# Back flip technique for pulmonary vein isolation: A case of radiofrequency ablation for paroxysmal atrial fibrillation in a patient with dextrocardia, situs inversus, and interrupted inferior vena cava

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## Introduction

An interrupted inferior vena cava (I-IVC) is a rare venous malformation, occurring in 0.6% of patients with congenital heart disease and 0.15% of the general population.[1,2] Pulmonary vein isolation (PVI) of atrial fibrillation (AF) is typically accessed through the femoral vein. However, the presence of an I-IVC requires consideration of alternative routes. Prior reports have described the PVI in patients with an I-IVC using the trans–superior vena cava (SVC), transaortic, and transhepatic veins, with the superior approach being notably prevalent.[3–6] The standard superior approach can complicate the catheter manipulation within the left atrium (LA), often necessitating a specific adjustment of both the puncture site and puncture device.[4]

The use of CARTO3 systems promises to enhance the safety and standardization of catheter manipulation techniques for the PVI via a superior approach, particularly in patients with complex anatomical structures—to the best of our knowledge, a topic not previously explored in the literature. In this case, we performed catheter ablation of paroxysmal AF in a patient with dextrocardia, situs inversus totalis, an I-IVC, and an azygos vein continuation, using a superior approach via the left jugular vein by using the CARTO3 system's inner view functionality.

## Case report

A 50-year-old man with dextrocardia and situs inversus totalis underwent a previous catheter ablation via the left femoral vein for paroxysmal AF, which was terminated owing to unforeseen vascular anomalies: an I-IVC and azygos vein continuation connected to the SVC (Figure 1A). Since then, the patient had been symptom free with antiarrhythmic medication until a recent exacerbation of palpitations necessitated the reevaluation for another catheter ablation procedure. Transthoracic echocardiography revealed a left atrial diameter of 42 mm and left ventricular ejection fraction of 57%. Preoperative contrast-enhanced computed tomography confirmed the presence of dextrocardia, situs inversus totalis, an I-IVC with an azygos vein continuation connected to the SVC, and no additional cardiovascular malformations (Figure 1B.1–3 and 1C.1–2). A common trunk of the left pulmonary veins (PV) was also identified (Figure 1D). Owing to the impossibility of transseptal access via the femoral route, a superior approach via the left jugular vein was pursued.

At the time of the procedure, the patient's rhythm was sinus rhythm. He was positioned on the operating table

### KEY TEACHING POINTS

- Performing pulmonary vein isolation via a superior approach in a patient with dextrocardia, situs inversus totalis, and an interrupted inferior vena cava is challenging. However, the combination of 2 methods facilitates the treatment.
- Firstly, adjusting the site of the transseptal puncture to a more superior and anterior position within the fossa ovalis can achieve stable catheter contact with the pulmonary vein.
- Secondly, rotating the inner view on the 3-dimensional navigation system by 180 degrees during the pulmonary vein isolation as usual simplifies the catheter manipulation.

**KEYWORDS** Catheter ablation; Atrial fibrillation; Dextrocardia; Interrupted inferior vena cava; Three-dimensional navigation system
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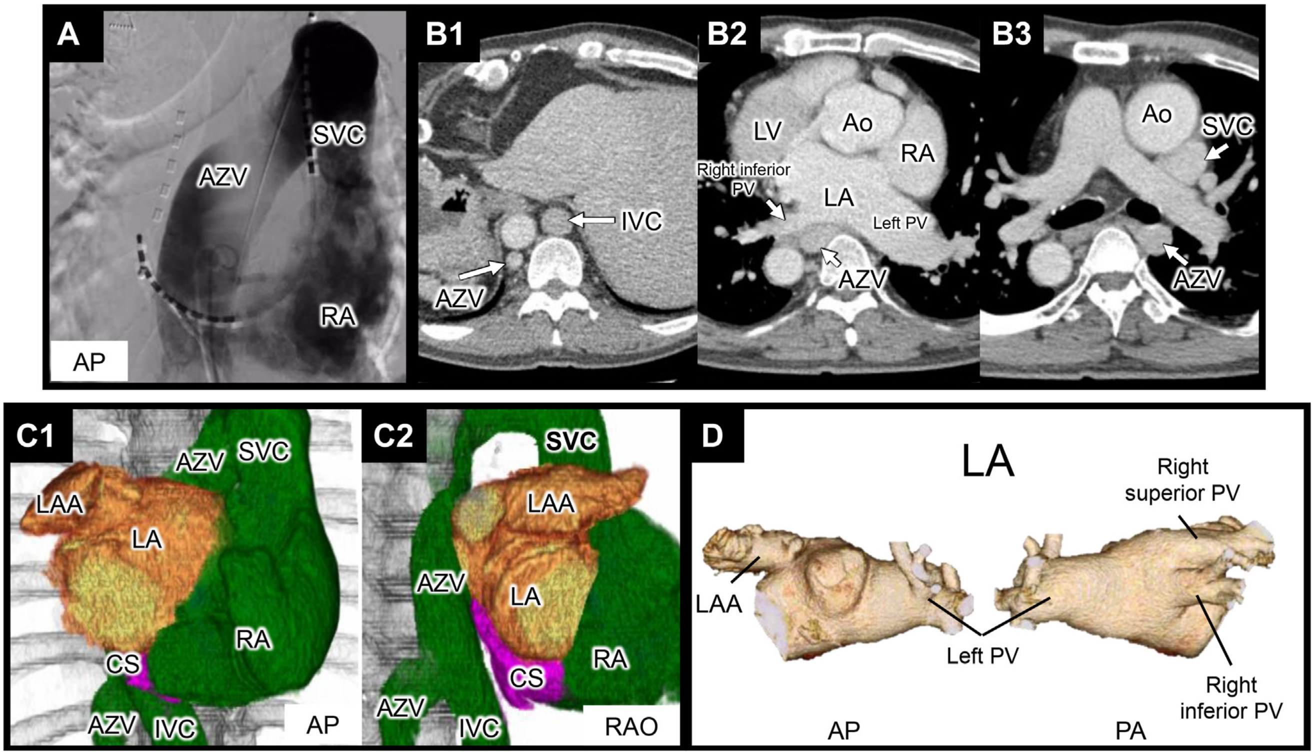


**Figure 1** A: Contrast images during the first attempted catheter ablation showing the inferior vena cava (IVC) interrupted and the azygos vein (AZV) continued to the superior vena cava (SVC). **B:** 1-3: Preoperative enhanced computed tomography images. **C:** 1-2: Three-dimensional enhanced computed tomography images. **D:** Left atrium model of the 3-dimensional enhanced computed tomography images, demonstrating a common trunk of the left pulmonary veins (PV). Ao = aorta; CS = coronary sinus; IVC = inferior vena cava; LA = left atrium; LAA = left atrial appendage; LV = left ventricle; RA = right atrium.

with his head and feet reversed from the standard setup. The procedure was conducted under general anesthesia with midazolam, propofol, and rocuronium and endotracheal intubation with a 7.5 mm tube, using a 3-dimensional navigation system (CARTO3; Biosense Webster, Diamond Bar, CA). Transesophageal echocardiography (TEE), performed by an experienced echocardiologist (Yoshiko.M.), assisted in accurately assessing the complex anatomy and ensuring a safe transseptal puncture. During the ablation, intravenous heparin was administered to maintain the activated clotting time above 300 seconds. An 8.5F long sheath (SL0; Abbott Medical Japan, Minneapolis, MN) was inserted through the right internal jugular vein, and a steerable sheath (SupraCross steerable sheath; Boston Scientific, Marlborough, MA) was inserted through the left jugular vein. TEE visualized the fossa ovalis, and the transseptal puncture was performed using a SupraCross steerable sheath and pigtail radiofrequency wire (SupraCross RF Wire; Boston Scientific). The puncture site was placed superiorly and anteriorly to the fossa with TEE guidance (Figure 2A.1–2). After gaining access to the LA, the sheath was exchanged for a visualized sheath (VIZIGO; Biosense Webster). A 6F 20-pole electrode catheter (BeeAT; Japan Lifeline, Tokyo, Japan) was positioned into the coronary sinus through the right jugular vein (Figure 2B). The geometry of the LA was mapped with a multipole mapping catheter (Pentaray; Biosense Webster) under pacing from the distal coronary sinus, which was then merged with the computed tomography model. Subsequently, a circumferential PVI was performed with an open-irrigated contact force-sensing catheter (ThermoCool SmartTouch ST-SF; Biosense Webster), targeting an ablation index of 450 with 45 W. During the procedure, TEE was inserted to confirm that there was no increase in the effusion and a conventional esophageal temperature probe was not inserted. It was determined undesirable to perform an extensive encircling PVI without esophageal temperature monitoring, so the PVI was performed near the PV ostium. The unique site of the transseptal puncture facilitated adequate catheter contact for the PVI without needing to loop the sheath. In the standard inner view of the CARTO3 system, the catheter's movement was counterintuitive, moving opposite to the expected direction during a typical PVI and complicating the operator's intuitive control. Hence, rotating the VIZIGO sheath counterclockwise should have caused the catheter to touch the left atrial appendage (LAA) ridge when targeting the right PVs during the PVI, and the conventional inner view corresponded to moving the catheter to the monitor's left. By rotating the conventional inner view by 180 degrees, the catheter viewed within the CARTO3 system could be controlled as smoothly and effectively as during a standard PVI through the femoral vein (Back Flip Technique, Figure 3). In this case, the inner view was adapted to make the PVI via a superior approach as intuitive as that for the typical PVI. When the VIZIGO sheath was rotated

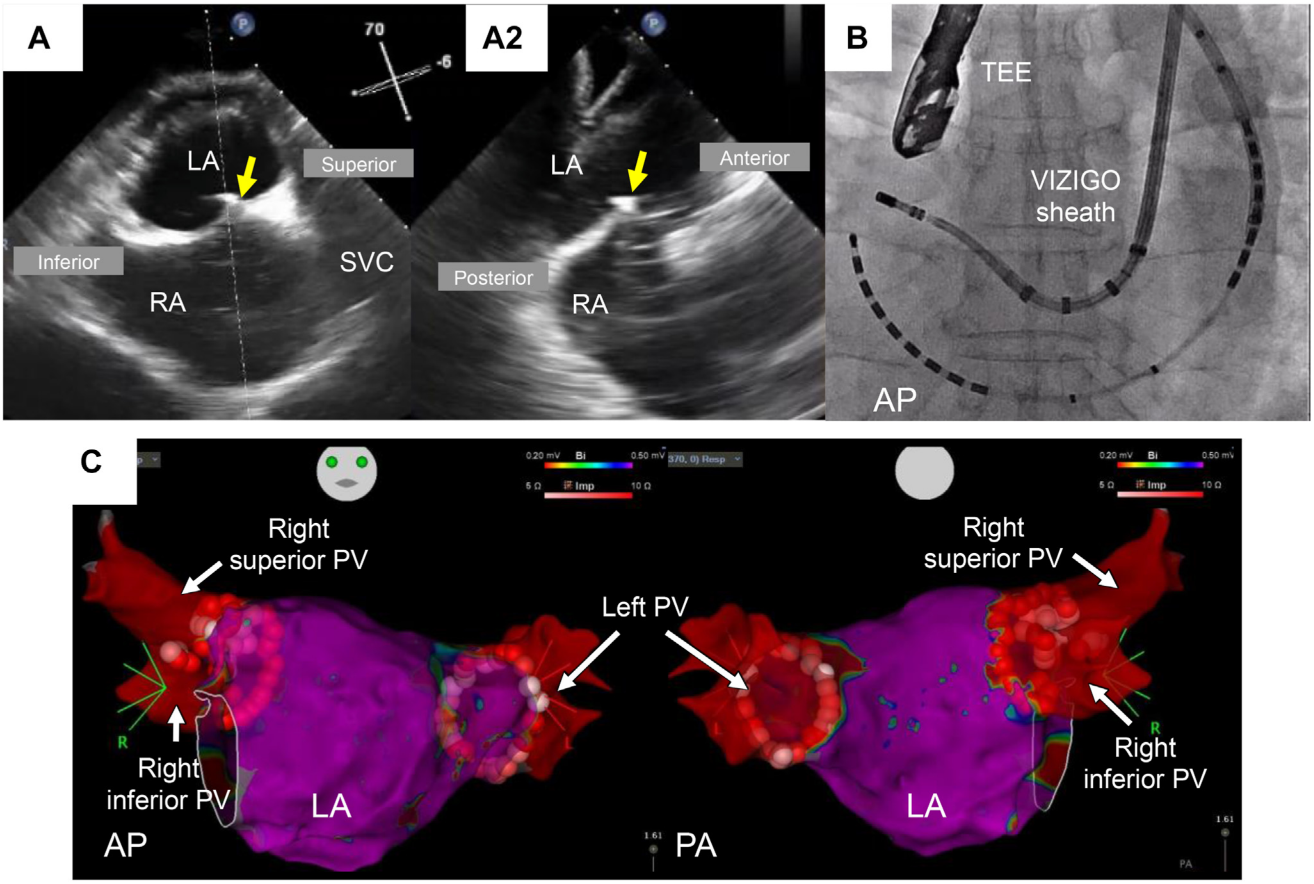


**Figure 2** **A:** 1-2: Transesophageal echocardiography (TEE) image during the transseptal puncture via a superior approach via the left jugular vein. The yellow arrow indicates the tenting of the fossa ovalis during the transseptal puncture. The puncture site was guided to be superior and anterior to the fossa ovalis by TEE. **B:** Fluoroscopic image post–transseptal puncture, showing the VIZIGO sheath (Biosense Webster, Diamond Bar, CA) and an electrode catheter positioned in the right and left pulmonary veins (PV). **C:** The voltage map created by a multipole mapping catheter after the PV isolation. LA = left atrium; RA = right atrium; SVC = superior vena cava.

counterclockwise, making the catheter come in contact with the ridge of the LAA for the right PVs, the catheter moved toward the right side of the screen in the inner view of the Back Flip Technique. When the VIZIGO sheath was deflected clockwise, the sheath and catheter moved toward the bottom of the screen—that is, toward the roof of the

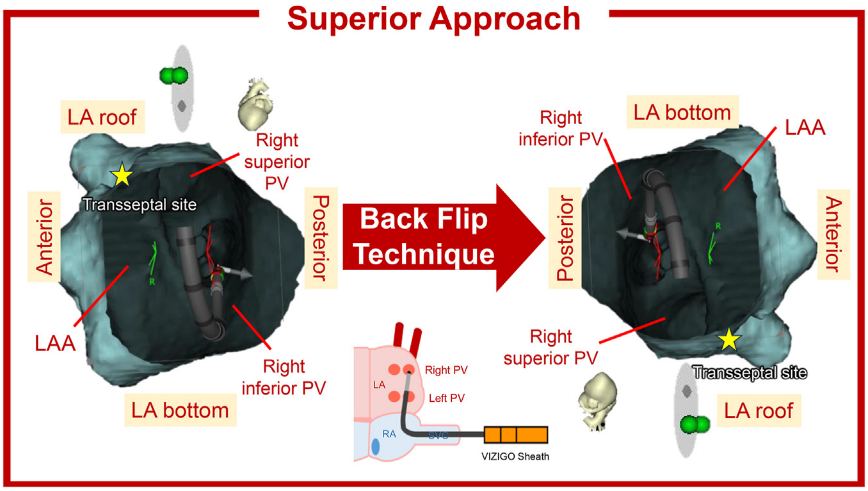


**Figure 3** Back Flip Technique: the technique of rotating the inner view of the CARTO3 navigation system (Biosense Webster, Diamond Bar, CA) by 180 degrees when performing pulmonary vein isolation via a superior approach. The yellow star indicates the transseptal puncture site, which is the superior and anterior site of the fossa ovalis. LA = left atrium; LAA = left atrial appendage; PV = pulmonary vein; RA = right atrium; SVC = superior vena cava.

LA. That allowed for the same intuitive manipulation as a conventional PVI. For both-sided PVs, the PVI was completed using the inner view with the Back Flip Technique. Thereafter, the LA was mapped using a Pentaray catheter, confirming the completion of the PVI (Figure 2C). Hemostasis of the bilateral internal jugular veins was achieved by manual compression, and the procedure was terminated without any complications. The procedure time was 165 minutes and fluoroscopy time 10.4 minutes. One year after the catheter ablation, the patient has been free of any atrial tachyarrhythmias without antiarrhythmic drugs.

## Discussion

Catheter ablation of AF presents unique anatomical challenges in patients with dextrocardia and situs inversus totalis. The complexity is further increased when an I-IVC is involved, making the standard femoral vein approach to the LA impractical. In individuals with dextrocardia, an I-IVC occurs in 8% of cases, which is a higher incidence compared to the general population; thus, its presence must be confirmed preoperatively.[7]

Several reports have detailed the catheter ablation of AF in patients with an I-IVC. Various alternative routes to access the LA exist, including via the transaortic[5,6] and transhepatic veins.[8,9] Nonetheless, a superior approach is relatively common.[4] With the transaortic route, maneuvering the catheter into the LA is technically demanding. While successful PVI has been documented,[6] others have reported difficulty in delivering the catheter to the right inferior PV even with a magnetic navigation system.[5] The limitations of the transaortic PVI with a magnetic navigation system include a scarcity of institutions that have access to such equipment and the necessity for an arterial puncture. The transhepatic vein approach may facilitate the transseptal puncture and PVI, offering a catheter manipulation similar to that of the femoral vein route.[8,9] However, it carries risks associated with the puncture and hemostasis. Especially at the end of the catheter ablation, specialized methods such as plugs and coils are required for hemostasis. Our limited experience with these techniques precluded its selection.

A superior approach is commonly favored in AF cases with an I-IVC owing to its straightforward compatibility with conventional puncture techniques and pressure hemostasis. The use of a specialized sheath, which allows for greater deflection angles, streamlines the transseptal puncture process, eliminating the need for unconventional methods or the manual reshaping of needles. However, guiding the catheter to each PV upon entering the LA, particularly the right inferior PV, significantly complicates the PVI via a superior approach procedure. Liang and colleagues[4] highlighted in their review of a superior approach method that the difficulty arises from the transseptal puncture at the posterior and inferior aspects of the fossa ovalis, similar to a standard transseptal puncture via a femoral vein. Performing the puncture at a more superior or anterior position enhances the safety and efficacy of the catheter positioning and contact with the PVs. In the case we present, the patient experienced no issues with the catheter placement into the PVs by performing of a superior and anterior fossa puncture guided by TEE and without the need to create a loop with the catheter. As reported previously,[3] there was a possibility that the fossa ovalis could have been visualized by intracardiac echocardiography through the azygos vein. However, a femoral vein puncture would have been complicated because the patient was in an opposite position and the area with a clean field of view was limited. The median contact force during the PVI is presented in Supplemental Figure 1. Stable contact forces of more than 7 g were achieved, and good contact was also obtained at the bottom of the left PVs.

The integration of CARTO3 systems with advanced tools such as visualizable sheath and contact force sensing catheter enhances the safety, reliability, and applicability of the PVI, even within complex cardiac anatomies. To the best of our knowledge, no reports exist on adapting the 3-dimensional visualization of the LA and PVs to simplify the PVI via a superior approach, making it comparable to more conventional methods. The Back Flip Technique is innovated by rotating the inner view by 180 degrees, providing the operators with a safer and more instinctive method for conducting the PVI via a superior approach. In this report, the Back Flip Technique was applied to a patient with dextrocardia and situs inversus. However, this technique could also be usable for a PVI via a superior approach in patients with a normal anatomy. The most critical aspect of this technique lies in the transseptal puncture site. Inserting the catheter straight will direct it toward the bottom of the LA—in other words, towards the bottom direction of the left inferior PV. Following this, the Back Flip Technique allows for catheter manipulation to become the same as usual. On the 3-dimensional navigation system, the LAA will be located behind the left PV, but by clockwise rotation of the catheter, it will be directed toward the ridge between the left PV and the LAA. Conversely, by counterclockwise rotation, it will move away from the ridge, and on the 3-dimensional navigation system, it will head toward the posterior wall of the LA.

The Back Flip Technique may enhance the efficacy of the PVI, as it aligns with the tactile and visual feedback operators are accustomed to, potentially leading to more durable outcomes of the PVI and reducing both the duration of the procedure and the exposure to fluoroscopy. Maintaining a familiar procedural environment and technique is crucial, even when applying unconventional methods to unique anatomical challenges, as it can improve the success rate of the PVI and decrease the operational time. The Back Flip Technique holds promise for becoming a standard modality for a PVI via a superior approach.

## Conclusion

The Back Flip Technique, which rotates the inner view of the 3-dimensional navigation system by 180 degrees, can make the PVI procedure via a superior approach safer and more consistent.

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## Appendix

### Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2024.03.014.

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