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CASE REPORT

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Successful coronary sinus left ventricular lead extraction 9 years postimplantation using the wire ThRoUgh Snare Twice (wire TRUST) technique

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Key Clinical Message

The newly-proposed tandem approach, Wire ThRoUgh Snare Twice (Wire TRUST) is effective for grasping a lead with inaccessible ends. This case report shows that Wire TRUST can also enable successful extraction of a left ventricular lead by iteratively grasping and repositioning to the distal portion of the lead.

KEYWORDS

femoral approach, iterative approach, left ventricular lead, pigtail catheter, transvenous lead extraction

1 | INTRODUCTION

Cardiac resynchronization therapy (CRT) is a highly effective intervention for patients experiencing systolic heart failure along with left ventricular (LV) contraction dyssynchrony.[1] However, with the expanding criteria for the indication of CRT, there has been an increase in cases requiring the removal and subsequent reimplantation of CRT devices because of infections or functional issues.[2] Notably, LV lead failure is a critical complication leading to the suspension of CRT, greatly elevating the risk of worsening heart failure. Therefore, LV lead removal and reimplantation are necessary in cases involving LV lead failure, though such procedures sometime pose challenges (e.g., tissue adhesion when removing; occlusion or stenosis of the originally-implanted branch when reimplanting). Percutaneous lead removal can be successfully achieved through simple traction alone for LV leads with a short duration of placement. However, in cases of LV leads with a longer duration of placement, removal may require the use of extraction tools for mechanical dissection of adhesive tissue within the innominate vein, superior vena cava, right atrium (RA), and coronary sinus (CS). LV leads remain with inaccessible ends until the adhesions within the CS are separated, allowing the lead tip to exit into the RA.[3]

When removing leads with extended dwell times, the tandem approach for extraction, using a combination of a femoral snare and a superior sheath, is effective. The Wire ThRoUgh Snare Twice (Wire TRUST) technique has been

reported as effective for grasping a lead with inaccessible ends.[4] In this report, we propose using the Wire TRUST technique not only for grasping an LV lead without a free end, but also for applying manual traction from the femoral approach, with step-by-step advancing of the grasping position closer to the tip of the LV lead.

2 | CASE HISTORY/EXAMINATION

A 57-year-old male patient with a history of left descending artery ST-segment elevation myocardial infarction was admitted for heart failure due to ischemic cardiomyopathy 9 years previously. The patient showed a reduced LV ejection fraction (LVEF) of 30% and demonstrated complete left bundle branch block on a 12-lead electrocardiogram. Additionally, he experienced a considerable reduction in exercise tolerance, with symptoms corresponding to Class III of the New York Heart Association Functional Classification. Nine years previously, the patient underwent implantation of a CRT defibrillator device (Viva Quad XT; Medtronic, Minneapolis, MN, USA) with an RA lead (Capsure Fix NOVUS 5076-52 cm; Medtronic), a screw-in right ventricular (RV) defibrillation lead (Sprint Quattro MRI Secure 6935 M-62 cm; Medtronic), and LV lead (Attain Performa Straight 4398-88 cm; Medtronic) (Figure 1A). Two years previously, after replacement of the generator (Claria MRI Quad; Medtronic), an elevation in the LV lead threshold was observed (Figure 1B). One year previously, the capacity for biventricular pacing was lost, leading to exclusive RV pacing and the LVEF, which was 40% 2 years ago, declined to 28%. A chest X-ray showed no abnormal findings related to the placement of the LV lead (Figure 1C). The patient was referred to our hospital and was scheduled for transvenous LV lead extraction and replacement of a new LV lead and generator exchange.

3 | METHODOLOGY

3.1 | Transvenous lead extraction

After confirming the patency of the left subclavian vein, we conducted LV lead extraction with cardiac surgical support in a hybrid operating room using general anesthesia.

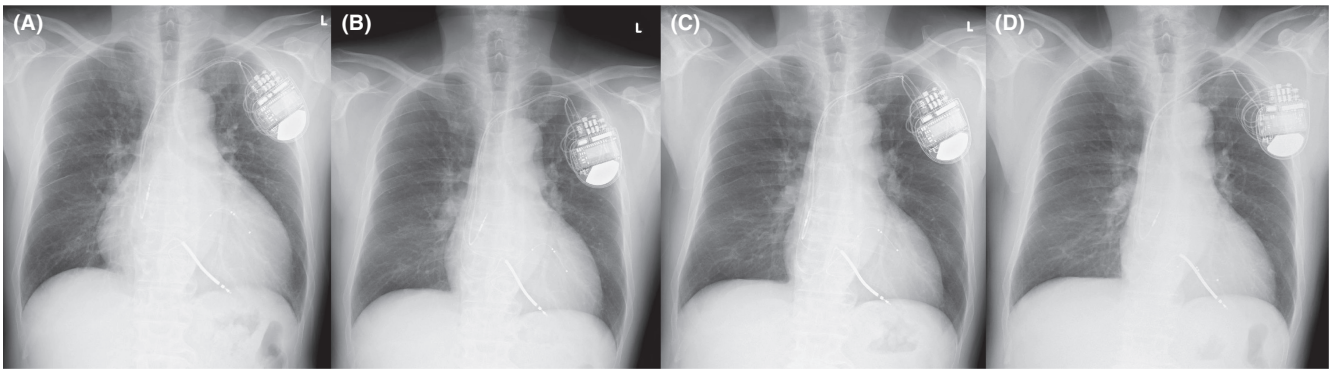
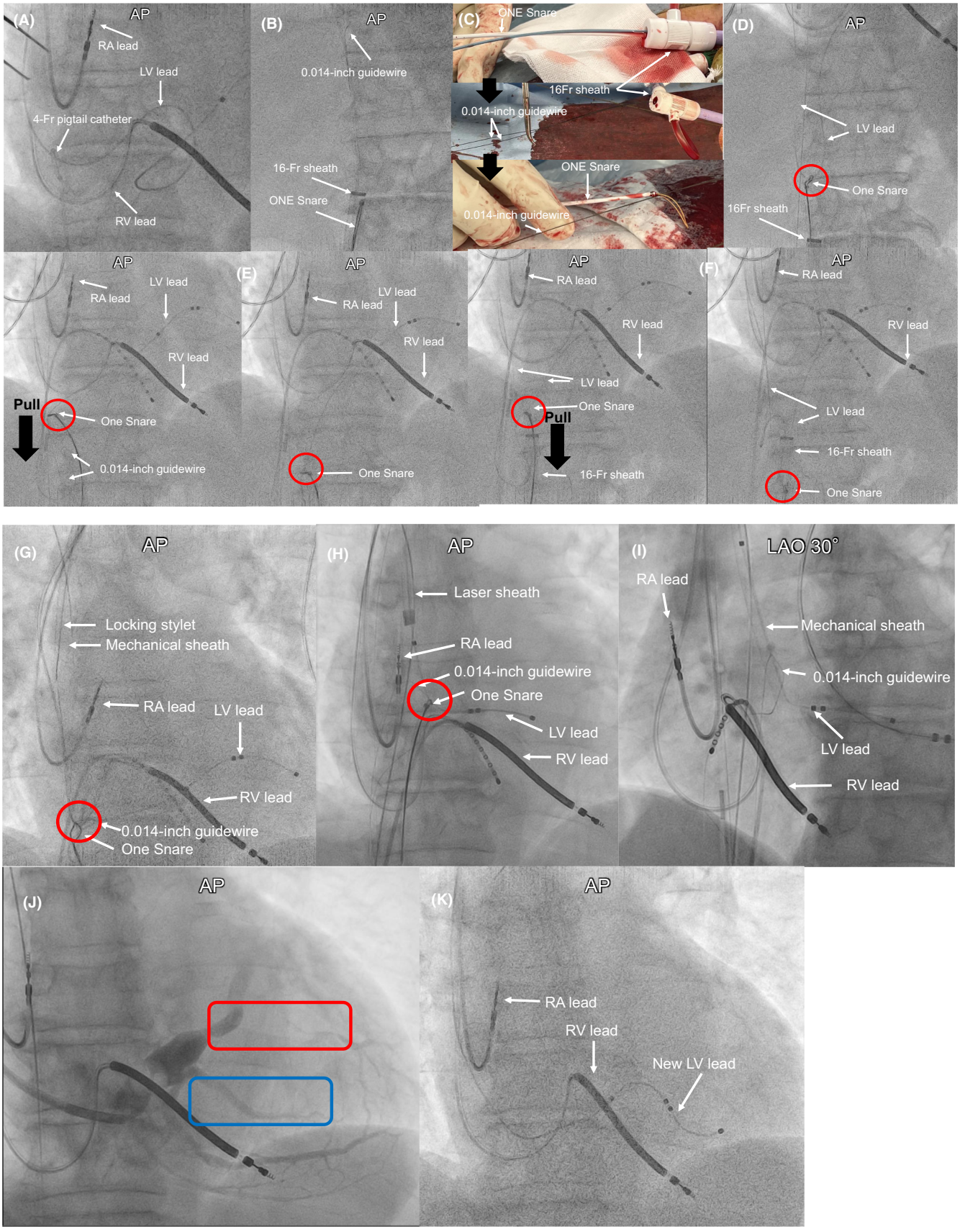


FIGURE 1 Chest X-ray findings. (A) Chest X-ray after the initial implantation of cardiac resynchronization therapy (CRT). (B) Chest X-ray after CRT generator exchange. (C) Chest X-ray before the procedure of the transveous lead extraction and reimplantation. (D) Chest X-ray following the procedure of the transveous lead extraction and reimplantation.

FIGURE 2 Transvenous LV lead extraction and new LV lead implantation. (A) Under multidirectional fluoroscopic guidance, a 4-Fr pigtail catheter that was inserted into a 16-Fr sheath hooked the LV lead. (B) The distal end of a 0.014-inch guidewire was inserted into the pigtail catheter, which had hooked the lead, and then passed through the ONE Snare and retracted into the 16-Fr sheath. (C) After externalization of the 0.014-inch guidewire, the pigtail catheter and snare catheter were removed. Subsequently, both ends of the guidewire were threaded through the snare, and then the snare was reinserted into the 16-Fr sheath. (D) The snare was initially opened and positioned near the lead. Subsequently, coordinating the advancement and closure of the snare with the tension applied to the guidewire facilitated successful grasping of the LV lead with inaccessible ends. (E, F) A step-by-step method where each step includes (1) clamping the LV lead with a snare while tightening the external guidewire, (2) pulling the lead down, and (3) releasing the snare and advancing the guidewire. With each cycle, the snare's grasp moves closer to the lead's distal end. (G, H, and I) Maintaining a firm grip on the LV lead using the Wire TRUST technique ensures co-axial alignment of the laser and mechanical sheath with the LV lead. Upon the mechanical sheath's arrival at the grasping point, the snare was opened and the externalized wire was pushed to relinquish the grasp, thereby guaranteeing that it did not hinder the counter traction. (J, K) Coronary sinus venography shows occlusion in the lateral branch that originally contained the LV lead (red rectangle). Consequently, the new LV lead was implanted in the posterolateral branch (blue rectangle). The red circles indicate where the LV lead was grasped with the Wire TRUST technique. AP, anterior–posterior; LAO, left anterior oblique; LV, left ventricular; RA, right atrial; RV, right ventricular.


(A)
AP
RA lead
LV lead
4-Fr pigtail catheter
RV lead
(B)
AP
0.014-inch guidewire
16-Fr sheath
ONE Snare
(C)
ONE Snare
16Fr sheath
0.014-inch guidewire
ONE Snare
0.014-inch guidewire
(D)
AP
LV lead
One Snare
16Fr sheath
AP
LV lead
RA lead
RV lead
Pull
One Snare
0.014-inch guidewire
(E)
AP
LV lead
RA lead
RV lead
One Snare
AP
RA lead
RV lead
LV lead
One Snare
Pull
16-Fr sheath
(F)
AP
RA lead
RV lead
LV lead
16-Fr sheath
One Snare
(G)
AP
Locking stylet
Mechanical sheath
RA lead
LV lead
RV lead
0.014-inch guidewire
One Snare
(H)
AP
Laser sheath
RA lead
0.014-inch guidewire
One Snare
LV lead
RV lead
(I)
LAO 30°
RA lead
Mechanical sheath
0.014-inch guidewire
LV lead
RV lead
(J)
AP
(K)
AP
RA lead
RV lead
New LV lead

We adopted a proactive approach from the outset because of the non-infectious indication and a relatively extended 9-year dwell time for the LV lead. We used a combined superior and femoral approach known as "tandem" to ensure co-axial alignment of the powered and mechanical sheath with the LV lead. Initially, we liberated the generator from its left prepectoral pocket and separated the adhesion of the LV lead in the pocket. We then inserted a locking stylet (LLD-EZ; Philips, Andover, MA, USA), which could not reach the lead tip. In fact, applying simple traction to the LV lead did not result in any movement. We performed subclavian vein puncture more distally to establish a new access route for a new LV lead.

3.2 | The Wire TRUST technique

Simultaneously, we began the femoral approach with the Wire TRUST technique. Specifically, a 16-Fr sheath (Check-Flo Performer; Cook Medical) was inserted into the right common femoral vein. A 4-Fr pigtail catheter (Terumo, Tokyo, Japan) was then introduced through the 16-Fr sheath and navigated into the RA using multidirectional fluoroscopic guidance to hook the LV lead (Figure 2A). Subsequently, a 0.014-inch guidewire (Hi-Torque Command 300 cm; Abbott Vascular, Santa Clara, CA, USA) was threaded through the pigtail catheter, past the ventricular lead and into the inferior vena cava. A 6-Fr snare catheter (35-mm ONE Snare; Merit Medical) was advanced into the inferior vena cava through the 16-Fr sheath and expanded. The guidewire was then passed through the snare and retracted into the femoral sheath for externalization (Figure 2B). After removing the pigtail catheter, both ends of the 0.014-inch guidewire were threaded through the snare outside the body (Figure 2C). The snare was reinserted into the 16-Fr sheath and advanced near the lead. The lead was securely grasped by closing the snare while tensioning the externalized guidewire (Figure 2D). The Wire TRUST technique uses an iterative approach, with each iteration involving (1) opening the snare and pushing the guidewire, (2) grasping the LV lead by closing the snare while tensioning the externalized guidewire, and (3) pulling the lead downwards (Figure 2E,F). The grasping point moved further toward the distal portion after each iteration. Using a 14-Fr GlideLight laser sheath (Philips) and a 12-Fr mechanical sheath (Byrd dilator sheath; Cook Medical, Bloomington, IN, USA) in the superior approach, we proceeded to strip the adhesions up to the grasping point near the CS ostium. During this process, we kept grasping the LV lead to facilitate co-axial alignment of the laser and mechanical sheath with the LV lead (Figure 2G,H). After the mechanical sheath reached the grasping point, we opened the snare and pushed the externalized wire to release the grasp, and ensured that it did not obstruct the counter traction (Figure 2I). The LV lead in the mechanical sheath was successfully removed using the counter traction technique without lead fragments remaining in the heart (Video S1). The snare catheter and sheaths inserted from the right femoral vein were removed.

3.3 | New LV lead reimplantation

Subsequently, we proceeded with LV lead reimplantation. After engaging the CS guiding catheter (Extended-hook; Medtronic), occlusive balloon angiography of the CS was conducted (Figure 2J). The posterolateral branch was selected because the branch that initially accommodated the LV lead was occluded. A new LV lead (Attain Performa S 4598-88 cm; Medtronic) was inserted into the posterolateral branch (Figure 2K), and we confirmed that there were no changes in the threshold or impedance of the RA lead and RV lead. A new generator (Cobalt XT HF Quad; Medtronic) was then implanted.

4 | RESULTS

No complication occurred during the removal and reimplantation procedure (Figure 1D). The patient has remained free of heart failure exacerbation for 1 year. The clinical course was favorable, and the patient was discharged 4 days after the procedure. Transthoracic echocardiography conducted 1 year later demonstrated that the LVEF, which was 30% before the procedure, improved to 42%.

5 | DISCUSSION

Prior research has shown that using a tandem superior–femoral approach in transvenous lead extraction increases the rate of complete procedural success.[5] This approach offers geometric benefits and is theoretically associated with a lower risk of superior vena cava injury.[6]

The optimal cut-off value of the LV lead dwell time to predict simple traction success is 4.7 years.[7] In our case, the likelihood of successfully removing the LV lead through simple traction was considered low because of the exceptionally long dwell time of 9 years. Furthermore, a non-infectious indication and probable strong tissue adhesion were involved. Therefore, choosing a primary (not bail out) tandem approach was considered appropriate. We previously reported a new technique called the Wire TRUST technique for extracting the RV lead with

inaccessible ends as an effective tandem approach.[4] In this case, the Wire TRUST technique was used for extracting the LV lead. When the superior approach is challenging, the femoral approach (the Wire TRUST technique) should be used; this enables altering the pulling direction and effectively releasing adhesions at the CS ostium or within the CS branches. The femoral approach is a practical alternative because of the high risk of venous laceration from mechanical dissection in these areas.

The Wire TRUST technique is relatively simple and effective for grasping a lead with inaccessible ends. Previous reports have shown that the pigtail catheter was effective in removing catheter fragments without accessible ends, leading to the development of the Wire TRUST technique utilizing the pigtail catheter.[8,9] A 4-Fr pigtail catheter (Terumo) must be positioned at the targeted lead using multidirectional fluoroscopic guidance to initiate the Wire TRUST technique. In situations where positioning the catheter is challenging, such as with an enlarged heart, using a steerable introducer might be beneficial. The safety of the Wire TRUST technique is contingent upon the use of a specific 0.014-inch guidewire. We consider the Nitinol guidewire, as opposed to stainless steel, to be safer due to its shape memory and the reduced presence of sharp edges where it secures the lead. Furthermore, we recommend utilizing a 300 cm wire since it must be folded and captured with a snare for subsequent externalization. This necessitates a length approximately three times the distance from the right femoral vein to the right atrium. The Wire TRUST technique is considered relatively safe because if the guidewire breaks, it can be promptly retrieved since the guidewire is externalized.

The Wire TRUST technique offers a straightforward approach to adjusting the grasp of the position on the lead owing to externalization of the 0.014-inch guidewire. This grasping is achieved by manipulating the guidewire through pulling and pushing actions, combined with the opening and closing movements of the snare (Videos S2 and S3). In this case, three iterations were performed until the grasping point fell between the third and fourth electrodes of the LV lead. These three iterations allowed for grasping at a position close enough to the distal portion, leading to successful extraction. The process of grasping the LV lead using the Wire TRUST technique, followed by iterations to secure a more distal position on the LV lead and applying counter traction until complete removal of the LV lead, is shown in Figure 3.

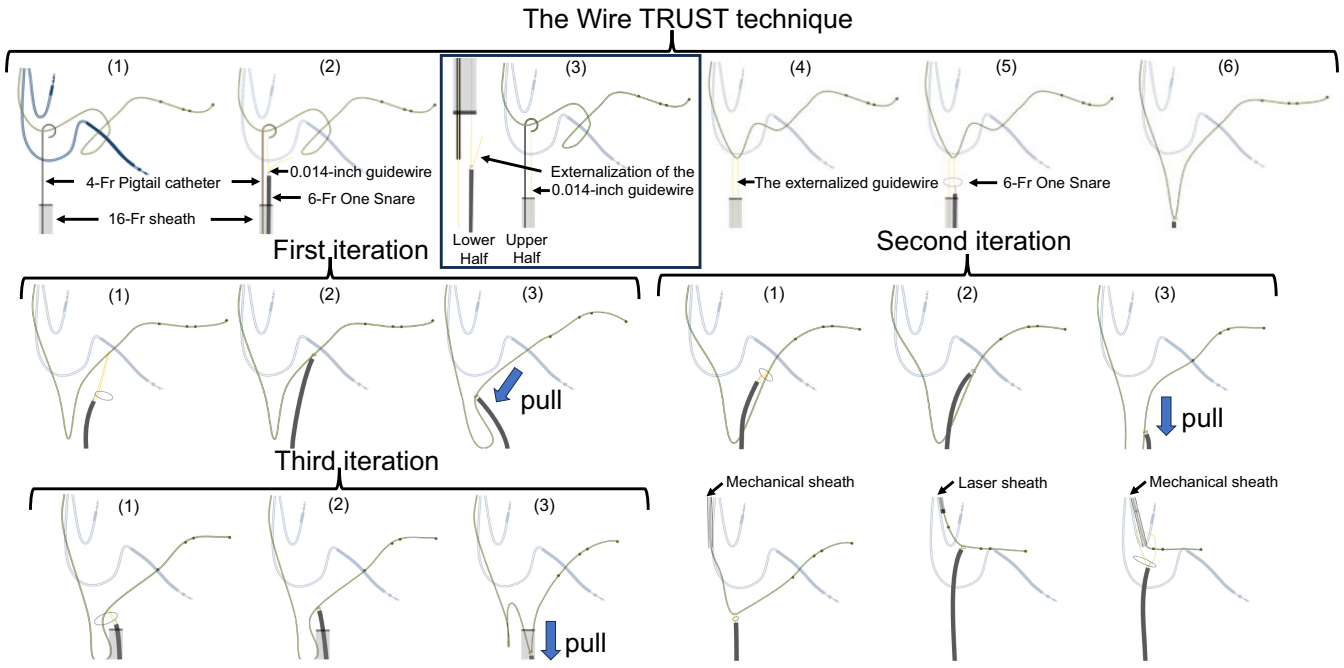


FIGURE 3 Schematic drawing of the Wire TRUST technique with emphasis on the iterative approach. The Wire TRUST technique (up to the point of grasping the LV lead). (1) A 4-Fr pigtail catheter hooks the LV lead under fluoroscopic guidance. (2) A 0.014-inch guidewire is inserted into the pigtail catheter, crosses over the LV lead, and then is passed through a 6-Fr One Snare, which is inserted in the same 16-Fr sheath. (3) The 0.014-inch guidewire is retracted into the 16-Fr sheath using the 6-Fr One Snare to facilitate the externalization of the guidewire. (4) After the externalization of the 0.014-inch guidewire, the 4-Fr pigtail catheter is removed. (5) Both ends of the externalized guidewire are threaded through the snare outside the body and introduced into the 16-Fr sheath. (6) Grasping the LV lead: Closing the snare while tensioning the externalized guidewire. Iterative approach. (1) Opening the snare and pushing the externalized guidewire. (2) Grasping the LV lead by closing the snare while maintaining tension on the externalized guidewire. (3) Pulling the LV lead downwards.

Ultimately, the successful complete removal of the LV lead was achieved through counter traction from the superior approach. However, if complete removal had not been possible through the superior approach, we planned to use the Wire TRUST technique to grasp as much of the distal portion of the LV lead as possible, and then bring a 16-Fr sheath closer for counter traction from the femoral approach.

The Needle's Eye Snare (Cook Medical) is designed to capture leads that do not have free ends.[10] However, its fixed-loop size and rigid threader can sometimes fail to secure leads, potentially leading to unsuccessful procedures and complications such as atrial septal perforation.[11]

As an alternative to the NES for unsuccessful lead extractions, a steerable introducer-assisted wire-loop snare can be used.[12] This technique pulls at the lowermost end of the targeted lead with a wire loop, rather than grasping the lead itself. Unlike the Wire TRUST technique, this method does not allow for the grasping point to be progressively moved toward the distal end.

In this case, the Wire TRUST technique played two crucial roles in ensuring the complete success of extracting an LV lead with a lengthy dwell time of 9 years. First, the Wire TRUST technique fulfilled the primary function of the femoral approach, proving particularly helpful in enabling the advancement of powered and mechanical sheaths via the superior approach. The second role was the effectiveness of this technique in manual traction via the femoral approach. Manipulating the 0.014-inch guidewire and snare to iteratively adjust the grasping position on the lead enabled secure grasping of more distal portions of the lead, thereby efficiently transmitting the pulling force to the lead's tip.

As a final discussion point, we address LV lead reimplantation after extraction. A previous study reported a 95.6% success rate, with reimplantation in the posterolateral area possible in 62% of cases.[13] However, the study also revealed that the branch originally containing the LV lead exhibited occlusion or stenosis in 80% of the cases, necessitating the examination of alternative optimal branches.[13] In our specific case, although the lateral branch originally holding the lead was occluded after removal, fortunately, a posterolateral branch was available where the new LV lead could be successfully implanted. If no suitable branches are available, venoplasty or a retrograde pull-through approach should be considered.[14,15] It is crucial to be well-prepared before the procedure.

6 | CONCLUSION

While further studies are needed to establish the safety and efficacy of the Wire TRUST technique, this is the first case report to show the feasibility of the Wire TRUST technique in LV lead extraction. The Wire TRUST technique, used as a tandem approach, facilitates successful extraction of an LV lead by iteratively grasping and repositioning to the distal portion of the lead.

AUTHOR CONTRIBUTIONS

Yuhei Kasai: Conceptualization; data curation; writing – original draft. **Junji Morita:** Data curation; writing – review and editing. **Takuya Haraguchi:** Conceptualization. **Takayuki Kitai:** Visualization; writing – review and editing. **Takuya Okada:** Data curation; visualization. **Kota Suzuki:** Data curation. **Ryuto Yamazaki:** Data curation. **Yumetsugu Munakata:** Data curation; visualization. **Jungo Kasai:** Writing – review and editing. **Tsutomu Fujita:** Supervision.

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CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

Data are available on request.

ETHICS STATEMENT

This research was conducted according to the principles of the Declaration of Helsinki.

CONSENT

Written informed consent was obtained from the patient to publish this report in accordance with the journal's patient consent policy.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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