A CASE FOR EDUCATION

Femoral-superior lead extraction complicated by venous dissection in chronic venous occlusion: How the alligator saved the day

Frank Eberhardt, MD,* Markus Kirch, MD,* Ehssan Berenjkoub, MD,† Anna Bonnert, MD,‡ Juergen Frey, MD,§ Dieter Bimmel, MD,‖ for the Köln Bonn cooperative lead extraction center

*From the *Department of Cardiology, Evangelisches Krankenhaus Kalk, Cologne, Germany, †Department of Cardiology, Electrophysiology and Rhythmology, Krankenhaus Porz am Rhein, Cologne, Germany, ‡Department of Cardiology, Kliniken der Stadt Köln, Standort Merheim, Cologne, Germany, §Department of Gastroenterology, Evangelisches Krankenhaus Kalk, Cologne, Germany, and ‖Department of Cardiology, GFO-Kliniken, Bonn, Germany.*

Introduction

Stenosis or chronic occlusion may occur in up to 25% of patients with indwelling leads and cardiac implantable electronic devices (CIED), which may hinder additional lead implantation in case of upgrades or lead dysfunction.[1–3] Several management strategies exist, including tunneling of a contralaterally implanted lead across the chest, venoplasty, and transvenous lead extraction (TLE) to create a channel through which additional leads may be implanted.[1,2] The present case illustrates various management strategies in this clinical scenario, highlights a complication in TLE, and presents an innovative and cost-effective method to treat these complex patients with a standard endoscopy forceps in a combined femoral-superior approach.

Case report

A 58-year-old woman was admitted to our hospital following syncope due to a sustained ventricular tachycardia (200 beats/min), which was terminated by external defibrillation. A dual-chamber pacemaker was implanted 7 years prior via the left subclavian vein owing to permanent atrioventricular (AV) block (Figure 1). Medical history included arterial hypertension and type 2 diabetes mellitus. On admission the patient was hemodynamically stable. The 12-lead electrocardiogram showed AV sequential right ventricular stimulation without signs of cardiac ischemia. Laboratory values were within normal range and troponins were only slightly elevated. Echocardiography showed maintained left ventricular function with no regional wall motion abnormalities. Relevant coronary artery disease was excluded by coronary angiography. Pacemaker interrogation showed regular device function in a pacemaker-dependent patient owing to permanent total AV block. A decision to upgrade the DDD pacemaker to a DDD implantable cardioverter-defibrillator (ICD) system was taken. As an institutional standard, all patients with chronically implanted devices receive a phlebography via the ipsilateral cubital vein to exclude chronic venous occlusion of the subclavian or innominate vein. In this case, digital subtraction angiography showed chronic occlusion of the left subclavian vein (Figure 2, Supplemental Video 1). Different treatment options were discussed with the patient, including contralateral implantation of the DDD-ICD system or implantation of the ICD lead via the right subclavian or cephalic vein with subsequent tunneling to the left side. Owing to the relatively young age of the patient, we opted for extraction of the right ventricular pacing lead using a mechanical extraction tool, thereby creating a venous channel to the heart to implant an ICD lead while preserving the atrial pacing lead for future use.

Lead extraction and implantation of the DDD-ICD was performed in a hybrid operation room under general anesthesia with transesophageal echocardiography and cardiothoracic standby. Arterial pressure was monitored via 4F femoral sheath. A 5F temporary pacing wire was inserted via the right femoral vein. Additionally, a super-stiff guide wire was inserted via the right femoral vein and placed in the right jugular vein to ensure rapid access for a compliant endovascular balloon (Bridge; Philips, Amsterdam, The Netherlands) in case of superior vena cava (SVC) laceration.[4] The pacemaker generator was externalized, and both leads were disconnected and freed from adhesions. The lead collars

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Address reprint requests and correspondence: PD Dr med Frank Eberhardt, Department of Cardiology, Evangelisches Krankenhaus Kalk, Buchforststr. 2, 51103 Cologne, Germany. E-mail address: frank.eberhardt@evkk.de.

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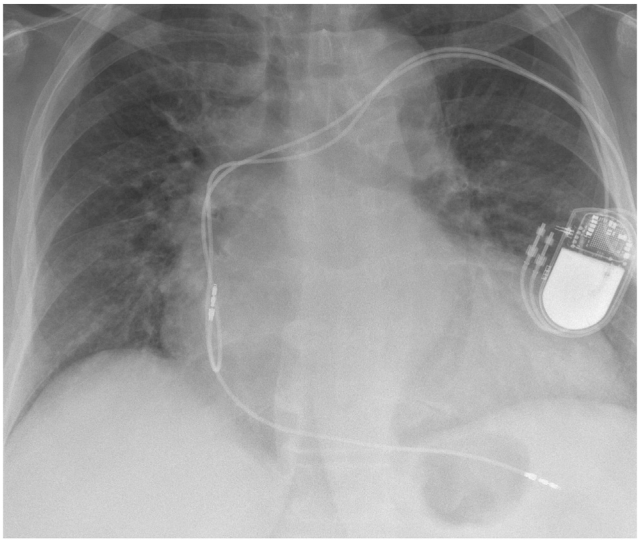

Figure 1 Preoperative chest radiograph with implanted dual-chamber pacemaker.

were identified and the sutures of the ventricular lead were cut. The ventricular pacing lead was shortened and stabilized using a lead locking device (LLD) (LLD EZ; Philips) which was secured with silk ties. After placement of a purse-string suture over the left subclavian vein, an 13F mechanical rotating dilator sheath (TightRail 13F; Philips) was introduced into the left subclavian vein and carefully advanced under constant traction with fluoroscopic guidance. The sheath easily passed the venous occlusion; however, there were additional tight adhesions between the innominate vein and the SVC. While we were freeing these adhesions by slowly advancing the dilator sheath, the ventricular lead snapped back into the dilator sheath. Inspection of the lead and fluoroscopy revealed that the tip of the lead had remained at the superior aspect of the SVC. A standard 0.035 inch guidewire was introduced via the rotating sheath to gain venous access to the heart; however, we could advance neither the standard guidewire nor a hydrophilic guidewire to the right atrium (RA). Venography via the rotating sheath confirmed extensive venous dissection of the large veins (Figure 3, Supplemental Video 2). The sheath was pulled back slowly while we repeatedly advanced a hydrophilic guidewire, which could not be advanced further than the distal pocket of contrast medium, ascertaining the suspected extensive dissection. Puncture of the left subclavian vein to access the true lumen of the vein was not successful.

At this point we opted to sacrifice the atrial lead to gain endovascular access to the right heart; however, a combined femoral-cranial approach was chosen to stabilize the atrial lead by caudal counter-traction to create a more stable rail. Again, the lead was shortened, an EZ LLD was introduced into the atrial lead for stabilization, and the 13F rotating dilator sheath was carefully advanced into the left subclavian vein. A 10F, 47 cm coronary sinus (CS) sheath with a 115°

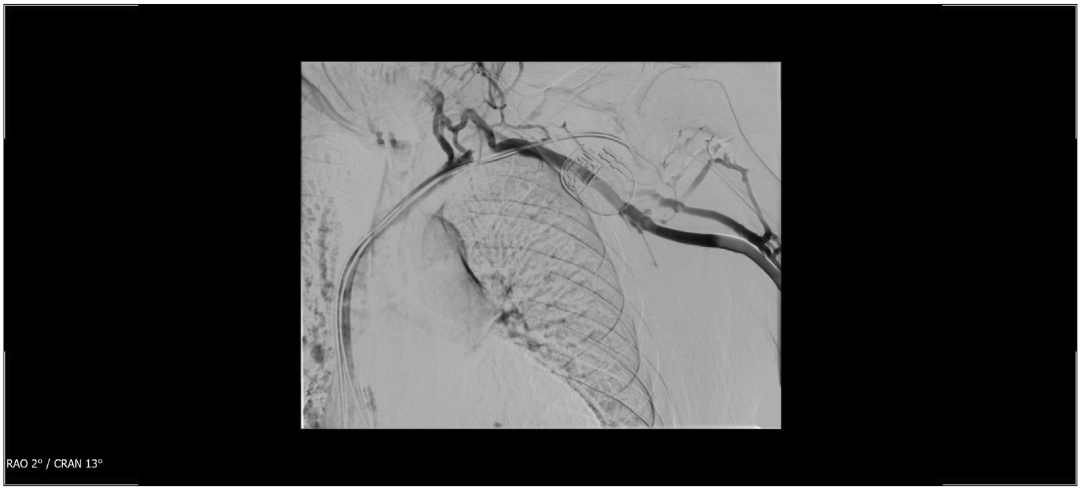

Figure 2 Digital subtraction angiography via the left cubital vein showing total chronic occlusion of the left subclavian vein.

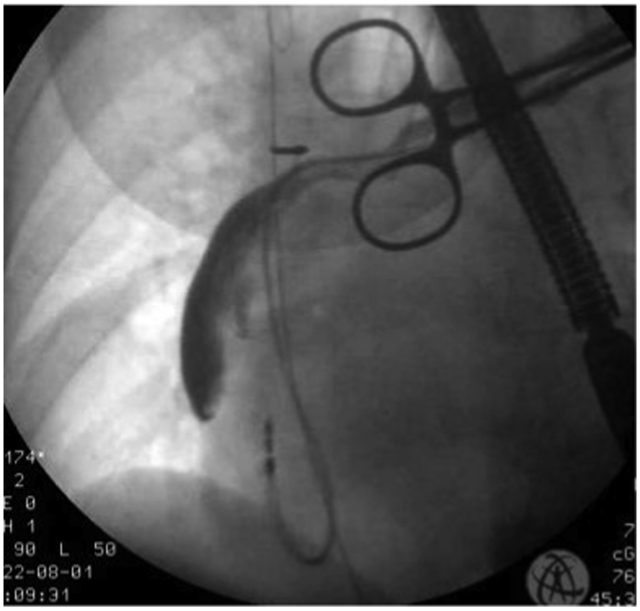

Figure 3 Intraoperative phlebography of the left subclavian vein via the rotating sheath after removing the ventricular pacing lead, showing extensive venous dissection from the left subclavian vein to the superior vena cava.

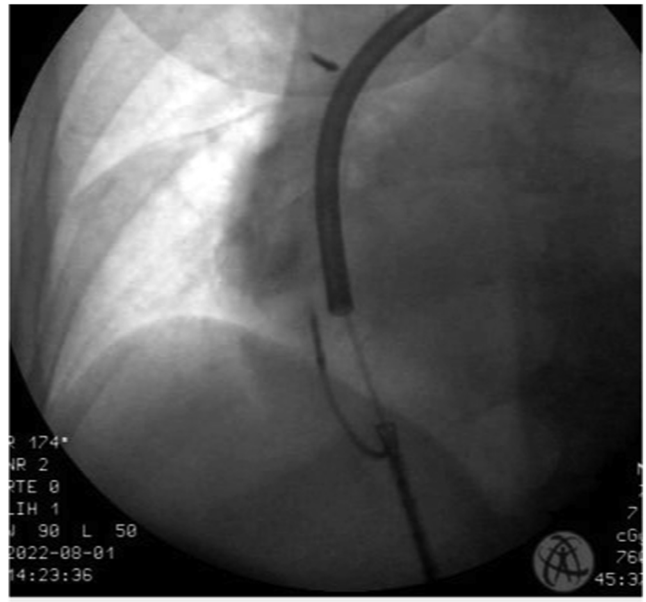

Figure 4 A rotation dissection sheath is advanced over the atrial lead with simultaneous counter-traction using an endoscopy alligator forceps advanced via the right femoral vein. A tight vertically oriented rail is created with a favorable angle between the superior vena cava and the tip of the mechanical rotating dilator sheath.

curve (CPS Direct Universal; Abbott, Sylmar, CA) was introduced into the right femoral vein and advanced into the RA with a 0.035 inch guidewire. Subsequently, a standard alligator (rat tooth) endoscopy forceps (Raptor grasping device; Steris, Mentor, OH) was introduced into the CS sheath and the atrial lead was grasped under fluoroscopic guidance (Figure 4, Supplemental Video 3). The CS sheath advanced toward the tip of the forceps to provide a stable anchor. Now the rotating dilator sheath was advanced under fluoroscopic guidance while exerting caudal counter-traction with the alligator forceps. Adhesions were freed by using a "see-saw" or "piston technique, alternating cranial traction via the LLD and caudal traction via the alligator forceps, thereby safely advancing the dilator sheath into the RA to the point where the lead was grasped from below. The RA lead was easily retracted into the dilator sheath and 2 standard 0.035 guidewires were introduced via the rotating dilator sheath. The dilator sheath was retracted and 2 7F 23 cm peel-away sheaths were advanced over the guidewires, and implantation of the DDD-ICD system was subsequently performed in a standard fashion. The patient was discharged 2 days later with a DDD-ICD system in stable condition and has done well (Figure 5).

Discussion

The incidence of subclavian venous stenosis or occlusion in patients with indwelling leads has been reported at rates of 3%–26%.[3,5] Although lead extraction is a class I indication for lead removal in SVC occlusion that prevents implantation of a necessary lead or in patients who suffer from a symptomatic SVC occlusion, it is considered to be a class IIa indication in asymptomatic subclavian vein stenosis or occlusion preventing the implantation of an additional lead according to the HRS 2017 Expert Consensus Statement on CIED lead management and extraction.[2] If CIED implantation or revision requires more than 4 leads on 1 side or 5 leads through the SVC lead, removal is also considered to be a class IIa indication according to the consensus statement. In cases of ipsilateral venous occlusion, an individualized approach should be taken based on operator and center experience and patient-related risk factors, in particular age and comorbidities.[1,2] In our case, several management strategies existed: implantation of the ICD lead on the contralateral side with subsequent tunneling across the chest, or abandonment of the atrial and ventricular pacing lead on the left side with implantation of the DDD-ICD system on the right side.[1,2] Venoplasty of a stenosed or occluded vein may be attempted in selected cases; however, in a long segment total occlusion, as in our patient, it was not considered to be a feasible option. Although the feasibility and long-term survival of tunneling has been reported in a small series, concerns about the long-term survival, particularly with the more complex ICD leads, remain.[6] Abandoned leads might also cause several potential risks owing to lead-lead interaction, tricuspid valve damage, contraindication to magnetic resonance imaging, and added complexity in case of lead endocarditis.[2] Our regional lead extraction center meets the criteria of a high-volume center according to the criteria of the ELECTRA registry, and thus it was decided to proceed with lead removal of the ventricular pacing lead to create a channel for the ICD lead.[7] Our initial strategy was a superior-only approach using an LLD and a mechanical rotating dilator sheath to remove the ventricular pacing lead,

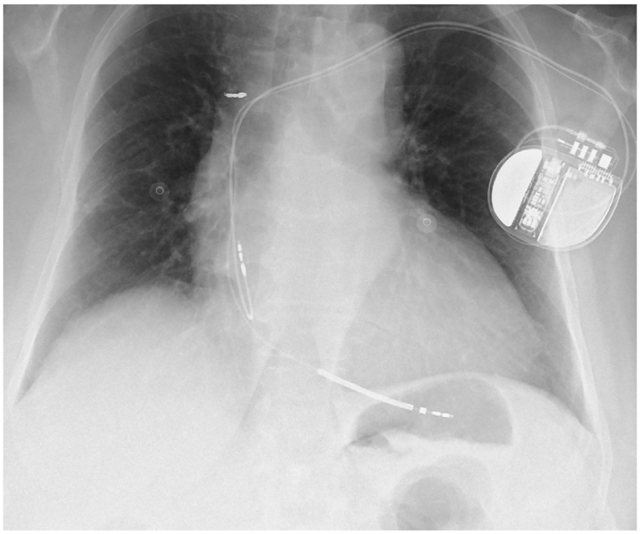

Figure 5 Postoperative chest radiograph with a functional DDD implantable cardioverter-defibrillator system. The tip of the extracted ventricular lead can be appreciated at the superior aspect of the superior vena cava.

with the potential to switch to a combined femoral-superior approach if needed while preserving the atrial lead. A prophylactic routine femoral access has been shown to establish a more rapid control of potential complications in transvenous lead extraction and the placement of a super-stiff wire in the right subclavian vein enables rapid delivery of a compliant endovascular balloon in case of SVC perforation.[4,8] Although the removal of the ventricular lead was initially successful and the rotating dilator sheath could be advanced further than the length of the venous occlusion, a dissection of the SVC prevented us from gaining access to the right heart. This dissection was probably caused by engagement of the leading edge of the rotating mechanical sheath with the SVC wall, as powered sheaths do not respect tissue planes, with resulting dissection or, in the worst case, SVC perforation.[9] If we had used a combined femoral superior approach for the ventricular lead as our first approach, we might have avoided venous dissection or we would have been able to advance the extraction sheath into the RA. Using a combined femoral superior strategy results in a tighter rail with a more vertically oriented tip of the mechanical sheath pulling the sheath tip toward the venous lumen.[9,10] This mechanism has been described in detail in a study using intravascular echocardiography and fluoroscopic images and probably applies to both rotational sheaths and laser-powered sheaths.[9,11] The true incidence of venous dissection is not known for the different types of sheath. A recent meta-analysis reported a considerably higher mortality for laser-powered sheaths, which is most probably due to vascular injury. One might infer from these data that the potential for venous dissection is probably higher with laser-powered sheaths.[12]

The armamentarium for combined femoral superior lead extraction is limited. Many investigators use the Needle's Eye Snare (Cook Medical LLC, Bloomington, IN), which can be used to grasp the lead with 2 loops via a femoral workstation.[2,9,10] Alternatively, a steerable electrophysiology catheter can be wrapped around the lead to be subsequently grasped by a goose neck snare.[9] Although a combined femoral superior approach increases the cost of the procedure, the additional tools and time are not reimbursed in our system. Thus we looked for several alternatives that allow for a flexible and efficient approach at reasonable cost.

The use of a standard endoscopy bioptome has been reported in lead extraction as a cost-effective and efficient tool for femoral lead removal.[13] At our institution we prefer to use an alligator (rat tooth) forceps, which has wider and longer prongs compared to a bioptome, facilitating engagement of larger-diameter leads (eg, ICD leads). One particular problem is how to safely navigate the endoscopy forceps to the heart and how to steer the prongs toward the lead. We have experimented with several sheaths and have finally opted for a straight or mildly curved standard CS sheath to advance and steer the endoscopy forceps. This combination allows for 3-dimensional navigation of the forceps within

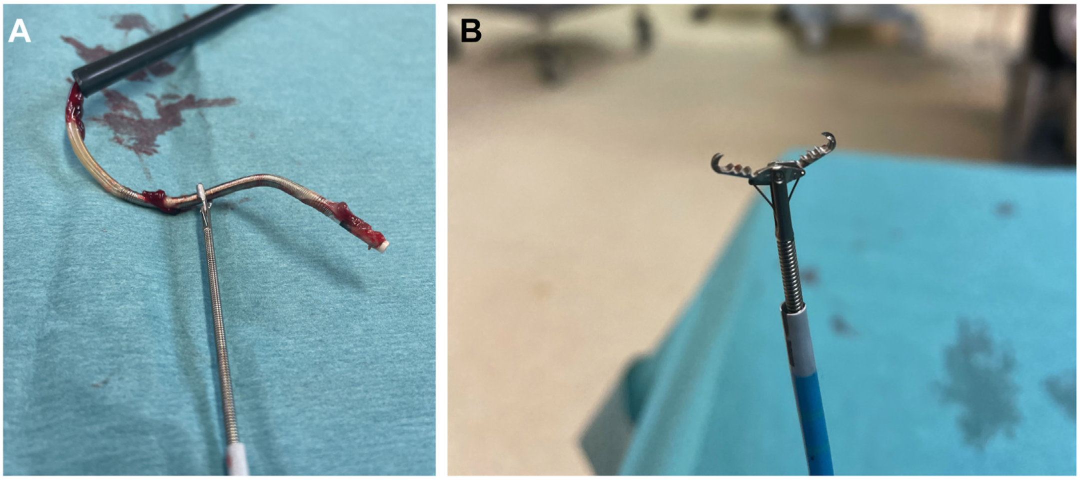

Figure 6 **A:** Endoscopy alligator forceps introduced into a 10F coronary sinus sheath grasping an implantable cardioverter-defibrillator lead, which was extracted using a 13F rotating dilator sheath. **B:** Alligator forceps with open prongs and tip of a 10F coronary sinus sheath.

the heart by combining rotational movement of the sheath with longitudinal movement of the forceps. To minimize the potential damage to intracardiac structures, the CS sheath is steered toward the lead. The forceps is externalized and the prongs of the forceps are only opened in close proximity to the lead. Transesophageal echocardiography can be used to monitor the procedure to avoid inadvertent grasping of valve structures. Once the lead is engaged, the tip of the CS sheath acts as a counter-bearing to exert continuous downward traction on the lead (Figure 6, Supplemental Video 4). The pulling force that can be achieved is similar to a Needle's Eye Snare. Once the lead is engaged, we have not experienced a single incidence where the lead has slipped from the forceps.

One drawback of the endoscopy forceps is the length of this tool in relation to the length of the CS sheath, which gives rise to a certain amount of redundancy. There is also a significant time lag between activation of the opening mechanism and actual opening of the prongs. A second experienced operator is required to steer the forceps and grasp the lead while the first operator exerts alternating traction via the mechanical dilator sheath from above. Depending on the target, a differently shaped CS sheath might be used. This tool can also be used to recover lead fragments during TLE owing to lead endocarditis. Lead fragments can be partly or fully withdrawn into the CS sheath and removed via the femoral vein. In some instances, we have also used larger 16F external sheaths to simplify femoral removal of lead fragments. Partly as a consequence of the case presented, we have changed our institutional strategy in TLE and venous occlusion from a facultative combined femoral-superior approach to a mandatory combined approach.

Conclusion

Lead extraction in chronic venous occlusion is an elegant technique to gain access to the heart for transvenous device therapy in case of lead dysfunction or the need for system upgrade. A combined femoral superior approach is our preferred access, as it lowers the risk for SVC laceration or tear and secures venous access to the heart in a more controlled fashion than a superior-only approach. The combination of a CS sheath with a standard endoscopy alligator forceps is an economical and effective method to create a tight rail, which prevents direct engagement of the mechanical dilator sheath with the SVC wall.

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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.2023.06.019.

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