Received: 27 October 2023 | Revised: 13 January 2024 | Accepted: 15 March 2024

DOI: 10.1002/joa3.13029

Journal of Arrhythmia Open Access WILEY

SPOTLIGHT

Simultaneous epicardial ablation based on intraoperative electroanatomic mapping during left ventricular assist device implantation

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KEYWORDS
cardiac arrhythmias, epicardial ablation, heart failure, left ventricular assist device, ventricular tachycardia

A left ventricular assist device (LVAD) is a therapeutic option in advanced heart failure. Ventricular tachycardia (VT) is common in patients with LVAD, and an electrical storm of ventricular arrhythmias following LVAD implantation is associated with increased mortality. A history of VT before LVAD implantation is an independent predictor of electrical storm; however, the pre- and intraoperative management of documented VT and ventricular arrhythmogenic substrates remains controversial. Herein, we present a case of a patient with severe heart failure having VTs refractory to endocardial ablation, who underwent simultaneous epicardial ablation and LVAD implantation.

A 58-year-old woman diagnosed with end-stage hypertrophic cardiomyopathy experienced sustained monomorphic VT and was provided an implantable cardioverter–defibrillator (ICD). Four years later, the patient was admitted to our hospital with an electrical storm because of monomorphic VT (Figure 1A). As pharmacotherapy using amiodarone and beta-blocker combined with sedation failed, endocardial radiofrequency catheter ablation was performed. The voltage map showed a broad area with low-voltage amplitude (<1.5 mV) in the apical aneurysm (Figure 2A). The activation map during VT showed that the site of earliest activation was at the left ventricular apical inferior wall (Figure 2B). However, no diastolic potential was observed, and the pace-mapping from the site of the earliest activation was different from the QRS morphology of the VT, suggesting that the central isthmus of the tachycardia circuit was in the epicardial or intramural myocardium. Although the electrical storm was suppressed, 2 months later, the patient required recurrent ICD therapy for another monomorphic VT (Figure 1B). VT showed a QRS morphology with an apparent pseudodelta wave and long maximum deflection index, suggesting an epicardial origin. During these repeated arrhythmic events, the patient experienced loss of appetite and fatigue, suggesting low-output syndrome, dependent on inotropes. A multidisciplinary team decided to implant LVAD and perform intraoperative VT ablation targeting the epicardial substrate.

Under general anesthesia, a median sternotomy was performed by cardiothoracic surgeons. Subsequently, before initiating cardiopulmonary bypass, three-dimensional electroanatomic mapping (EAM) of the epicardial surface was performed manually by the cardiac electrophysiologist using the CARTO system (Biosense Webster, Diamond Bar, CA, USA) and a 3.5-mm-tip open-irrigated radiofrequency ablation catheter (ThermoCool SmartTouch SF; Biosense Webster) (Figure 3A). An extensive low-voltage zone was observed in the posterior and inferior walls and ventricular apex (Figure 3B). Isolated delayed potentials were recorded at the border zones of the lateral and septal walls (Figure 3C). The pace map at the posterolateral wall area with a delayed potential showed QRS morphology similar to that of clinical VTs, with a long stimulus-to-QRS delay of 170 ms (Figure 3D). Radiofrequency applications onto the epicardial myocardium were applied, targeting all late and prolonged, fragmented potentials independently of their relation to an induced VT, with delayed potentials in the lateral and septal walls until stimulation with high output pacing (10 mA, 2 ms) failed

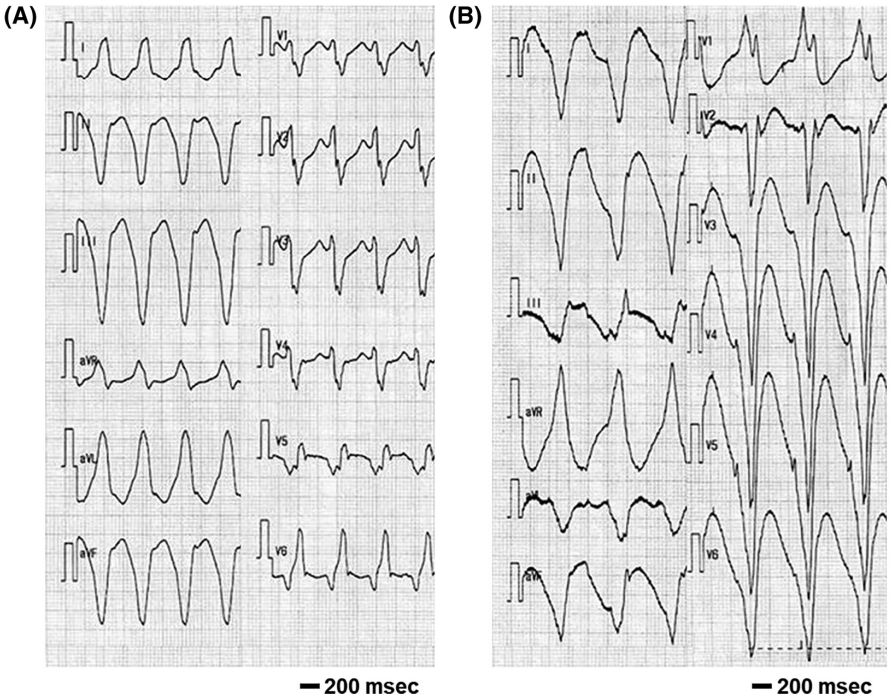

FIGURE 1 Electrocardiogram recorded during the first VT storm (A) and when VT recurred after endocardial catheter ablation (B). (A) Monomorphic VT with a QRS width of 450 ms and left axis deviation. (B) Monomorphic VT with a right bundle branch block-type QRS morphology and northwest QRS axis with apparent pseudodelta wave. VT, ventricular tachycardia.

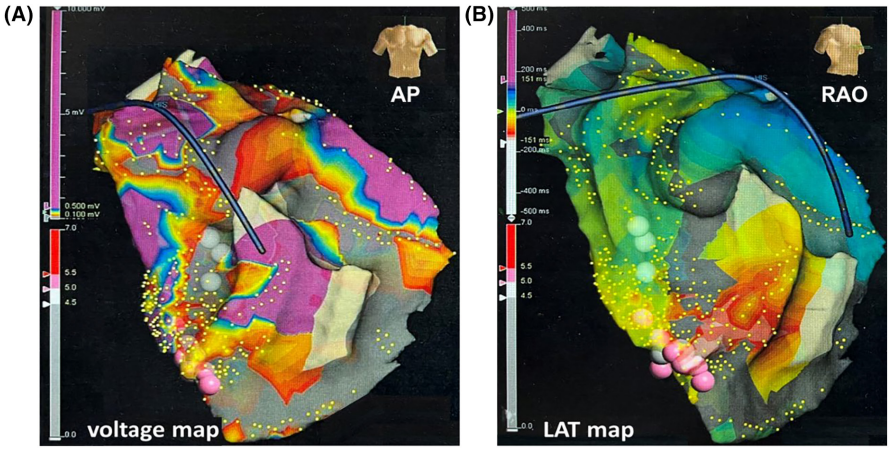

FIGURE 2 Voltage map in anteroposterior (AP) view (A) and activation map in right anterior oblique (RAO) view (B) recorded during the endocardial catheter ablation targeting VT. The site of the earliest activation can be observed in the left ventricular apical inferior wall; however, no diastolic potential is observed. VT, ventricular tachycardia.

to capture. We initiated each radiofrequency application with 10–20 W and titrated up to a maximum of 35 W (temperature limit, 43°C; flow rate 15 mL/min; 15–30 s). Ablation time for each point typically ranged from 15 to 30 s, with an impedance drop of 20 ohms or 20% below baseline serving as the endpoint for each ablation point. Postablation induction was not performed to save the procedure time. The procedure time for EAM and radiofrequency applications was 98 min. Thereafter, cardiopulmonary bypass was initiated, and a HeartMate 3 (Abbott, Chicago, Illinois, USA) LVAD was successfully implanted. No procedure-related complications were observed, and there was no recurrence of ventricular arrhythmias during 3 years of follow-up.

LVADs mitigate hemodynamic deterioration and can reduce adverse cardiovascular events because of VT; however, the crude mortality rate is as high as 54% in patients who develop VT within the first week after LVAD implantation.[1] Additionally, patients with LVAD often experience ICD shocks when during consciousness; the experience is extremely uncomfortable and causes significant psychological trauma.

Radiofrequency catheter ablation is a therapeutic option for the treatment of recurrent VT. A recent meta-analysis of the efficacy of VT ablation after LVAD implantation showed that procedural success was achieved in 77.9% of patients and the complication rate was 9.4%. However, the recurrence rate was high (43.6%).[2] The increase in recurrence in these patients, especially those with VT with an epicardial circuit, may be because of technical and anatomical limitations.

Preexisting VT is one of the strongest predictors of VT occurrence after LVAD implantation. Currently, there is no consensus regarding the optimal management strategy for VT prior to LVAD implantation. Surgical cryoablation or radiofrequency ablation of the VT at the time of LVAD implantation reduces postoperative

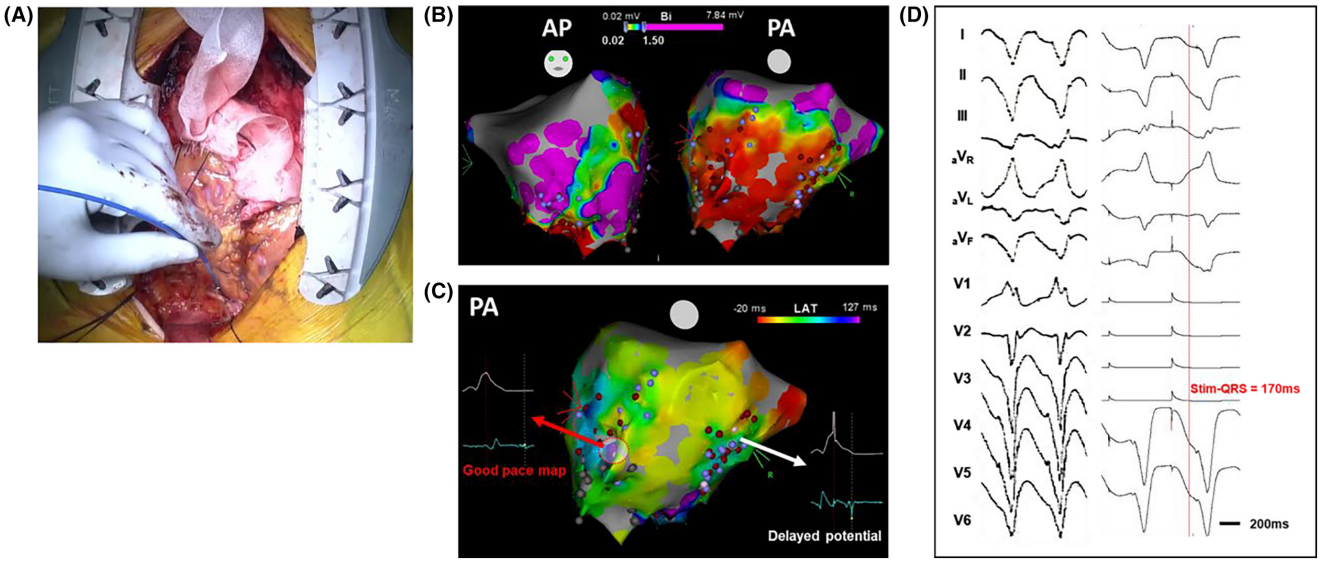

FIGURE 3 After a median sternotomy, three-dimensional electroanatomic mapping of the epicardial surface is performed manually using the radiofrequency ablation catheter before initiation of cardiopulmonary bypass (A), and a voltage map in anteroposterior (AP) and posteroanterior (PA) view (B) and a sinus rhythm activation map in PA view (C) are subsequently made. A QRS morphology similar to that of clinical VTs (D, *left*) can be observed in the pace map at the posterolateral wall with delayed potential (D, *right*). VT, ventricular tachycardia.

VT recurrence without increasing adverse events. The advantages are that the epicardial surface can be exposed during open-chest surgery, left ventricular endocardium can be visualized through the ventriculotomy required for the placement of the LVAD inflow cannula, and mapping and ablation can be performed in a more stable state with a cardiopulmonary bypass. However, there have been reports of cannula occlusion because of acute myocardial edema[3] and LVAD thrombosis.[4] Therefore, careful preoperative evaluation and perioperative management are required before this procedure.

In this case, open-chest EAM was performed based on the electrocardiographic and electrophysiological findings during endocardial ablation. Radiofrequency ablation was successfully performed within a short period without intraoperative complications. Although a reduction in VT events after LVAD implantation by intraoperative ablation has been reported, the recurrence rate was relatively high (three of six cases by Gupta et al.).[5] A key limitation of these reports is the inconsistent use of EAM during the procedure. Conversely, we used EAM and carefully decided on the potential critical isthmus for the reentry circuit. Our case proved that EAM can be safely performed during LVAD implantation and that an ablation strategy based on electrophysiological information may reduce VT recurrence after LVAD implantation. A larger-scale clinical trial is needed to test the efficacy of simultaneous epicardial ablation during LVAD implantation.

Intraoperative VT ablation targeting the epicardial substrate using EAM was performed during LVAD implantation. Although there is currently no consensus on the optimal management of documented VT before LVAD implantation, concomitant epicardial VT ablation may be considered for patients with epicardial arrhythmogenic substrates.

ACKNOWLEDGMENTS

None.

FUNDING INFORMATION

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article because of the case report.

ETHICS STATEMENT

None.

PATIENT CONSENT STATEMENT

Informed consent was obtained from the patient.

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How to cite this article: Nishino K, Watanabe M, Ooka T, Sato T, Anzai T. Simultaneous epicardial ablation based on intraoperative electroanatomic mapping during left ventricular assist device implantation. J Arrhythmia. 2024;40:632–635. https://doi.org/10.1002/joa3.13029