First-in-human high-density endo-epicardial mapping and ablation through left minithoracotomy in a patient with unstable ventricular tachycardia requiring ECMO

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Introduction

High-definition (HD) and multielectrode mapping catheters have been introduced in order to perform high-quality activation and substrate map during catheter ablation of complex arrhythmias. A peculiar HD multielectrode mapping catheter is the Advisor HD Grid Sensor Enabled (SE) multipolar mapping catheter (Abbott Medical, Minneapolis, MN), designed with 16 × 1 mm equidistant electrodes (4 splines, 4 electrodes for each spline) with 3 mm electrode spacing that, in combination with the automated HD wave algorithm, allows the rapid assessment of voltage, activation, and directionality of conduction.[1] We report the first-in-human case of endo-epicardial mapping and ablation via left minithoracotomy in a severely obese patient with nonischemic dilated cardiomyopathy, and unstable ventricular tachycardia (VT) requiring extracorporeal membrane oxygenation (ECMO) support.

KEY TEACHING POINTS

- The Advisor HD Grid Sensor Enabled multipolar mapping catheter (Abbott Medical, Minneapolis, MN) has a unique design allowing for bipolar recording along and across the splines. This catheter is designed to facilitate substrate mapping and account for directionality. Also, it allows for the differentiation of far-field and near-field signals, particularly helpful in complex ventricular scar.
- High-density mapping is helpful in all cases in which a fast mapping is required.
- Epicardial high-density mapping was feasible via left minithoracotomy with no major map distortion and/or shift.

Case report

A 56-year-old obese man (body mass index 41) with a history of nonischemic dilated cardiomyopathy, severely reduced left ventricular ejection fraction (LVEF), and frequent episodes of nontolerated VT despite therapy with amiodarone, beta-blockers, and mexiletine was admitted to our center. The patient had a single-chamber implantable cardioverter-defibrillator implanted in 2013 and recently he underwent an unsuccessful attempt of upgrading to a cardiac resynchronization therapy defibrillator (CRT-D). Previously, the patient underwent an attempt of catheter ablation, which was aborted because of hemodynamic instability during VT. After hospital admission, the patient underwent transthoracic echocardiography, which confirmed severely reduced LVEF of 15%, and coronary angiogram that showed no significant coronary artery lesions. Owing to the severely reduced LVEF and the hemodynamic instability of VT, endo-epicardial mapping and ablation were scheduled with ECMO assistance. In addition, owing to the severe trunk obesity and the previously failed CRT-D upgrade, surgical access to the epicardium has been planned. The procedure was performed in the hybrid procedural operating room under general anesthesia and transesophageal and fluoroscopic guidance. Invasive monitoring included the use of an arterial catheter positioned in the right radial artery and a triple-lumen central venous catheter inserted through the right internal jugular vein after the induction of anesthesia.

KEYWORDS Ablation; ECMO; Endo-epicardial mapping; High-density mapping; Multielectrode mapping; Minithoracotomy; Ventricular tachycardia
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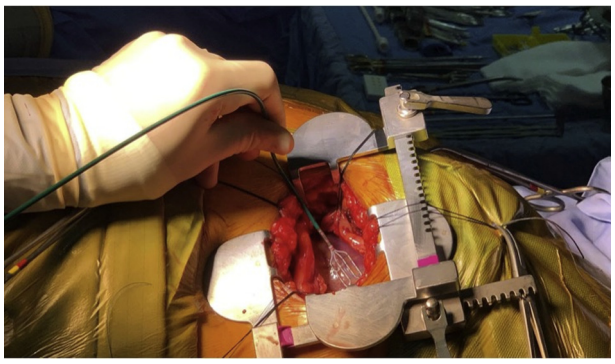

Figure 1 Direct insertion of the multielectrode high-density mapping catheter (Advisor HD Grid, Abbott Medical, Minneapolis, MN) through the left minithoracotomy and mapping of the epicardial surface.

Nasopharyngeal temperature, urine output, heart rate, and blood pressure were monitored throughout the procedure. A double-lumen endotracheal tube was used for the 1-lung ventilation. Once the surgeons have placed the surgical left femorofemoral venoarterial ECMO cannulas, we obtained percutaneous access to the right femoral vein and artery. A standard quadripolar catheter was placed into the right ventricular apex. Transseptal access to the left ventricle was established at the beginning of the procedure. Electroanatomical 3D mapping was used to map the endocardial and epicardial surface using the Advisor HD Grid SE mapping catheter in conjunction with the AutoMap and TurboMap features of the EnSite Precision Cardiac Mapping System (Abbott Medical, Minneapolis, MN). Endocardial bipolar and activation mapping were recorded in sinus rhythm and voltage mapping was performed. The endocardial map did not show significant areas of scar and there were no late potentials as well as local abnormal ventricular activities (LAVAs). The epicardial map was performed through the left minithoracotomy. We directly inserted and positioned onto the epicardial surface a multipolar HD mapping catheter (Advisor HD Grid; Abbott Medical, Minneapolis, MN) (Figure 1). The epicardial substrate map showed a scar involving the basal lateral, mid-basal posterior-lateral, and mid-posterior LV wall (Figure 2A). Late potentials and LAVAs were identified in the border zone of the scar regions (Figure 2B and C). Programmed stimulation was performed at drive cycle lengths of 500 and 400 ms up to 3 extrastimuli down to ventricular effective refractory period. We were able to observe only a few runs of nonsustained VT. Induced VTs were mapped in the endocardium and in the epicardium assessing for mid-diastolic potentials as targets for ablation. During the nonsustained VT, a mid-diastolic activity was mapped on the LV posterior wall using the HD Grid (Figure 3). Catheter ablation was performed using a FlexAbility SE F-J curve (Abbott Medical, Minneapolis, MN) aiming for the complete abolition of late potentials and LAVAs. Once the ablation set was considered completed, programmed ventricular stimulation was performed with no induction of VT. A CRT-D was implanted by the cardiac surgeons. A left femoral artery thrombosis occurred and was treated by Fogarty catheter-based embolectomy. After postsurgery rehab, the patient was discharged uneventfully. During the first 6 months of follow-up, there were no further VTs.

This is the first-in-human endo-epicardial HD mapping and ablation directly performed through left minithoracotomy in a patient with unstable VT requiring ECMO. Ablation of unstable VTs can be safely supported by ECMO. Baratto and colleagues[2] published the largest series of ECMO-supported catheter ablation of unstable VT. The authors reported that this hemodynamic support was safe and effective to help patients to overcome the unstable and clinically challenging perioperative phase by reducing acute decompensation and incidence of postablation acute mortality (1.5%). However, peripheral ECMO is characterized by a significant rate of vascular complications, and in particular acute limb ischemia ranges from 10% to 70%.[3] The mechanisms of such adverse events are often multifactorial (ie,

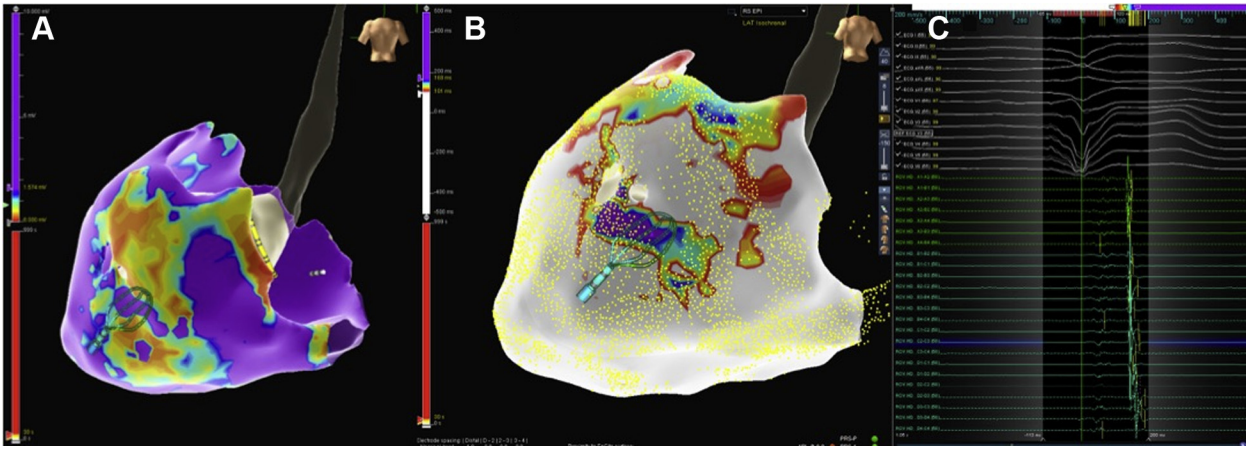

Figure 2 **A:** Epicardial bipolar substrate map showing scar involving the basal lateral, mid-basal posterior-lateral, and mid-posterior left ventricular wall. **B:** Epicardial activation map in sinus rhythm showing late potentials. **C:** Late potentials as shown by the Advisor HD Grid (Abbott Medical, Minneapolis, MN) in the region shown in panel B.

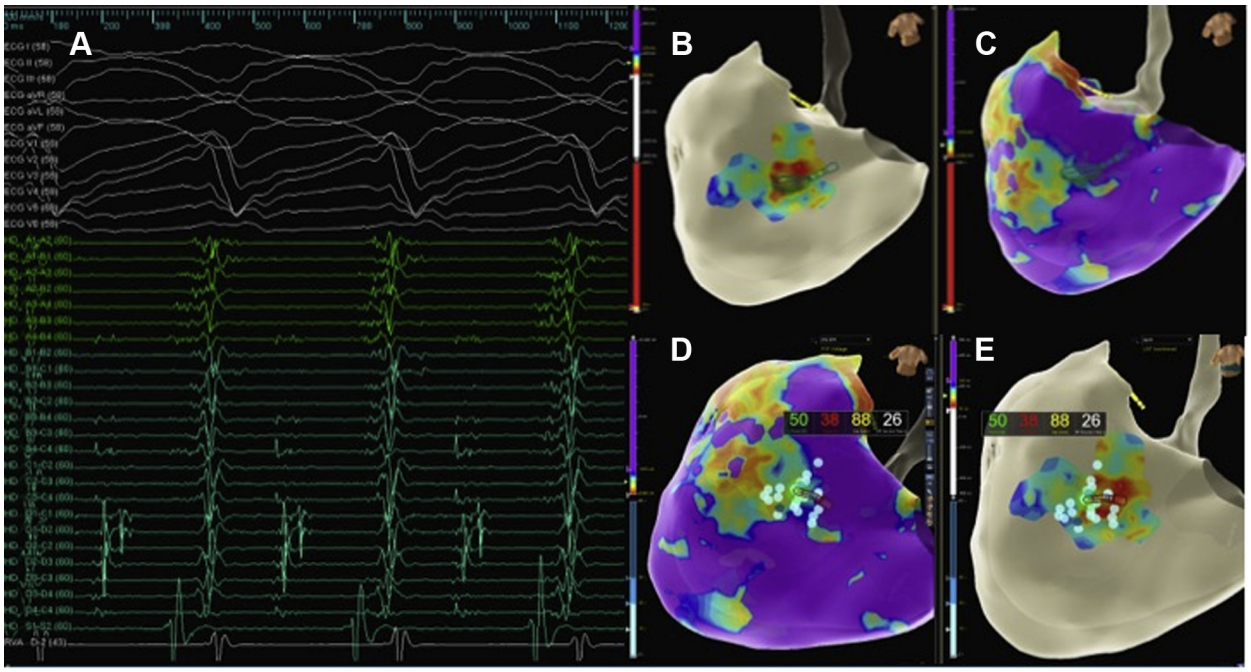

Figure 3 **A:** Mid-diastolic activity shown with the Advisor HD Grid (Abbott Medical, Minneapolis, MN). **B:** Epicardial activation map in ventricular tachycardia. **C:** Epicardial bipolar substrate map with the HD Grid in the location of the mid-diastolic activity during ventricular tachycardia. **D:** Ablation catheter (FlexAbility SE F-J curve, Abbott Medical, Minneapolis, MN) during radiofrequency delivery shown on the substrate bipolar map. **E:** Ablation catheter during radiofrequency delivery shown on the activation map in ventricular tachycardia.

suboptimal arterial perfusion, peripheral vascular disease, subocclusive cannulas). Regarding the 1-lung ventilation, the use of a double-lumen endotracheal tube results in a low risk of movement after positioning, and allows for continuous positive airway ventilation to the deflated lung.[4] Previous reports of surgical epicardial access for VT ablation have been published.[5,6] The indications for surgical epicardial access were (1) prior cardiac surgery or (2) ablation under direct vision. However, both in the paper of Michowitz and colleagues[5] and in the paper of Li and colleagues[6] electroanatomical mapping was not performed with the newer generation of high-density mapping catheters. Patel and colleagues[7] first described the feasibility of open-chest epicardial mapping and ablation of VT at the time of left ventricular assist device implantation. However, a significant difference compared to the case reported herein is that the authors used a 4 mm internally cooled ablation catheter (Chilli; Boston Scientific, Marlborough, MA) to perform the epicardial mapping. In our experience, we have added to the procedure the value of the multielectrode high-density mapping. It is also important to acknowledge that we performed an exhaustive and accurate epicardial map using a high-density multielectrode mapping catheter directly inserted into the epicardium via left minithoracotomy without any technical issues. The strength of the Advisor HD Grid SE is in its peculiar structure. It has equidistant spacing, allowing HD wave bipolar recording along and across splines designed to remove bias created by wavefront direction during substrate mapping. Moreover, a small surface area of 1-mm electrodes improves electrogram quality. Finally, uniform spacing along and across the splines allows for the collection of orthogonal bipolar electrodes, which both improves voltage mapping data and reveals circuits in activation maps. The Advisor HD Grid SE has improved the art of multielectrode mapping, in particular in case of very complex atrial and ventricular substrates, providing us in a shorter time with more detailed information not previously seen with standard multielectrode mapping catheters. Finally, having previously failed the CRT-D upgrade, this hybrid approach allowed performing of the epicardial surgical left ventricular lead implantation at the same time as the ablation procedure.

Although the procedure was technically feasible and we had no acute complications, we recognize that this was an extreme clinical scenario and this procedure cannot be widely adopted. Issues related to the ECMO support and to the 1-lung ventilation need to be evaluated when planning this procedure. Very select patients may benefit from a combined surgical and electrophysiology approach for VT ablation, particularly in case of a difficult epicardial puncture owing to unfavorable anatomy or severe obesity.

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