Dual-Chamber Pacemaker Implantation Through a Persistent Left Superior Vena Cava With Absent Right Superior Vena Cava: The Alpha-Loop Technique.

ABSTRACT:

Persistent left superior vena cava (PLSVC) is the most common thoracic venous anomaly, but its coexistence with an absent right superior vena cava (RSVC) is uncommon and may make transvenous cardiac device implantation technically challenging. A 56-year-old woman with recurrent syncope and complete atrioventricular block underwent temporary pacing followed by planned dual-chamber permanent pacemaker implantation. Left-sided venography demonstrated drainage through a PLSVC into the coronary sinus and right atrium. Right-sided venography showed drainage through the innominate vein into the PLSVC, confirming absence of the RSVC. Because the coronary sinus-to-tricuspid valve trajectory was unfavorable for direct right ventricular lead delivery, the ventricular lead was advanced through the PLSVC and coronary sinus into the right atrium and an alpha-loop was created using stylet manipulation. This facilitated prolapse of the lead across the tricuspid valve and stable positioning at the right ventricular apex. A right atrial lead was also successfully positioned, and satisfactory acute pacing parameters were obtained. Recognition of anomalous systemic venous anatomy and deliberate loop formation can permit conventional transvenous dual-chamber pacing in patients with PLSVC and absent RSVC.

Learning objective

Persistent left superior vena cava with absent right superior vena cava can substantially complicate transvenous pacemaker implantation because the lead enters the right atrium through the coronary sinus and approaches the tricuspid valve at an unfavourable angle. Venography should be considered when the venous course is unexpected. Creation of an alpha-loop in the right atrium using appropriate stylet shaping and controlled lead prolapse can facilitate tricuspid valve crossing and stable right ventricular lead placement.

Keywords: Persistent left superior vena cava; Absent right superior vena cava; Permanent pacemaker; Alpha-loop; Cardiac implantable electronic device

1.Introduction: Persistent left superior vena cava (PLSVC) results from persistence of the embryonic left anterior cardinal vein and is encountered in approximately 0.3–0.5% of the general population, with a higher prevalence among patients with congenital heart disease. Although many cases are clinically silent, the anomaly becomes important during central venous access and transvenous cardiac implantable electronic device procedures. The combination of PLSVC and absent right superior vena cava (RSVC) is particularly uncommon. In this anatomy, pacing leads introduced from the upper venous system reach the right atrium through the coronary sinus, creating an unfavorable orientation toward the tricuspid valve and making right ventricular lead placement difficult. We report successful dual-chamber pacemaker implantation using deliberate alpha-loop formation to overcome this anatomical challenge.

2. **Case Report:**A 56-year-old woman was admitted with recurrent episodes of syncope during the preceding 6 months. She had no history of chest pain or dyspnea. On the index presentation, loss of consciousness lasted approximately 2 minutes. Blood pressure was 150/88 mmHg and heart rate was 60 beats/min; neurological status was intact (Glasgow Coma Scale score 15/15). Electrocardiography demonstrated complete atrioventricular block. An urgent temporary transvenous pacemaker was inserted through the femoral venous route under fluoroscopic guidance. The temporary pacing threshold was 1.0 V, the programmed output was 5.0 V, and the pacing rate was 80 beats/min. Transthoracic echocardiography showed preserved left ventricular systolic function with an ejection fraction of 60%. In view of symptomatic complete atrioventricular block, dual-chamber permanent pacemaker implantation was planned.

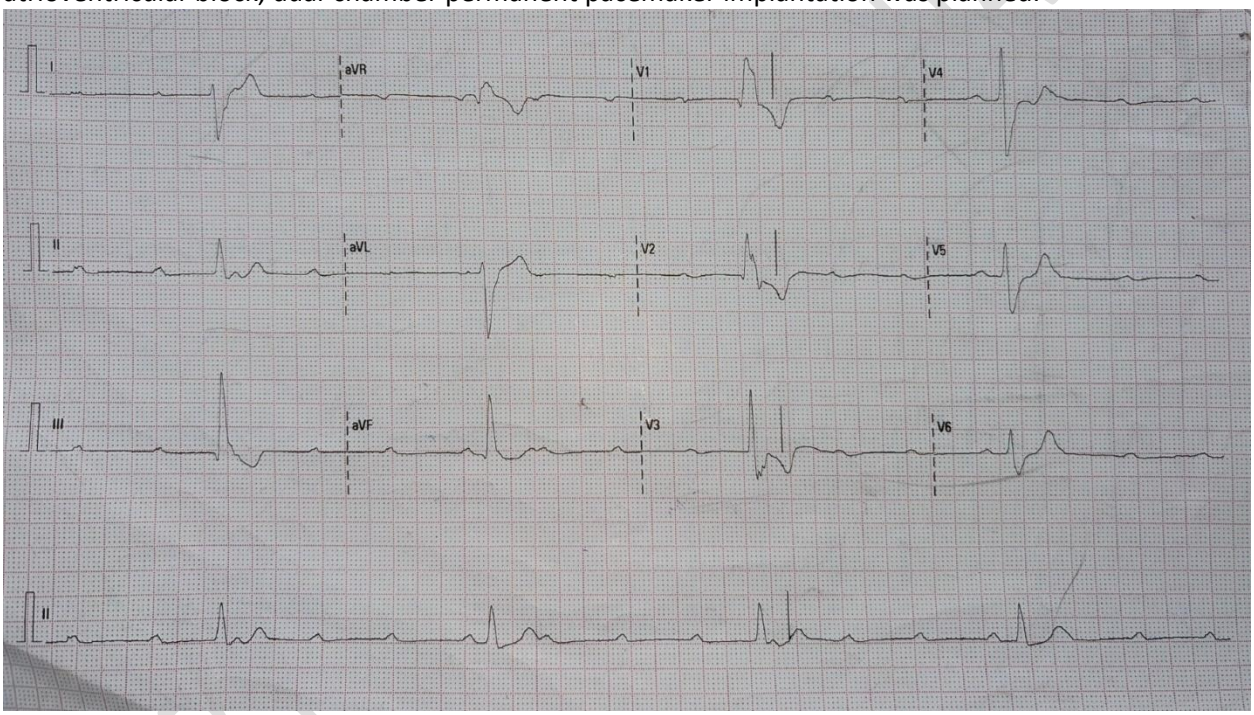

Figure 1.12 lead ECG :

2.1 Implantation Procedure: Venography from the left subclavian venous system showed contrast descending along the left side of the mediastinum through a PLSVC and entering the right atrium through the coronary sinus (Figure 2A). A right-sided approach was then evaluated. Right subclavian venography demonstrated passage of contrast through the innominate vein toward the left side and subsequently into the PLSVC, with no RSVC visualized (Figure 2B). These findings established PLSVC with absent RSVC.

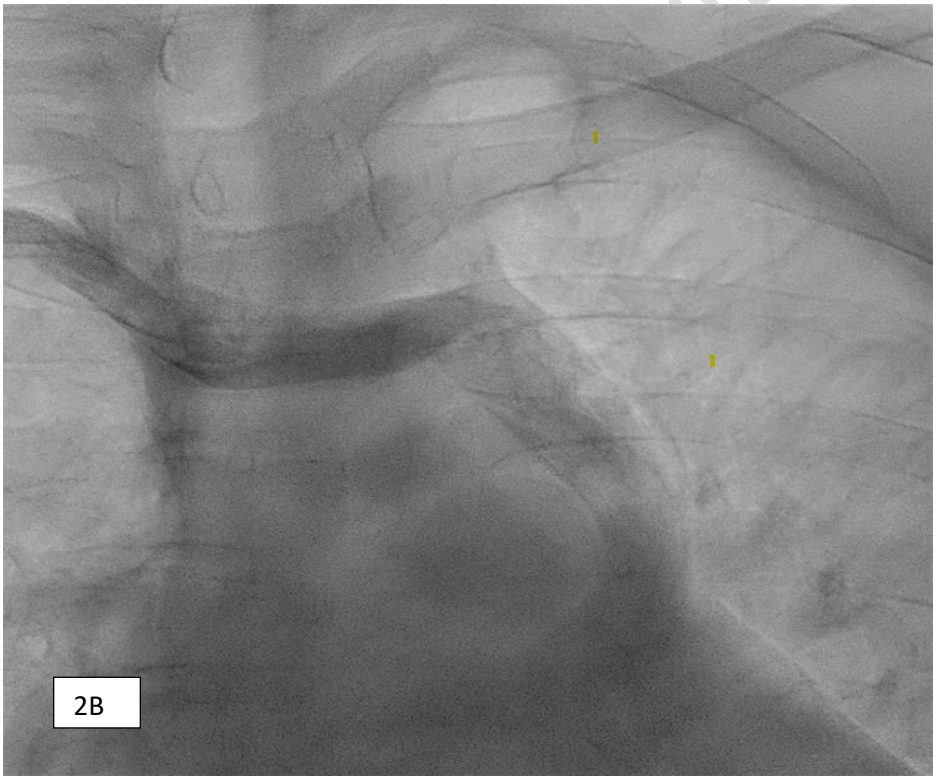

Figure 2. Persistence Left Superior Vena Cava and Absence of Right Superior Vena Cava. A) The Venography from Left Subclavian Vein Revealed the Presence of Persistence Left Superior Vena Cava. B) The Venography from Right Subclavian Vein: Dye Passed Through Innominate Vein and Then Drained into Persistence Left Superior Vena Cava.

A left axillary venous approach was therefore used. The ventricular lead followed the course left axillary vein → PLSVC → coronary sinus → right atrium. After the lead reached the right atrium with a straight stylet, the straight stylet was exchanged for a curved stylet and the lead was directed toward the lateral/anterolateral right atrial wall and tricuspid valve. The stylet was then withdrawn by approximately 3–5 cm while the lead was advanced in a controlled fashion, allowing the lead body to prolapse and form an alpha-loop within the right atrium. This maneuver redirected the lead tip across the tricuspid valve into the right ventricle, where stable apical positioning was achieved (Figure 3). The right atrial lead was subsequently positioned successfully through the same anomalous venous route.

The leads were connected to a Medtronic pulse generator and programmed in DDDR mode. Acute right atrial and right ventricular pacing thresholds were 0.5 V and 0.4 V, respectively; lead impedances were 513 Ω and 830 Ω, respectively. The measured atrial electrogram amplitude was 1.75 mV. The patient remained clinically stable and was discharged with satisfactory pacing and sensing parameters. At 6-month follow-up, pacemaker interrogation demonstrated normal device function with 99% ventricular pacing. Lead impedance remained within the normal range, and no device-recorded events were noted

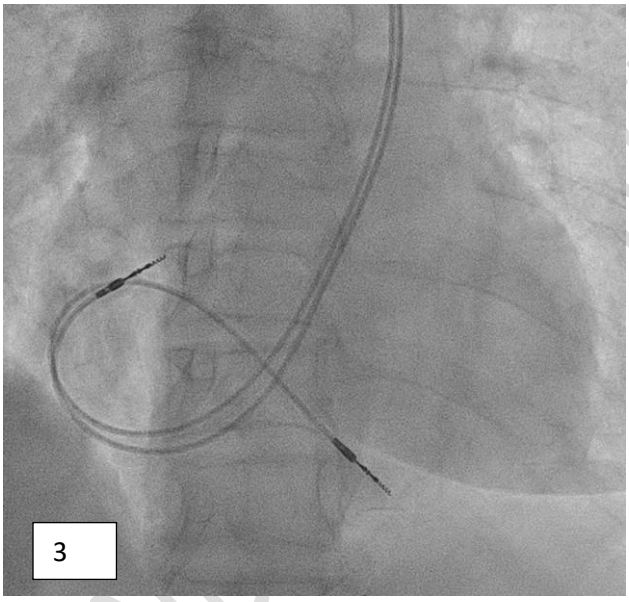

Figure 3The Right Atrium and Right Ventricle Leads Implantation Was Performed via the Persistent Left Superior Vena Cava

3. Discussion:

Persistent left superior vena cava (PLSVC) is the most common congenital anomaly of the thoracic venous system, occurring in approximately 0.3–0.5% of the general population. However, the coexistence of PLSVC with an absent right superior vena cava (RSVC) is considerably less common, with a reported prevalence of approximately 0.09–0.13% [1–5]. In most patients, PLSVC drains into the right atrium through the coronary sinus and does not cause significant hemodynamic disturbance.

Consequently, the anomaly often remains clinically silent and may only become apparent during central venous access, electrophysiological procedures, or cardiac device implantation [2–4].

In our patient, the anomalous venous anatomy was discovered unexpectedly during pacemaker implantation. Left-sided venography demonstrated drainage through the PLSVC into the coronary sinus and subsequently the right atrium. At this stage, changing to a right-sided approach appeared to be a possible solution. However, right-sided venography showed that the right subclavian venous return crossed through the innominate vein and entered the PLSVC, confirming absence of the RSVC. This finding was important because simply changing the side of implantation would not provide the usual RSVC–right atrial route. Similar anatomical configurations have been described in previous reports of pacemaker implantation in patients with PLSVC and absent RSVC [5,13,14].

The major challenge in our case was not obtaining venous access, but directing the ventricular lead across the tricuspid valve. In normal anatomy, a lead entering the right atrium through the RSVC is naturally oriented toward the tricuspid valve. With a PLSVC, the lead reaches the right atrium through the coronary sinus, creating an unfavourable angle between the coronary sinus ostium and the tricuspid valve. As a result, the lead tends to be directed away from the tricuspid orifice, making direct advancement into the right ventricle difficult [9–14]. This represents one of the principal technical challenges of pacemaker implantation through a PLSVC. Contemporary experience continues to identify lead orientation and manipulation as central procedural difficulties in this anatomy.

We encountered exactly this problem. Although the ventricular lead could be advanced through the left axillary vein, PLSVC, and coronary sinus into the right atrium, repeated direct advancement did not provide a favourable trajectory toward the tricuspid valve. We therefore used the right atrial cavity itself to redirect the lead. After advancing the lead into the right atrium with a straight stylet, the stylet was exchanged for a curved stylet and the lead was directed toward the lateral/anterolateral right atrial wall. The stylet was then withdrawn by approximately 3–5 cm while the lead was gently advanced. This allowed the lead to prolapse and form a broad alpha-loop within the right atrium. The loop changed the direction of the lead tip toward the tricuspid valve, permitting successful passage into the right ventricle and stable positioning at the RV apex.Importantly, the satisfactory procedural result was maintained during follow-up. At 6 months, device interrogation demonstrated normal pacemaker function with 99% ventricular pacing, normal lead impedance, and no recorded events. This finding is reassuring regarding lead stability despite the unusual venous course and the right atrial loop required for ventricular lead placement

Loop formation within the right atrium is a useful way of overcoming this unfavourable geometry and has been described in different forms in previous reports [9–14]. Various investigators have used manually shaped, curved, or J-shaped stylets to create a sufficiently large atrial loop and redirect the ventricular lead toward the tricuspid valve. Our case therefore does not suggest that transvenous pacing through this anatomy is unprecedented. Rather, its practical value lies in demonstrating a simple and reproducible stylet-based alpha-loop maneuver that allowed conventional ventricular lead implantation despite the unfavourable coronary sinus–tricuspid valve relationship. No specialized delivery system was required. The key was to avoid forcing the lead directly toward the tricuspid valve and instead create a sufficiently broad right atrial loop to obtain a more favourable direction for valve crossing.

This experience also emphasizes the importance of defining the venous anatomy before prolonged lead manipulation. An abnormal guidewire or lead course should raise suspicion of a systemic venous

anomaly. A dilated coronary sinus on echocardiography may provide an initial clue to PLSVC, while venography can rapidly establish the venous pathway during implantation. Cross-sectional imaging with computed tomography or magnetic resonance imaging may provide additional anatomical information when required [6–8]. In our patient, bilateral venography was particularly useful because it not only demonstrated the PLSVC but also confirmed absence of the RSVC and explained why changing to a right-sided approach would not circumvent the anatomical difficulty.

Several strategies may be considered when conventional lead advancement through a PLSVC is difficult, including modification of stylet shape, creation of a large right atrial loop, active-fixation leads, and dedicated delivery sheaths or catheter-based systems [9–14]. Recent experience continues to demonstrate that successful conventional pacing is possible even when the RSVC is absent, provided that the venous anatomy is understood and the implantation strategy is adapted accordingly.

The present case highlights two simple but important procedural lessons. First, when an unexpected venous course is encountered during pacemaker implantation, defining the anatomy is more useful than repeatedly attempting lead advancement or simply changing the side of access. Second, when the ventricular lead emerging from the coronary sinus cannot be aligned with the tricuspid valve, creation of a broad right atrial alpha-loop may provide an effective way of redirecting the lead. Familiarity with this maneuver can allow successful conventional dual-chamber pacemaker implantation even in the challenging combination of PLSVC and absent RSVC.

Conclusion:

In conclusion, PLSVC with absent RSVC is an uncommon systemic venous anomaly that can make transvenous pacemaker implantation technically challenging. Careful delineation of the venous anatomy by venography and creation of a broad right atrial alpha-loop can overcome the unfavorable coronary sinus–tricuspid valve geometry and facilitate successful right ventricular lead placement using conventional equipment. In our patient, satisfactory device function was maintained at 6-month follow-up. Familiarity with this simple maneuver may help operators manage similar unexpected venous anatomy during pacemaker implantation.

Acknowledgments: There is no acknowledgement.

Authors' Contribution: Akash Swain contributed to the conception of the case report, data collection, literature review, and drafting of the manuscript. Barun Kumar supervised the clinical management of the patient, contributed to the conception of the report, and critically revised the manuscript for important intellectual content. Aditya Agarwal, and Akash Paruthi contributed to patient management, data acquisition, and critical revision of the manuscript. All authors reviewed and approved the final version of the manuscript

Informed Consent: Written informed consent was obtained from the patient for publication of this case report and the accompanying clinical images

Conflict of Interest: The authors have no conflicts of interest.

Funding/Support: No funding required

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