Novel technique targeting left ventricular summit premature ventricular contractions using radiofrequency ablation through a guidewire

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Introduction

Ablation of ventricular arrhythmias or premature ventricular contractions (PVCs) from the left ventricular (LV) summit remains challenging because of anatomical constraints, including myocardial thickness and the availability of access (proximity to major coronary arteries, thick epicardium in an epicardial approach). Procedural failure is relatively common despite both endocardial and epicardial attempts.[1–3] Considering the low efficacy, safety, and tolerance of long-term antiarrhythmic drug therapies, we need novel mapping and ablation techniques to treat these arrhythmias.

Case report

Case 1

A 46-year-old woman, without previous history of cardiovascular disease, presented owing to frequent symptomatic PVCs that had been diagnosed 5 years earlier (PVC burden of 25%, 33,000/24 h). The initial 12-lead electrocardiogram showed a PVC with left bundle branch block morphology and inferior axis with an early transition in lead V_3 (Figure 1a). The PVC displayed a QRS duration of 148 ms, a QS pattern in lead I, a maximum deflection index of 0.8, an intrinsicoid deflection time of 52 ms, and an aVL/aVR Q-wave ratio of 1.6. These features were suggestive of an epicardial origin at the LV outflow tract (ie, LV summit). Transthoracic echocardiogram showed a mildly reduced LV ejection fraction of 45%, while coronary angiography revealed normal coronary arteries. Cardiac magnetic resonance imaging did not demonstrate regions of late gadolinium enhancement. Owing to suspected arrhythmia-induced cardiomyopathy, the patient was referred for an ablation procedure. During the electrophysiological study, right ventricular and LV mapping was performed using a 3.5 mm, 1-6-2 mm ThermoCool SmartTouch mapping unidirectional ablation catheter (Biosense Webster, Diamond Bar, CA). The right ventricular outflow tract (RVOT), sinuses of Valsalva, and aortomitral continuity were mapped with earliest activation times not earlier than -4 ms ahead of the QRS onset (Figure 1b). Subsequently, the mapping catheter was advanced into the coronary sinus (CS), demonstrating earlier activation times at the junction of the great cardiac vein (GCV) and the anterior interventricular vein (AIV) (-22 ms), but the catheter could not be advanced further. A 0.014-inch Vision guidewire (Biotronik SE&CO KG, Berlin, Germany) was then advanced into the AIV via an Inquiry Luma-Cath catheter (7F; St Jude, CA), usually used for CS cannulation, and demonstrated the earliest activation time (-28 ms) (Figure 1c and 1d). Radiofrequency (RF) ablation was undertaken through the guidewire using the SmartAblate generator (Biosense Webster). We placed the proximal end of the guidewire in a saline bath along with the ablation catheter in order to deliver RF (up to a power of 20 W, impedance 250–260 ohms, impedance drop 10 ohms) for a total of 30 seconds, achieving complete elimination of the PVCs (Figure 1d and 1e). Coronary angiography after RF ablation showed patency of epicardial coronary arteries without stenosis. No early complications occurred, and the patient was discharged the next day. At 6-month follow-up, the patient had a significant improvement in her symptoms, while the 24-hour Holter recording showed complete elimination of the PVCs. Follow-up echocardiography revealed normalization of LV systolic function, and the prior dysfunction was therefore attributed to PVC-induced cardiomyopathy.

KEYWORDS Guidewire ablation; Left ventricular summit; Premature ventricular contractions; PVC ablation; Radiofrequency ablation
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Conflicts of Interest: Nothing to declare. **Address reprint requests and correspondence:** Dr Konstantinos Vlachos, Department of Cardiology, General Hospital of Athens "Evangelismos," Ipsilantou 47, Athens, Greece 10676. E-mail address: vlachos.konstantinos7@gmail.com.

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KEY TEACHING POINTS

- Premature ventricular contractions originating from the left ventricular (LV) summit pose a serious challenge to catheter ablation, as myocardial thickness, epicardial fat, and coronary vessels impede appropriate radiofrequency (RF) energy delivery to the target areas. In a significant number of cases, it is not possible to advance the ablation catheter to the coronary venous system and approach the great cardiac vein (GCV) / anterior interventricular vein (AIV) and their branches. In addition, the high impedance and/or limited cooling from blood flow possibly contributes to the relatively low success rate of ablation within the distal GCV/AIV.
- Our study provides a novel ablation technique of epicardial or intramural LV summit ventricular arrhythmias through the coronary venous system. Meticulous activation mapping in a unipolar fashion from either epicardial sites of the LV summit or intramural sites can be easily performed via 0.014-inch guidewire ((Biotronik SE&CO KG, Berlin, Germany) through the distal GCV/AIV or the septal perforator branches, respectively.
- RF ablation through a guidewire using low energy protocols (10–20 W, impedance drop of 10 ohms for 20–30 seconds) is feasible and effective, without affecting the integrity of the wire. This remains to be validated in future experimental and clinical studies. This novel ablation technique may have implications in catheter ablation of challenging epicardial or intramural ventricular arrhythmias.

Case 2

A 65-year-old man without structural heart disease was referred for catheter ablation owing to frequent PVCs (PVC burden of 20%, 20,000/24 h) and salvos of ventricular tachycardia. The PVCs displayed left bundle branch block morphology and inferior axis with an early transition in lead V_3 (Figure 2a). An rS pattern in lead I and a peak deflection index in inferior leads of 0.8 were noted. The RVOT and the aortic cusps were initially mapped as described in case 1. The CS mapping catheter (decapolar or ablation) could not be advanced at the level of GCV. The earliest activation time was recorded at the anterior septal aspect of the RVOT (-20 ms) (Figure 2b and 2c). RF ablation at this area failed to eliminate the PVCs. An intramural origin of the arrhythmia was considered plausible. A 0.014-inch Vision guidewire (Biotronik SE&CO KG) was then advanced into the AIV via an Inquiry Luma-Cath catheter (7F, St Jude). Mapping of the coronary venous system using the guidewire demonstrated a unipolar signal of QS morphology that was slightly later than RVOT activation time (-18 ms) at the beginning of the AIV (Figure 2c and 2d). RF ablation was delivered through the guidewire (10–15 W, impedance 155–164 ohms, impedance drop 10 ohms) for a total of 20 seconds, achieving complete elimination of the PVCs (Figure 2d). The integrity of the guidewire after the RF energy delivery was carefully checked, and damage to the guidewire was not seen (Figure 2e). Coronary angiography following ablation revealed normal epicardial coronary arteries. At 6-month follow-up, the patient had a significant improvement in her symptoms, while the 7-day Holter recording showed a significant reduction of the PVC burden (400/24 h).

Discussion

PVCs originating from the LV summit pose a serious challenge to catheter ablation, as myocardial thickness, epicardial fat, and coronary vessels impede appropriate RF energy delivery to the target areas.[1–3] In a significant number of case, it is not possible to advance the ablation catheter to the coronary venous system and approach the GCV/AIV and their branches. In addition, the high impedance and/or limited cooling from blood flow possibly contributes to the relatively low success rate of ablation within the distal GCV/AIV.[1–3] Apart from the epicardial aspect of the LV summit, mapping and ablation of the intramural component is also extremely challenging.[4] Different options for inaccessible LV summit PVC/VT ablation may include alcohol[5] or bipolar ablation.[6] Segal and colleagues[7] first demonstrated the utility of wire mapping to guide ablation of ventricular tachycardias in humans. Briceño and colleagues[8] have recently described activation mapping of intramural ventricular arrhythmias from a selected septal perforator branch of the AIV using a 0.014-inch guidewire (Biotronik SE&CO KG) with its proximal end connected to an alligator clip in a unipolar configuration and the skin serving as the reference electrode. The septal coronary venous guidewire was used as a fluoroscopic anatomic landmark to guide RF energy application from adjacent structures.[8] Romero and colleagues[9] have previously reported a novel technique of intracoronary mapping and RF ablation of intramural LV summit ventricular arrhythmias through a system routinely used to treat coronary artery chronic total occlusions. Briefly, the intracoronary mapping guidewire was positioned in the first septal perforator, and a Stingray LP device (Boston Scientific, Marlborough, MA) was advanced into the proximal portion of this branch. The artery was then deliberately perforated and the Stingray guidewire advanced deep into the interventricular septal myocardium for mapping and ablation.[9]

Our study provides a novel ablation technique of epicardial or intramural LV summit ventricular arrhythmias through the coronary venous system. Meticulous activation mapping in a unipolar fashion from either epicardial sites of the LV summit or intramural sites can be easily performed

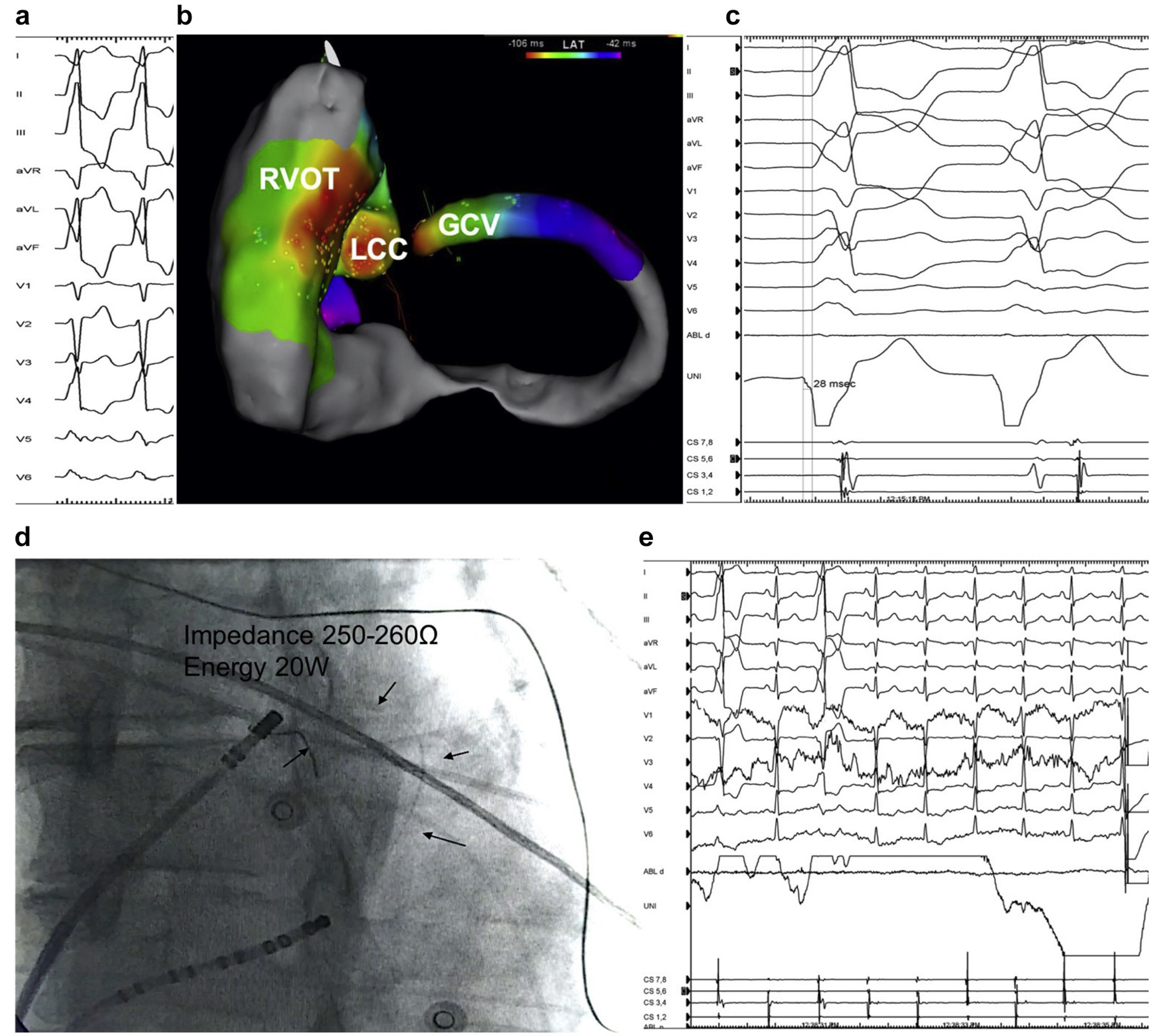

Figure 1 **a:** Standard 12-lead electrocardiogram (paper speed 25 mm/s) showing the morphology of the premature ventricular contraction (PVC). **b:** Three-dimensional activation mapping of the right ventricular outflow tract (RVOT) and coronary venous system (great cardiac vein [GCV]) and aortic cusp (left coronary cusp [LCC]). **c:** Activation mapping in a unipolar fashion via a 0.014-inch angioplasty guidewire showing the earliest ventricular activation at the proximal anterior interventricular vein (AIV) (-28 ms) (UNI). **d:** Left anterior oblique view showing the course of the guidewire at the proximal AIV (*arrows*). The impedance at this site was 250–260 ohms. **e:** Radiofrequency energy delivery up to 20 W through the guidewire abolished the PVCs.

via a 0.014-inch guidewire though the distal GCV/AIV or the septal perforator branches, respectively. This approach overcomes the inability to advance the traditional mapping and ablation catheters in these vessels in a significant number of cases, provided that coronary sinus is accessible. Ablating distal CS/GCV/AIV has the advantage of avoiding arterial puncture and all the complications related with an arterial approach targeting the septal perforator branches. The venous femoral approach can reduce all vascular complications(hematoma, pseudoaneurysm) and avoid possible complications of arterial approach and ablation using wires for RF delivery inside the coronary artery system (septal perforator), such as dissection of the aorta, coronary artery damage, or thromboembolic events including cerebral embolic lesion incidence and overall neurocognitive function. The disadvantage of ablating AIV via the wire is that the vein should be in close proximity to the myocardium and not surrounded by adipose tissue to improve the success rates of our procedure. On the other hand, RF ablation through the guidewire in the AIV increases the risk of coronary artery damage owing to the close proximity of the AIV to the major coronary arteries (left main, left anterior descending, or left circumflex artery). Factors that mitigate the risk of coronary damage are the presence of perivascular fat, the blood flow through the veins, and the existence of the venous layers. In addition, we used low energy protocols

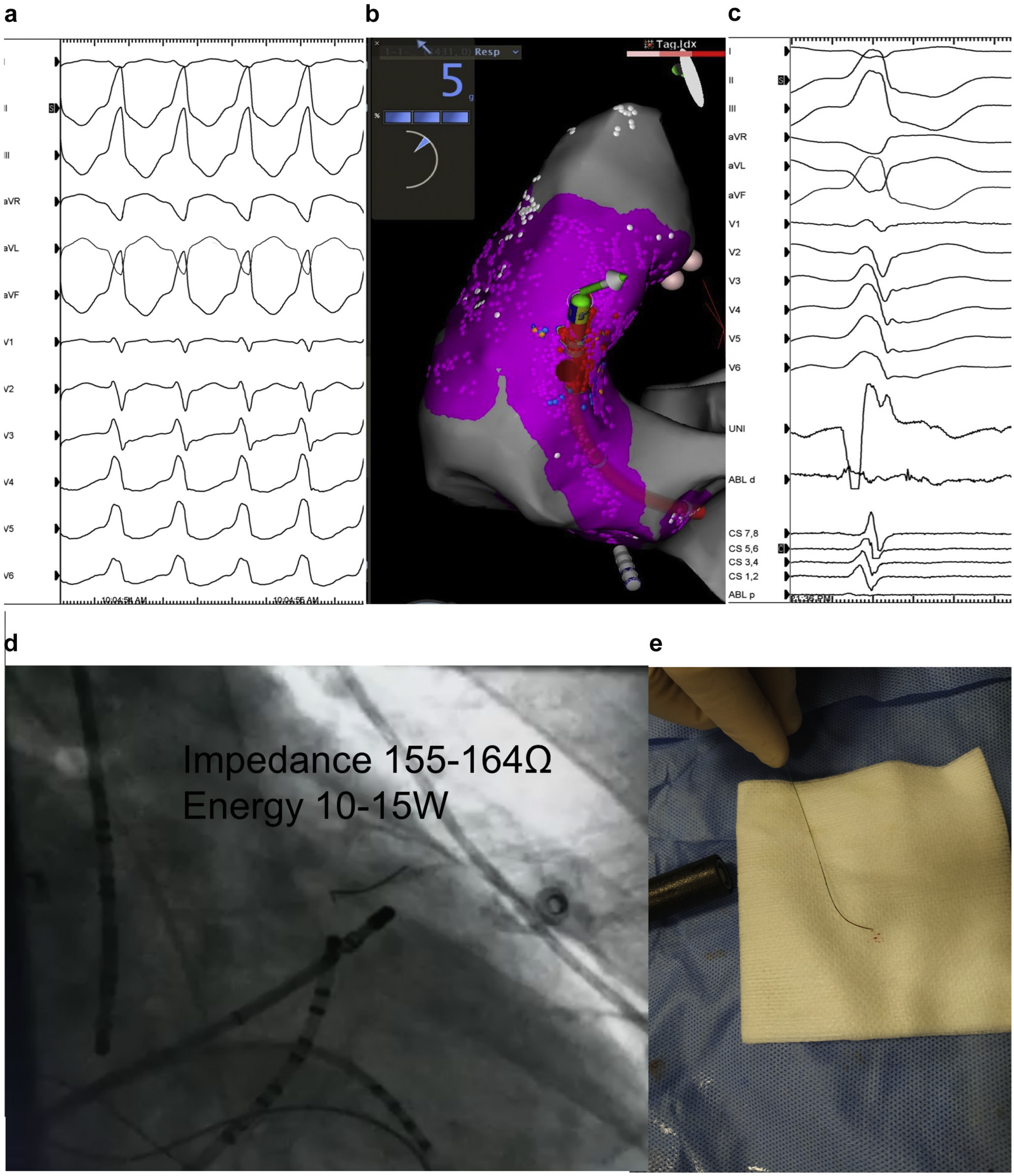

Figure 2 **a:** Standard 12-lead electrocardiogram showing salvos of idiopathic ventricular tachycardia (paper speed 50 mm/s). **b:** Three-dimensional activation mapping of the right ventricular outflow tract (RVOT) showing the earliest ventricular activation at the anterior septal aspect of the RVOT. **c:** Mapping of the coronary venous system in a unipolar fashion with a 0.014-inch guidewire via the specific diagnostic catheter with the central lumen demonstrated a unipolar signal of QS morphology that was slightly later than RVOT activation time at the beginning of the anterior interventricular vein (AIV) (-18 ms) (UNI). The ablation catheter (ABL d) is positioned at the RVOT (-20 ms). **d:** Modified right anterior oblique view showing the course of the guidewire at the proximal AIV (*arrows*). The impedance at this site was 155–164 ohms. **e:** No damage to the guidewire was seen after radiofrequency energy delivery.

(10–20 W, impedance drop of 10 ohms for 20–30 seconds). The Vision wire is insulated along most of its length, leaving only the distal 15 mm uninsulated. The RF current is directed through this uninsulated portion. This avoids RF delivery along the length of the guidewire in the CS/GCV/AIV, which might be ineffective and lead to complications. We hypothesized that RF current delivery through the guidewire was efficient based on the following criteria: (1) as contact of the tip-distal (15 mm) uninsulated part of the guidewire with the tissue (AIV) improves, the impedance of the RF electrical circuit decreases (impedance drop of 10 ohms for 20–30 seconds), since there is lower impedance at an electrode–tissue interface than at an electrode–blood interface; (2) direct resistive heating is related with the surface area of the tip of the wire and the small surface area of the tip ($\sim$16.9 mm^2) leads to high current density, since direct resistive heating of the tissue decreases proportionally with the distance from the electrode to the fourth power. Even though the coronary angiogram after the procedures revealed normal epicardial coronary arteries, it is prudent to perform coronary angiogram before RF ablation, since the AIV is usually above or beside the left anterior descending artery. We additionally demonstrated that RF ablation through a guidewire used in coronary interventions is feasible and effective, without affecting the integrity of the wire. This remains to be validated in future experimental and clinical studies. In conclusion, this novel ablation technique may have implications in the catheter ablation of challenging epicardial or intramural ventricular arrhythmias.

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