Left ventricular lead implantation using the crossover technique in a steeply bifurcated lateral branch

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Introduction

Cardiac resynchronization results in significant clinical improvement in patients with moderate-to-severe heart failure and delayed intraventricular conduction.[1] However, the ability to place stable pacing leads in the coronary sinus (CS) tributaries for left ventricle (LV) pacing remains a major limiting factor. The high degree of variability in the coronary venous anatomy poses a challenge to implanting electrophysiologists.[2]

The endovascular therapy (EVT) for lower extremity artery disease has developed remarkably in recent years, in terms of both interventionists' techniques and catheter devices.[3] In this field, the crossover technique[4] is a common strategy for crossing a wire from the ipsilateral to the contralateral iliac artery using a 4F deep-angle angiographic catheter (TEMPO SIM1; Cordis, Miami, FL) (Supplemental Figure 1).

We describe a case of a successful delivery of the LV lead to a remarkably steep lateral branch using the TEMPO SIM1 catheter–based crossover technique.

KEY TEACHING POINTS

- The steep angle of the lateral veins is an anatomical problem with left ventricular (LV) lead implantation.
- The angle between the coronary sinus and lateral branch was distributed between 22.7 and 160.0 degrees in the 5-year database, with the present case being the steepest at 22.7 degrees.
- The crossover technique using the TEMPO SIM1 (Cordis, Miami, FL) catheter, a common strategy in endovascular therapy, may be useful for LV lead implantation in patients with a steeply bifurcated lateral branch.

Case report

A 67-year-old male patient with nonischemic cardiomyopathy, permanent atrial fibrillation, and advanced heart failure experienced a complete atrioventricular block during outpatient follow-up. Electrocardiography revealed atrial fibrillation with a regular junctional rhythm (37 beats/min) (Figure 1A). Holter electrocardiography showed a total heart beats of 54,229 beats/min over a 24-hour period, with a minimum heart rate of 27 beats/min. His cardiothoracic ratio was 66.4%, and serum brain natriuretic peptide (BNP) concentration was 511 pg/mL. Echocardiography showed a remarkably enlarged left atrium (left atrial dimension, 86 mm) and enlarged LV with low systolic LV function (LV end-diastolic diameter, 68 mm; LV ejection fraction, 33%) (Figure 1B). Nonsustained ventricular tachycardia was also observed; thus, we decided to implant a cardiac resynchronization therapy (CRT) defibrillator to resolve the symptoms of decompensated heart failure.

A shock lead (6935M Sprint Quattro Secure S, TDL261345G; Medtronic, Minneapolis, MN) was positioned at the right ventricle; the right ventricular pacing threshold was 0.75 V at 0.4 ms. CS venography showed a tortuous lateral vein that branched off at a steep angle from the giant CS (Figure 2A). This steeply angled lateral branch was the only candidate vessel for LV lead implantation.

Although lead-guiding catheter cannulation was expected to be difficult, a 4F deep-angle angiographic catheter (TEMPO SIM1) was successfully inserted into the lateral vein (Figure 2B). Subsequently, a microcatheter (Corsair PV; ASAHI INTECC, Aichi, Seto, Japan) and 0.014-inch guidewire (Cruise; ASAHI INTECC) for EVT enabled the passage of the tortuous lateral vein. The wire was advanced in the shape of a knuckle to avoid damaging the vessels. The Cruise wire tip was advanced into the superior vena cava for sufficient backup force and the Corsair PV microcatheter was inserted deep into the CS bifurcation

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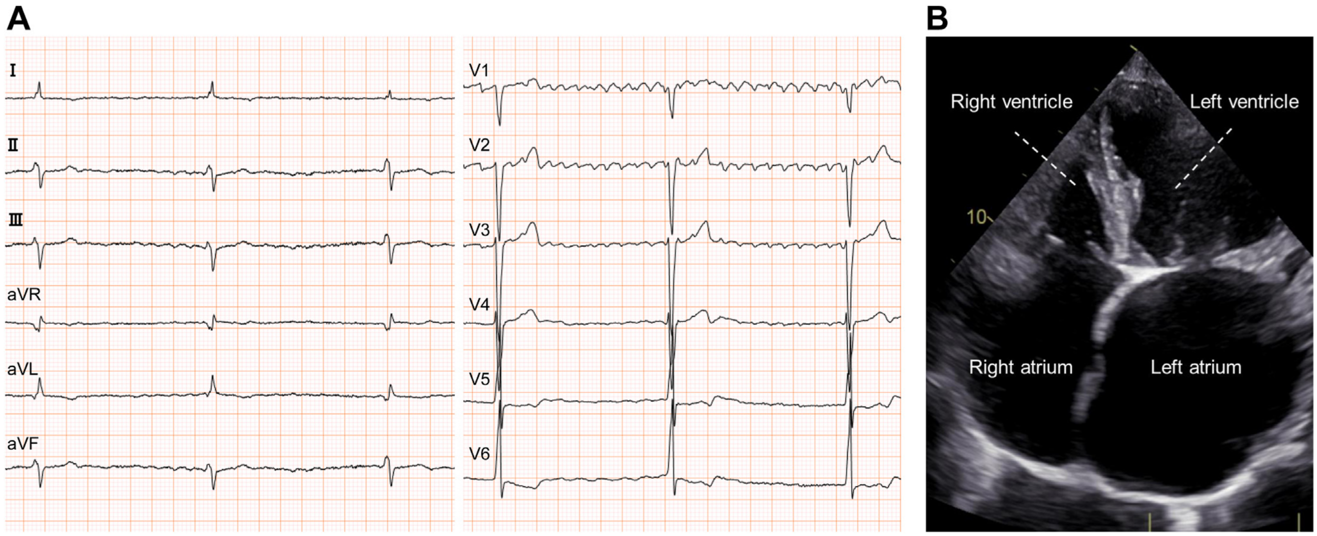

Figure 1 **A:** A 12-lead electrocardiogram before device implantation. **B:** Echocardiography 4-chamber view before device implantation. The left atrium shows significant enlargement.

(Figure 2C). After removal of the TEMPO SIM1 catheter, the Corsair PV microcatheter was slowly withdrawn. Once the Cruise wire was placed in the superior vena cava, the backup force improved sufficiently to allow for the easy advancement of the LV lead-guiding catheter (Figure 2D). The LV lead (4798 Attain Stability Quad MRI, QFX09878V; Medtronic) was successfully implanted in the mid portion of the lateral vein (Figure 2E). The LV lead pacing threshold was 0.5 V at 0.4 ms from electrode 2–3 without phrenic nerve stimulation. These leads were connected to a CRT defibrillator (DTPA2QQ Cobalt XT HF Quad CRT Defibrillator; Medtronic). The QRS complex (122 ms) was observed after

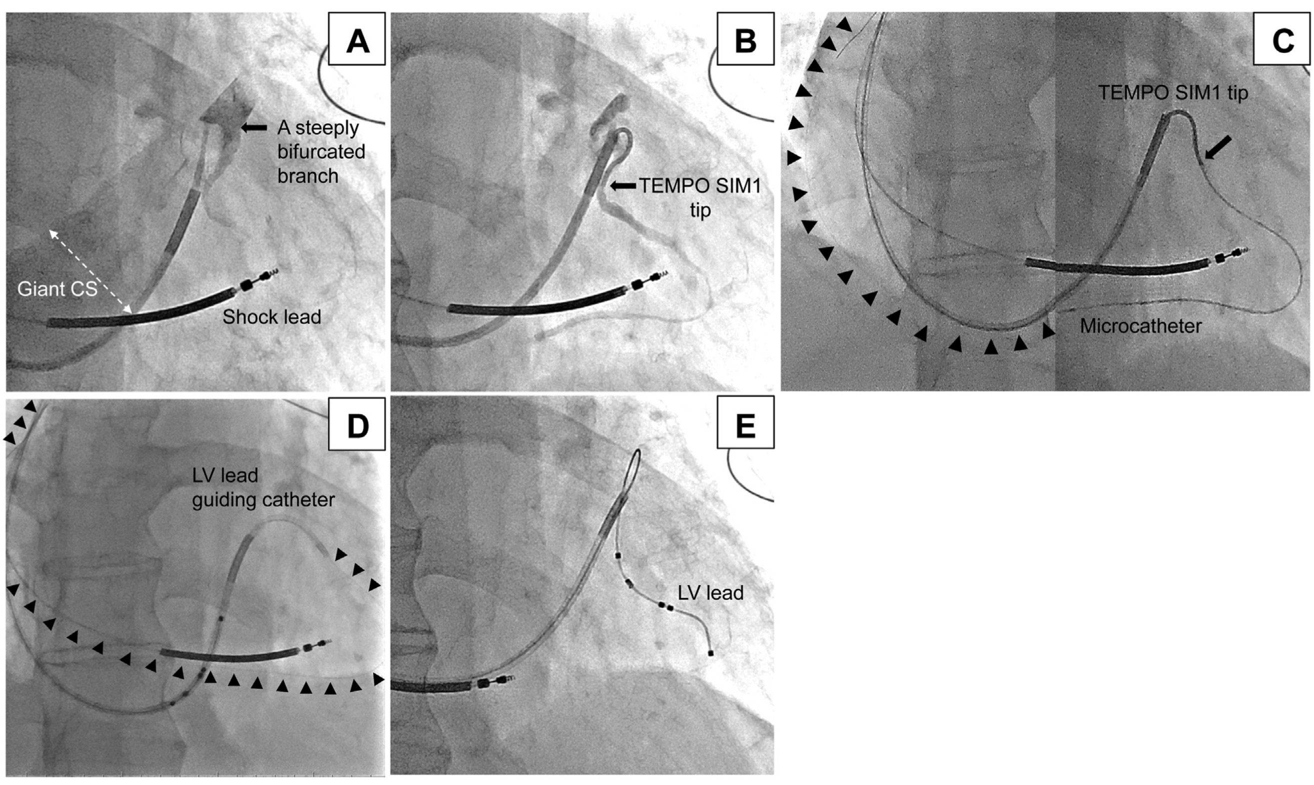

Figure 2 **A:** Coronary venography showing the steep branching of a lateral vein from the giant coronary sinus (CS). **B:** Successful engagement of the steeply branched lateral vein using the TEMPO SIM1 catheter (Cordis, Miami, FL). Lateral vein contrast with the TEMPO SIM1 catheter. **C:** A microcatheter and 0.014-inch stainless steel core guidewire for endovascular therapy enabled passage through the tortuous lateral vein. The wire (*arrowheads*) was placed in the superior vena cava (SVC). **D:** Placing the 0.014-inch wire tip in the SVC allowed for the easy advancement of the left ventricular (LV) lead–guiding catheter. **E:** The LV lead was successfully implanted at the mid portion of the lateral vein.

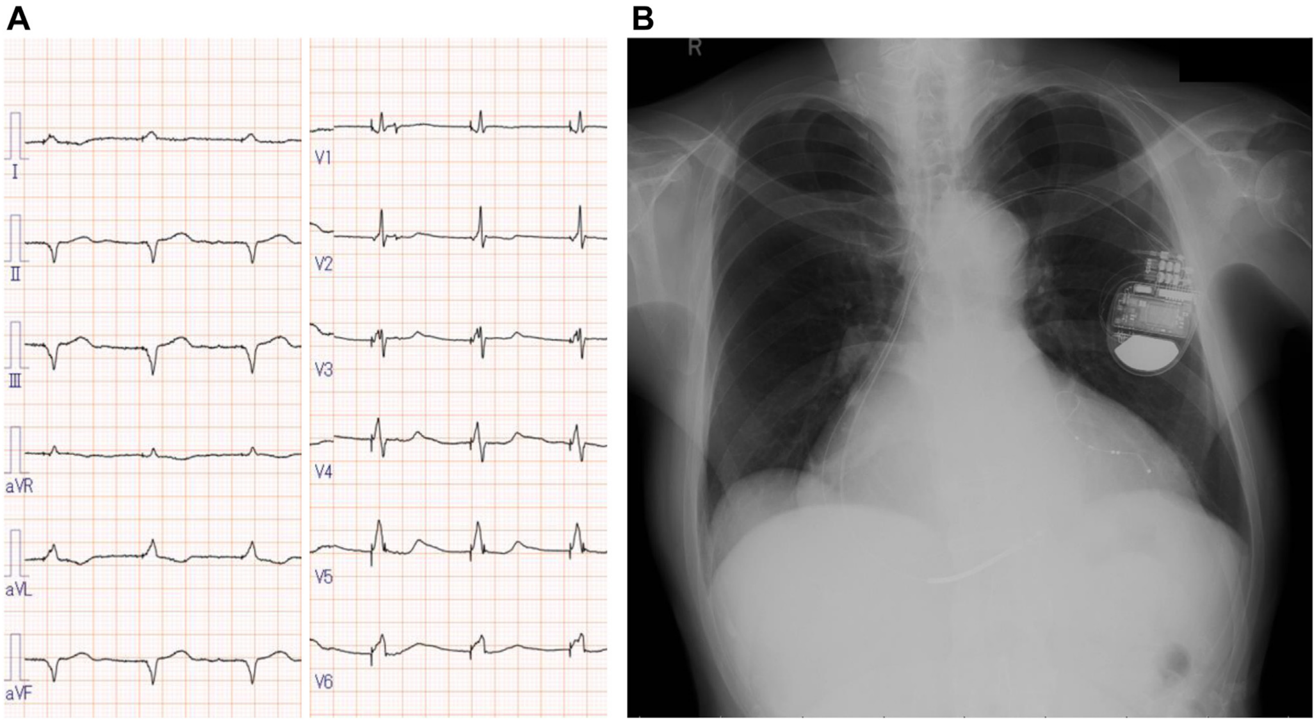

Figure 3 **A:** Twelve-lead electrocardiogram after device implantation. **B:** Chest radiography showing 60.5% cardiothoracic ratio after device implantation.

successful device implantation (Figure 3A). After implantation of the CRT defibrillator, the serum BNP concentration was 134 pg/mL and cardiothoracic ratio improved to 60.5% (Figure 3B). No complications occurred during or after the procedures. The patient remained stable during the 6-month follow-up period.

Crossover technique using TEMPO SIM1 catheter during LV lead implantation

To apply the crossover technique using the TEMPO SIM1 catheter for LV lead implantation, 55 consecutive patients were studied who underwent CRT device implantation at Yamagata University Hospital over a 5-year period. The clinical characteristics of the patients are summarized in Table 1. The mean age was 67 ± 9 years, and 39 patients (71%) were male. The mean left ventricular ejection fraction was 31% ± 8%. The median serum BNP level was 198 pg/mL (range, 86–410 pg/mL). There were 46 (84%) and 9 (16%) patients implanted with CRT defibrillators and CRT pacemakers, respectively. The angles of the CS and lateral branches were measured using the right anterior oblique view of CS venography. The angles of CS and lateral branch were distributed between 22.7 and 160.0 degrees, with a mean angle of 114.3 ± 31.9 degrees. The angle in the present case was the steepest, at 22.7 degrees. Among the 55 consecutive CRT implantations, 2 patients (3.6%) required advanced techniques for LV lead implantation. In addition, we investigated patients who underwent EVT for lower extremity artery disease. Among 375 consecutive patients who underwent EVT over a 3-year period, 20 required a TEMPO SIM1 catheter for wire crossing from the ipsilateral iliac artery to the contralateral iliac artery. The aortoiliac bifurcation angles were distributed between 18.4 and 88.0 degrees, with a mean angle of 55.5 ± 18.4 degrees (Supplemental Figure 2).

Table 1 Clinical characteristics of patients with cardiac resynchronization therapy device implantation

	All patients (n = 55)
Age (years)	67 ± 9
Male, n (%)	39 (71)
Etiology, n (%)	
Ischemic	16 (29%)
Nonischemic	39 (71%)
LVEF (%)	31 ± 8
BNP (pg/mL)	198 (86–410)
CRT-D/CRT-P, n (%)	46 (84%) / 9 (16%)
Angle of coronary sinus and lateral branch (degrees)	114.3 ± 31.9
Advanced technique for LV lead implantation[†]	2 (3.6)

Data are expressed as mean ± SD, number (percentage), or median (interquartile range).

BNP = brain natriuretic peptide; CRT-D = cardiac resynchronization therapy defibrillator; CRT-P = cardiac resynchronization therapy pacemaker; LVEF = left ventricular ejection fraction.

[†]Advanced techniques included the anchor balloon[8] and crossover techniques in the present case.

Discussion

Steep-angle and tortuous lateral branches are commonly encountered challenges during device implantation and may require an array of tools to overcome. LV lead implantation was difficult in 2.4% of cases owing to anatomical problems.[5] Among the inhibiting factors are well-known anatomical problems, such as stenosis and steep angulation of the lateral vein. Coronary vein venoplasty, stenting of the lateral vein, and the anchor balloon technique[6–8] have been reported for insertion of the pacing lead implant into the target vein. During the 5-year period at our hospital, 2 of 55 (3.6%) patients required special techniques owing to a tortuous or steeply angled lateral vein: the anchor balloon technique[8] was used in 1 patient and the crossover technique with a TEMPO SIM1 catheter for LV lead implantation was used in another patient (the current patient). The frequency of LV lead implantation requiring special techniques was similar to that reported in previous studies. Giant CS is often associated with persistent left superior vena cava (PLSVC). Although there have been several reports of successful LV lead implantation via the PLSVC, these cases did not have steeply bifurcated lateral veins.[9–12] The present case involved significant remodeling of the heart owing to more than 30 years of permanent atrial fibrillation. Unfortunately, the only target vein available was steeply angled along with an enlarged CS, similar to a PLSVC.

The crossover technique is a common EVT strategy for passing a wire from the ipsilateral to the contralateral iliac artery using a TEMPO SIM1 catheter. In the present case, specialist electrophysiologists were able to work with EVT specialists to overcome any difficulties. There are other catheters that may be helpful for lateral vein branch cannulation. The internal mammary and Judkins left 1.0 angiographic catheters are also available for the crossover technique in EVT. However, these catheters could be suitable for gently bifurcated vessels but not for steeply bifurcated challenging cases. A 9F internal diameter Braided Core Worley-STD anatomically shaped, peel-away sheath (Pressure Products, San Pedro, CA) is a great tool for implanting LV leads in a steeply bifurcated CS branch.[13] This catheter may be less readily available than the TEMPO SIM1 catheter. The TEMPO SIM1 catheter is simply rotated, adjusted the direction, and pulled in the lateral vein. A wire could be used to make the angle of the tip a little gentler in shape (Supplemental Figure 1C). Importantly, the TEMPO SIM1 catheter backup was sufficiently powerful, even for the giant CS. According to the additional investigation reviewing past EVT procedures, the crossover technique for aortoiliac bifurcation was performed between 18.4 and 88.0 degrees, with a mean angle of 55.5 ± 18.4 degrees. The present case details the steepest angle of the CS and lateral branch (22.7 degrees) seen in the 5-year database study period.

Conclusion

The crossover technique using the TEMPO SIM1 catheter is a useful strategy for wire insertion into steeply bifurcated CS branches. This technique contributes to successful LV lead implantation in difficult cases.

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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.2023.09.020.

References

1. Cazeau S, Leclercq C, Lavergne T, et al. Effects of multisite biventricular pacing in patients with heart failure and intraventricular conduction delay. N Engl J Med 2001;344:873–880.
2. Daubert JC, Saxon L, Adamson PB, et al. 2012 EHRA/HRS expert consensus statement on cardiac resynchronization therapy in heart failure: implant and follow-up recommendations and management. Heart Rhythm 2012; 9:1524–1576.
3. Gerhard-Herman, Gornik HL, Barrett C, et al. 2016 AHA/ACC guideline on the management of patients with lower extremity peripheral artery disease: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. Circulation 2017;135:e726–e779.
4. Wakana N, Zen K, Kambayashi D, et al. A newly designed 0.018-in.-compatible inner dilator as a novel option for endovascular therapy with the crossover approach. Cardiovasc Interv Ther 2020;35:276–282.
5. Gamble JHP, Herring N, Ginks M, Rajappan K, Bashir Y, Betts TR. Procedural success of left ventricular lead placement for cardiac resynchronization therapy: a meta-analysis. JACC Clin Electrophysiol 2016;2:69–77.
6. Worley SJ. Implant venoplasty: dilation of subclavian and coronary veins to facilitate device implantation: indications, frequency, methods, and complications. J Cardiovasc Electrophysiol 2008;19:1004–1007.
7. Soga Y, Ando K, Yamada T, et al. Efficacy of coronary venoplasty for left ventricular lead implantation. Circ J 2007;71:1442–1445.
8. Kumagai Y, Arimoto T, Yamauchi S, et al. Implantation of a cardiac resynchronization therapy device using the anchor balloon technique in a patient with a tortuous coronary sinus branch. HeartRhythm Case Rep 2018;4:339–342.
9. Guenther M, Kolschmann S, Rauwolf TP, et al. Implantable cardioverter defibrillator lead implantation in patients with a persistent left superior vena cava–feasibility, chances, and limitations: representative cases in adults. Europace 2013; 15:273–277.
10. Taguchi Y, Matsumoto K, Ishikawa T, et al. Right-sided cardiac resynchronization therapy with defibrillator implantation in a patient with corrected transposition of great arteries and persistent left superior vena cava. J Cardiol Cases 2017;15:111–114.
11. Tamura K, Kimura K. Successful implantation of left ventricular lead for a cardiac resynchronization therapy defibrillator through a persistent left superior vena cava using the anchor balloon technique. J Cardiol Cases 2021;25:308–311.
12. Nicolis D, Mugnai G, Pepi P, Ribichini FL, Lettieri C. Active fixation of bipolar left ventricular lead through a persistent left superior vena cava. J Arrhythm 2022; 38:488–490.
13. Worley SJ. CRT delivery systems based on guide support for LV lead placement. Heart Rhythm 2009;6:1383–1387.