Bipolar ablation with half normal saline for deep intramural outflow tract premature ventricular contraction

Andres Enriquez, MD,* Victor Neira, MD,* David Bakker, BScH,† Jason Baley, BScH,‡ Gianluigi Bisleri, MD,‡ Adrian Baranchuk, MD,* Damian Redfearn, MD*

*From the *Division of Cardiology, Queen's University, Kingston, Ontario, Canada, †Abbott Canada, Mississauga, Ontario, Canada, and ‡Division of Surgery, Queen's University, Kingston, Ontario, Canada.*

Introduction

Radiofrequency (RF) catheter ablation is an effective therapeutic strategy for the management of ventricular arrhythmias (VAs).[1–3] However, efficacy of RF ablation may be limited when the arrhythmogenic substrate is deep within the myocardium and inaccessible to the ablation catheter, as occurs with certain septal VAs.

Intramural septal VAs can be found in 8% of patients with VAs and structurally normal hearts.[4] Among patients with postinfarction ventricular tachycardia (VT), a critical isthmus may involve the interventricular septum in 22%, and in 11% of these the critical component is intramural.[5] A variety of solutions have been proposed to overcome the challenges of intramural substrate, including needle ablation, transcoronary alcohol ablation, simultaneous unipolar ablation, and bipolar ablation.

We describe a case of outflow tract premature ventricular contractions (PVCs) that had been refractory to antiarrhythmic therapy and prior ablation attempts. Successful PVC elimination was achieved with a combination of bipolar ablation and use of half normal saline (HNS) as cooling irrigant.

KEY TEACHING POINTS

- In ventricular arrhythmias, an intramural septal origin should be suspected in case of poor precocity or pace map in either side of the septum, far-field local electrograms, and/or diffuse areas of earlier activation recorded on the mapped surfaces.
- Bipolar ablation using half normal saline as irrigant can be effectively and safely performed to treat intramural septal ventricular arrhythmias when conventional ablation has failed.
- Gradual titration of power, real-time monitoring with intracardiac echocardiography, and close attention to impedance and temperature are recommended to minimize complications.

Case report

A 69-year-old man with nonischemic cardiomyopathy and frequent PVCs was referred for catheter ablation. He had failed various antiarrhythmic medications, including propafenone, sotalol, and amiodarone. He had also undergone 3 prior ablation procedures, including an epicardial ablation and, more recently, a surgical ablation, which was limited by early mechanical suppression of the PVC. The QRS on 12-lead electrocardiogram was characterized by a right bundle branch block pattern with no transition and right inferior axis (Figure 1), and his last Holter monitor showed a 40% PVC burden with bigeminy through most of the recording. A recent echocardiogram estimated his left ventricular ejection fraction at 25%.

The patient presented to the electrophysiology laboratory in sinus rhythm with ventricular bigeminy. The procedure was conducted under general anesthesia and mapping and ablation was aided by the EnSite Precision system (Abbott, St Paul, MN). A 9 French phased-array intracardiac echocardiography (ICE) catheter (ViewFlex Xtra, Abbott, St Paul, MN) was advanced into the right ventricle to guide mapping, catheter contact, and lesion formation and to monitor for complications. A quadripolar catheter was positioned in the right ventricular (RV) apex and a decapolar catheter was advanced to the great cardiac vein–anterior interventricular vein junction, where no early activation was observed during PVCs (20 ms after QRS onset). RV mapping demonstrated earliest activation at the most anterior and septal aspect of the RV outflow tract (RVOT), below the valvular plane (20–24 ms pre-QRS, far-field-looking), while the left

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Address reprint requests and correspondence: Dr Andres Enriquez, Division of Cardiology, Queen's University, 76 Stuart St, Kingston, Ontario K7L 2V7, Canada. E-mail address: Andres.Enriquez@kingstonhsc.ca.

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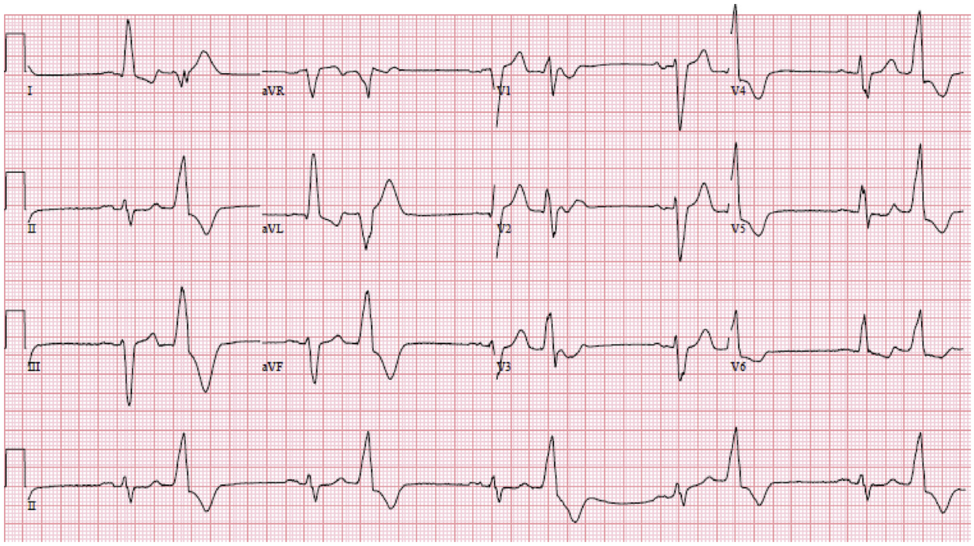

Figure 1 Baseline 12-lead electrocardiogram demonstrating ventricular bigeminy. The QRS morphology shows a right bundle branch block pattern with right inferior axis, suggesting most likely a left ventricular outflow tract origin.

ventricular outflow tract (LVOT) was only "on time" with the QRS onset (Figure 2). Pace maps from either side were poor. Given prior failure of RVOT ablation, bipolar ablation was attempted with the settings previously described by Sauer and colleagues.[6] An ablation catheter with contact force capabilities was placed at the RVOT (TactiCath, Abbott, St Paul, MN), while another ablation catheter (FlexAbility, Abbott, St. Paul, MN) was positioned in the adjacent aspect of the LVOT, below the right coronary cusp (RCC)–left coronary cusp (LCC) commissure (Figure 3). A T connection was used to allow simultaneous electrogram recording and visualization of the ground catheter on the electroanatomic map. The distance between both catheter tips was 20 mm. RF was applied using the RVOT catheter as the active catheter and the LVOT catheter as ground, and vice versa (25–45 W, 2 min lesions), without PVC suppression. Epicardial access was gained and epicardial mapping was also performed, showing a diffuse area of early activation (20–26 ms pre-QRS), but far-field electrograms. A coronary angiogram was performed, showing safe distance to the area of interest, and additional epicardial lesions were applied using HNS, again without success. A deep intramural source was

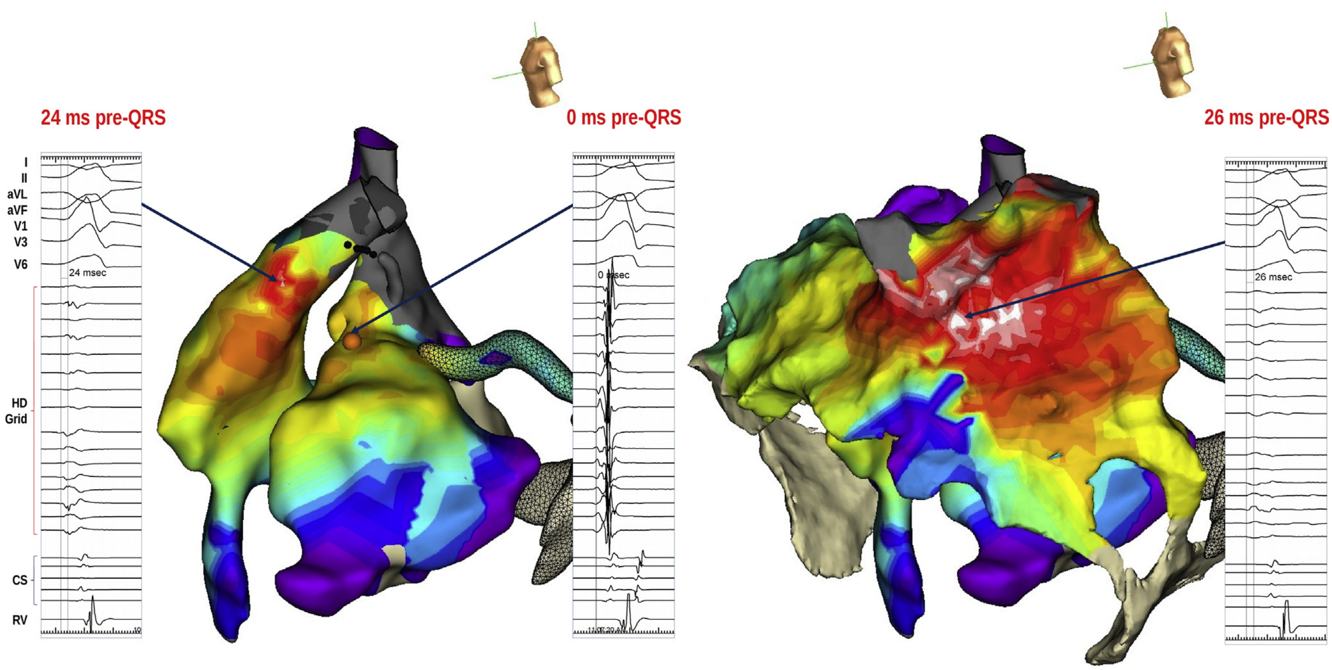

Figure 2 Activation map showing earliest sites of activation on right ventricular outflow tract (20–24 ms ahead of QRS, far-field), left ventricular outflow tract (on time with QRS), and epicardium (26 ms ahead of QRS, far-field).

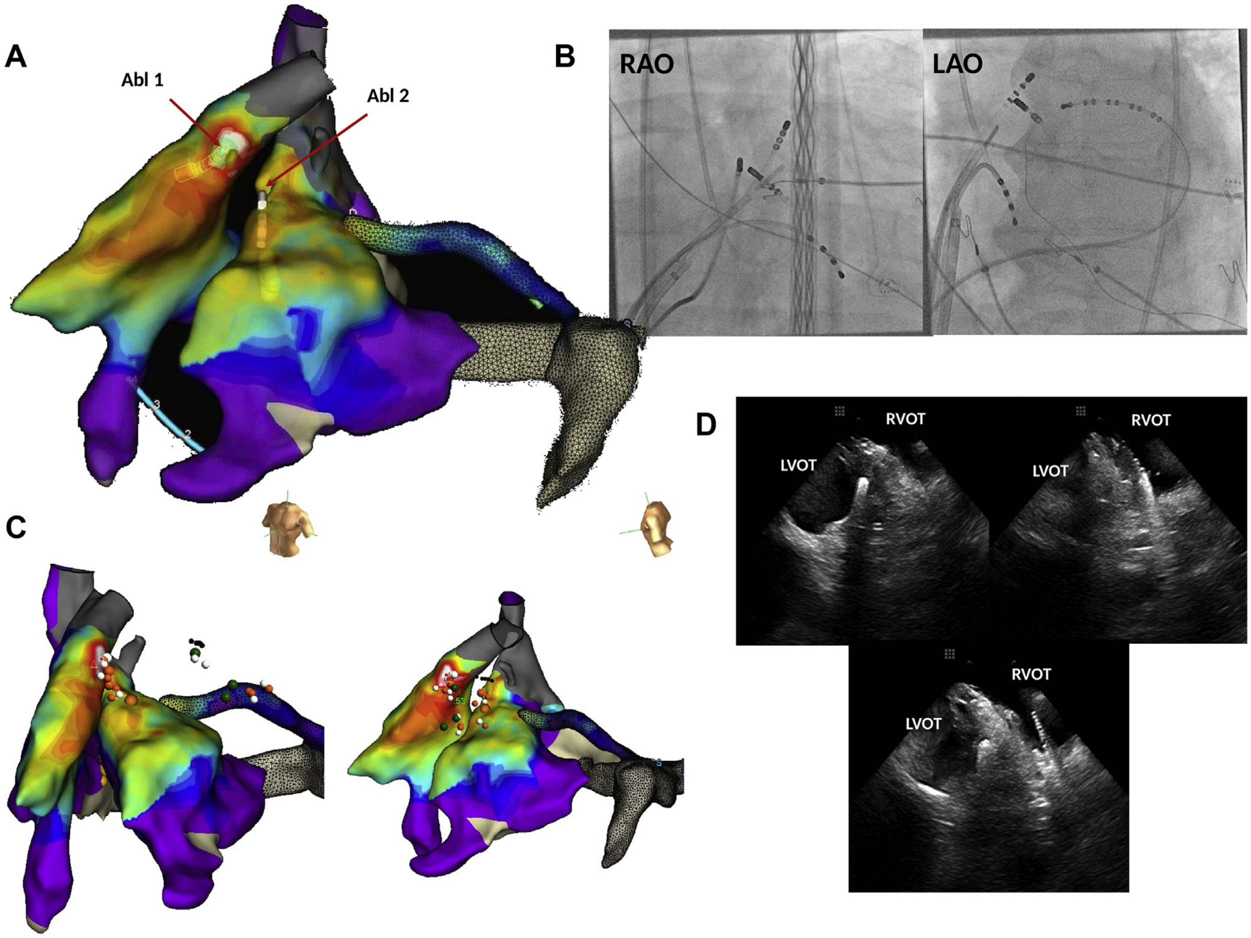

Figure 3 Bipolar ablation. **A:** Two ablation catheters (Abl1 or active and Abl2 or ground) are positioned in opposite sides of the right ventricular outflow tract (RVOT) and left ventricular outflow tract (LVOT), respectively, with a distance of 20 mm separating them. The active and ground catheters were alternated by switching the connections. **B:** Position of the catheters on right anterior oblique (RAO) and left anterior oblique (LAO) fluoroscopic views; a decapolar catheter is placed inside the coronary sinus with the distal tip at the level of the great cardiac vein–anterior interventricular vein junction. **C:** Final lesions delivered from the RVOT and LVOT to achieve premature ventricular contraction elimination. **D:** Intracardiac echocardiography views of the RVOT/LVOT obtained with the probe positioned at the base of the right ventricle followed by clockwise rotation; the catheter tip position can be discerned by the acoustic shadows; note increased echogenicity of the septum after initial lesions.

suspected and a new attempt of bipolar ablation was conducted, this time using irrigation with HNS. RF was applied from the LVOT to RVOT (30–45 W, 2 min lesion, 18 ohm impedance drop) under monitoring with ICE, achieving persistent PVC suppression without steam pops. Two consolidation lesions (2 and 3 min) were applied and no recurrence was observed after a 30-minute waiting period with and without isoproterenol infusion. At 4-week follow-up, a 24-hour Holter monitor showed no recurrence of the clinical PVC ($<1\%$ PVC burden).

Discussion

The present case illustrates the challenges we face when approaching ablation of intramural VT/PVCs. Failure with conventional RF ablation is not uncommon and usually the use of innovative and or experimental approaches is required. In our case, a favorable outcome was achieved by combining 2 novel strategies that have shown to enhance transmurality of ablation lesions.

No pathognomonic electrocardiogram criteria exist to predict a midmyocardial arrhythmia source, and the diagnosis is typically made at the time of the electrophysiology study. As evidenced in this case, an intramural septal source should be suspected when activation time on both sides of the septum is only on time or slightly pre-QRS. Often, far-field electrograms and/or diffuse areas of early activation are recorded on the mapped surfaces, and pace maps from the earliest sites in each of the ventricles are poor. In scar-related VT, a prolonged transseptal conduction time during septal pacing may alert about the presence of intraseptal substrate.[7]

Bipolar RF ablation involves the application of RF current between 2 ablation catheters positioned on either side of the target substrate (interventricular septum or free wall). Experimental models have demonstrated that bipolar RF ablation has the ability to achieve deeper lesions compared to simultaneous unipolar ablation, with transmurality achieved in tissues as thick as 20–25 mm.[8] In addition, bipolar ablation appears to be less sensitive to contact and catheter alignment when compared to unipolar ablation, which may be an advantage when trying to maintain catheter-tissue contact in the beating heart.[9] Teh and colleagues[10] reported the use of bipolar ablation in 4 patients with refractory outflow tract VAs. RF was applied between the earliest RVOT site and the earliest aortic cusp site (RCC in 2 and LCC in 2). This approach eliminated PVCs in 3 of 4 cases, without recurrence after a mean follow-up of 4 months. In our case the earliest site in the LVOT was observed below the RCC-LCC commissure and the successful ablation lesion was delivered from this site, even when activation was later than in the RVOT.

Use of HNS as cooling irrigant is another novel strategy that has been described for ablation of deep myocardial circuits.[11,12] By decreasing ionic concentration of the irrigant solution, HNS reduces the dispersion of RF to the environment surrounding the ablation catheter and allows for more effective current delivered to myocardial tissue, resulting in deeper and larger lesions. A recent multicenter experience has been published reporting the outcomes of HNS ablation in 94 PVC/VTs refractory to standard ablation.[13] Acute success was achieved in 83% of patients, with a 1-year PVC/VT-free survival of 89.4%. Steam pops were observed among 12.6% of patients.

Safety is one of the logical concerns when both strategies are combined. In an experimental model, bipolar ablation using HNS created deeper lesions and larger lesion volumes than either sequential unipolar ablation with HNS or bipolar ablation with normal saline, but it was also associated with a higher rate of steam pops.[12] To minimize this risk, we started RF energy at 25–30 W every time and progressively titrated up to a maximum of 45 W, paying close attention to the impedance and temperature curves, and also maintaining real-time visualization of the tissue target with ICE to detect steam bubbles that sometimes precede pops. No steam pops were observed and a postprocedure echocardiography ruled out ablation-related complications.

Conclusion

Bipolar ablation using HNS as cooling irrigant can be used to treat intramural septal VAs when conventional ablation has failed. Further research and larger case series are warranted to validate the efficacy and safety of this approach.

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