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Transvenous Extraction of Pacemaker and Defibrillator Leads for Device-Related Infection: An 8-Year Single-Center Experience from a Moroccan Tertiary Military Hospital

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ABSTRACT

Background: Infection of cardiac implantable electronic devices (CIEDs) requires complete system removal. Data on transvenous lead extraction (TLE) from North African centers remain scarce.

Objective: To describe the clinical profile, procedural outcomes, and complications of TLE for CIED infection in a Moroccan tertiary center.

Methods: We conducted a single-center observational study of all consecutive patients who underwent TLE for CIED infection at the Mohammed V Military Teaching Hospital, Rabat, between January 2018 and June 2026. Procedural data were recorded prospectively; clinical data were completed retrospectively from medical records. Outcomes were defined according to Heart Rhythm Society criteria.

Results: Forty patients (mean age 68 years, range 45–92; 67.5% men) underwent 40 procedures for the removal of 76 leads. The mean lead dwell time was 96 ± 59.5 months, and 82.5% of patients had leads implanted for more than 5 years. Lead-related infective endocarditis was present in 23 patients (57.5%), and vegetations were seen on echocardiography in 19 (47.5%). Blood cultures were positive in 21 patients (52.5%), mostly with *Staphylococcus aureus* (9/21). Extraction used laser sheaths in 21 procedures (52.5%) and simple traction in 19 (47.5%). Complete procedural success was achieved in 82.5% and clinical success in 92.5%. Complete radiological success was obtained for 81.6% of leads and partial success for 13.2%. Major intraprocedural complications occurred in two patients (5.0%), including one death from a superior vena cava tear (2.5%). Thirty-day mortality was 5.0%. Longer lead dwell time was associated with lower radiological success.

Conclusion: TLE for CIED infection is feasible in our setting, with outcomes close to, though slightly below, those of high-volume centers. Wider access to powered sheaths, rescue balloons, and on-site surgical backup could further improve safety.

KEYWORDS

cardiac implantable electronic device; infective endocarditis; lead extraction; excimer laser; pacemaker; implantable cardioverter-defibrillator; complications; Morocco

MAIN ARTICLE

INTRODUCTION

The number of patients living with a pacemaker, an implantable cardioverter-defibrillator (ICD), or a cardiac resynchronization therapy (CRT) device has grown steadily over the past three decades, driven by population aging and broader indications. Device-related infections have increased even faster than implantation rates (1,2,28). CIED infection carries substantial morbidity and an in-hospital mortality that may exceed 5%, and long-term mortality is higher still (3).

Current European and North American guidelines recommend complete and early removal of the entire system, including all leads, whenever CIED infection is confirmed, whether it is limited to the generator pocket or involves the leads and endocardium (4–6). Antibiotic therapy alone, or partial removal, is associated with high relapse and mortality rates (3,4).

Removing chronically implanted leads is technically demanding. From the first days after implantation, a fibrin sheath forms along the lead and progressively turns into dense fibrous adhesions at the venous entry site, the superior vena cava, the tricuspid valve, and the electrode–myocardium interface (6,7). Simple traction is often insufficient for leads implanted for more than one year. Locking stylets, mechanical and powered telescoping sheaths, and excimer laser sheaths have therefore been developed, and they have replaced open-heart surgery as the first-line approach in experienced centers (7–9). In large registries, transvenous lead extraction (TLE) achieves clinical success in more than 95% of procedures, with procedure-related major complications of 1% to 2% and procedure-related mortality below 1% (8).

These results come largely from high-volume European and North American centers. Data from North Africa, where access to extraction tools, dedicated hybrid rooms, and on-site cardiac surgery is more limited, remain scarce. The aim of this study was to describe the clinical and microbiological profile of patients undergoing TLE for CIED infection at a

Moroccan tertiary military hospital, and to report procedural success, radiological success, and complications over eight and a half years of practice.

METHODS

Study Design and Setting

This was a single-center observational study with prospective collection of procedural data and retrospective collection of clinical data. It was conducted in the Department of Cardiac Electrophysiology of the Cardiology Center, Mohammed V Military Teaching Hospital, Rabat, Morocco. All consecutive TLE procedures performed between January 2018 and June 2026 were included. During the same period, 815 patients underwent a CIED implantation or generator replacement in our department.

Study Population

Patients were identified from the department's hospitalization registers and from the CIED implantation and extraction registers. We included all patients with a pacemaker, ICD, or CRT device who underwent percutaneous removal of at least one transvenous lead for device-related infection. Leads had to be implanted transvenously in the right atrium, right ventricle, or coronary sinus and connected to a pectoral or abdominal generator. Extractions by the superior route, the femoral route, or both were included, with or without dedicated extraction tools and without a minimum implant duration. Leads removed by sternotomy or thoracotomy during another cardiac surgery (valve surgery or heart transplantation) and epicardial leads or patches were excluded.

Data Collection

The operator recorded procedural data prospectively on a standardized form immediately after each procedure and during hospitalization: tools used, procedural, clinical and radiological success, and early complications. Other data were completed retrospectively from hospitalization and operative reports. Collected variables included age, sex, cardiovascular risk factors, underlying heart disease, left ventricular ejection fraction (LVEF), anticoagulant or antiplatelet therapy, initial pacing or defibrillation indication, time since the last device procedure (≤ 3 months or > 3 months), lead number, type, location and dwell time, clinical presentation, blood cultures, inflammatory markers, transthoracic and transesophageal echocardiography (TTE/TEE) findings, antibiotic therapy, extraction technique, anesthesia, reimplantation strategy, complications, and 30-day outcome.

Infection was classified as isolated pocket infection or lead-related infective endocarditis (LRIE) according to the 2020 European Heart Rhythm Association (EHRA) consensus and the 2023 European Society of Cardiology (ESC) guidelines (4,5).

Extraction Procedure

Procedures were performed in a hybrid catheterization room by three experienced operators, following EHRA and ESC recommendations (5,7). A cardiac surgeon was available on site for emergencies. Each patient had a large-bore peripheral venous line, an arterial line for high-risk cases, and a surgical field wide enough to allow emergency pericardiocentesis, sternotomy, or femoral cannulation for cardiopulmonary bypass. A temporary pacing lead was inserted through the femoral or jugular vein when needed.

After pocket opening, generator removal, and microbiological sampling, leads were freed from the pocket adhesions. Simple manual traction, with or without a standard stylet, was attempted first. When traction failed, a locking stylet was inserted and the lead was extracted with a 16F excimer laser sheath. The laser became available in our department during the study period; earlier procedures were performed by traction only. Fluoroscopy was used to confirm complete removal and to measure any retained fragment.

All patients received empirical intravenous antibiotics (amoxicillin–clavulanate plus gentamicin), adapted after microbiological results, in collaboration with an infectious disease specialist. Reimplantation was decided after re-evaluation of the device indication.

Definitions

Outcomes were defined according to the 2009 Heart Rhythm Society consensus (11):

- **Complete procedural success:** removal of all targeted leads and material from the vascular space, without permanent disabling complication or procedure-related death.
- **Clinical success:** removal of all targeted leads, or retention of a small fragment (<4 cm) that does not increase the risk of perforation, embolism, or persistent infection, without permanent disabling complication or procedure-related death.
- **Failure:** inability to achieve procedural or clinical success, or occurrence of a permanent disabling complication or procedure-related death.

- **Radiological success (per lead):** complete when fluoroscopy confirmed removal of all lead material; partial when a fragment <2 cm remained; failure when >2 cm remained.
- **Major complication:** any event that was life-threatening, caused death, resulted in significant or permanent disability, or required surgical intervention.
- **Minor complication:** any undesired event requiring medical treatment or a minor procedure, without lasting effect.

Intraprocedural complications were events occurring between entry into and exit from the procedure room. Post-procedural complications were those occurring within 30 days.

Statistical Analysis

Continuous variables are presented as mean $\pm$ standard deviation (SD) with range, and categorical variables as numbers and percentages. Associations between candidate factors and radiological success or major complications were assessed by univariate analysis. A two-sided P value <.05 was considered statistically significant.

RESULTS

Patient Characteristics

Forty patients underwent 40 TLE procedures for the removal of 76 leads. Of the 815 patients who had a CIED procedure in our department during the study period, 32 (3.9%) developed a device infection requiring extraction. The other eight patients (20.0%) had been implanted elsewhere and were referred for extraction. Patient characteristics are summarized in Table 1. The mean age was 68 years (range 45–92), and 27 patients (67.5%) were men. Hypertension (47.5%) and diabetes (40.0%) were the most frequent risk factors. No patient had active cancer.

The last device procedure was a generator replacement in 30 patients (75.0%) and a first implantation in 10 (25.0%). Infection occurred within 3 months of the last procedure in six patients (15.0%) and later in 34 (85.0%).

Table 1. Baseline characteristics of the 40 patients

Characteristic	Value
Age, mean (range), y	68 (45–92)
Male sex, No. (%)	27 (67.5)
Hypertension, No. (%)	19 (47.5)

Characteristic	Value
Diabetes, No. (%)	16 (40.0)
Dyslipidemia, No. (%)	9 (22.5)
Current or former smoking, No. (%)	8 (20.0)
Ischemic heart disease, No. (%)	3 (7.5)
Valvular heart disease, No. (%)	5 (12.5)
Dilated cardiomyopathy or heart failure, No. (%)	7 (17.5)
Atrial fibrillation, No. (%)	3 (7.5)
LVEF, mean $\pm$ SD (range), %	41.3 $\pm$ 15.1 (15–62)
Oral anticoagulation, No. (%)	10 (25.0)
Antiplatelet therapy, No. (%)	2 (5.0)
Initial indication: complete atrioventricular block, No. (%)	29 (72.5)
Initial indication: slow atrial fibrillation, No. (%)	3 (7.5)
Initial indication: ischemic cardiomyopathy with LVEF $<30\%$ (CRT), No. (%)	5 (12.5)
Initial indication: ventricular tachycardia with sinus node disease, No. (%)	3 (7.5)
Device implanted at our center, No. (%)	32 (80.0)

Abbreviations: CRT, cardiac resynchronization therapy; LVEF, left ventricular ejection fraction.

Lead Characteristics

Of the 76 extracted leads, 39 (51.3%) were in the right ventricle, 32 (42.1%) in the right atrium, and five (6.6%) in the coronary sinus. Fifty-two leads (68.4%) were connected to a pacemaker and 24 (31.6%) to an ICD or CRT device. The mean lead dwell time was 96 ± 59.5 months (range 3–168). Thirty-three patients (82.5%) had leads implanted for more than 5 years.

Infection Characteristics

All procedures were performed for device infection (Table 2). LRIE was diagnosed in 23 patients (57.5%) and isolated pocket infection in 10 (25.0%). Local pocket signs (erythema, swelling, pain, fluctuation, erosion, or device exteriorization) were present in 32 patients (80.0%). Fever was present in 19 (47.5%). Echocardiography showed lead vegetations in 19 patients (47.5%). Blood cultures were positive in 21 patients (52.5%), with *Staphylococcus aureus* as the leading pathogen. Chest computed tomography was performed in six patients and showed pulmonary embolism in two.

Table 2. Infection characteristics (N = 40)

Variable	No. (%)
Lead-related infective endocarditis	23 (57.5)
Isolated pocket infection	10 (25.0)

Variable	No. (%)
Local pocket signs	32 (80.0)
Fever	19 (47.5)
Elevated inflammatory markers	25 (62.5)
Lead vegetations on TTE/TEE	19 (47.5)
Positive blood cultures	21 (52.5)
<i>Staphylococcus aureus</i>	9/21 (42.9)
Coagulase-negative staphylococci	5/21 (23.8)
<i>Enterococcus</i> spp	5/21 (23.8)
Oral streptococci or <i>Streptococcus bovis</i> group	2/21 (9.5)
Pulmonary embolism before extraction	2 (5.0)

Abbreviations: TEE, transesophageal echocardiography; TTE, transthoracic echocardiography.

After empirical therapy, 27 patients (67.5%) received flucloxacillin for 4 to 6 weeks plus gentamicin for 2 weeks. The other 13 (32.5%) received vancomycin and rifampicin for 4 to 6 weeks plus gentamicin for 2 weeks. The mean number of antibiotics per patient was 2.1 ± 1.5 (range 1–6), and the mean treatment duration was 5.2 weeks (range 2–10).

Procedural Data

Laser-assisted extraction was used in 21 procedures (52.5%) and simple traction in 19 (47.5%). Traction alone was used for most leads implanted for less than 5 years (six of seven patients). Procedures were performed under local anesthesia with sedation in 29 patients (72.5%) and under general anesthesia in 11 (27.5%). A temporary pacing lead was placed during 36 procedures (90.0%). Eight patients required temporary jugular pacing while awaiting reimplantation.

Procedural and Radiological Success

Complete procedural success was achieved in 33 procedures (82.5%) and clinical success in 37 (92.5%) (Table 3). Complete radiological success was obtained for 62 leads (81.6%), and partial success for 10 (13.2%). In univariate analysis, longer lead dwell time was associated with lower radiological success (odds ratio 0.86 per year of implantation; $P = .032$).

Table 3. Procedural and radiological outcomes

Outcome	No. (%)
Per procedure (n = 40)	
Complete procedural success	33 (82.5)
Clinical success	37 (92.5)

Outcome	No. (%)
Failure	3 (7.5)
Per lead (n = 76)	
Complete radiological success	62 (81.6)
Partial radiological success (fragment <2 cm)	10 (13.2)
Radiological failure (fragment >2 cm)	4 (5.3)

Complications and Mortality

Two major intraprocedural complications occurred (5.0%) (Table 4). The first was a tear of the superior vena cava extending to the posterior wall of the right atrium during extraction of a ventricular lead in a woman with LRIE. Despite emergency sternotomy, she died of hemorrhagic shock (intraprocedural mortality 2.5%). The second patient had an abscess of the mitral–aortic intervalvular fibrosa and was transferred to cardiac surgery for double mitral and aortic valve replacement with epicardial lead implantation.

Within 30 days, three major complications (7.5%) occurred: cardiogenic shock due to tricuspid valve injury, septic shock, and mixed septic and cardiogenic shock. The first two patients recovered after intensive care; the third died. Four minor complications (10.0%) occurred: three pocket hematomas requiring surgical drainage and one episode of heart failure related to loss of biventricular pacing. All resolved. Thirty-day all-cause mortality was 5.0% (2/40). The outcome was favorable in 35 patients (87.5%).

In univariate analysis, major complications (intraprocedural or within 30 days) were associated with LRIE ($P = .009$) and with the presence of vegetations ($P = .014$). Female sex showed a nonsignificant trend ($P = .075$).

Table 4. Complications (N = 40 procedures)

Complication	No. (%)
Major intraprocedural	2 (5.0)
Superior vena cava and right atrial tear, fatal hemorrhagic shock	1 (2.5)
Mitral–aortic intervalvular fibrosa abscess requiring surgery	1 (2.5)
Major within 30 days	3 (7.5)
Cardiogenic shock from tricuspid injury	1 (2.5)
Septic shock	1 (2.5)
Mixed septic and cardiogenic shock, fatal	1 (2.5)
Minor within 30 days	4 (10.0)
Pocket hematoma requiring drainage	3 (7.5)
Heart failure from loss of biventricular pacing	1 (2.5)
Intraprocedural death	1 (2.5)
30-day all-cause death	2 (5.0)

Reimplantation

A new device was implanted in 28 patients (70.0%) (Table 5). Reimplantation was performed during the same procedure in 14 patients and was delayed in 14, with a mean delay of 48.3 ± 122.1 days (range 1–510). The new system was placed on the contralateral side in 16 patients (57.1%), on the ipsilateral side in 10 (35.7%), and epicardially in two (7.1%).

Table 5. Reimplantation (N = 40)

Variable	No. (%)
Reimplanted	28 (70.0)
Same procedure	14/28 (50.0)
Delayed	14/28 (50.0)
Contralateral transvenous	16/28 (57.1)
Ipsilateral transvenous	10/28 (35.7)
Epicardial	2/28 (7.1)
Not reimplanted	12 (30.0)
Indication no longer present	6/12 (50.0)
Risk judged greater than benefit	4/12 (33.3)
Contralateral device already in place	1/12 (8.3)
Death or heart transplantation	2/12 (16.7)

DISCUSSION

This study reports 8.5 years of TLE for CIED infection in a Moroccan tertiary center. Its main findings are a procedural success rate of 82.5%, a clinical success rate of 92.5%, a major intraprocedural complication rate of 5.0%, and a 30-day mortality of 5.0%. Older leads were less likely to be removed completely, and LRIE and vegetations were associated with major complications. Table 6 compares our results with published series.

Table 6. Comparison with published lead extraction series

Study	Period	Procedures	Leads	Mean dwell time, mo	Infection, %	Leser, %	Procedural success, %	Complete radiological success, %	Major complications, %	Procedural death, %
Present study	2018–2026	40	76	96	100	52.5	82.5	81.6	5.0	2.5
Roux et al (15)	2000–2005	177	250	94	50	100	85.3	—	—	—
Oto et al (16)	2009–2011	66	140	85	59	0 ^a	95.5	—	—	0

Study	Period	Procedures	Leads	Mean dwell time, mo	Infection, %	Laser, %	Procedural success, %	Complete radiological success, %	Major complications, %	Procedural death, %
Bracke et al (17)	Published 2004	82	160	84	100	67	85.4	—	7.0	2.4
Jones et al (18)	2000–2007	498	975	90	60	78	—	97.5 ^b	—	0
Gaca et al (19)	2002–2008	112	205	70	59	100	—	92.0 ^b	5.4	2.6
Calvagna et al (20)	2002–2008	300	518	86	74	0	—	96.9 ^b	0.3	0
Hamid et al (21)	2003–2007	183	369	75	77	44	—	90.7 ^b	2.2	0

^a Powered mechanical sheath (Evolution, Cook Medical) in all procedures. ^b Partial success threshold of 4 cm (2000 North American Society of Pacing and Electrophysiology definition), vs 2 cm in the present study.

Procedural and Radiological Success

Our procedural success rate (82.5%) is close to that of Roux et al (85.3%) and Bracke et al (85.4%), but below that of Oto et al (95.5%) and of the European Lead Extraction ConTROLled (ELECTRa) registry, which reported clinical success in 96.7% of 3,510 patients (8,15–17). Three factors likely explain this gap. First, our leads were older (mean 96 months, vs 84–94 months in the comparison series), and lead dwell time is one of the strongest predictors of incomplete extraction (8,15,25). This was confirmed in our cohort, where each additional year of implantation reduced the odds of radiological success (odds ratio 0.86). Second, nearly half of our procedures (47.5%) used traction alone, because laser sheaths were introduced in our department only during the study period. Comparison series used powered sheaths in 67% to 100% of cases. Third, our center has a low annual volume, and outcomes of TLE improve with operator and center experience (7,8,22).

Our complete radiological success rate (81.6%) is also lower than in published series (90.7%–97.5%) (18–21). However, these series used the older threshold of 4 cm to separate partial success from failure (12), whereas we used the stricter 2-cm threshold of the 2009 Heart Rhythm Society consensus (11). This difference in definition mechanically lowers our

apparent success rate. Most of our incomplete extractions left a fragment smaller than 2 cm (13.2% of leads), which usually does not prevent cure of the infection when the remaining fragment is small and free of vegetation (4,6).

Complications and Mortality

The major intraprocedural complication rate in our series (5.0%) lies within the range of published single-center series (0.3%–7.0%) (17–21), but is higher than the 1.7% reported in ELECTRa (8). Our intraprocedural mortality (2.5%, one patient) is similar to that of Bracke et al (2.4%) and Gaca et al (2.6%), but higher than in large contemporary registries, where procedure-related mortality is about 0.5% (8,23). The fatal event was a superior vena cava tear, the most lethal complication of TLE. An endovascular occlusion balloon placed in the superior vena cava before high-risk extractions reduces the mortality of such tears (27). This device was not available in our center, and its introduction is a priority.

LRIE and lead vegetations were associated with major complications in our cohort. Patients with systemic infection are older, sicker, and more often hemodynamically unstable, and infection has been identified as a predictor of adverse outcomes in large extraction cohorts (25,26). Female sex showed a trend toward more complications, consistent with registry data (8,26).

Our 30-day mortality (5.0%) falls between the in-hospital mortality of 1.9% in the LExIcon study and 7.5% in a cohort limited to infected patients (23,24). Hamid et al reported a hospital mortality of 2.7%, mainly from sepsis (21). Mortality after TLE for infection reflects the severity of the underlying disease more than the procedure itself, and early extraction is associated with better survival (3,10).

Microbiology and Antibiotic Therapy

Staphylococcus aureus and coagulase-negative staphylococci accounted for two-thirds of documented infections, in line with large CIED infection cohorts (3,14). Nearly half of our patients had negative blood cultures, often because antibiotics had been started before referral. Our empirical regimen of amoxicillin–clavulanate plus gentamicin differs from guideline recommendations, which favor vancomycin-based therapy covering methicillin-resistant staphylococci (4,5). This choice was driven by drug availability in our setting and should be reconsidered as access improves.

Reimplantation and Prevention

Seventy percent of our patients received a new device, compared with 58% in the series of Bracke et al (17). Thirty percent no longer needed a device after re-evaluation, which underlines the importance of reassessing the indication before reimplantation (4,30). Half of our reimplantations were performed during the extraction procedure. Current guidelines recommend delaying reimplantation until blood cultures have been negative for at least 72 hours, or 2 weeks when vegetations were present, and placing the new device on the contralateral side (4,5).

Three-quarters of our infections followed a generator replacement, a well-established risk factor for CIED infection (13). Prevention remains essential: antibiotic prophylaxis covering *S aureus*, careful hemostasis to avoid pocket hematoma, limiting repeat procedures, and use of an antibacterial envelope in high-risk patients, which reduced major CIED infections by 40% in a randomized trial (5,29).

Limitations

This study has several limitations. It is a single-center study with a small sample, which limits statistical power and the generalizability of the results. Clinical data were partly collected retrospectively, which exposes the study to missing data. Only univariate analyses could be performed, so the associations reported may be confounded. The study covers two periods, before and after the introduction of laser sheaths, which may affect outcomes. Finally, follow-up was limited to 30 days, and long-term outcomes such as reinfection and survival were not assessed.

CONCLUSION

In this Moroccan single-center experience, TLE for CIED infection achieved clinical success in 92.5% of procedures and complete radiological success in 81.6% of leads. Major intraprocedural complications occurred in 5.0% of procedures, with one procedural death. Longer lead dwell time reduced the likelihood of complete removal, and LRIE and vegetations were associated with major complications. These results are close to, though slightly below, those of high-volume centers. Wider use of powered sheaths, availability of a superior vena cava occlusion balloon, guideline-based antibiotic therapy, and delayed contralateral reimplantation could further improve outcomes. Strict asepsis at implantation and at generator replacement remains the best prevention.

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Ethics approval and consent to participate: This study was conducted in accordance with the Declaration of Helsinki and the institutional policies of the Mohammed V Military Teaching Hospital. All patient data were anonymized before analysis.

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Availability of data and materials: The data supporting the findings of this study are available from the corresponding author on reasonable request.

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Authors' contributions: ESSM collected and analyzed the data and wrote the manuscript. JK designed the study, performed the procedures, and critically revised the manuscript. YOC contributed to the study and reviewed the manuscript. All authors read and approved the final manuscript

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