Successful, urgent, single-stage endo-epicardial catheter ablation with a surgically subxiphoid pericardial window for a drug-resistant ventricular tachycardia storm in an extremely old hemodialysis patient with ischemic cardiomyopathy

Yuhei Kasai, MD,* Takayuki Kitai, MD,* Junji Morita, MD,* Takuya Okada,†
Jungo Kasai, BS,‡ Tsutomu Fujita, MD*

*From the *Department of Cardiology, Sapporo Cardiovascular Clinic, Sapporo, Japan, †Department of Clinical Engineering, Sapporo Cardiovascular Clinic, Sapporo, Japan, and ‡Paul G. Allen School of Computer Science & Engineering, University of Washington, Seattle, Washington.*

Introduction

Ischemic cardiomyopathy is the most common cause of scar-related ventricular tachycardia (VT) leading to sudden cardiac death. Catheter ablation of VT is important in managing drug-refractory VT.[1] There has been a recent rise in the performance of epicardial access and mapping ablation for treating VT because of epicardial or transmural location of the clinical VT isthmuses.[2] Although the endo-epicardial approach for ablation of scar-related VT is associated with lower rates of VT recurrence and subsequent mortality than endocardial-only VT ablation, it is associated with a greater incidence of procedural complications.[3] In particular, in patients with a high bleeding risk, there should be awareness of the complications associated with epicardial access. We report a case of a VT storm in a very old patient with high bleeding risk who had a good outcome after successful 1-stage ablation including the surgical subxiphoid epicardial approach.

Case report

The patient was a 91-year-old man with a 4-year history of hemodialysis owing to nephrosclerosis. He had an extensive medical history, including ischemic cardiomyopathy and a history of percutaneous coronary intervention to the right coronary artery 15 years previously and percutaneous coronary intervention to the left anterior descending artery 8 years previously. He had no previous history of catheter ablation or cardiac surgery. He was being followed up for heart failure with reduced ejection fraction at our hospital. He was admitted 7 days earlier owing to dyspnea, palpitation, and syncope and was then referred to our hospital. A sustained event of monomorphic broad-complex VT at 180–200 beats per minute was documented on a 12-lead electrocardiogram (Figure 1A).

Initial management with intravenous amiodarone 300 mg was unsuccessful. Subsequently, he received a biphasic 150 J shock owing to hemodynamic instability, and he reverted to sinus rhythm (SR). An urgent coronary angiogram confirmed the patency of the coronary arteries. He was intubated and sedated with intravenous propofol. On the ninth day after

KEY TEACHING POINTS

- In patients with ventricular tachycardia (VT) and ischemic cardiomyopathy, an endocardial approach alone may be insufficient to achieve a high success rate, and an endo-epicardial approach may be necessary.
- Single-stage endo-epicardial catheter ablation can be effective for patients with a high risk (eg, extremely old and hemodialysis).
- One reason why physicians may hesitate to perform epicardial catheter ablation, especially in patients with a high bleeding risk, is because the most common procedural complications are associated with percutaneous epicardial access. A surgical subxiphoid epicardial approach could be a relatively safe technique for verifying the access route for epicardial catheter ablation.

KEYWORDS VT storm; Surgically subxiphoid epicardial ablation; Ischemic cardiomyopathy; High bleeding risk; Endo-epicardial
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Address reprint requests and correspondence: Dr Yuhei Kasai, North 49, East 16, 8-1, Higashi Ward, Sapporo, Hokkaido, 007-0849, Japan. E-mail address: yuheikasai_1025@yahoo.co.jp.

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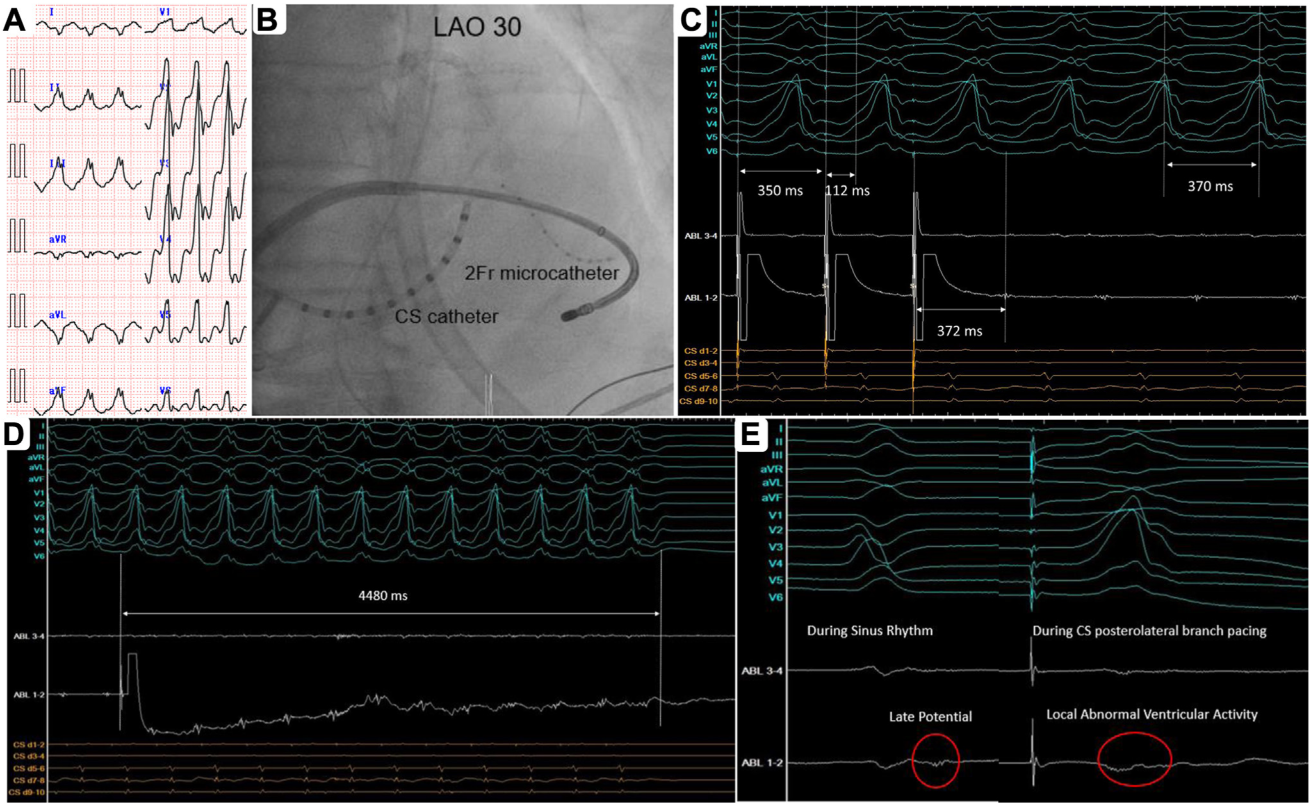

Figure 1 **A:** Twelve-lead electrocardiogram of ventricular tachycardia (VT). **B:** Fluoroscopic image of the ablation site. **C:** Entrainment with concealed fusion. The postpacing interval was 372 ms, which was almost consistent with VT cycle length, and the S-QRS interval was 112 ms. **D:** VT was terminated approximately 4.5 seconds after initiating radiofrequency application. **E:** The difference between sinus rhythm and coronary sinus posterolateral branch pacing in ablation catheter potentials.

extubation, the same morphology of VT appeared and was defibrillated, but it recurred, and we diagnosed it as a VT storm. The patient was sedated and intubated again, and after consultation with the family and the departments of cardiology and cardiac surgery, emergency ablation for the VT storm was performed on the same day. On the basis of the morphology of VT on a 12-lead electrocardiogram, we predicted that the arrhythmia substrates may be located in the basal posterolateral wall of the left ventricular (LV) epicardium. Because the patient was very old and a second session may not have been possible in the event of recurrence, we explained to the family that we may need to perform an epicardial approach in addition to the endocardial approach if necessary. The patient was on full heparinization and single antiplatelet therapy, as well as dialysis, with an increased risk of complications related to percutaneous epicardial access. Therefore, we requested the assistance of a cardiac surgeon in advance to establish a surgical epicardial approach if necessary. The PAINESD score[4] for this patient was 20, as they meet the criteria for age, ischemic cardiomyopathy, NYHA class 3, and storm (high-risk category).

The procedure was performed under general anesthesia with endotracheal intubation. A decapolar electrode catheter with a lumen (5-mm interelectrode spacing; EPstar FIX; Japan Lifeline, Tokyo, Japan) was introduced into the coronary sinus (CS). A 2F microcatheter (1.3-mm electrode with 5-mm interelectrode spacing; EPstar Fix AIV; Japan Lifeline, Tokyo, Japan) was introduced through the inner lumen of the decapolar catheter into the posterolateral branch of the CS. Electroanatomical mapping (EAM) was obtained using the CARTO 3 system (Biosense Webster, Diamond Bar, CA). The left ventricle was accessed via a transseptal puncture. We considered mapping under right ventricular (RV) pacing or during SR, where late potentials (LPs) can be pronounced.[5] However, we observed RV pacing led to the hypotension caused by LV dyssynchrony; moreover, the patient's sinus rate was 40–50/min, making mapping during SR time-consuming. On the basis of these observations, LV endocardial EAM was initially performed using DECANAV (2-8-2-mm, interelectrode spacing; Biosense Webster) during posterolateral branch pacing. LPs were not observed in the LV endocardial EAM. The latest activation point was also located before the QRS offset (Figure 2A). During SR, we mapped around the site of the latest activation point. However, any LPs could not be identified. Moreover, based on the morphology of the VT observed in the 12-lead electrocardiogram (Figure 1A), we estimated that the exit site of the VT was epicardial. Therefore, we switched to an epicardial approach. Owing to the presence of hepatomegaly in addition to the high bleeding risk, we chose a surgical approach to avoid the possibility of accidentally puncturing the liver. A 2-inch vertical incision was made at the

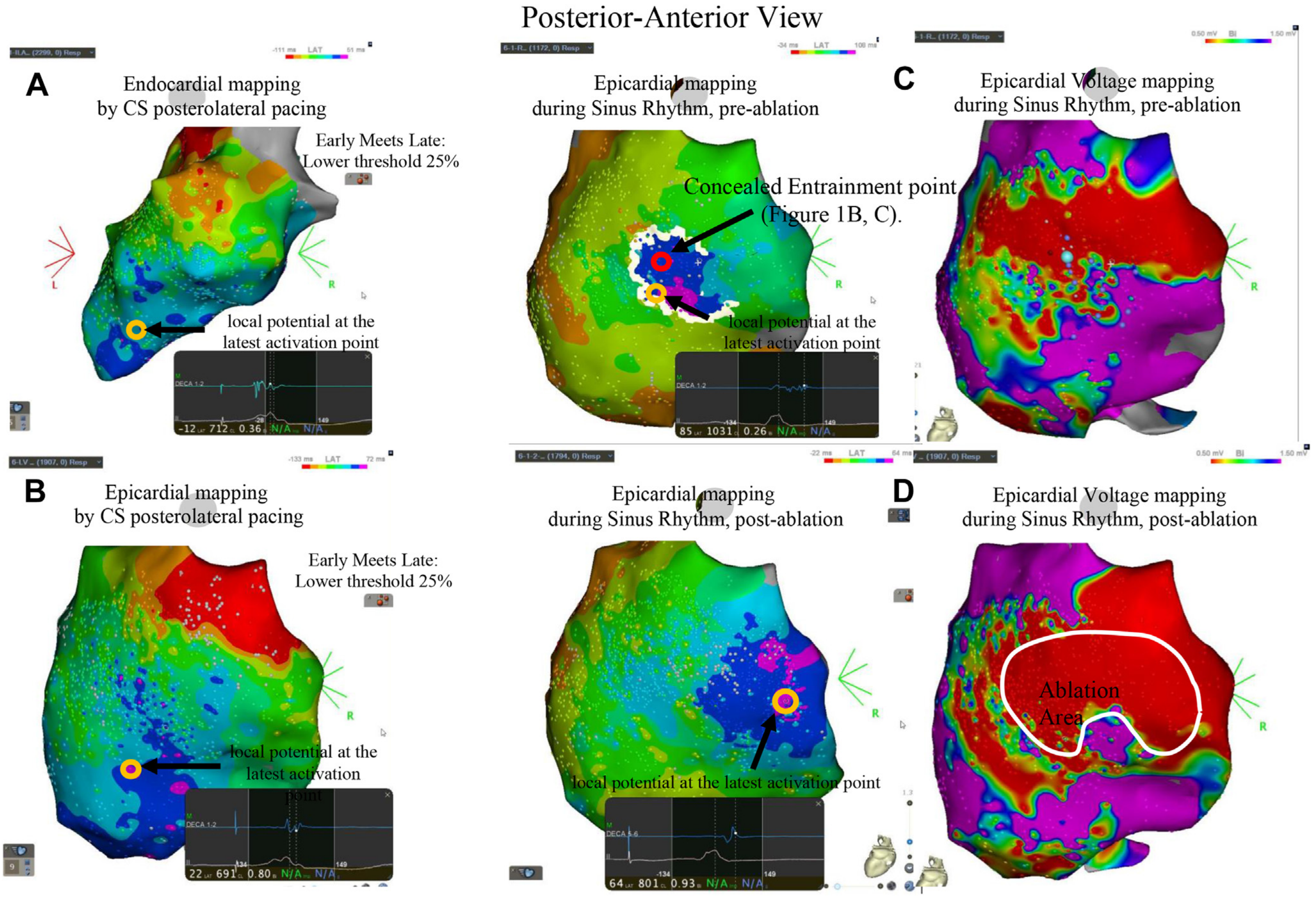

Figure 2 **A:** Electroanatomical endocardial mapping by coronary sinus (CS) posterolateral vein pacing. Isochronal late activation mapping (ILAM). **B:** Electroanatomical epicardial mapping by CS posterolateral vein pacing. ILAM. **C:** Electroanatomical epicardial mapping during sinus rhythm. Left: ILAM; right: voltage map. **D:** Postablation electroanatomical epicardial mapping during sinus rhythm. Left: ILAM; right: voltage map.

subxiphoid area. After exposure and opening of the pericardium, the pericardiotomy was extended to the left to improve visualization of the ventricles. An 8.5F deflectable sheath (Agilis middle curve; St. Jude Medical, Saint Paul, MN) was inserted into the pericardial space (Figure 3A). EAM of the epicardial surface was performed using DECANAV during posterolateral branch pacing. However, we did not observe clear LPs (Figure 2B). EAM of the epicardial surface was then performed using DECANAV during SR. Clear LPs were recorded (Figure 2C). VT was easily induced by CS posterolateral branch pacing with programmed electrical stimulation (600 ms / 320 ms / 300 ms). However, because of hemodynamic instability, creating a VT activation map using DECANAV was impossible. We attempted pace termination of VT, but the VT could not be terminated, resulting in the requirement of cardioversion.

We switched from DECANAV to a SmartTouch Surround Flow ablation catheter (ThermoCool; Biosense Webster) and placed it at the location shown in Figures 1B and 2C. Mid-diastolic potentials were recorded at the ablation catheter. Immediately, we performed entrainment pacing with a cycle length of 350 ms by the ablation catheter at this site. Concealed entrainment was observed, and the postpacing interval was 372 ms, which was almost consistent with the VT cycle length, and the S-QRS interval was 112 ms (Figure 1C). These findings suggested that this site was near the central site of the clinical isthmus. VT was terminated approximately 4.5 seconds after the radiofrequency application was started at this site (Figure 1D). To achieve total LP abolition, we performed additional radiofrequency applications using epicardial functional substrate mapping during SR as a reference (Figure 2D).

After the ablation, successful LP abolition was confirmed by epicardial remapping during SR, and VT was no longer inducible, despite aggressive programmed electrical stimulation. A pericardial drainage tube was inserted (Figure 3B), and the procedure was terminated.

On the 10th day, the patient was extubated, but he did not experience any recurrence of VT. On the 11th day, the pericardial drainage tube removed a total of 30 mL of blood effusion during 48 hours after completing the ablation. Therefore, we removed the pericardial drainage tube. On the 12th day, he received a dual-chamber implantable cardioverter-defibrillator (Biotronik, KG, Berlin, Germany) for secondary

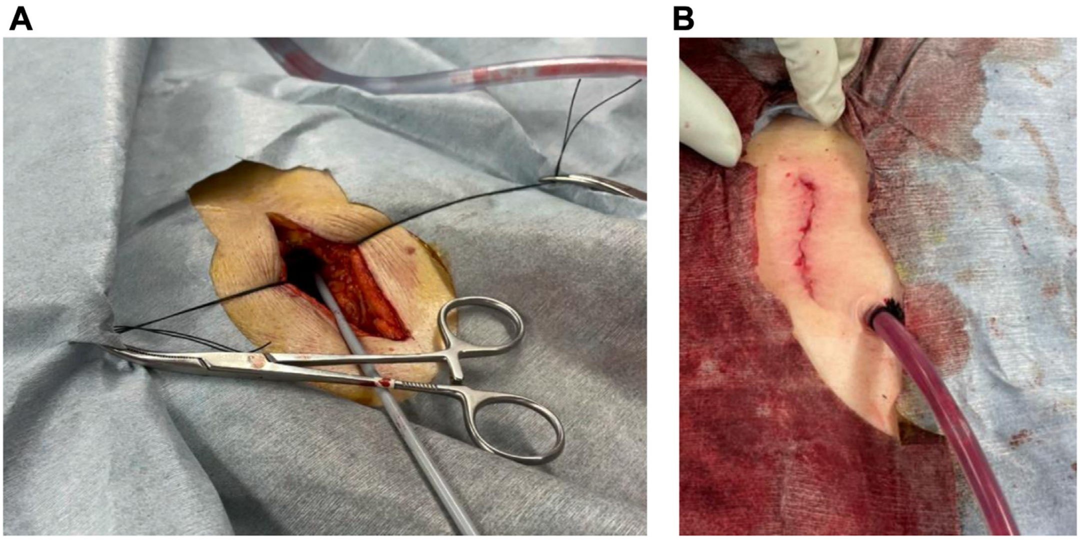

Figure 3 **A:** Surgical epicardial exposure is shown. A 2-inch vertical incision was made at the subxiphoid area, and an 8.5F deflectable sheath was inserted into the pericardial space. **B:** The surgical wound was sutured after insertion of the pericardial drainage tube.

prevention because his condition substantially improved. He was discharged home on the 28th day without recurrence of VT or any postoperative complications.

Discussion

Catheter ablation is effective for treating a VT storm.[6] Endocardial catheter ablation is usually performed first, and epicardial ablation is only attempted if endocardial ablation fails. The substrates of VT associated with ischemic cardiomyopathy are commonly located in the endocardium, but there are also deep intramural and epicardial substrates that cannot be properly assessed through endocardial lesions. Combined endo-epicardial catheter ablation results in a higher success rate at 5 years of follow-up than endocardial catheter ablation alone.[7]

Recent advances in mapping systems have enabled the assessment of detailed conduction properties and the development of a strategy targeting functionally abnormal areas. This analysis has been made possible by the ability to evaluate the intricate details of the myocardium using these mapping technologies. By creating a functional substrate map during SR or ventricular pacing, a detailed analysis of conduction abnormalities in ischemic cardiomyopathy can be conducted. Areas of slow conduction can be detected as LPs. The presence or absence of LPs is closely related to the endpoint and the success rate of ablation.[8]

In the present case, endocardial functional substrate mapping did not identify any LP. The reason why LPs are not visible endocardially may be that the clinical VT isthmus is located epicardially or transmurally. We considered that performing the second session with prolonged intubation would be difficult because our patient was very old and had a VT storm. Therefore, we decided to perform the epicardial approach during the first session.

However, we need to be aware of the complications associated with the epicardial approach. Acute procedural complications were higher with the combined endo-epicardial approach than with endocardial ablation alone.[6] A recent multicenter series reported major complication rates of 5% for acute complications related to epicardial VT ablation.[9] Complications related to percutaneous epicardial access are most common. RV puncture and liver puncture are among the common complications associated with percutaneous epicardial access. When attempting percutaneous access, RV puncture can occur in as many as 17% of patients.[9] Approximately 50% of these patients will develop pericardial bleeding, and although most cases resolve on their own, larger RV perforations may require surgical repair in rare instances owing to persistent bleeding. Liver puncture is another potential complication associated with percutaneous epicardial access that can occur, like pericardiocentesis for cardiac tamponade.[10] We performed the endocardial procedure under full heparinization to prevent blood clots. As we switched to the epicardial approach, we kept the catheter in place within the left ventricle at all times, and also used full heparinization (activated clotting time >300) during the procedure, with an elevated risk of complications associated with percutaneous epicardial access. After completing the ablation, we removed the catheter from the left ventricle and used protamine to reverse the effects of heparin before closing the incision. A direct surgical subxiphoid epicardial approach in the electrophysiology laboratory is feasible for patients with challenging pericardial access who require ablation of epicardial arrhythmia foci.[11] Therefore, a direct surgical subxiphoid epicardial approach was chosen.

In our patient, epicardial functional substrate mapping during posterolateral branch pacing did not identify any LP. However, during SR, epicardial functional substrate mapping showed the presence of LPs. When examining the potential during SR just before VT induction, LPs were clearly observed in the ablation catheter (Figure 1E). However, even with the ablation catheter in the same position, when CS posterolateral pacing was performed, an abnormal potential was present before the QRS offset, which was not an LP, but rather local abnormal ventricular activity (Figure 1E). CS posterolateral branch pacing did not show LPs because the pacing site was very close to the clinical isthmus of the VT (indeed, CS posterolateral branch pacing showed a good pace map of the clinical VT). If LPs can be identified, the endpoint for VT ablation would be total abolition of the LP. To clarify the endpoint for VT ablation and reduce the recurrence rate, it is crucial to create a functional substrate map at a pacing site where LPs can be more clearly identified.[12]

Conclusion

The effectiveness of the combined endocardial-epicardial ablation approach as an initial treatment for VT has been previously reported in the literature. However, to the best of our knowledge, this is the first case report about an epicardial approach using a surgically created subxiphoid pericardial window (not percutaneously) in a very old patient on hemodialysis.

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References

1. Sapp JL, Wells GA, Parkash R, et al. Ventricular tachycardia ablation versus escalation of antiarrhythmic drugs. N Engl J Med 2016;375:111–121.
2. Tung R, Raiman M, Liao H, et al. Simultaneous endocardial and epicardial delineation of 3D reentrant ventricular tachycardia. J Am Coll Cardiol 2020; 75:884–897.
3. Romero J, Cerrud-Rodriguez RC, Di Biase L, et al. Combined endocardial-epicardial versus endocardial catheter ablation alone for ventricular tachycardia in structural heart disease: a systematic review and meta-analysis. JACC Clin Electrophysiol 2019;5:13–24.
4. Muser D, Castro SA, Liang JJ, Santangeli P. Identifying risk and management of acute haemodynamic decompensation during catheter ablation of ventricular tachycardia. Arrhythm Electrophysiol Rev 2018;7:282–287.
5. Anter E, Neuzil P, Reddy VY, et al. Ablation of reentry-vulnerable zones determined by left ventricular activation from multiple directions: a novel approach for ventricular tachycardia ablation: a multicenter study (PHYSIO-VT). Circ Arrhythm Electrophysiol 2020;13:e008625.
6. Vergara P, Tung R, Vaseghi M, et al. Successful ventricular tachycardia ablation in patients with electrical storm reduces recurrences and improves survival. Heart Rhythm 2018;15:48–55.
7. Mohanty S, Trivedi C, Di Biase L, et al. Endocardial scar-homogenization with vs without epicardial ablation in VT patients with ischemic cardiomyopathy. JACC Clin Electrophysiol 2022;8:453–461.
8. Silberbauer J, Oloriz T, Maccabelli G, et al. Noninducibility and late potential abolition: a novel combined prognostic procedural end point for catheter ablation of postinfarction ventricular tachycardia. Circ Arrhythm Electrophysiol 2014; 7:424–435.
9. Sacher F, Roberts-Thomson K, Maury P, et al. Epicardial ventricular tachycardia ablation a multicenter safety study. J Am Coll Cardiol 2010; 55:2366–2372.
10. Kasai Y, Kasai J, Asano S, et al. Removing pericardial drainage tube for acute cardiac tamponade associated with catheter ablation of atrial fibrillation can trigger hemoperitoneum from severe liver bleeding. HeartRhythm Case Rep 2022; 8:618–621.
11. Soejima K, Couper G, Cooper JM, et al. Subxiphoid surgical approach for epicardial catheter-based mapping and ablation in patients with prior cardiac surgery or difficult pericardial access. Circulation 2004;110:1197–1201.
12. Porta-Sánchez A, Jackson N, Lukac P, et al. Multicenter study of ischemic ventricular tachycardia ablation with decrement-evoked potential (DEEP) mapping with extra stimulus. JACC Clin Electrophysiol 2018;4:307–315.