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CASE REPORT

CLINICAL CASE

Sequential Unipolar Biventricular Pulsed Field Ablation for Refractory Intramural Septal Ventricular Tachycardia

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ABSTRACT

Catheter ablation of septal ventricular tachycardia (VT) is challenging. Pulsed field ablation is a promising technology, potentially reaching deep substrates. We report the first sequential unipolar biventricular pulsed field ablation targeting refractory septal VT. Besides, we illustrate the importance of searching underlying cardiomyopathy in patients with recurrent multiple morphology VTs and normal magnetic resonance imaging. (J Am Coll Cardiol Case Rep 2024;29:102356)

HISTORY OF PRESENTATION

A 60-year-old man presented with incessant episodes of sustained monomorphic slow ventricular tachycardia (VT) (-VT1, depicted in **Figure 1A**). The implantable cardioverter-defibrillator (ICD) interrogation showed multiple episodes of sustained and nonsustained (NS) VTs in the previous days (between 133 and 167 beats/min).

LEARNING OBJECTIVES

- To recognize that PFA is a novel, effective, and safe alternative treatment for deep-septal VT.
- To consider an expectant approach for acute conduction disturbances after PFA.
- To contemplate ARVC as an important alternative diagnosis, in patients presenting with idiopathic RV multiple morphology VTs, even in the absence of apparent structural abnormalities on MRI.

PAST MEDICAL HISTORY

The patient had a history of idiopathic recurrent and multiple morphology VTs. The echocardiogram, coronarography, positron emission tomography scan, and magnetic resonance imaging (MRI) examinations showed no abnormalities. There was no family history of sudden death, and no pathogenic variants for arrhythmic disorders were found on genetic examination. He underwent an ICD insertion and 2 radiofrequency ablation procedures in another institution, targeting the septo-apical region of the right ventricle (RV) in the first and RV outflow-tract and moderator band in the second procedure.

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ABBREVIATIONS AND ACRONYMS

ARVC = arrhythmogenic right ventricular cardiomyopathy

BBB = bundle-branch block

EGM = electrogram

ICD = implantable cardioverter-defibrillator

IVS = interventricular septum

LV = left ventricular

MRI = magnetic resonance imaging

NS = nonsustained

PFA = pulsed field ablation

RV = right ventricle

VPS = ventricular programmed stimulation

VT = ventricular tachycardia

DIFFERENTIAL DIAGNOSIS

The presence of recurrent VT originating from the RV (especially if sustained and with superior frontal-plane axis), even in the absence of apparent structural abnormalities, must raise concerns about subclinical cardiomyopathies, most frequently arrhythmogenic right ventricular cardiomyopathy (ARVC).[1]

INVESTIGATIONS

Given the multiple VT cycle lengths and electrogram (EGM) morphologies of unclear etiology occurring during physical activity, despite amiodarone and verapamil treatment and 2 previous endocardial ablation procedures, a hybrid procedure (combining percutaneous endocardial and epicardial thoracoscopic mapping and ablation), with concomitant myocardial biopsy and sympathectomy were planned.

MANAGEMENT

Following thoracoscopic access, RV epicardium was mapped in sinus rhythm by the surgeon manipulating an ablation catheter (Thermocool SmartTouch, Biosense Webster) and showed low amplitude, fractionated, and late bipolar EGMs in the mid-anterior and peritricuspid area (**Figure 2A**). While mapping this region, NS VT1 was elicited, showing diastolic activity. Focal radiofrequency ablation was performed at this site, along with linear cryoapplications (AtriCure cryo-probe) for scar homogenization in the surrounding region, given the large pathological area. In addition, left C8-T5 sympathectomy was performed. Visually, marked fibrofatty degeneration was observed on the anterior RV epicardium. Subsequently, percutaneous endocardial electroanatomical mapping of the epicardially ablated area was performed by the electrophysiologist using the same catheter. Although low-voltage EGMs were still observed, abolishment of late potentials was noted (**Figure 2B**).

Ventricular programmed stimulation (VPS) easily and reproducibly induced VT2 (**Figure 1C**) and, less frequently, NSVT3 (**Figure 1D**). Mapping during VT2 showed the earliest activation simultaneous with QRS onset in a relatively large region of the basal-anterior interventricular septum (IVS), 1 cm below the His region, with "rS" unipolar EGM morphology (**Figure 2C**), suggesting deep-septal origin. Pace mapping in this region showed maximum 85% match. Five focal pulsed electrical field applications using monopolar and biphasic waveform (25 mA) were delivered via the CENTAURI system (Galvanize-Therapeutics) with a mean contact force of 10.6 $\pm$ 3.1g. Neither conduction disturbances, nor signs of ischemia were detected on the electrocardiogram. After a 30-minute waiting period, although high-output pacing showed local noncapture in the ablated area, a more aggressive VPS could still induce VT2.

As intramural septal origin was suspected, left ventricular (LV) mapping was performed. Earliest LV septal activation was 10 ms later than QRS onset, with maximum 75% pattern match at pace mapping. Two focal pulsed electrical field applications targeting the LV septal side of the RV applications (25 mA, mean contact force of 14 $\pm$ 7.1 g) were performed. Following the second application, incomplete right bundle-branch block (BBB) with left anterior fascicular block was observed (**Figure 1E**). After these applications, persistent absence of capture at high-output stimulation was demonstrated on both sides of the septum, and VPS failed to induce any sustained VT. Pace mapping was performed for NSVT3, showing 96% pattern match in the RV apex, close to ICD lead insertion. Considering the NS and hardly inducible character of VT3, questionable clinical significance, and the proximity of ICD lead, this region was not targeted. Twenty-four hours later, the electrocardiogram showed recovered intraventricular conduction to baseline QRS morphology and width (**Figure 1F**).

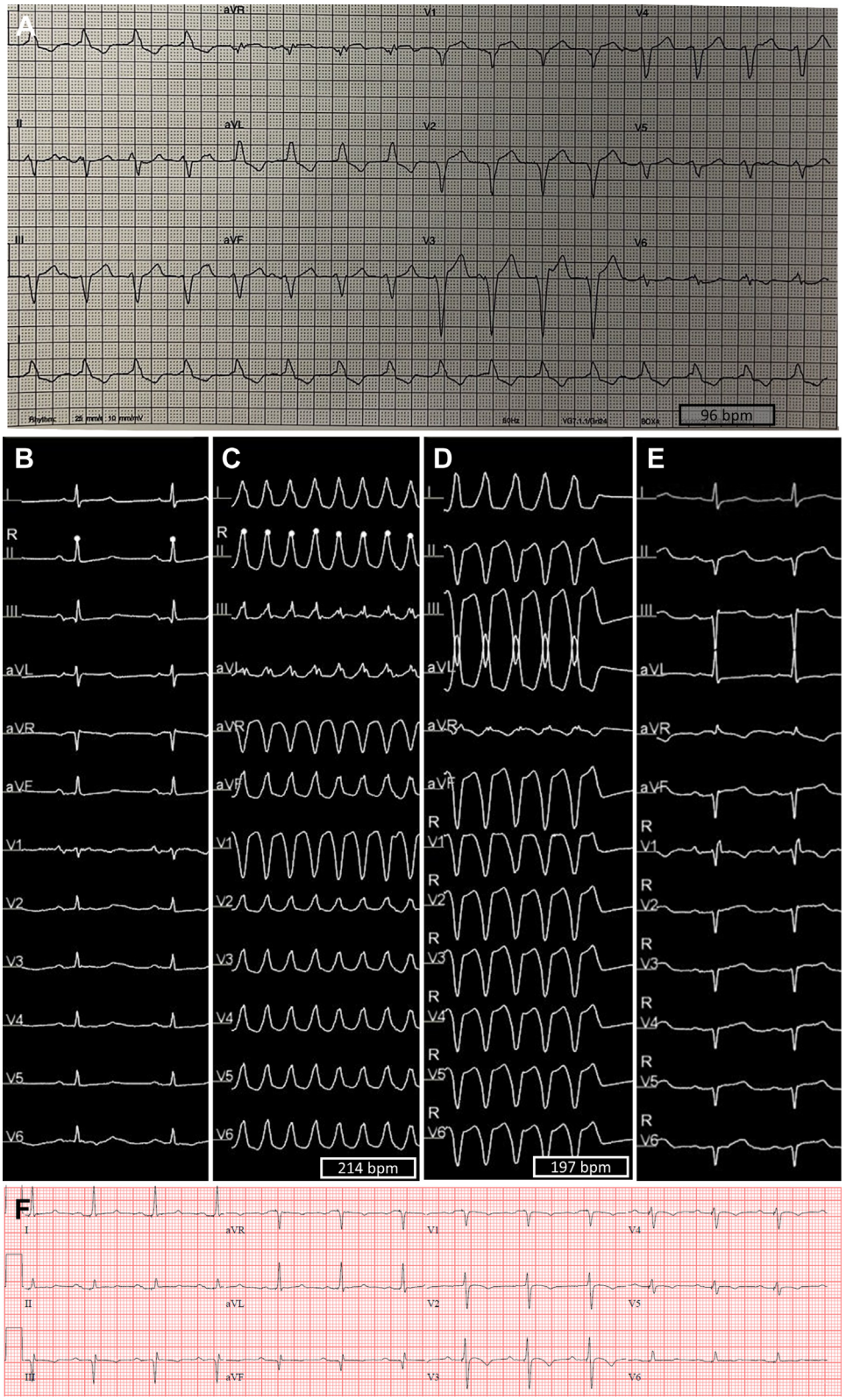
DISCUSSION

Herein, we present the first case of unipolar sequential right and LV pulsed field ablation (PFA) for the treatment of refractory intramural septal VT.

Ablation of VTs arising from deep IVS can be challenging, mainly because of the incapacity of conventional energy sources (ie, radiofrequency) to generate deep lesions.[2] Bipolar radiofrequency energy delivery, high-impedance irrigation, ethanol, or needle ablation constitute valid therapeutic options for intramural septal VT, but their higher risk of complications should be considered.[3,4]

Several preclinical studies analyzing PFA lesions in ventricular tissue confirmed its capacity to generate

FIGURE 1 **12-Lead ECG Recordings**



(A) VT1 (spontaneous tachycardia). (B) Baseline ECG. (C) Intraoperative VT2. (D) Nonsustained VT3. (E) End of the procedure (note incomplete right bundle-branch block and left anterior fascicular block, QRS: 110 ms). (F) Twenty-four hours after the procedure (recovered intraventricular conduction, QRS: 78 ms). ECG = electrocardiogram.

FIGURE 2 **Electroanatomical Maps**

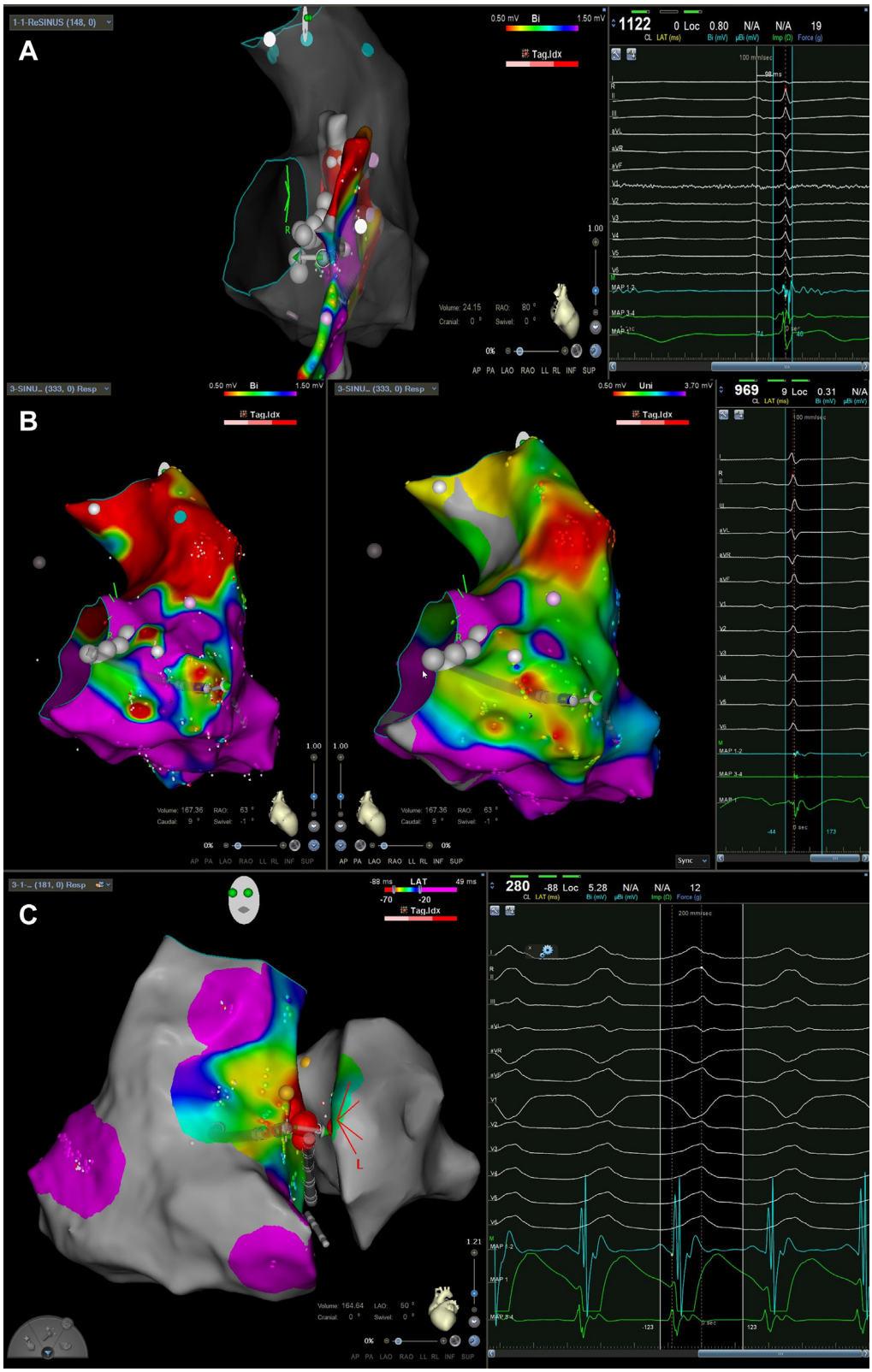


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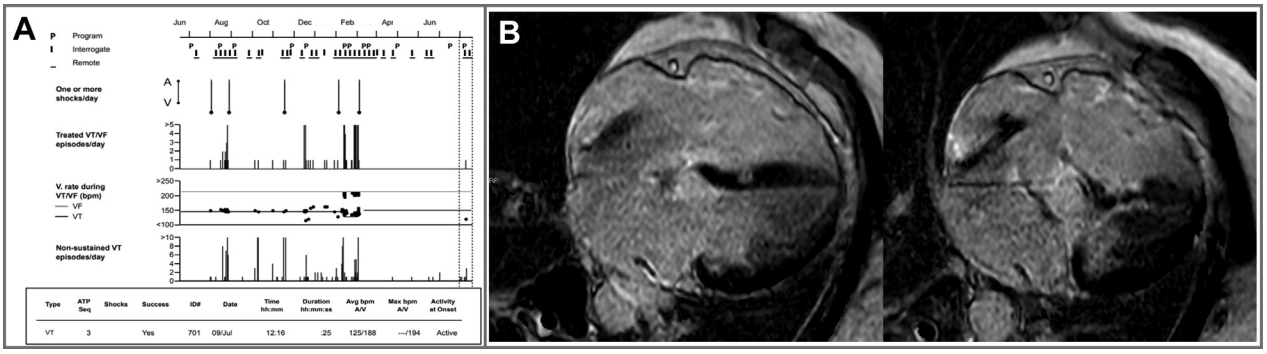
FIGURE 3 Supplementary Tests During Follow-Up



(A) Implantable cardioverter-defibrillator interrogation 6 months after ablation, showing a significant decrease of arrhythmic burden, with a single sustained ventricular tachycardia recurrence (successfully treated by antitachycardia pacing). (B) Magnetic resonance imaging performed 1 month after ablation showing basal-septal nearly transmural delayed-enhancement.

deep lesions (>6 mm) with homogeneous fibrotic replacement of the myocardium.[5]

Bipolar delivery of PFA across the IVS was tested in canine models, demonstrating deep lesions (up to 10 mm, nearly reaching transmurality). However, it was associated with significant conduction disturbances, namely atrioventricular block, and BBB, which were persistent in some cases.[6]

Conduction system damage caused by PFA is dependent on the energy delivery protocol (usually reversible with low energy and reduced number of pulses) and site of application (more frequent in anteroseptal location).[7] Sequential right and left septal PFA might be an adequate alternative, as lesion formation subsequently occurs from both sides, allowing gradual titration while monitoring conduction.

To the best of our knowledge, this is the first human case of intramural septal VT PFA. There is only one other case reported of focal endocardial PFA for a VT arising from LV basal-anterolateral region, with a likely epicardial origin.[8] In our case, the sequential biventricular approach was effective, and it was not associated with long-term side effects. Of note, the reversibility of the conduction disturbance in less than 24 hours suggests that ventricular PFA is associated with a reversible zone effect that might have clinical consequences.

FOLLOW-UP

Verapamil and amiodarone were discontinued 1 and 3 months after ablation, respectively. During 6 months of follow-up, only a few episodes of NS and 1 episode of sustained VT at 188 beats/min, successfully treated by antitachycardia pacing, were registered (**Figure 3A**). MRI performed 1 month after ablation showed mid-septal nearly transmural fibrosis (**Figure 3B**). Left-sided lesions seemed to be deeper, possibly due to the increased contact force,[9] although the MRI planes might underestimate lesion depth, given their possible tangential evaluation. Although morphological criteria for ARVC were not met, the histological study of RV biopsy showed fibrofatty replacement. This finding, together with the presence of a sustained VT with left BBB, fulfilled the diagnostic criteria for ARVC (2 major criteria).[10]

It is worth noting that the contribution of PFA, epicardial large area cryoablation, and sympathectomy to clinical success cannot be separately

FIGURE 2 Continued

(A) Epicardial bipolar-voltage map of the peritricuspid region, showing late and fractionated potentials. Catheter position is indicated by a circular tag and a green arrow (contact force vector direction). (B) Endocardial right ventricular bipolar (left) and unipolar-voltage (right) maps showing disappearance of late potentials and the extension of epicardial low-voltage area after epicardial ablation. (C) VT2 biventricular activation map (red tags locate pulsed field ablation applications and yellow tags mark His recording sites). VF = ventricular fibrillation; VT = ventricular tachycardia.

addressed, especially in the context of a chronic and progressive disease with extensive pathological substrate. However, the significant decrease of both fast and slow arrhythmia burden after ablation suggests the contribution not only of the slow (VT1) but also fast (VT2) ablation, perhaps with the additive effect of sympathectomy and epicardial cryoablation. Of note, the impossibility of ablating fast NSVT3 could impact VT recurrence, especially given the similar frequency.

Besides, only a focal ablation catheter was used for both mapping and ablation, mainly for limiting procedural duration and due to the important epi/endocardial impedance-mismatch caused by single-lung ventilation and high-pressure CO_2 insufflation of the pleural space, inherent to thoracoscopic hybrid procedures.

CONCLUSIONS

Sequential biventricular focal septal PFA constitutes a safe and effective alternative for the treatment of VT arising from deep-septal substrate.

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