High-power bipolar ablation for incessant ventricular tachycardia utilizing a deep midmyocardial septal circuit

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Case report

A 68-year-old man with cardiomyopathy out of proportion to ischemic heart disease, previous coronary artery bypass grafting, and a biventricular implantable cardioverter-defibrillator presented with incessant ventricular tachycardia (VT) refractory to amiodarone and previous ablation attempts. Recent nuclear stress testing demonstrated no evidence of ischemia and a small area of scar at the inferior and basal left ventricle. The patient's ejection fraction was estimated to be between 30% and35% from the recent echocardiogram. During his previous ablation procedure, bipolar voltage maps demonstrated minimal left ventricular (LV) endocardial scar while unipolar maps suggested a moderate burden of basal and anterior LV epicardial scar.[1] Several VTs were mapped along the aortomitral continuity, basal and inferior LV septum, and right ventricular outflow tract (RVOT), all of which were ablated successfully. There was 1 VT morphology with diffuse early activation on both the left and right sides of the ventricular septum that was not affected with ablation. It was opted to continue amiodarone and β-blocker therapy until the current hospital admission.

The patient presented for this hospitalization with incessant VT despite high-dose amiodarone and lidocaine, prompting referral for repeat ablation. The VT morphology had an LV outflow axis (left bundle, left inferior transitioning at lead V_3) with a cycle length of 500 ms (Figure 1). This VT was mapped to the ventricular septum that was slightly earlier at the septal left ventricular outflow tract (LVOT). Significant ablation on both sides of the ventricular septum was applied to regions of earliest activity along the septal LVOT, right coronary cusp, and posterior RVOT without VT suppression despite aggressive power titration (50 W for up to 5 minutes) with a 3.5-mm open-irrigated ablation catheter (ThermoCool SF, Biosense Webster, Inc, Diamond Bar, CA). The procedure had to be stopped because of prolonged procedure times and impending congestive heart failure. Overall, activation maps and VT morphology suggested a midseptal VT focus that could not be successfully ablated with any ablation catheter.

The patient was evaluated for potential heart transplant but incessant VT with the same left-bundle, left inferior axis transitioning at lead V_3 at 110–120 beats/min ensued despite intubation and sedation on multiple antiarrhythmic agents. It was felt that the VT was originating from the basal to mid ventricular septum and that alcohol septal ablation or bipolar catheter ablation might allow for a greater likelihood of affecting a midmyocardial circuit. The basal septal myocardial thickness measured 1.4 cm by transthoracic and 1.6 cm by intracardiac echocardiographic (ICE) imaging. Coronary angiography was initially performed, and 1 small septal perforator was identified; however, it was distal to the basal septal region of interest and therefore was not considered for selective alcohol injection.

The right ventricular (RV) and LV aspects of the septum were again mapped, identifying a region of early activity along the superior basal RVOT (30–40 ms pre-QRS) and LVOT (20–30 ms pre-QRS). Pace maps were excellent from the RVOT, with a 96% match to the clinical VT using the CARTO Paso software (Biosense Webster, Inc). Entrainment of the VT from the basal septal RVOT and LVOT was performed and demonstrated a difference between the postpacing interval and the tachycardia cycle length of less than 30 ms, with evidence of differing degrees of manifest fusion consisting of outer loop sites and a VT exit within the intervening ventricular septum. Ablation with a 3.5-mm open-irrigated catheter at this site septum (ThermoCool SF) at the RV and LV basal septum transiently suppressed VT after long applications of energy. Given that sequential unipolar ablation was not successful from both sides of the septum, we proceeded to bipolar ablation. The grounding patch was disconnected and an 8-mm Celsius catheter (Biosense Webster, Inc) was plugged into the grounding port on the radiofrequency (RF) generator, using a custom-designed cable. The 3.5-mm ThermoCool SF catheter remained plugged into the generator as the "active" component of the ablation. After this configuration proved unsuccessful,

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ABBREVIATIONS ICE = intracardiac echocardiographic; **LV** = left ventricular; **LVOT** = left ventricular outflow tract; **RF** = radiofrequency; **RV** = right ventricular; **RVOT** = right ventricular outflow tract; **VT** = ventricular tachycardia
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KEY TEACHING POINTS

- Bipolar ablation can be used to affect a deep intramural ventricular tachycardia circuit to create a transmural lesion.
- Power greater than 50 W can be delivered through a 3.5-mm catheter using existing ablation equipment if the radiofrequency circuit is modified to include an 8-mm catheter.
- Intracardiac echocardiography can be used to evaluate lesion formation at the site of the "ground" catheter.

the 8-mm and ThermoCool catheter assignments were switched, thus allowing for the 8-mm catheter to become the "active" ablation catheter and the ThermoCool to become the "ground" catheter. This combination allowed for 70-W lesions to be delivered across the septum. Power titration and temperature measurements could be ascertained only for the ablation catheter connected to the RF generator, while the catheter connected to the RF grounding cable could not be monitored except by direct visualization on ICE imaging. It was noted that the greatest impedance declines occurred when the catheters were aligned directly across from each other on both ICE and biplane fluoroscopy imaging (Figure 2). Lesions were delivered with power titration up to 70 W for as long as 5 minutes, with slow impedance drops of 10–15 Ω noted during ablation. On 2 occasions, the LV septal myocardium at the tip of the 3.5-mm open-irrigated ground catheter was noted to become echogenic (Figure 2, right panel) with small bubble formation on ICE imaging and ablation was stopped because of a presumed steam pop. Bipolar ablations were performed from the mid to basal intraventricular septum. Bipolar ablation terminated the incessant VT in 69 seconds, and additional ablation was performed in this region of the septum to homogenize the ablation lesions and to fully extinguish any spontaneous or inducible VT. After this successful ablation, the procedure was concluded and the patient remained stable without further VT during the hospitalization. He has remained without any VT for 1 year and therefore further cardiac transplant workup has been deferred.

Discussion

Our case demonstrates the effectiveness of high-power bipolar ablation across the interventricular septum for incessant VT. To our knowledge, this is also the first reported case of safely applying RF power at 70 W using an 8-mm nonirrigated catheter and a 3.5-mm irrigated catheter across the interventricular septum in this manner. Our patient was refractory to previous high-powered septal ablations using previously described configurations and sequential "unipolar" ablation. It was not until the high-power bipolar ablation was applied that the VT was successfully ablated. When the 8-mm ablation was designated as the active catheter, we had greater success terminating the VT, which we hypothesize was due to the ability to deliver a higher power lesion (compared with 50 W via the 3.5-mm externally irrigated catheter) with the associated higher current density of bipolar ablation.

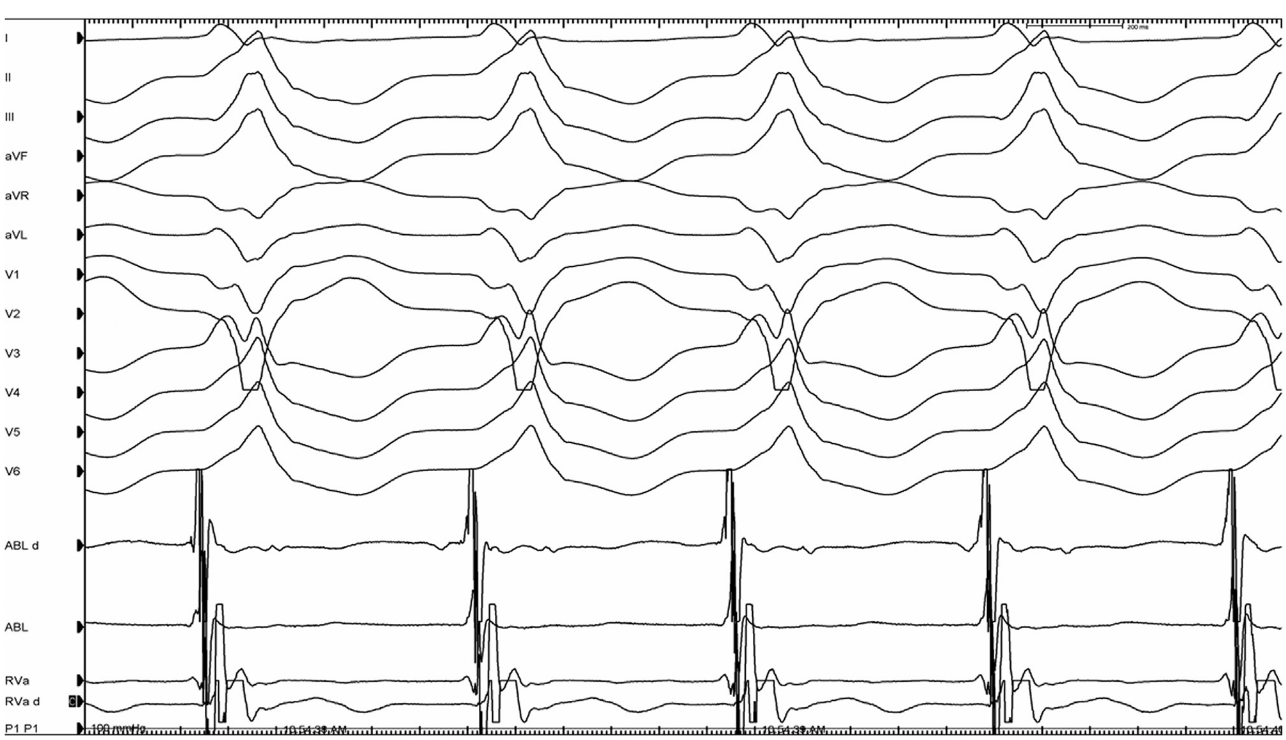

Figure 1 Targeted septal ventricular tachycardia. The RV catheter is positioned on the mid-right ventricular septum, and the ablation catheter is positioned on the basal left ventricular septum. ABL = ablation; d = distal; RV = right ventricle.

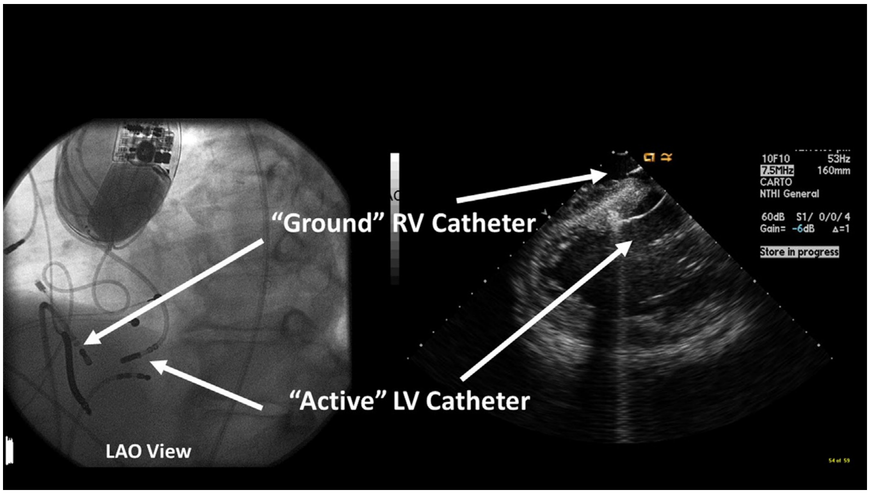

Figure 2 Left anterior oblique (LAO) fluoroscopy and intracardiac echo echocardiography demonstrating catheter positioning across the interventricular septum. Left panel: An LAO image depicting an 8-mm catheter within the right ventricle (RV) and a 3.5-mm open-irrigated catheter within the left ventricle (LV). Right panel: Intracardiac echocardiogram depicting the septal positioning of the RV and LV ablation catheters during bipolar radiofrequency ablation. When acute echogenicity or the presence of bubbles was seen on the intracardiac echocardiogram, as denoted by the asterisk, ablation was stopped.

The primary reason for the refractory nature of the septal VT despite high-powered standard ablation is related to the lack of lesion depth across the septum. Depending on VT location and substrate, recurrence rates after RF ablation have ranged from a quarter to two-thirds of patients.[2] Previous work has demonstrated the synergistic effect of ablation with simultaneous unipolar ablation from opposing ventricular myocardium, leading to larger and deeper ablation lesions.[1–4] The common finding in several animal models has been that bipolar ablation with one catheter used for power delivery and the other as a ground catheter produced deeper and larger lesions than ablation with 2 catheters in parallel with a common ground or 2 catheters each delivering standard unipolar ablation simultaneously with individual grounding electrodes.

In a case report with a similar clinical scenario to ours, Iyer et al[5] reported on the success of simultaneous unipolar radiofrequency ablation to treat incessant septal VT. In their case, an 8-mm catheter (Blazer II XP, Boston Scientific, Natick, MA) was positioned on the RV septum and a 3.5-mm open-irrigated catheter (ThermoCool SF) was positioned directly opposite along the LV septum.[5] In this manner, each catheter could be monitored for power and temperatures during ablation. A maximum of 55 W via the 8-mm and 50 W via the 3.5-mm catheter was applied simultaneously across the septum, resulting in successful termination of VT and clinical suppression. They hypothesize that with increased contact force and power, resistive intramyocardial heating could be optimized and conductive heating to the midmyocardial channels could be increased over other RF methods.[5]

In the largest study to date investigating the use of bipolar ablation to increase RF lesion depth, Koruth et al[6] demonstrated the effectiveness of bipolar ablation to suppress 6 refractory septal VT in 4 patients. Two 3.5-mm open-irrigated ablation catheters were placed across the septum (ThermoCool SF), with 30–50 W applied only from the LV catheter plugged into the RF generator to the RV catheter that was plugged directly into the indifferent electrode port of the generator through the use of a custom cable. Lesion depth was increased over unipolar ablation alone. Bipolar ablation was most useful in patients with thicker interventricular septum measuring more than 1.5 cm, with transmural lesions penetrating as deep as 2.5 cm. In a computer-generated model of the temperature distribution using this same setup for bipolar ablation, the lesion width became more narrow at the middle of the septum, with thicker tissue (>15 mm) resembling an hourglass shape.[7] The total duration of ablation in this model was 120 seconds, which is in contrast to our case in which longer lesions were applied for up to 5 minutes to allow more time for conductive heating and presumably deeper lesions. Bipolar ablation increased current density and thermal energy between catheter tips, resulting in effective RF lesions.

In our case, we used an 8-mm nonirrigated catheter, which may have allowed for a greater area of resistive heating but less lesion depth compared with the 3.5-mm irrigated ablation catheter. We did observe initial baseline and average impedances that were greater with bipolar ablation (range 140–160 Ω) than with sequential unipolar ablation (range 100–120 Ω), which reflects the greater current density between the 2 ablation catheters. Similarly, we observed higher impedances and greater impedance declines when the catheters were placed in proximity on either side of the septum using ICE and fluoroscopy, as depicted in Figure 3. Further investigation of the lesions created with our bipolar ablation approach would be worthwhile.

Other limitations to our approach include the lack of temperature or power regulation from the catheter plugged into the grounding port, and lack of precise adjustment of catheter position due to inability to visualize the grounded

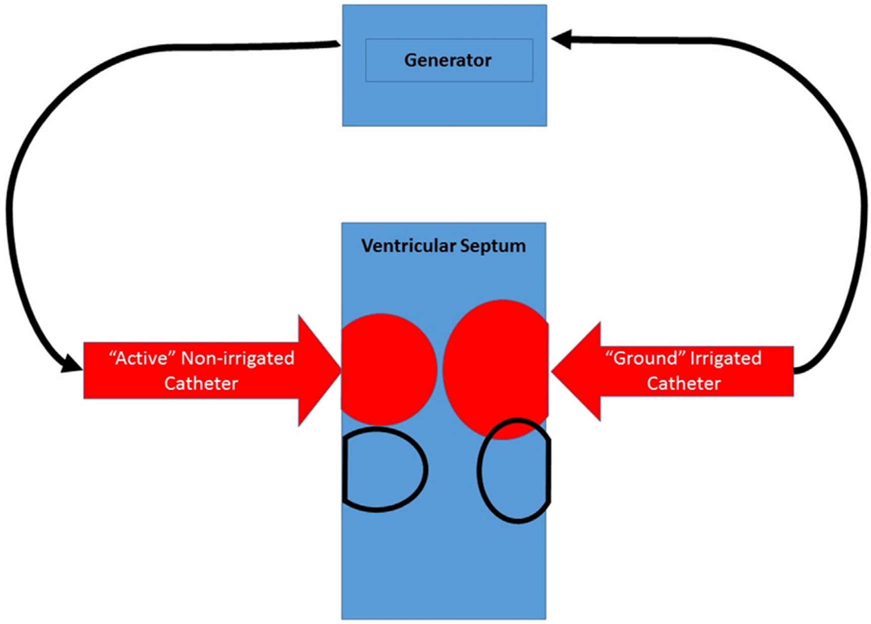

Figure 3 Depiction of the positioning of the active and ground catheters to maximize lesion depth and current density. When the catheters were positioned close together on opposite sides of the septum, we had greater baseline impedances and impedance declines as well as ventricular tachycardia termination that we presume to be due to an overall deeper lesion in the septum as depicted by the solid red semicircles. When the catheters were not closely positioned, the baseline impedance and impedance declines were less potentially indicative of less current density and a less than transmural lesion as depicted by black outlined semicircles.

catheter on the mapping system. A standard cable could be used to position the catheter because the customized grounding cable is required only at the time of ablation. The design and production of a standard "ground" cable that could be used with the ablation catheter would be useful to monitor ablation and would probably make bipolar ablation a more accepted procedure. Finally, we recognize that the use of 70 W of energy focused to a 3.5-mm catheter is not standard in the manner we used and therefore informed consent regarding the experimental and off-label use of equipment was obtained.

In conclusion, we present a unique case of using 70-W bipolar lesions directed from an 8-mm nonirrigated ablation catheter to a 3.5-mm irrigated ablation catheter from either side of the interventricular septum to successfully ablate a basal septal VT that was refractory to standard unipolar and bipolar ablation approaches. Our patient remains VT free after this method for 70-W bipolar ablation and is no longer under consideration for cardiac transplantation.

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