 ceases 4.5 seconds after ablation initiation, as indicated by the black arrow. ABLp = proximal ablation catheter; CSd = distal coronary sinus; HRA = high right atrium; SVC = superior vena cava.

atrium via the PLSVC and the coronary sinus. In our case, the right subclavian vein was a good match for these criteria, and our institution had familiarity with the right subclavian approach. Hence, we chose the right subclavian vein as the access route.

ABS serves as a safe and effective bailout strategy when TSP proves difficult.[3] Patients who have previously undergone transseptal catheter ablation or surgical or percutaneous atrial septal repair procedures may present with septal scarring or thickening at the transseptal access site, potentially complicating the TSP process. However, there are situations where TSP is challenging for patients despite the absence of a relevant medical history. In the case of the superior approach, the sheath-pushing force is directed downward, which may lead to the sheath dislodging from the contact point of the fossa ovalis. To address this challenge, previous reports have suggested the use of a deflectable sheath and a stiff guidewire to provide adequate support for successful TSP.[12] In our case, the atrial septal plane exhibited an almost horizontal tilt (Figure 2A), necessitating an upward pushing force as the sheath traversed from the right atrium to the LA. In essence, the downward force applied to push the sheath needed to be transformed into an upward force, a task facilitated by the support of the guidewire. Initially, the sheath encountered significant resistance when attempting to pass through the atrial septum, and replacing it with another deflectable sheath did not yield success, even though the SupraCross wire had sufficient stiffness. Therefore, ABS was performed to reduce the resistance of the sheath to cross the atrial septum. Following ABS, the atrial septum presented reduced resistance to the sheath. As a result, the sheath was easily inserted into the LA after ABS. Thus, ABS is a very effective solution when the cause of TSP refractoriness is the resistive force from the atrial septum that the sheath receives as it passes through the septum.

Conclusion

The trans-subclavian approach is considered a useful alternative when the femoral vein approach is not feasible. ABS proves to be an effective and safe solution for challenging LA access. To our knowledge, ABS had previously been employed exclusively in adult patients via the inferior approach. Nevertheless, our experience demonstrates that even with the superior approach, ABS remains a safe and effective option.

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