Adjuvant use of a cryoballoon to facilitate ablation of premature ventricular contraction–triggered ventricular fibrillation originating from the moderator band

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Introduction

Idiopathic ventricular fibrillation (VF) may be initiated by short-coupled premature ventricular contractions (PVCs) originating from the Purkinje network, and such triggers may originate from the moderator band within the right ventricle (RV). While catheter ablation is an effective method to localize and eliminate PVC triggers, successful ablation on the moderator band may be limited by difficulties with catheter stability, variable anatomy, and multiple exit sites along the length of this endocardial structure. This case demonstrates a novel approach to facilitate successful ablation of PVC-triggered VF originating from the moderator band.

Case report

A 40-year-old woman with history of recurrent syncope and episodes of polymorphic ventricular tachycardia presented with multiple implantable cardioverter-defibrillator (ICD) shocks. Frequent monomorphic PVCs were noted and initiated recurrent VF events that continued after inpatient admission (Figure 1). She initially presented with syncope 9 years prior and underwent secondary prevention ICD implant at that time after PVC-triggered VF episodes had been documented. Radiofrequency (RF) ablation was performed on 4 prior occasions at various high-volume institutions and was guided by electroanatomic mapping and intracardiac ultrasound to identify and incorporate intracardiac structures. PVCs were mapped in each case to the RV in the region of the lateral insertion of the moderator band; however, despite extensive ablation in this region, only transient PVC suppression was achieved each time and permanent right bundle branch block occurred secondary to ablation targeting right ventricular Purkinje potentials. Ablation was often limited by PVC suppression with sedation, as well as by change in PVC morphology after ablation guided by activation and pace-mapping on the moderator band. No regions of low endocardial voltage were noted on electroanatomic mapping. Epicardial mapping revealed a localized scar on the inferior wall of the RV, but activation timing during clinical PVCs was not pre-QRS and ablation of the abnormal epicardial substrate did not alter the PVCs. Despite ablation as well as trials of multiple antiarrhythmic medications, including beta-blockers, flecainide, and amiodarone, she continued to have recurrent ICD shocks. PVC suppression had been achieved with quinidine; however, this medication was complicated by the development of severe thrombocytopenia. The patient had been listed for cardiac transplant owing to intractable arrhythmia.

After the patient presented with recurrent VF events resulting in multiple shocks in a 48-hour period and frequent

KEY TEACHING POINTS

- Idiopathic ventricular fibrillation may be initiated by premature ventricular contractions (PVCs) originating from the moderator band. However, catheter ablation of PVCs from the moderator band may be limited by difficulties with catheter stability, variable anatomy, and multiple exit sites along the length of this endocardial structure.
- Effective ablation on the moderator band can be facilitated by intracardiac echocardiography to visualize contact between the ablation catheter and the moderator band.
- Use of a cryoballoon as an adjunctive strategy may overcome some of the challenges posed by radiofrequency ablation on the moderator band.

KEYWORDS Ablation; Cryoballoon; Cryoablation; Moderator band; Premature ventricular contraction; Ventricular fibrillation
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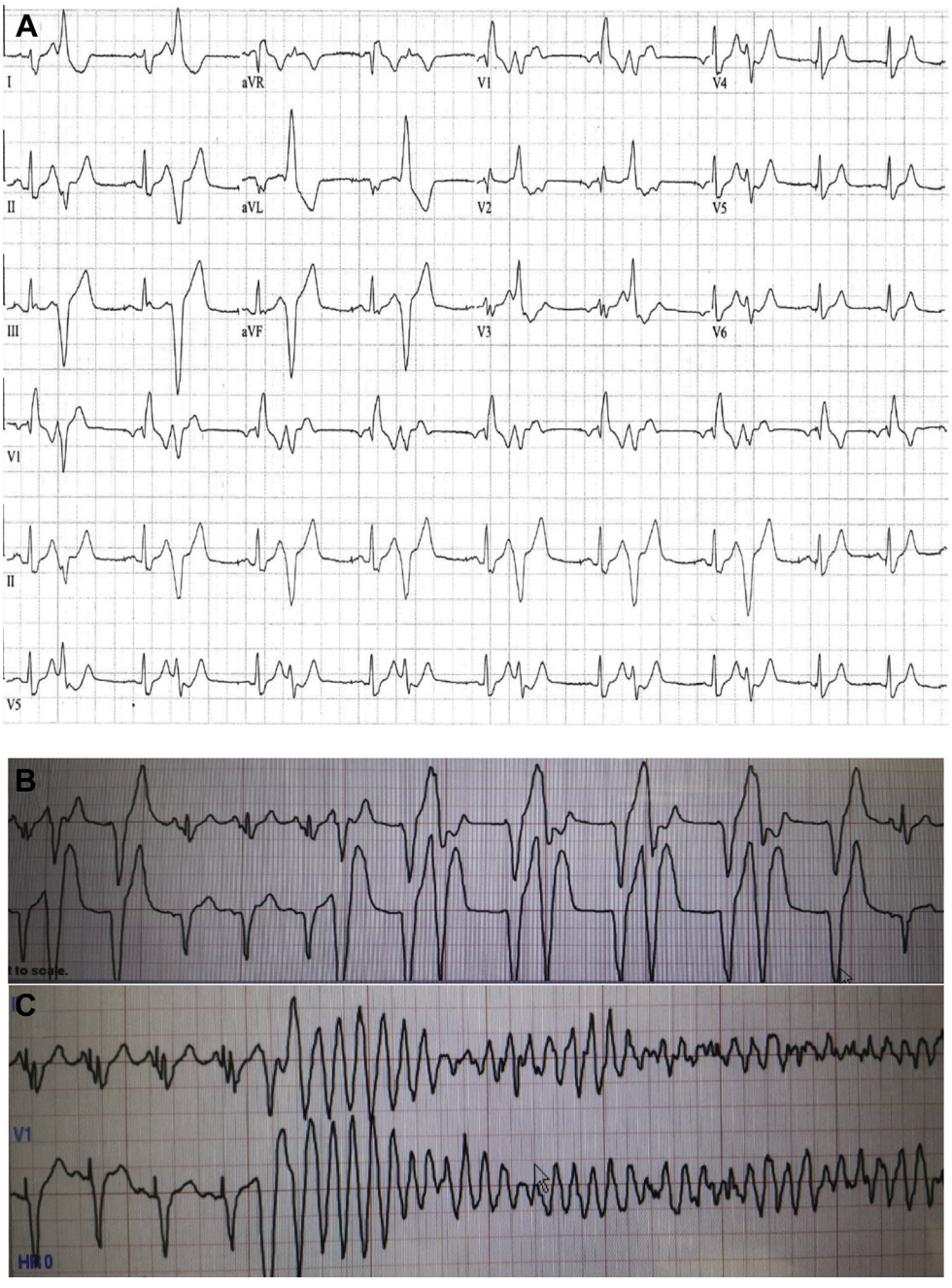

Figure 1 **A:** Electrocardiogram on presentation with sinus rhythm and frequent monomorphic premature ventricular contractions (PVCs). **B:** Frequent short-coupled monomorphic PVCs. **C:** Ventricular fibrillation initiated by a PVC.

short-coupled monomorphic PVCs, another ablation was pursued. The procedure was performed under general anesthesia owing to anticipation of potential frequent need for defibrillation during a prolonged procedure. Ventricular ectopy was suppressed with anesthesia, and empiric ablation targeting the endocardial RV moderator band was performed. The RV endocardial structures, including the moderator band and papillary muscles, were marked on intracardiac ultrasound (10F SoundStar, Biosense Webster, Diamond Bar, CA) and integrated into the electroanatomic map (CartoSound Module, Biosense Webster). Pace-mapping at sites along the lateral aspect of the moderator band revealed paced QRS nearly identical to the clinical PVC, but PVCs with varying axis were elicited with adjacent pacing points along the moderator band (Supplemental Figure 1). RF ablation irrigated with half normal saline was performed along the length of the moderator band at 30–50 W with a contact force–sensing ablation catheter aiming for contact force >5 g on the moderator band and an impedance reduction of at least 10 ohm during ablation (Figure 2). Following completion of RF ablation, occasional PVCs of variable QRS morphology were still

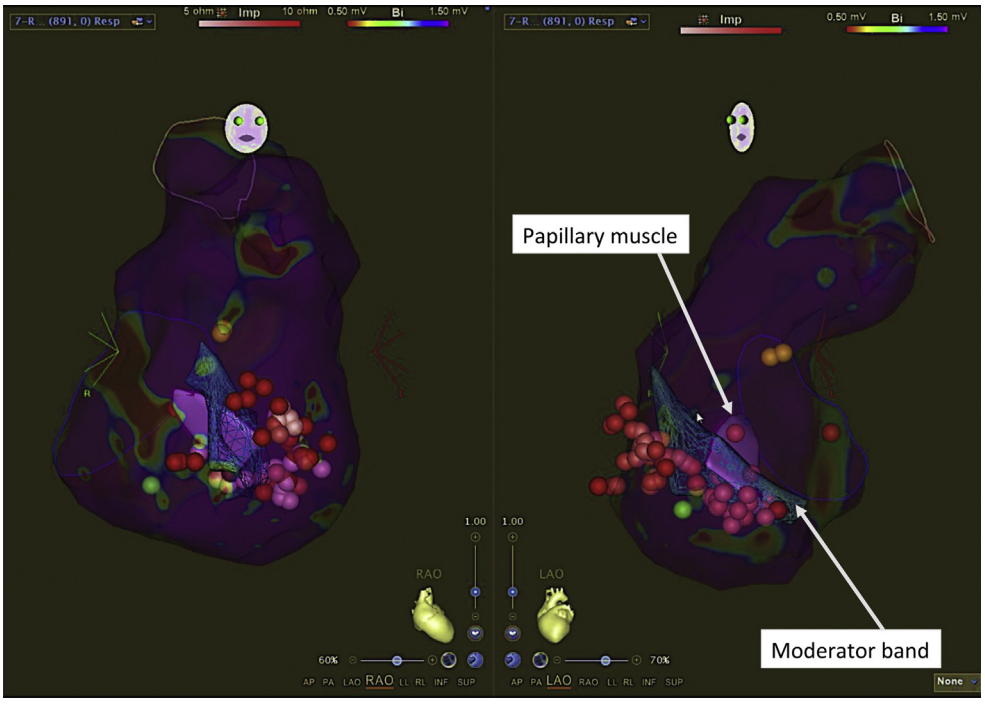

Figure 2 Electroanatomic map of the right ventricle. Endocardial structures were identified on intracardiac echocardiography and incorporated into the map: the *blue semitransparent structure* represents the moderator band and the solid gray structure the anterior papillary muscle. Ablation markers (*red and pink dots*) are indicated across the length of the moderator band as well as on the anterior papillary muscle. The *yellow circles* indicate the region of the His bundle.

observed. Cryoablation was then performed using a 23 mm cryoballoon applied consecutively on the septal and lateral aspect of the moderator band; apposition of the cryoballoon along the moderator band was ensured using continuous intracardiac ultrasound to visualize contact (Figure 3). Two applications with angulations to direct the balloon toward the septal side and lateral margin of the moderator band were delivered for 4 minutes each. Lowest temperature was -47°C. Care was taken to make sure that the points of balloon contact did not include the tip of the ICD lead that was more apical. Pacing and sensing thresholds were unaffected by the cryo applications. Sedation was then lifted, and there was no recurrence of PVCs. During inpatient monitoring for over 48 hours no further ventricular ectopy was seen. On follow-up, ICD interrogations have documented no further ventricular arrhythmia events and near-elimination of the PVC burden.

Discussion

Idiopathic VF occurs in patients without demonstrable structural heart disease. PVCs, often short-coupled and originating within the Purkinje network, have been identified as a source of triggered VF, and present a potential target for curative ablation.[1–3] The moderator band is a muscular structure in the RV that contains Purkinje fibers, and it has been reported as an origin of PVC-triggered VF.[4,5] However, mapping and effective ablation at this site may be limited by

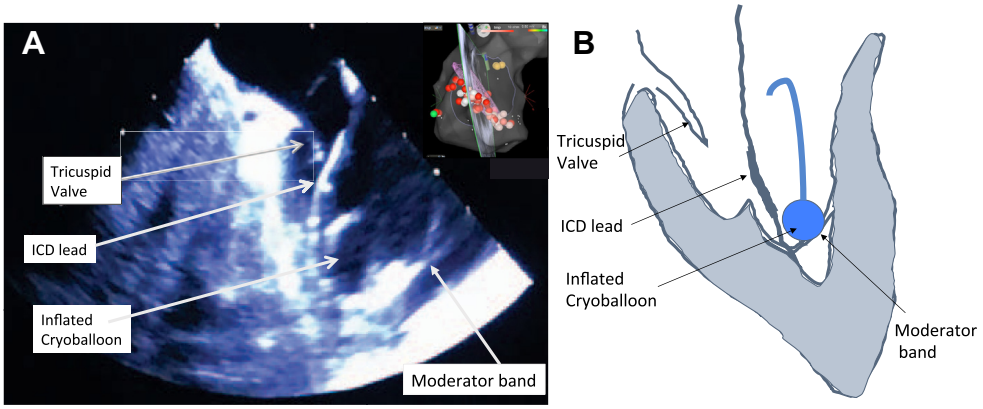

Figure 3 **A:** The inflated cryoballoon visualized within the right ventricle and apposed to the moderator band visualized on intracardiac echocardiography. The position of the ultrasound beam depicted within the electroanatomic map is shown in the top right corner. **B:** Diagram illustrating the structures identified in A. ICD = implantable cardioverter-defibrillator.

difficultly achieving consistent contact,[5] PVC suppression with sedation, and difficulty differentiating pace capture of Purkinje tissue as opposed to adjacent myocardium. Furthermore, the variable morphology of the moderator band and presence of Purkinje tissue along its length supports different PVC exit sites (Supplemental Figure 1) that may need to be targeted at various points from the lateral RV wall to the anterior RV papillary muscle and interventricular septum.[5–7]

Intracardiac echocardiography can be used to visualize intracardiac structures that may be involved in the arrhythmia, and help facilitate contact with the ablation catheter along the moderator band.[5] However, ICE alone may not facilitate effective ablation in all necessary sites across the variable and complex structure of the moderator band.

An adjunctive ablation strategy using a cryoballoon may overcome the limitations in catheter stability and limited lesion size that frustrate point-by-point RF ablation on mobile intracardiac structures. The cryoballoon forms an ice crystal that fuses to myocardial tissue, ensuring consistent contact during the duration of the cryoapplication, and creates a broad-based lesion that can be used to span intracardiac structures. While a point-by-point cryoablation catheter could have also been used to improve catheter stability with focal ablation, a larger cryoballoon was chosen in order to ablate more substrate along the length of the moderator band. In general large-area ablation lesions are prudently avoided when targeting focal arrhythmias, particularly in functionally normal myocardial tissue; however, in this case cryoablation as an adjuvant strategy after RF ablation likely contributed to durable elimination of a PVC originating from the moderator band, whereas prior attempts with more traditional focal ablation alone were unsuccessful. The RV moderator band, being an intracardiac structure in the apical half of the RV cavity, lends itself well to ablation using a balloon catheter that can be tilted under intracardiac echocardiography visualization to make adequate contact with the structure. We chose a 23 mm balloon to avoid extensive contact with the RV myocardium and prevent RV dysfunction. Care is also to be exercised in making sure that the tip electrodes of the RV defibrillating leads are not in the region of freeze to avoid loss of sensing or pacing.

Conclusion

This case highlights the challenges that may arise in ablation of PVCs originating in the region of the RV moderator band. Despite multiple ablation attempts at various experienced electrophysiology laboratories, PVC suppression was not achieved with conventional RF ablation, allowing persistence of a life-threatening arrhythmia. A larger ablation catheter such as the cryoballoon is able to overcome the issues of contact stability and allows contact along the entire length of the moderator band. This is the first case that describes the adjunctive use of a cryoballoon to facilitate successful ablation of PVC-mediated VF originating from the moderator band.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2019.09.001.

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