Ventricular intramyocardial navigation for tachycardia ablation guided by electrograms for left ventricular summit arrythmia in a human

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Introduction

Catheter ablation is the cornerstone treatment for drug refractory ventricular arrhythmias,[1] although success rates remain suboptimal in patients with intramyocardial substrate.[2] To improve ablation outcomes, we have developed ventricular intramyocardial navigation for tachycardia ablation by electrograms (VINTAGE), a novel intramyocardial ablation technique for the treatment of intramyocardial and otherwise anatomically inaccessible areas. Here, we report a first in human experience using VINTAGE. This patient experienced premature ventricular contractions (PVCs) arising from the left ventricular summit, having failed antiarrhythmic medications and a previous ablation.

Case report

A 56-year-old man was referred to Emory University Hospital for a second attempt at catheter ablation for highly symptomatic PVCs originating from the left ventricle (LV) summit. His previous ablation was unsuccessful despite extensive ablation using both unipolar and bipolar ablation from the right ventricular outflow tract (RVOT), left ventricular outflow tract (LVOT), and coronary sinus. He had failed class Ic, II, III, and IV anti-arrhythmic medications. A 48-hour Holter monitor showed a monomorphic PVC burden of 11.8% despite concurrent flecainide, diltiazem, and metoprolol. A review of his prior electrophysiology study indicated likely origin of PVC from the inaccessible LV summit, and it was thus considered for VINTAGE approach for his repeat ablation. The patient consented to proceed after an extensive discussion that covered the novelty of the procedure.

KEY TEACHING POINTS

- Ventricular arrhythmias from the left summit region and other inaccessible areas remain a significant challenge given the inability to perform detailed mapping and to deliver as well delivering effective ablation lesions
- Intramyocardial navigation using a coronary guidewire, while using unipolar electrograms for guidewire trajectory, is feasible and allows for delivery of effective ablation to midmyocardial tissue.
- This novel approach allows for precise and localized ablation lesions and is not dependent on coronary vascular in the proximity to the target of interest.

The procedure was performed under monitored anesthesia care with Ensite Precision 3D electroanatomic mapping system (Abbott, Minneapolis, MN). Baseline PVCs were evident (Figure 1A) with right bundle branch morphology (positive precordial leads, inferior axis, and negative in lead I). Vascular access included two arteries (left and right femoral) and four veins (left and right femoral).

Activation mapping was performed using HD grid catheter (Abbott) in the RVOT, LVOT, LV, and coronary sinus. Venous tributary mapping used the EPstar mapping catheter (Baylis, Boston Scientific, Marlborough, MA). Earliest activation was at the anterior interventricular vein (AIV), which was 31 ms ahead of QRS, followed

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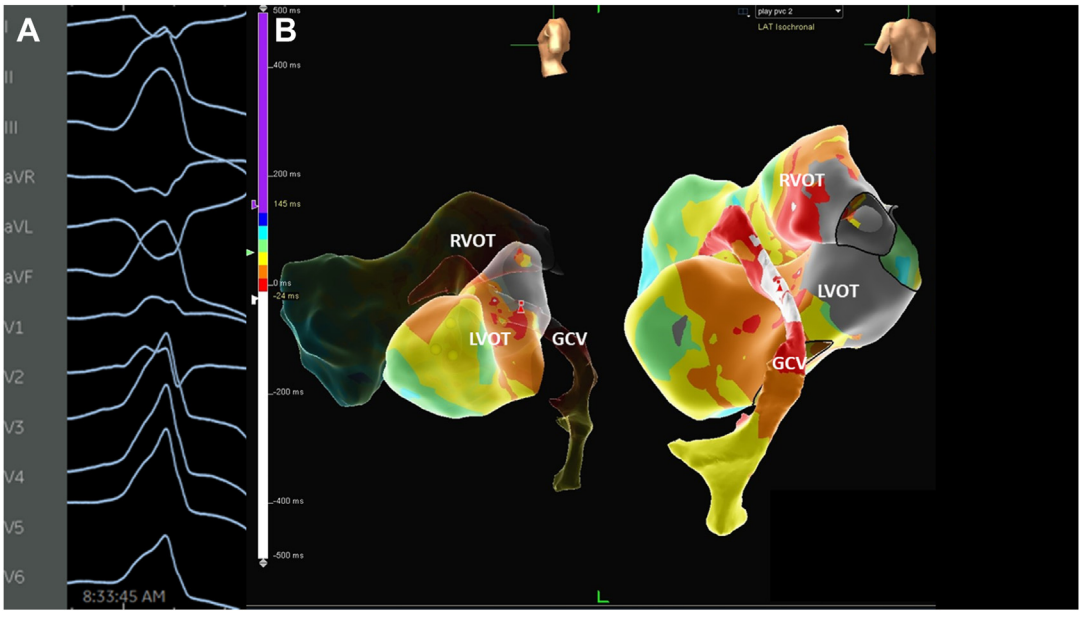

Figure 1 Mapping and localization of premature ventricular contractions. **A:** Twelve-lead electrocardiogram of clinical premature ventricular contractions. **B:** Three-dimensional electroanatomic map showing earliest activation at the great cardiac vein/anterior interventricular vein; later activation is seen in the right ventricular outflow tract and left ventricular outflow tract. GCV = great cardiac vein; LVOT = left ventricular outflow tract; RVOT = right ventricular outflow tract.

by RVOT and LVOT, which was 10 ms ahead and on time, respectively (Figure 1B). This suggested a LV summit site of origin.

The procedural steps of VINTAGE were described previously in animals.[3] Patient-specific fluoroscopic projection angles were derived from pre-procedure contrast-enhanced computed tomography (CT), intended to depict a side-projection and an "en face" or short-axis projection of the left ventricle. The main steps of VINTAGE are depicted in Figure 2. First, sequential right and left ventriculograms were performed (Figure 2A) to correspond CT with fluoroscopy landmarks. The right ventricular septum was engaged from the femoral vein using an 8F internal mammary shape coronary guiding catheter positioned inside the RV using a deflectable guiding sheath (Agilis, Abbott). Next, an anchor guidewire (Astato XS20, Asahi) was placed for support from the femoral vein, directly through the interventricular septum myocardium into the LV, and externalized from the femoral artery via a snare. This provided counter-traction support of the coaxial RV guiding catheter system to allow the operator to advance VINTAGE equipment into the LV myocardium. Next, we advanced a 0.035-inch microcatheter containing a 0.014-inch microcatheter containing an Astato XS20 guidewire for intramyocardial navigation. The guidewire was inserted manually from the coaxial RV guiding catheter system directly into the RV septal muscle, alongside the anchor guidewire.

Guidewire navigation through the myocardium to the targeted region of interest (Figure 2B) was guided with a combination of electrogram radial depth navigation (EDEN),[4] which depicts radial intramyocardial guidewire depth, and fluoroscopy, which depicts regional position (Figure 2C). EDEN uses unipolar electrogram signals from the tip of the wire to allow for intramyocardial navigation based on morphology to determine depth location during navigation. We found intracardiac echocardiography to be less consistently helpful to guide intramyocardial navigation. Once the 0.035-in microcatheter was delivered to the target, we removed the guidewire and 0.014-in microcatheter, and inserted in the EPstar (Baylis, Boston Scientific; Figure 2D). Here, we were able to record intramyocardial electrograms that were 41 ms ahead of PVC with a QS on unipolar signal (Figure 2E). Pace mapping showed a 95% pace match. Once satisfied with device position, the EPstar was replaced with a 0.025-in guidewire for combined ablation and intramyocardial irrigation (Figure 3A). The guidewire was connected to an ablation catheter (Tacticath, Abbott) and generator (Ampere RF generator, Abbott) using alligator clips (Supplemental Figure 1). Four VINTAGE RF ablations (Figure 3B), guided by impedance, were delivered to the LV summit accompanied by intramyocardial saline irrigation. During the second ablation, there was cessation of clinical PVCs. Total ablation time was 174 seconds. A total of 4 ablations lesions were delivered; the last two were prematurely stopped because of rising impedance. Impedance trends are noted in Supplemental Figure 2. Isoproterenol bolus was administered after ablation, which showed multifocal PVCs that did not match to the clinical PVCs. Post procedure coronary angiography was normal. There were no procedural complications. Total fluoroscopy time was 105.1 minutes.

The patient was observed overnight with no significant events. The patient had rare PVCs on telemetry, which were not clinical. He developed pleuritic chest pain which resolved with colchicine. Post-procedure cardiac magnetic

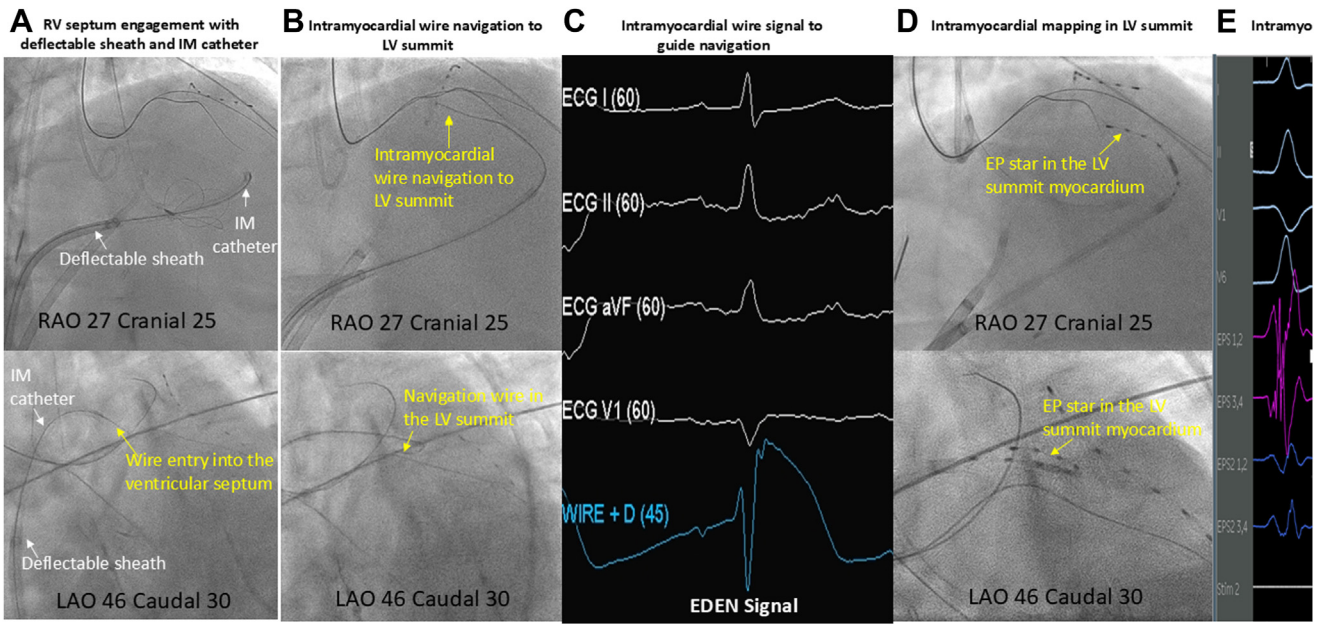

Figure 2 Procedure steps of VINTAGE. **A:** Engagement of the RV septum with deflectable sheath and guide catheter. **B:** Intramyocardial wire navigation to the LV summit aided by (**C**) EDEN via wire mapping to navigate by radial depth. **D:** Intramyocardial mapping via EPstar, which shows (**E**) intramyocardial electrocardiograms with near field activation 41 ms ahead, compared with far-field signal seen in the coronary sinus. LV = left ventricle; RV = right ventricle; VINTAGE = ventricular intramyocardial navigation for tachycardia ablation by electrograms.

resonance obtained on day 1 after ablation demonstrated acute microvascular necrosis surrounded by a rim of edema in the area of the LV summit, consistent with findings in animals (Figure 3C). The largest lesion measured 16 × 14 × 22 mm, with a total combined lesion mass of 4.3 g. The patient recovered well after the procedure and was discharged the following day. At 6-week follow-up, the patient had reported symptomatic resolution of PVCs and stopped taking all cardiac medications. A repeated 48 hour Holter monitor demonstrated a reduction of PVC burden from 11.8% to 2.3%. At 6 months, an electrocardiogram demonstrated no ventricular ectopy along with continued resolution of symptoms off antiarrhythmic medications.

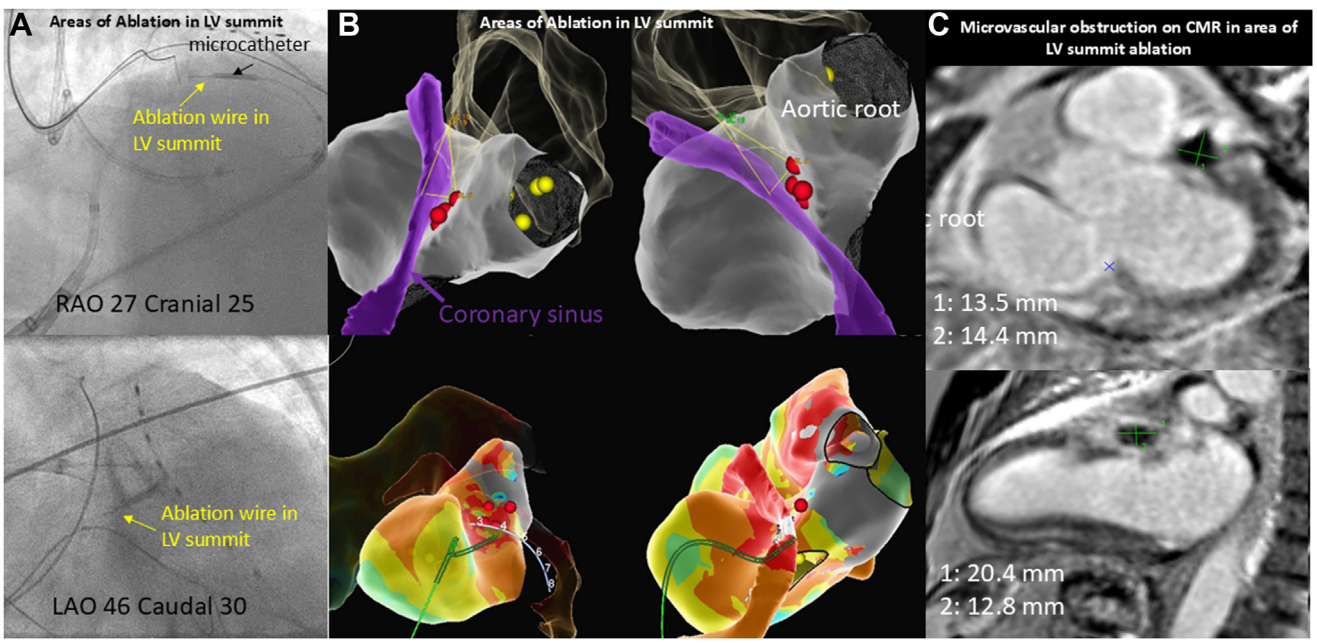

Figure 3 Intramyocardial ablation at the LV summit. (A) Intramyocardial ablation using a 0.025" guidewire at the area of interest. (B) Final ablation lesion set (red) in the myocardium at the LV summit region. (C) Post ablation cardiac magnetic resonance imaging demonstrating acute microvascular necrosis at the area of the LV summit. CMR = cardiac magnetic resonance; LV = left ventricle.

Discussion

This is the first reported human experience of VINTAGE for the treatment of intramural ventricular arrhythmias. Localization and treatment of intramyocardial ventricular arrhythmias remains a challenge given the poor ability to access, map, and ablate in these regions. While strategies such as bipolar ablation or half normal saline catheter irrigation may accomplish deeper ablation,[5] they do not afford intramyocardial mapping to localize therapy delivery. Other strategies, such as needle ablation catheters,[6] provide intramyocardial mapping and deep lesion delivery, although they are limited to the depth of the needle and are not always applicable to certain anatomy, such as LV summit. Romero et al.[7] demonstrated that delivering radiofrequency energy through a guidewire using a chronic total occlusion device is feasible and effective to deliver intramyocardial ablation. However, this approach is dependent on coronary vasculature, which might not allow for proximity in the area of interest. In addition, it would be ideal to have both bipolar and unipolar electrogram recordings to determine the precise location.

VINTAGE offers several advantages. First, VINTAGE allows access to any portion of the left ventricle myocardium, irrespective of overlying structures (e.g., coronary arteries, fat, papillary muscles). Second, VINTAGE allows deep bipolar intramyocardial mapping and pacing for enhanced precision in localizing arrhythmic targets. Third, VINTAGE allows creation of large intramyocardial ablation lesions with minimal risk of bystander injury, such as to nearby coronary arteries. While this is promising, there are significant challenges. This includes improved workflow given the long fluoroscopy time, improved mapping and ablation delivery, and risk of complications given this novel technique to access the mid-myocardial space. In addition, longer follow-up time is necessary to determine whether these lesions effectively suppress ventricular arrhythmias.

VINTAGE belongs to a family of intramyocardial navigation therapies that include MIRTH (myocardial intramural remodeling by transvenous interstitial tether) ventriculoplasty[8] and SESAME (septal scoring along the midline endocardium) transcatheter myotomy procedures.[9] VINTAGE may provide a therapeutic option for patients with deep intramural ventricular arrhythmia that fail standard ablation and anti-arrhythmic therapies. Further experience may clarify the safety and effectiveness of this approach in targeting relatively-inaccessible myocardium.

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2024.10.027.

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