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Transvenous lead extraction: predictors of procedure complexity

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ABSTRACT

Background and aims Over the past decades, high-volume lead extraction centres gained broad experience in advanced transvenous lead extractions (TLE). However, access to advanced TLE techniques is limited, thus it would be beneficial to predict which extractions can be performed safely and effectively by simple procedures. We aimed to report on predictors of procedure complexity in clinically successful TLEs.

Methods Our retrospective study included 70 infectious TLEs, of which 65 were clinically successful. TLEs were defined as simple if only simple manual traction or a locking stylet was required, and complex if a rotational mechanical sheath or a femoral snare was used.

Results 42 patients underwent a complex procedure and 23 patients underwent a simple procedure. Overall, 129 leads were extracted. Complex procedures were characterised by longer lead dwell time (mean: 10.7±6.5 years vs 3.2±2.1 years; p<0.01), and a greater rate of passive lead extraction (50% vs 17.4%; p=0.02). In multivariate logistic regression analysis, longer lead dwell time (OR=1.69; 95% CI 1.24 to 2.30; p=0.001) was an independent predictor of procedural complexity. Among active fixation leads, the cut-off lead age for complex extractions was 4.5 years.

Conclusions In the current single centre study, older lead age was the only independent predictor of procedural complexity. Based on this, the majority of infectious TLEs involving active fixation electrodes younger than 4.5 years may be safely performed even in centres where advanced TLE tools are unavailable.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Risk factors of transvenous lead extraction (TLE) complications are well-described, but available data to predict the need for advanced extraction technique use in those TLEs which are clinically successful is scarce.

WHAT THIS STUDY ADDS

⇒ We reported on predictors of procedure complexity in clinically successful TLEs where TLEs were defined as simple if only simple manual traction or a locking stylet was required, and complex if a rotational mechanical sheath or a femoral snare was used

⇒ In multivariate logistic regression analysis, longer lead dwell time was the only independent predictor of procedural complexity. Among active fixation electrodes, the cut-off electrode age for complex extractions was 4.5 years

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ Infected active fixation leads younger than 4.5 years can be safely and successfully extracted in centres where advanced technique is not available.

INTRODUCTION

Over the past decades, the need for transvenous lead extractions (TLE) has risen markedly due to the increased number of cardiac implantable electronic device (CIED) implantations and an increase in device-related complications.[1] Extraction techniques have evolved over the past decades from simple manual traction, through the use of locking stylets, to the use of advanced TLE techniques.[1–4] High-volume lead extraction centres have gained significant experience in using mechanically powered sheaths.[1–3] Advanced TLE techniques are not available in all centres, thus for concerns of patient safety, optimal timing of infectious extractions, resource management and training, there is a need to predict which patients could be managed in centres where only simple extraction-including locking stylets-is available. Risk factors of TLE complications such as younger patient age, female sex, non-infectious indication, longer lead dwelling time, greater number of extracted leads, the presence of implantable cardioverter defibrillator (ICD) leads and the presence of passive fixation leads are well-described,[5–8] but available data to predict the need for advanced extraction technique use in those TLEs which are clinically successful is scarce.

The aim of this study was to identify key factors that can predict the need for implementation of advanced lead extraction tools beyond locking stylets in clinically successful procedures. Risk factors of TLE complications such as younger patient age, female gender, longer lead dwelling time, greater number of treated leads, passive fixation leads and shock leads are well-known.[5–8] We compared simple and complex procedures according to these risk factors when analysing predictors of procedure complexity. We hypothesised that the above-mentioned risk factors of TLE complications also identify the need for advanced technique use, thus helping to identify which TLEs can be performed in centres where only simple extraction is feasible.

MATERIAL AND METHODS

Study population

In our retrospective study, we included consecutive patients who underwent TLE with an infectious indication at a tertiary referral centre. All procedures were performed between January 2014 and December 2023 by three expert electrophysiologists at the Gottsegen Gyorgy National Cardiovascular Centre, Budapest, Hungary.

Definitions

A percutaneous lead extraction, the procedural efficacy and the complications were defined according to the 2018 European Heart Rhythm Association guidelines.[9] Complete procedural success was defined as the removal of all targeted leads and material, with the absence of any permanently disabling complication or procedure-related death.[9] Clinical procedural success was defined as the retention of a small portion of a lead that did not negatively impact the outcome goals of the procedure.[9] Major complications were defined as outcomes which were life-threatening or resulted in death, caused disability or required prolongation of hospitalisation or surgical intervention.[9] Minor complications were defined as any event that required medical intervention.[9]

A lead extraction was considered simple if only simple manual traction or a locking stylet was required and was defined as complex if a rotational mechanical sheath or a femoral snare was used. The indications for TLEs were categorised as infectious (pocket infection, infective endocarditis, bacteraemia) or non-infectious (lead failure, dislocation or system upgrade).[10]

Primary hypothesis and study design

The primary hypothesis of this study was that the classic risk factors of TLE complications are also predictors of the procedure complexity in clinically successful percutaneous lead extractions. In our study, we first identified percutaneous lead extractions performed with an infectious indication. Among these procedures, we selected TLEs which were clinically successful. We then compared simple procedures with complex procedures according to the presence of classic risk factors of TLE complications. Risk factors such as patient age, patient sex, lead age, lead number, the presence of ICD leads, the presence of abandoned leads and the presence of active fixation leads were analysed. Based on factors which proved to be risk factors of procedure complexity, we proposed a new prediction method of complex procedures. We examined the performance of the prognostic scores of procedure complexity previously described in literature in our patient population[8 11–13] and then compared the performance of the Lead Extraction Complexity (LECOM) method[8] with our newly proposed prediction method for predicting complex TLEs in our patient population.

Extraction procedures

TLEs were performed either in the electrophysiology laboratory or in a cardiac surgical operating room equipped with a fluoroscopy system. Local anaesthesia or general anaesthesia was applied based on the heart team's decision. Standby cardiac surgery was available during all TLE procedures. Continuous intraoperative transoesophageal echocardiography (TEE) or intracardiac echocardiography (ICE) was added in TLEs when a difficult procedure was anticipated.

First, an incision was made at the site of the pulse generator; next, the leads were disconnected; and then, a dissection was performed along the leads to the suture sleeves. The sleeves were removed and leads were cut. All leads were removed using a standard stepwise approach: first, a straight stylet and simple manual traction was applied; then, a locking stylet was used; and last, a mechanically powered sheath (Evolution, Cook Medical, Bloomington, USA, or TightRail, Philips Healthcare), if necessary. The rotational mechanical sheath sizes included 9, 11 or 13-Fr sheaths. In the case of lead fracture, a femoral approach by applying the snare technique (Needle's Eye snare (Cook Medical Inc, Bloomington, Indiana, USA) was also used.[14]

Data collection

Data from hospital records and chest X-ray images were collected in a database retrospectively. The following demographic data were collected: age, sex and comorbidities. The indication for lead extraction, the types of

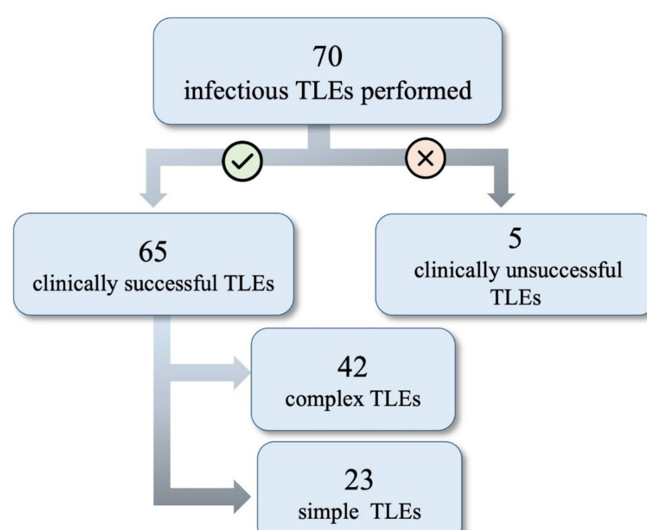

Figure 1 Study flow chart of the simple and complex procedures. TLEs, transvenous lead extractions.

implantable cardiac devices and the lead characteristics, such as the lead implant duration, the number of leads present, the number of leads treated per patient, the number of extracted ICD leads, the number of extracted passive fixation electrodes and the number of extracted abandoned leads were collected. Methodological data on lead extraction, such as the use of a powered sheath and the procedure's duration, were also collected.

Statistical analysis

The mean and SD were calculated for normally distributed continuous variables, while the median and IQR were used for continuous variables with a non-normal distribution. Categorical data were presented as absolute numbers and percentages. To compare continuous data between simple and complex procedures, we used the Mann-Whitney U-test. Fisher's exact test was used to compare baseline, procedural and outcome characteristics between patient groups, to compare predictor scores between simple and complex procedures, and to evaluate the performance of the LECOM method versus our own prediction model. A multiple logistic regression analysis was performed to determine the independent predictors of the complex procedures. Optimal value of independent predictors for complex technique use was determined using receiver-operating characteristic curves, and the Youden index was applied to identify the optimal threshold. A p value of less than 0.05 was considered significant. Statistical analysis was performed using the Stata software V.9.0 (Stata).

RESULTS

Study population

Our retrospective database contained 70 infectious percutaneous lead extractions.

Infectious TLEs had a clinical success rate of 92.8%, thus we analysed 65 clinically successful percutaneous lead extractions. Our analysis included 42 complex procedures and 23 simple procedures. Among complex procedures, where the type of powered sheath was documented, TightRail powered sheath was used in 62% of patients, Evolution powered sheath was applied in 37% of patients. Femoral snare as an additional technique was required in 6.1% of patients.

The study flow chart of the simple and complex TLE procedures is provided in figure 1.

Baseline patient demographics

Baseline patient demographics of infectious TLEs are presented in table 1.

The patients in the complex extraction group were younger than the patients in the simple extraction group at the time of lead extraction (56.2±20.1 vs 66.3±14.9 years; p=0.06). There was no significant difference in the proportion of female patients, prior cardiac surgery, prior prosthetic valve implantation or diabetes mellitus between the complex procedure group and the simple procedure group. Congenital heart disease was only present in the complex procedure group. The two patient groups did not differ in the proportion of an ejection fraction of <50%, with a similar distribution of New York Heart Association functional class among heart failure patients. The patients' indications for lead extractions were a system infection in every case. Infectious indications were further subclassified into the following categories: an isolated pocket infection, isolated pocket erosion, CIED-related endocarditis and bacteraemia. In both groups, most infectious TLEs were performed with an indication of CIED-related endocarditis. The second most common indication for TLE was pocket infection in both patient

Table 1 Baseline patient demographics of infectious TLEs

	Complex extractions (N=42)	Simple extractions (N=23)	P value
Female gender n (%)	9 (21.4)	4 (17.3)	0.76
Patient age at time of extraction (mean) (years)	56.2±20.1	66.3±14.9	0.06
Prior cardiac surgery n (%)	9 (21.4)	4 (17.3)	0.76
Previous valve prosthesis implantation n (%)	4 (9.5)	2 (8.6)	1.0
CHD n (%)	4 (9.5)	0	0.29
HFrEF and HFmrEF n (%)	26 (61.9)	14 (60.8)	1.0
NYHA I	4 (21.4)	2 (8.6)	0.75
NYHA II	9 (21.4)	5 (21.7)	
NYHA III	7 (16.6)	6 (26)	
NYHA IV	5 (11.9)	1 (4.3)	
Diabetes mellitus	8 (19)	7 (30.4)	0.36

CHD: congenital heart disease
HFmrEF, Heart Failure with Mildly Reduced Ejection Fraction; HFrEF, Heart Failure with Reduced Ejection Fraction; NYHA, New York Heart Association; TLE, transvenous lead extraction.

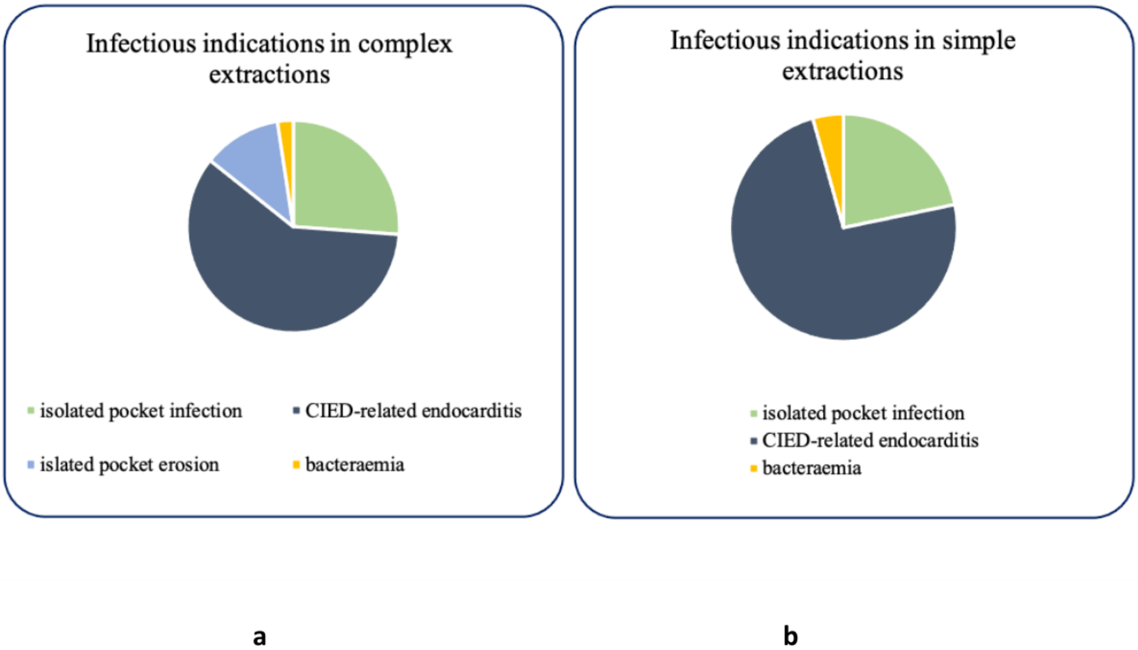

Figure 2 Infectious indications for transvenous lead extraction (TLE) in (a) complex extractions and (b) simple extractions. CIED, cardiac implantable electronic device.

groups. Only a minority of TLEs was performed with an indication of bacteraemia. The subclassification of infectious indications in the simple and complex extraction groups is provided in figure 2.

Device type and lead characteristics

The device types present at the time of extraction and the lead characteristics are shown in table 2.

The two groups did not differ significantly regarding the device type. The most common devices in the complex extraction group were CRT-Ds (26.2%) and dual chamber pacemakers (23.8%) while in the simple extraction group most patients had single chamber ICDs (30.4%) and dual chamber pacemakers (30.4%) (p=0.74).

Overall, 129 leads were extracted, 41 leads were removed by simple procedure and 88 leads were extracted by complex procedure. The mean lead dwelling time was longer for the complex procedures (10.7±6.5 years) than for the simple procedures (3.2±2.1 years) (p<0.01). The two groups differed significantly in the rate of passive lead extractions: passive electrodes were extracted in 50% of the complex extractions and only in 17.4% of simple extractions (p=0.02). Simple and complex procedures did not differ significantly in the distribution of the number of treated electrodes. In most complex and simple extractions, two leads were targeted (33.3% vs 43.4%; p=0.49). The frequency of ICD lead extraction was also similar in the two groups: ICD lead was extracted in 57.1% of the complex procedures and in 65.2% of the simple procedures (p=0.6). Abandoned leads were extracted only by complex procedures (9.5%).

Predictors of procedure complexity

Predictors of procedure complexity are shown in table 3. In multivariate logistic regression analysis, longer lead dwelling time (OR=1.69, 95% CI 1.24 to 2.30; p=0.001) was the only independent predictor of procedural complexity. The analysis confirmed a 69% increased risk of rotational-mechanical powered sheath use for each year of lead age. We performed receiver-operating characteristic analysis among active fixation leads to identify the cut-off value of implant duration that best predicted complex technique use. Based on the Youden index, implant duration greater than 4.5 years best predicted the need for complex technique use (sensitivity at cut point was 71%, specificity at cut point was 89%, area under receiver operating characteristics curve (ROC) curve at cut point was 80%) among active fixation leads. The ROC of active fixation electrode age is presented in figure 3.

The MB,[13] the LED,[11] the Mazzone[12] and the LECOM[8] risk scores were significantly higher in the complex patient group than in the simple extraction group (table 4). According to our prediction method, all active fixation leads younger than 4.5 years were anticipated to be extracted by a simple procedure, and leads which were passive or were older than 4.5 years were expected to be extracted by a complex procedure. Our prediction model predicted 85.6% of complex procedures correctly. The LECOM method with a cut-off value of 9.679 LECOM points predicted 23.8% of the complex procedures correctly in our patient population.

The performance of the two methods in predicting procedure complexity in our patient population is presented in table 5.

Complications

As we studied only clinically successful TLEs for procedure complexity, there was no major complication,

Table 2 Extracted device types and lead characteristics of infectious TLEs

	Complex extractions (N=42)	Simple extraction (N=23)	P value
Devices			0.74
Single chamber (atrial) PM	1 (2.3%)	0	
Single chamber (ventricular) PM	3 (7.1%)	1 (4.3%)	
Dual chamber PM	10 (23.8%)	7 (30.4%)	
Single chamber VDD PM	1 (2.3%)	0	
CRT PM	3 (7.1%)	0	
Single chamber ICD	8 (19 %)	7 (30.4%)	
Single chamber VDD ICD	0	1 (4.3%)	
Dual chamber ICD	5 (11.9%)	3 (13 %)	
CRT-D	11 (26.2%)	4 (17.3%)	
Leads			
Lead dwelling time (mean) (years)	10.7±6.5	3.2±2.1	**<0.01**
Number of leads treated per patient			
1 lead	13 (30.9%)	9 (39.1%)	0.49
2 leads	14 (33.3%)	10 (43.4%)	
3 leads	13 (30.9%)	4 (17.3%)	
4 leads	2 (4.7%)	0	
Number of ICD lead extractions n (%)	24 (57.1)	15 (65.2)	0.6
Number of abandoned lead extractions n (%)	4 (9.5)	0	0.29
Number of passive lead extractions n (%)	21 (50)	4 (17.4)	**0.02**

CRT-D, cardiac resynchronisation therapy-defibrillator; ICD, implantable cardioverter defibrillator; PM, pacemaker; TLEs, transvenous lead extractions; VDD, ventricular lead with atrial sensing.

Table 3 Multivariate logistic regression analysis of infectious TLE complexity predictors

	OR (95% CI)	P value
Female gender	0.98 (0.10 to 8.86)	0.99
Patient age	0.95 (0.89 to 1.0)	0.07
Lead dwelling time	1.69 (1.24 to 2.3)	0.001
Number of leads extracted	1.88 (0.71 to 4.93)	0.19
ICD lead extraction	1.06 (0.17 to 6.6)	0.94
Passive lead extraction	0.49 (0.04 to 5.18)	0.56

ORs for patient age and implant duration are given for every year. ICD, implantable cardioverter defibrillator; TLE, transvenous lead extraction.

by definition. The following minor complications occurred: bleeding requiring blood transfusion, pulmonary embolism which did not require intervention and acute left heart failure. There was no significant difference in the abovementioned minor complications between the two patient groups (17.4% vs 16.7%; p=1.0). Complications of the complex and simple procedures are presented in table 6.

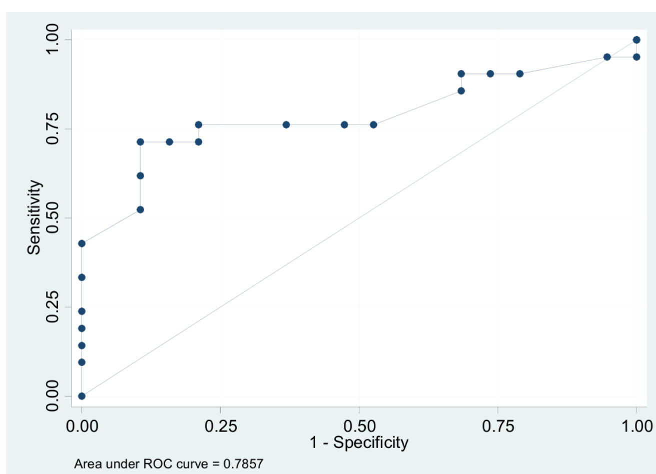

Figure 3 Receiver operating characteristics (ROC) curve of electrode age among active fixation leads.

DISCUSSION

The main finding of the present study is that electrode age is an independent predictor of the complexity of the TLE intervention in clinically successful TLEs performed with an infectious indication. We identified a cut-off value of 4.5 years that predicted the need for complex

Table 4 MB, LED, Mazzone and LECOM scores of simple and complex TLEs

	Complex extractions (N=42)	Simple extractions (N=23)	P value
MB (points) (mean)	4.02±1.49	2.09±1.08	<0.01
LED (points) (mean)	12.31±6.78	4.32±2.39	<0.01
Mazzone (points) (mean)	2.9±0.85	2.26±0.92	<0.01
LECOM (points) (mean)	7.47±3.14	4.15±1.61	<0.01

MB,[13] Mazzone.[12]
LECOM, Lead Extraction Complexity; LED, lead extraction difficulty; Mazzone, Mazzone score; MB, MB score; TLEs, transvenous lead extractions.

technique use when extracting active fixation leads with an infectious indication.

Describing procedure complexity

Complexity of TLE was the objective of several previous reports. However, previous studies differed in their definition of a 'difficult' or 'complex' procedure: In a single-centre experience, prolonged fluoroscopy time was regarded as an index of difficulty.[11] Levi defined difficult extractions as the use of an additional jugular or femoral approach or the requirement of any specific extraction tool other than powered sheaths.[15] Kutarski *et al* characterised complex procedures with prolonged procedure time and unexpected procedure difficulty,[16] while only a few reports defined complex procedures as the requirement of advanced tools.[12,13] In everyday patient management, when the goal is to discriminate which patients should be referred to high-volume centres, it is crucial to foresee which patients require advanced extraction technique. This information is pivotal when planning TLEs of infected leads, as the transfer of patients to high volume centres delays extraction, which is associated with higher mortality and increased healthcare costs.[17]

Studies which addressed the need for advanced technique analysed extractions where a combination of non-powered mechanical dilators, rotational-mechanical dilators and laser powered tools were used.[12,13,16] Due to the increased risk of lead fracture, non-powered dilator sheaths are not routinely used in most centres. It is also suggested that laser-powered tools may have a lower safety profile compared with mechanical-powered tools,[4,18] thus predicting the complexity of procedures from such combined data may not be precise or useful for centres where only rotational-mechanical dilators are available.

Former reports on risk factors of procedure complexity analysed the complexity of TLEs regardless of the outcome of extractions, thus in certain cases, procedure complexity might have been inferred from simple procedures which resulted in major complications or were not clinically successful.

In former reports of procedure complexity, where both non-infectious and infectious TLEs were analysed, the extraction rate of infectious and non-infectious cases was not calculated separately.[11–13,15,16] Thus, the impact of selection bias among non-infectious TLEs was not considered, which might have affected the outcome of procedural complexity.

In the present study, we tried to overcome these limitations by defining complex procedures as the need for mechanically powered sheath and by analysing only clinically successful TLEs. To overcome the effect of selection bias among non-infectious TLEs, we included only infectious TLEs in our analysis.

Table 5 Performance of our prediction method and LECOM method for predicting complex procedures

	Predicted to be simple by our prediction method	Predicted to be complex by our prediction method	P value	Predicted to be simple by LECOM method	Predicted to be complex by LECOM method	P value
Simple extractions (N=23)	17	6	<0.01	23	0	0.01
	73.9%	26.1%		100%		
	73.9%	14.3%		41.8%		
Complex extractions (N=42)	6	36		32	10	
	14.3%	85.7%		76.2%	23.8%	
	26.1%	85.7%		58.2%	100%	

Predicted to be simple by our prediction method: procedures where active fixation leads are all younger than 4.5 years.
Predicted to be complex by our prediction method: procedures where any lead is passive, or any active fixation lead is older than 4.5 years.
Predicted to be simple by LECOM method: procedures with LECOM score <9.679.
Predicted to be complex by LECOM method: procedures with LECOM score >9.679.
LECOM, Lead Extraction Complexity.

Table 6 Complications of infectious TLEs

	Complex extractions (N=42)	Simple extractions (N=23)	P value
Major complications	0	0	
Minor complications	7 (16.7%)	4 (17.4%)	1.0
Bleeding requiring transfusion	5 (11.9%)	1 (4.3%)	0.41
Pulmonary embolism not requiring intervention	2 (4.8%)	1 (4.3%)	1.0
Acute left heart failure	0	2 (8.7%)	0.12

TLEs, transvenous lead extractions.

Risk factors of complex procedures

The present study demonstrated that in clinically successful TLEs performed with an infectious indication, complex procedures were characterised by longer implant duration and a greater rate of passive fixation electrode extraction.

Moreover, we have shown that longer lead dwell time is the only independent predictor of complex technique use. This finding is in accordance with other studies which identified lead age as a risk factor of advanced technique use.[12 13 19 20] The explanation for this finding is that over longer implant duration, fibrotic adhesions are converted to heavily calcified scarring with extensive tensile strength.[21] Although it had been formerly described that lead dwell time is a predictor of complex technique use,[12 13 19 20] the novelty of our study is that among infectious TLES, we have identified a cut-off age of 4.5 years for active fixation electrodes when the procedure is expected to be complex.

Our study suggests that TLE of passive fixation leads was associated with advanced technique use, which is in line with Levi's analysis where passive fixation lead was an independent risk factor of difficult TLE procedures.[15] In Levi's survey, difficult TLE procedures were defined by the use of alternative venous approaches, alternative extraction tools or intraprocedural technical issues such as insulation break or fragment migration.

In our analysis, passive fixation, however, was not an independent risk factor of complex extractions. The explanation for this might be that passive fixation electrodes had a longer implant duration compared with active fixation electrodes, thus the fixation mechanism could not become an independent risk factor. Another reason might be the fact that the aforementioned study by Levi[15] defined complex procedure differently from our report.

Contrary to previous reports which also listed female gender, patient age, the number of treated leads and ICD lead extraction as predictors of difficult TLEs,[11–13 16] in our study, these factors were not independent risk factors of advanced technique use. We explain this with the homogenous nature of our study population as we analysed only clinically successful TLEs and all TLEs in our report were performed with an infectious indication, while in the above-mentioned studies, results were inferred from a patient population heterogenous concerning both indication and clinical success.

Prediction of complex extractions

In our study, we have proposed a new prediction method of complex procedures among infectious TLEs. According to our prediction method, active fixation leads younger than 4.5 years old were predicted to be extracted by simple procedure, whereas leads with passive fixation mechanism or leads older than 4.5 years were anticipated to require complex techniques. Our method identified 85.7% of complex procedures; thus, it performed well in infectious TLEs. By comparison, the LECOM method with a cut-off point of 9.697 could only predict a minority of complex TLEs in our patient population. This might be explained by the different distribution of infectious and non-infectious TLEs in our patient population and in the patient population from which the LECOM score system was derived. The TLEs we examined were all performed with an infectious indication, whereas in the LECOM cohort, TLEs were mostly performed with a non-infectious indication. Because guidelines for infectious TLEs differ in strength from guidelines for non-infectious TLEs, the extraction rate of infected and non-infected leads differs in most centres: while all infected leads are usually extracted, it is possible that only those non-infectious TLEs that were anticipated to be simple were performed. It is probable that such a selection bias might have been also present among the LECOM subgroup of non-infectious TLEs, as well. Because of this selection bias, probably a lower LECOM cut-off point should be determined for infectious cases in order to predict complex procedures reliably.

Clinical applications

Over the past two decades, rates of CIED implantations and TLE procedures have been rising.[22] Patients undergoing CIED procedures have an increasing number of comorbidities which resulted in a growing proportion of infectious TLEs among percutaneous lead extractions over the past years.[23] It has been shown that early diagnosis of CIED infection and performing lead extraction within 3 days of diagnosis is associated with lower in-hospital mortality[24] and that immediate device removal was associated with improved outcomes.[25] It is crucial to remove infected CIEDs as early as possible, without any delay caused by patient transfer. However, many patients with infected devices are hospitalised in centres where advanced TLE technique is unavailable and have to be transferred to high-volume centres with a consequent delay in device removal. Thus, it is necessary to discriminate which patients can undergo infectious TLE procedure in centres where advanced TLE technique is either unavailable or is not used routinely. According to our results, infected active fixation leads younger than 4.5

years can be safely and successfully extracted in centres where advanced technique is not available; this facilitates the decision-making process of infectious TLE procedures.

In our study, we did not touch on the safety of performing TLEs without surgical backup. Rates of emergent surgery are consistently lower than complication rates as shown by the largest series reported by Deshmukh *et al*,[23] where in spite of a 4.9% rate of major complications, only 0.2% required emergent cardiothoracic surgery, a study conducted before the routine use of the vascular occlusion balloon, which is known for improved outcomes in Superior Vena Cava (SVC) injuries.[26] In a retrospective study of non-infectious TLEs led by Issa, it has been shown that in patients who were deemed low risk by the operator, extractions could be safely performed without surgical backup if laser application within the SVC was prohibited.[27] In the above-mentioned study, lead extraction was also abandoned whenever the operator declared the procedure to be high risk. We cannot advocate for performing infectious extractions without surgical backup as a subset of the patients in our analysis underwent TLE in a cardiac surgical operating room, and even in TLEs done in the electrophysiology room, a cardiothoracic surgeon was available. Greater registry data would be required to investigate the safety of performing infectious TLEs without immediate surgical availability.

Another clinical implication of our analysis relates to lead fixation mechanism. We have shown that in infectious TLEs, passive fixation of the leads was associated with advanced technique use. In anticipation of possible future TLEs, in young patients whose lifetime risk of CIED infection is high because of comorbidities or previous device infection,[28] it might be prudent to use active fixation leads instead of passive fixation leads.

Limitations

The relatively small sample size of the study is the most important limitation of our analysis. However, it should be noted that as our lead extraction centre is the only centre in the country that uses exclusively mechanical rotational devices as complex interventions from superior approach, it was not possible to include patients from other centres. As our centre is a tertiary referral centre for TLE procedures, the analysed population was subject to referral bias.

Continuous intraoperative TEE or ICE monitoring was performed in only 10.9% of TLEs, which is another limitation of our study.[29] Since intraoperative imaging data were not consistently available, we did not include it in our retrospective analysis.

CONCLUSIONS

In conclusion, in infectious TLE procedures, we identified longer lead dwell time as an independent risk factor of complex TLEs, which may help the operator plan the circumstances of the extraction procedure. Our findings suggest that after a careful risk-benefit analysis, infected active fixation leads younger than 4.5 years may be removed even in centres where advanced TLE technique is not available.

Contributors Conceptualisation: AFC and TS-T; methodology: AFC and TS-T; software: GJS; validation: GJS and RG; formal analysis: GJS and RG; investigation: AFC; resources: AK, CF and ZS; writing—original draft preparation: AFC and RG; writing—review and editing: GJS, MV, LS, AN and TS-T; supervision: TS-T. TS-T as guarantor. All authors have read and agreed to the published version of the manuscript.

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