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CASE REPORT

INTERMEDIATE

HEART CARE TEAM/MULTIDISCIPLINARY TEAM LIVE

Hybrid Lead Extraction Technique

Combined Transatrial Laser Lead Extraction and Surgical Removal of Calcified Lesions

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CME/MOC/ECME Objective for This Article: Upon completion of this activity, the learner should be able to: 1) diagnose pacemaker lead infection; 2) understand the technique and main principles of hybrid lead extraction; 3) understand the anatomy which is useful for the technique; and 4) identify the criteria when surgical lead extraction is necessary.

Author Disclosures: The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

Medium of Participation: Online (article and quiz).

CME/MOC/ECME Term of Approval

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ABSTRACT

This report presents a new hybrid lead extraction technique combined with transatrial laser lead extraction and surgical removal of calcified lesions in a 50-year-old man with superior vena cava syndrome and bilateral subclavian vein occlusion caused by an abandoned lead, which had been infected for 11 years. (**Level of Difficulty: Intermediate.**)

A 50-year-old man, who underwent implantation of a VVI pacemaker on the right side for third-degree atrioventricular block 38 years previously, presented with generator pocket infection for 11 years. At 39 years of age, he presented with pocket pain, swelling, and erythema. He had no systemic infectious manifestations, such as fever, an elevated white blood cell count, or an increased plasma C-reactive protein level. Because the infection was limited to the generator pocket, generator extraction, partial lead cutout, and debridement were performed. A new VVI pacemaker was re-implanted on the left side (**Figure 1A**). However, 6 months after debridement, purulent fluid from the wound was observed on the right side, where the retained lead was located (**Figure 1B**). Five attempts of local debridement were made; however, the pocket infection was difficult to control. He was referred to our hospital for complete extraction of the retained lead.

LEARNING OBJECTIVES

- To diagnose pacemaker lead infection.
- To understand the technique and main principles of hybrid lead extraction.
- To identify the indications when surgical lead extraction is necessary.
- To select a hybrid technique combining transatrial laser lead extraction and surgical removal of calcified lesions as an alternative strategy for cases of previous lead removal failure by transvenous lead extraction alone.

QUESTION 1: WHICH PRE-OPERATIVE EXAMINATION WOULD YOU CHOOSE TO DETERMINE THE MOST APPROPRIATE TREATMENT STRATEGIES?

ANSWER 1. Before lead extraction is performed, it is necessary to confirm whether leads are present in the extravascular space, because misplaced leads can enter through the atrial structures or through the erosion of the venous or myocardial walls. Examination is done by cardiac computed tomography (CT), transthoracic echocardiography, or angiography. Performing transvenous lead extraction of the leads, a part of which is extravascular, causes venous lacerations or myocardial perforations, and can result in life-threatening complications (1). It has been reported that high accuracies of electrocardiographically (ECG)-gated, contrast-enhanced cardiac CT imaging are superior to both chest radiography and transthoracic echocardiography imaging for the assessment of cardiac lead perforation (2). Moreover, pre-operative evaluation of ECG-gated, contrast-enhanced cardiac CT images for lead adhesion to vessels and calcification around the leads are useful to decide strategies and which devices to use for lead extraction (3).

In the present case, using ECG-gated cardiac CT and angiography, the following issues were noted: 1) superior vena cava (SVC) and bilateral subclavian veins were completely occluded (**Figure 2A**); 2) the infected lead strongly adhered to the SVC and intracardiac structures with dense calcification (**Figure 2B**); and 3) the proximal end of the infected lead was cut.

QUESTION 2: IS TRANSVENOUS LEAD EXTRACTION BY THE ANTEROGRADE APPROACH FEASIBLE FOR THE PRESENT CASE?

ANSWER 2. The infected lead implanted on the right side could not be extracted via the subclavian vein because the proximal end of the lead was cut. The anterograde lead extraction of the lead implanted on the left side was difficult in the achievement of complete lead removal, and use of powered sheaths would have caused the lead to break because of the thick fibrous adhesions and dense calcification around the lead.

QUESTION 3: IS SURGICAL LEAD REMOVAL THE BEST STRATEGY IN THIS CASE?

ANSWER 3. Techniques and tools for transvenous lead extraction are being rapidly developed to enhance the high success rate and minimize complications. Major cardiac complications associated with transvenous lead extraction have been widely reported as cardiovascular perforation (4) and traumatic tricuspid regurgitation (5). Surgical removal still remains the choice in cases of long-term (>10 years) implanted leads, large vegetation (>2 cm) or thrombi, fractured leads, and previously failed transvenous extraction. Surgical removal has advantages over transvenous lead extraction because cardiovascular perforation can be prevented, and tricuspid valve repair surgery for tricuspid regurgitation secondary to valve leaflet avulsion is possible after lead removal. However, such a surgical approach requires extremely invasive surgical procedures, including extensive incisions from the innominate vein to the SVC.

Considering these issues, we attempted to extract all the leads using a novel hybrid technique that involved retrograde laser lead extraction via an atrial approach and surgical removal of calcified lesions under direct visualization. A median sternotomy was performed, heparin was administered, and cardiopulmonary bypass was established. After making an incision in the right atrium, thick fibrous adhesions with patches of calcification were observed along the abandoned lead (**Figure 3A**). Moreover, this lead was tightly attached to the SVC, the free wall of the right atrium, the tricuspid valve (septal leaflet), and the papillary muscle. After surgical separation of this lead from the right heart and SVC, tricuspid valve repair was needed because of damaged chordae tendineae of the tricuspid valve and papillary muscle of the right ventricle. This lead was cut at the portion in the right atrium, and a locking stylet (Liberator Beacon Tip locking stylet, Cook Medical, Bloomington, Indiana) was inserted from the intracardiac side of the cut end. After surgical separation of the calcified lesions around the abandoned lead from the ventricle to SVC, an excimer laser sheath (SLS II, Spectranetics, Colorado Springs, Colorado) was retrogradely advanced into the SVC via the right atrium using an excimer laser ablation system (CVX-300, Spectranetics) (**Figure 3B**, Video 1). The entire lead was successfully

ABBREVIATIONS AND ACRONYMS

CECT = contrast-enhanced computed tomography

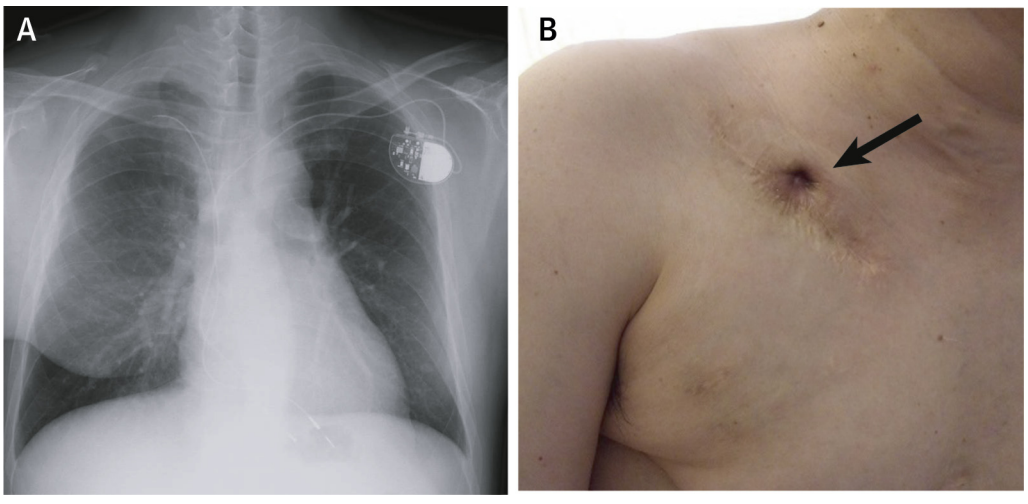
CIED = cardiac implantable electronic device

CPB = cardiopulmonary bypass

CT = computed tomography

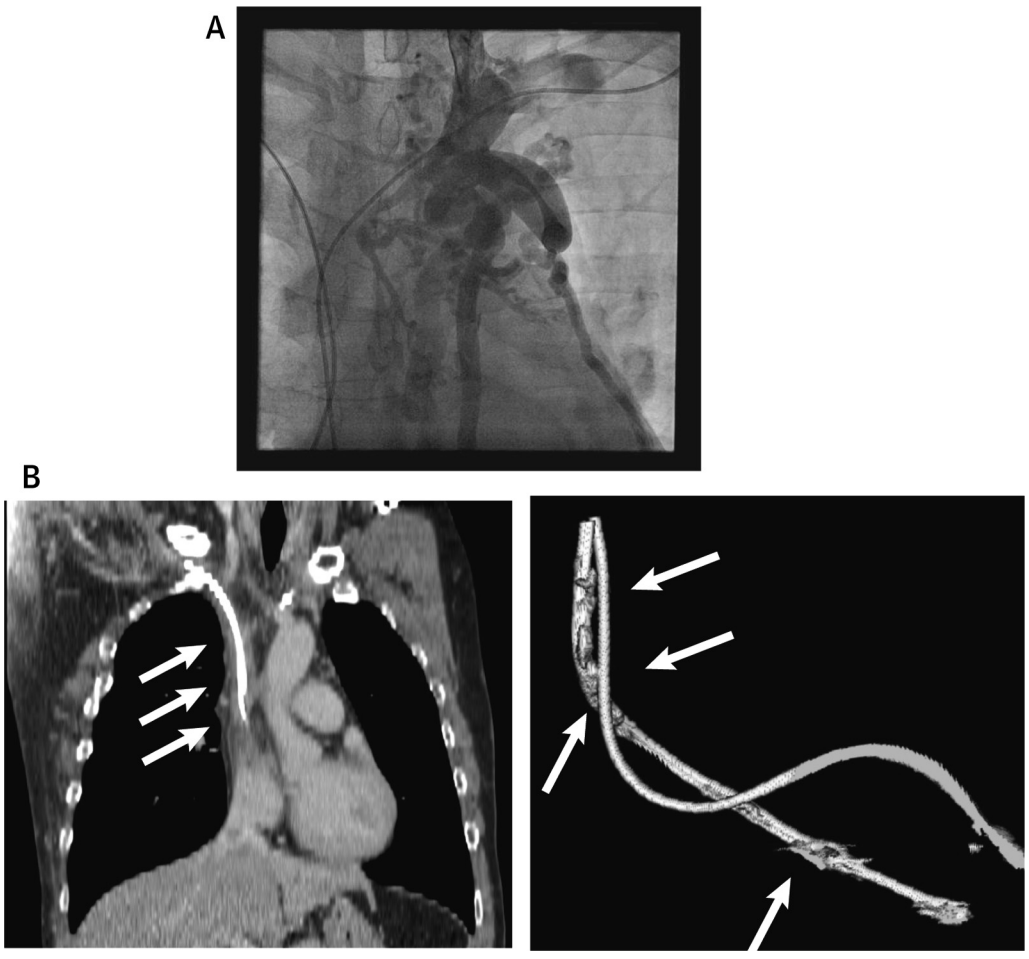
SVC = superior vena cava

FIGURE 1 Chest X-Ray and Open Wound on Hospital Admission



(A) Chest radiography shows an implanted pacemaker on the left side and an abandoned lead on the right side. **(B)** Purulent matter from the infected retained lead that was located at the occluded subclavian vein for 11 years.

FIGURE 2 Findings of Right Ventricular Venography and Electrocardiographically-Gated Cardiac CECT



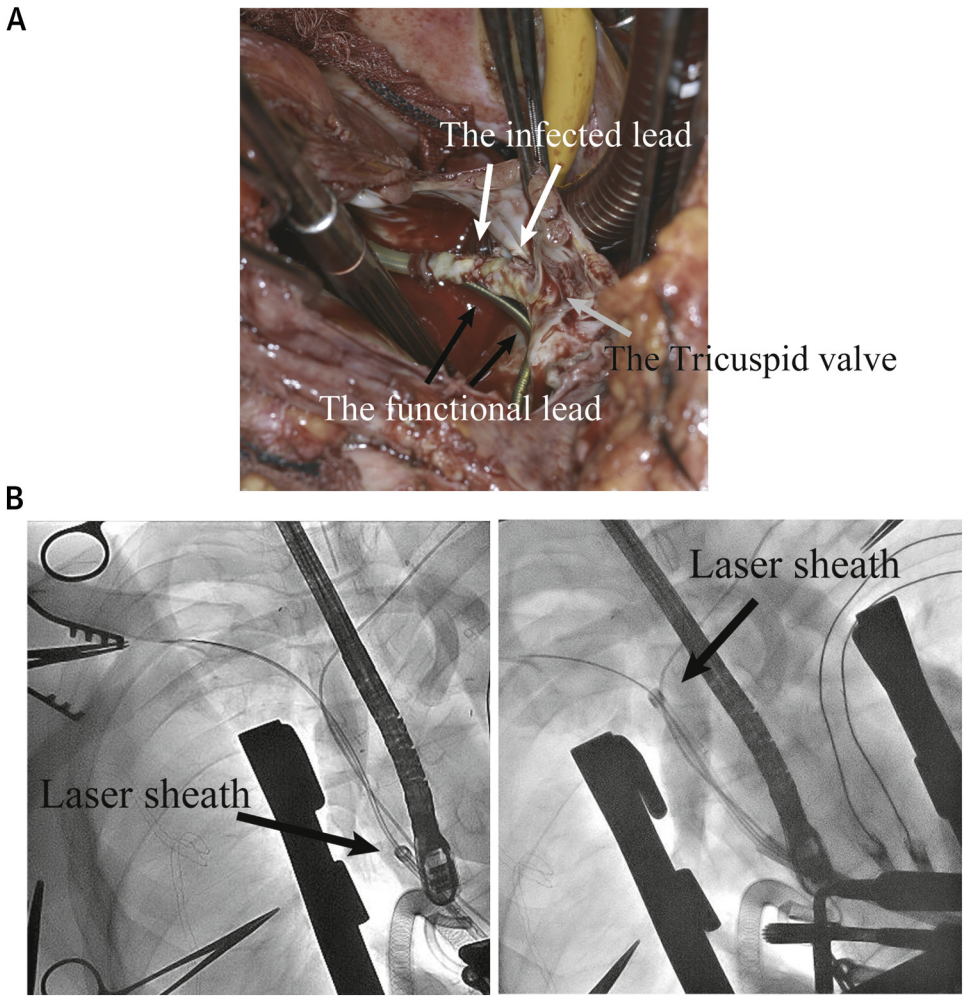
(A) Right ventricular venography shows long-distance occlusion of the subclavian veins and superior vena cava (SVC) with abundant collateral venous circulation. **(B)** Contrast-enhanced computed tomography (CECT) shows strong adhesion of the abandoned lead to SVC. Three-dimensional reconstructed CT of the infected lead using 3-dimensional workstation software (Ziostation 2, Ziosoft, Inc., Tokyo, Japan) shows high calcification around the infected lead **(white arrows)**.

removed without any complications. After weaning from cardiopulmonary bypass, a new pacemaker with an epicardial pacing lead generator was implanted on the left side.

QUESTION 4: PREVIOUS REPORTS PRESENTED TRANSVENOUS LEAD EXTRACTION COMBINED WITH MINIMALLY INVASIVE SURGERIES. HAVE THESE METHODS BEEN APPLIED TO THE PRESENTED CASE?

ANSWER 4. To reduce surgical invasion, a hybrid technique that involves anterograde transvenous lead extraction combined with minimally invasive surgery has been recently applied to remove leads that exhibit strong adhesion to vessels and the endocardium. Bontempi et al. (6) and Migliore et al. (7) described a hybrid procedure of anterograde lead extraction under continuous monitoring of the site of potential vascular injury (SVC, cavoatrial junction, and right atrium) during lead extraction by mini-thoractomic or thoracoscopic approach in high-risk patients. This hybrid procedure allowed the surgeon to prepare for rapid cardiovascular repair in case cardiovascular injury occurred. Rodriguez et al. (8) reported retrograde laser-assisted atrial lead extraction using a thoracoscopic transatrial approach. This approach is minimally invasive and provides unique advantages in cases of extracardiac atrial lead

FIGURE 3 **Intraoperative Findings**



(A) The infected lead on the right side **(white arrow)** and the functional pacing lead on the left side **(black arrow)** are shown. The infected lead shows adherence to the right atrium and tricuspid valve, with high calcification. **(B)** Retrograde lead extraction via an atrial approach. An excimer laser sheath **(black arrow)** is advanced toward the subclavian vein from the right atrium using the excimer laser ablation system. See Video 1.

migration or atrial lead-caused erosion (8). However, these approaches could not be adapted for the present case because we needed to catch either end of the lead in the atrium.

QUESTION 5: IS A SNARING TECHNIQUE AVAILABLE FOR THE EXTRACTION OF THE INFECTED LEAD?

ANSWER 5. Bongiorni et al. (9) advocated the snaring technique for pulling and catching the end of the lead. This snaring technique was often available for extracting the abandoned lead with the proximal portion cut. If either end of the lead could be caught and pulled into the atrium by snare catheters, lead extraction via a thoracoscopic transatrial approach or percutaneous transfemoral approach might be feasible. However, long-term infected leads that caused total SVC occlusion and showed strong adhesion to intracardiac structures, with severely calcified lesions, could not have been free-floating by traction using the snare catheter, even if the lead was grasped at the level of the right atrium. Extracting the leads too hard would increase the risk of causing perforation of the vessels and cardiac wall, as well as injury to the tricuspid valve. We predicted that it was

impossible to pull either end of the lead safely in the atrium by snaring from pre-operative CT and echocardiographic findings.

QUESTION 6: WHAT ARE THE INDICATIONS FOR HYBRID LEAD EXTRACTION?

Infection was the most frequent indication for lead extraction in the ELECTRa (European Lead Extraction ConTRolled) registry (10). Other indications included: 1) superficial incisional infection; 2) isolated pocket infection; 3) isolated pocket erosion; 4) bacteremia; 5) pocket infection (open or closed) with bacteremia; 6) cardiac implantable electronic device (CIED)-related endocarditis without pocket infection; 7) pocket infection with lead and/or valvular endocarditis; and 7) occult bacteremia with probable CIED infection (10).

Therefore, with the aim of complete CIED system removal, we adopted a hybrid technique that involved retrograde laser lead extraction via the atrial approach and surgical removal of calcified lesions under direct visualization for the prevention of an incision in the SVC. The patient showed good progress and was discharged 2 weeks post-operatively. There has been no recurrence of infection over 3 years.

We performed retrograde laser lead extraction under open-heart surgery and successfully removed a long-term infected lead associated with calcified lesions. To the authors' knowledge, this is the first such report in the literature. Our hybrid technique, which involved retrograde laser extraction and a surgical approach, is a promising strategy for complicated cases of CIED infection.

The ethics committee approval (No. 2650-6) and informed consent for reporting a case were obtained.

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KEY WORDS abandoned lead, infected pacemaker, superior vena cava, tricuspid valve repair

APPENDIX For a supplemental video, please see the online version of this paper.