Case 02

CRT-D IMPLANTATION IN PERSISTENT LEFT SUPERIOR VENA CAVA: OVERCOMING COMPLEX VENOUS ANATOMY WITH SNARE-ASSISTED LEAD DELIVERY TECHNIQUES



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CASE BRIEF

A 64-year-old female, a diagnosed case of idiopathic dilated cardiomyopathy, presented with recurrent heart failure symptoms (New York Heart Association Class III) despite being on guideline-directed medical therapy. The 12-lead electrocardiogram showed left bundle branch block with a QRS duration of 160 ms. Echocardiography revealed a left ventricular end-diastolic volume of 344 mL and left ventricular end-systolic volume of 268 mL with a severely reduced left ventricular ejection fraction of 22%. In view of persistent symptoms and severe left ventricular dysfunction, a decision was made to proceed with cardiac resynchronization therapy-defibrillator implantation after stabilization.

Left coronary angiogram in the venous phase revealed a dilated coronary sinus with a prominent lateral vein. Bilateral venography demonstrated the coexistence of both right superior vena cava and persistent left superior vena cava without the presence of an interconnecting vein **(Figs. 1A and B, (Video 1 and 2)**. Selective angiography of the coronary sinus through the persistent left superior vena cava (PLSVC) revealed that the origin of the lateral vein exhibited an almost hairpin bend angle as it took off from the coronary sinus **(Fig. 1C)**.

While implantation from the right side through the right superior vena cava might appear technically simpler, right-sided implantable cardioverter-defibrillator implantation is associated with higher defibrillation thresholds compared to the left side.[4] Therefore, a decision was made to proceed with a left-sided approach via the PLSVC.

In pursuit of implanting the coronary sinus lead, multiple attempts were made to engage the lateral vein through the PLSVC **(Video 3)**. Owing to the superior take-off and sharp hairpin bend of the lateral vein, we attempted engagement using a Judkins right guiding catheter (Medtronic, Minneapolis, MN), an internal mammary guiding catheter (Medtronic), and a hockey stick guiding catheter (Boston Scientific, Marlborough, MA) **(Fig. 1D)**. A 0.014-inch hydrophilic guidewire (HI-TORQUE WHISPER ES guidewire; Abbott Vascular, Abbott Park, IL) was used in an attempt to cross the bend; however, these attempts were unsuccessful.

Following several attempts, successful engagement of the lateral vein was achieved using a 6 Fr Extra Back-Up guiding catheter 3.5 (Medtronic) **(Fig. 2A and Video 4)**. The favorable curvature of the EBU catheter allowed alignment with the superior origin of the lateral vein. A whisper wire was then advanced into the lateral vein and navigated deep into the right atrium through venous collaterals.

In anticipation of the difficulty associated with delivering the coronary sinus lead across a reverse angle, a sub-selector (St Jude Medical CPS Aim SL inner catheter; Abbott) was used to negotiate the bend **(Fig. 2B and**

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Video 5). Despite improved support from the deep wire position and subselector catheter, advancement of the quadripolar coronary sinus lead (St Jude Medical Quartet 1458Q; Abbott) remained difficult due to the reverse angle and hairpin bend.

To overcome this limitation, a snare-assisted venovenous loop technique was employed. The guidewire was advanced into the right atrium through venous collaterals, and its distal end was subsequently snared via femoral venous access using a 10-mm endovascular snare (Merit Medical, South Jordan, UT) introduced through a 6-Fr Judkins right guiding catheter **(Figs. 2C and D,Video 6)**. During snaring, the wire slipped partially **(Video 7)**; however, a significant portion remained within the guiding catheter. To stabilize the system, a coronary angioplasty balloon (Sprinter 2.5 × 15 mm; Medtronic) was advanced through the femoral route and inflated at 14 atm near the tip of the guiding catheter **(Fig. 2E and Video 8)**. This maneuver secured the wire and created a stable venovenous rail, providing the necessary support for lead delivery.

Using this enhanced support, the quadripolar coronary sinus lead was successfully advanced and positioned in the lateral vein with acceptable electrical parameters (pacing threshold 1.5 V @ 0.5 ms; pacing impedance 760 Ω) **(Fig. 2F and Video 9)**.

Subsequently, the alpha loop technique was employed for right ventricular lead placement. Using a combination of J-shaped and U-shaped stylets with repeated manipulation and adjustment of stylet curvature, a loop was created within the right atrium to direct the lead toward the tricuspid valve. This allowed successful placement of a single-coil implantable cardioverter-defibrillator lead (St Jude Medical Durata 7122Q, 58 cm; Abbott) in the right ventricular apex with stable electrical parameters (sensed R wave 10.2 mV; pacing threshold 0.9 V @ 0.4 ms; pacing impedance 520 Ω) **(Video 10)**.

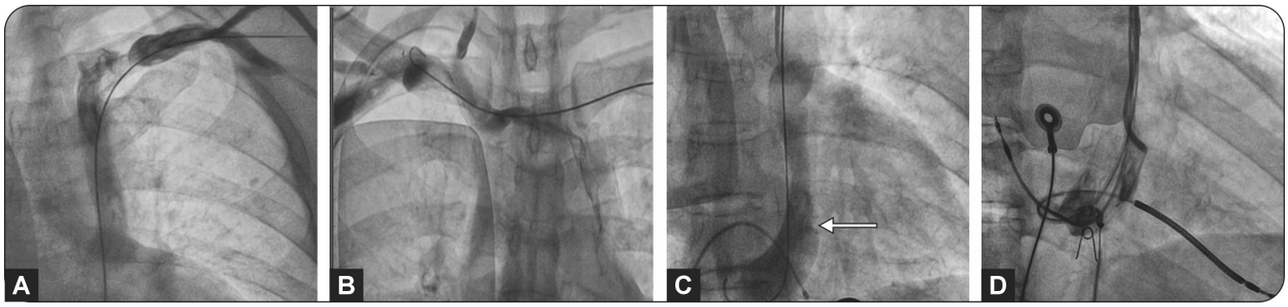
Finally, an active-fixation right atrial lead (St Jude Medical Tendril STS, 52 cm; Abbott) was positioned in the right atrial appendage without difficulty. The total procedural time was 188 minutes, and the fluoroscopy time was 66 minutes. The procedure was completed successfully without complications, and all lead parameters remained stable.

ABSTRACT

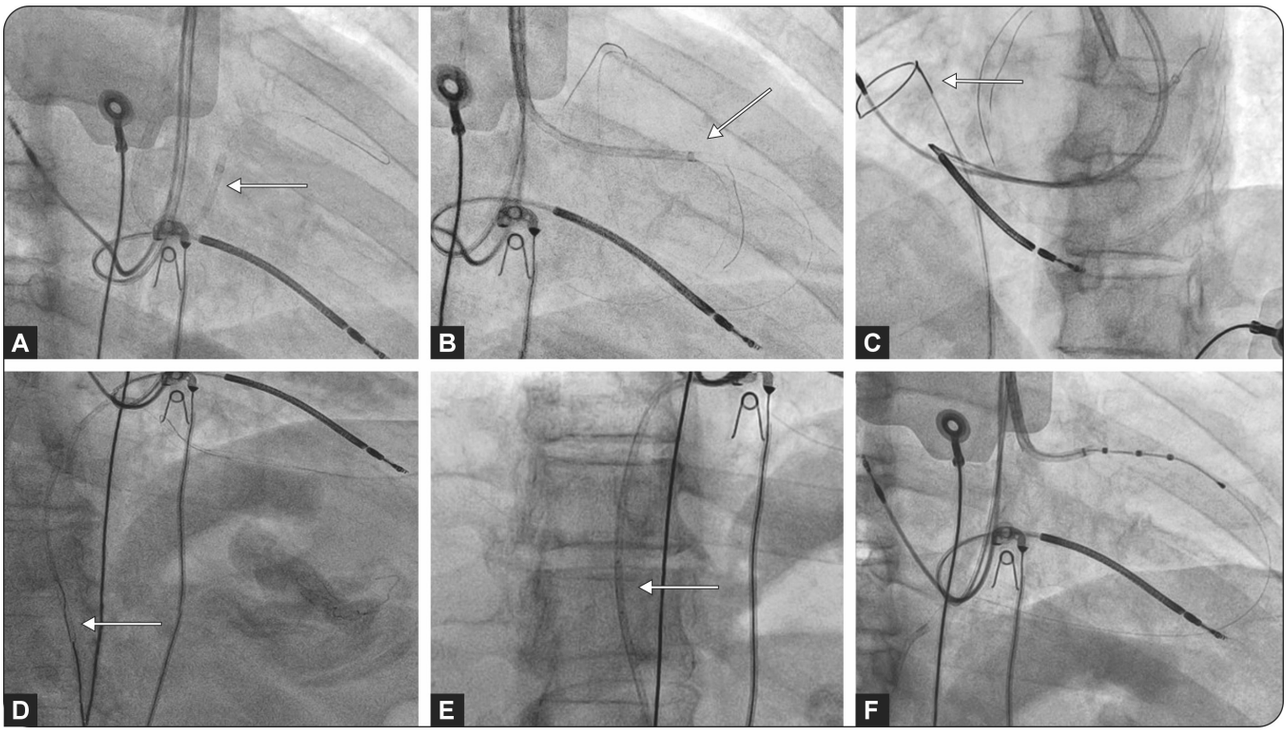
Persistent left superior vena cava (PLSVC) is a rare congenital venous anomaly that can pose significant technical challenges during cardiac resynchronization therapy (CRT) implantation. We report a case of a 64-year-old female with dilated cardiomyopathy, severe left ventricular dysfunction, and left bundle branch block who underwent successful cardiac resynchronization therapy-defibrillator (CRT-D) implantation via PLSVC. Venous imaging revealed the absence of an interconnecting innominate vein and a lateral coronary sinus branch with a sharp hairpin angulation. Multiple conventional catheter strategies failed to achieve stable left ventricular lead positioning. A snare-assisted venovenous loop technique via femoral access was employed to enhance support and facilitate successful lead delivery. Right ventricular lead placement was accomplished using the alpha loop technique. The procedure was completed successfully with stable electrical parameters and no complications. This case highlights the importance of detailed anatomical assessment and advanced technical strategies in achieving successful CRT implantation in challenging venous anatomy.

INTRODUCTION

Persistent left superior vena cava (PLSVC) is an uncommon congenital anomaly with a reported prevalence of approximately 0.3–0.5% in the general population.[1] It results from the persistence of the left superior cardinal vein and typically drains into the right atrium (RA) via a dilated coronary sinus (CS).[2] Although usually asymptomatic, its presence becomes clinically significant during cardiac implantable electronic device procedures, particularly cardiac resynchronization therapy (CRT), where it introduces substantial technical challenges.[3] These challenges include difficulty in coronary sinus cannulation, acute angulation of its tributaries, and an unfavorable trajectory for right ventricular (RV) lead placement.



Figs. 1A to D: (A) Coronary angiogram in venous phase demonstrating a dilated coronary sinus with a prominent lateral vein; (B) Bilateral venography showing coexistence of right superior vena cava and persistent left superior vena cava without an interconnecting innominate vein; (C) Selective coronary sinus angiogram via persistent left superior vena cava demonstrating a dilated coronary sinus with the lateral vein arising at a sharp hairpin angle (arrow denotes) and (D) Multiple unsuccessful attempts to engage the lateral vein using different guiding catheters, including Judkins right, internal mammary, and hockey stick catheters.



Figs. 2A to F: (A) Successful engagement of the lateral vein using a 6 Fr Extra Back-Up guiding catheter (arrow denotes); (B) Use of a sub-selector (arrow denotes) catheter to facilitate navigation across the sharply angulated lateral vein; (C and D) Advancement of the guidewire into the right atrium through venous collaterals and snaring of the guidewire (arrow denotes) via femoral venous access to create a venovenous loop; (E) Inflation of a coronary angioplasty balloon (arrow denotes) within the guiding catheter to stabilize the system and enhance support and (F) Final successful positioning of the quadripolar coronary sinus lead in the lateral vein with stable lead parameters.

DISCUSSION

Persistent left superior vena cava represents an important anatomical variant that significantly influences procedural strategy during cardiac resynchronization therapy implantation.[5] In this case, the absence of an interconnecting innominate vein (Schummer type IIIb) necessitated reliance on the PLSVC route, thereby increasing procedural complexity.

The major challenge was engagement and delivery of the left ventricular lead into a lateral vein with a superior

take-off and sharp hairpin angulation. Conventional catheters failed to achieve alignment, whereas the extra back-up guiding catheter provided optimal orientation. However, inadequate support required the use of a snare-assisted venovenous loop technique, which created a stable rail and significantly enhanced support for lead delivery.

Right ventricular lead placement was also challenging due to the acute angle between the coronary sinus and tricuspid valve. The alpha loop technique proved essential in overcoming this difficulty by enabling redirection of the lead into the right ventricle through controlled loop formation in the right atrium.

Preprocedural bilateral venography is crucial for identifying venous anatomy and guiding procedural strategy. With appropriate planning, use of specialized tools, and operator expertise, successful CRT implantation can be achieved even in complex PLSVC anatomy.

CONCLUSION

Persistent left superior vena cava poses significant technical challenges during CRT implantation; however, it does not preclude success. With appropriate planning and advanced techniques such as snare-assisted support and alpha-loop RV lead placement, successful outcomes can be consistently achieved in such complex cases.

LEARNING POINTS

- Persistent left superior vena cava significantly alters venous anatomy and requires detailed preprocedural imaging for optimal CRT planning.
- Snare-assisted venovenous loop technique is highly effective in overcoming inadequate support during left ventricular lead delivery in complex anatomy.
- The alpha-loop technique is a key maneuver for successful right ventricular lead placement in PLSVC cases.

REFERENCES

1. Azizova A, Onder O, Arslan S, et al. Persistent left superior vena cava: clinical importance and differential diagnoses. Insights Imaging. 2020;11(1):110.
2. Dave V, Sesham K, Mehra S, et al. Persistent left superior vena cava: an anatomical variation. Med J Armed Forces India. 2022;78(Suppl 1):S277-81.
3. Bera D, Bachani N, Pawar P, et al. Cardiac resynchronization therapy device implantation in a patient with a persistent left superior vena cava without a communicating innominate vein. Indian Pacing Electrophysiol J. 2018;18:112-4.
4. Friedman PA, Rasmussen MJ, Grice S, et al. Defibrillation thresholds are increased by right-sided implantation of totally transvenous implantable cardioverter defibrillators. Pacing Clin Electrophysiol. 1999;22:1186-92.
5. Schummer W, Schummer C, Fröber R. Persistent left superior vena cava and central venous catheter position: clinical impact illustrated by four cases. Surg Radiol Anat. 2003; 25:315-21.