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Editorial

Needle Ablation for Ventricular Tachycardia: From Bench to Bedside

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See article by Sanchez-Somonte et al., pages 1277−1285 of this issue.

Implantable defibrillators have dramatically changed the natural history of ventricular tachycardia (VT). Yet, they do not prevent recurrences, which are associated with significant impairment in quality of life and prognosis. Although it is not yet clear whether prognosis can be modified with suppression of intermittent VT,[1] recurrent defibrillator shocks are highly burdensome to patients. Our options for suppression of VT include antiarrhythmic pharmacotherapy, and catheter ablation.[2,3] When either of these options are insufficiently effective, clinicians typically turn to the other. All too often however, both of these options are ineffective, and clinicians need to get creative.[4] Despite major technological and clinical advances, in the setting of ischemic cardiomyopathy and antiarrhythmic drug-refractory VT in the **V**entricular Tachycardia **A**blation vs E**n**hanced Drug Therapy **I**n **S**tructural **H**eart Disease (VANISH) trial, 38% of patients who underwent ablation had at least 1 further appropriate shock during a median of 28 months of follow-up.[5]

Catheter ablation for VT is not always successful. At the time of the procedure, clinically relevant VT is often not inducible, or is poorly tolerated. Procedures have therefore evolved to merge substrate-based ablation with efforts to focus particular attention on scar regions, which are especially likely to mediate reentry.[3] Yet, even when ablation is targeted at all identifiable endocardial substrate, VT might recur or might remain inducible. Culprit substrate might be deeper within the myocardium, it might be epicardial, or it might not even be identified with preprocedural imaging or intraprocedural electroanatomic mapping. We do have several measures that may be undertaken when usual approaches for endocardial radiofrequency (RF) catheter ablation fail. These include means to optimize catheter contact and RF energy delivery, and manipulation of RF delivery parameters, such as the dispersive electrode, and tonicity or flow rate of the catheter irrigant. Despite these measures, in some cases endocardially delivered RF ablation lesions are not large or deep enough to disrupt VT circuits.

Epicardial substrate might be suspected on the basis of preprocedural imaging and electrocardiographic data, or findings during endocardial contact mapping. Epicardial mapping and ablation has become a standard procedure in many laboratories providing catheter ablation of VT. This procedure does carry additional risk, including approximately 5% risk of major complications,[6] and the need for special skills and experience, and is limited in the presence of pericardial adhesions, including previous cardiac surgery. The success of epicardial catheter ablation can be further limited in the presence of deeper myocardial substrate, epicardial fat, and proximity to coronary arteries and the left phrenic nerve. These limitations, particularly the need to create deep intramural lesions, have led to several more novel approaches to ablate VT. Transvascular ethanol ablation, bipolar ablation, and stereotactic body radiotherapy have all been described as methods to create deeper or larger lesions. Intramyocardial needle ablation has been explored as an option for at least 2 decades.[4,7,8]

Initial experimentation with needle ablation in preclinical models revealed that intramyocardial infusion of saline was necessary to create lesions that were deep and of sufficient volume to be clinically useful.[9,10] Infusion of a small volume of saline through the end hole of a 27-gauge extendable/retractable needle electrode into the myocardial interstitium created a larger virtual electrode, avoiding very high current density at the electrode/tissue interface, and allowing greater energy delivery and large, deep lesions. When applied to an initial series of 8 patients with treatment-refractory VT (patients had high burden recurrent VT despite up to 4 previous ablation procedures (7 had $\geq$ 2 previous procedures), and inefficacy of amiodarone and at least 1 other antiarrhythmic drug), it resulted in no further VT in 4 patients, 2 early recurrences, and 2 later recurrences. One patient suffered cardiac perforation, thought to be related to transeptal puncture rather than ablation, and 2 with septal substrate experienced (expected and accepted) heart block. A further multicentre experience in 31 patients with treatment-refractory VT was undertaken. These patients had predominantly nonischemic

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cardiomyopathies (71%), and a median of 2 antiarrhythmic drugs and 2 prior ablation procedures that had failed, including epicardial procedures in 39%. A median of 15 needle ablation lesions were delivered in each patient. In this group, at 6-month follow-up, 48% had no further VT, and 19% had clinically improved (diminishment from incessant or high burden VT preprocedure to experiencing 1-6 episodes during follow-up). Procedural complications included 1 patient with an intraprocedural pericardial effusion, which was drained, 1 patient with (expected and accepted) heart block, 1 femoral hematoma, and 1 left ventricular lead dislodgement. Other adverse events during 30 days postprocedure included a heart failure exacerbation in 1, pulmonary embolism after a long flight in 1, pneumonia, and a urinary tract infection.[11] This catheter has also been studied in a multicentre prospective cohort experience of 35 patients to ablate treatment-refractory (mean of 2 previous ablation procedures, drug-refractory) high burden premature ventricular complexes, with clinical effectiveness in 73%. Among this group, 3 patients who underwent needle ablation at the left ventricular summit had pericardial effusions drained during the procedure, 1 had intermittent heart block, and 1 had femoral arterial dissection.[12]

Intramyocardial needle ablation has some important advantages. The deployment of a "plunge" electrode within the ventricle allows *in vivo* real-time recording of intramyocardial electrograms. This makes activation mapping, pace mapping, and entrainment mapping possible. In several cases, this revealed clear physiologic evidence of intramyocardial, deep, culprit substrate.[13] It also revealed that endocardial electrogram characteristics might correlate with the presence of this substrate,[14] and that contrast injection was useful to predict lesion creation with this catheter design.[15,16] The small needle was deployable within the myocardium multiple times with relatively low risk, although repeated intramyocardial ablation in normal myocardium might have led to the observed cardiac perforations, which appeared to be due to subepicardial hematomas that bled into the pericardial space and resolved with pericardiocentesis.[11,12]

In this issue of the *Canadian Journal of Cardiology*, Sanchez-Somonte and colleagues[17] report the first human experience of a different intramyocardial needle ablation catheter design. The needle is 25-gauge and has 24 radial side holes through which heated saline is irrigated during ablation at 10 mL/min, creating large, deep ablation lesions. This catheter has been developed and tested in preclinical models.[18,19] It is likely that this needle ablation catheter is effective through a different mechanism. The larger irrigation volume and heating of the irrigant likely lead to a greater degree of convective heating, rather than resistive heating. Adverse effects of infiltration of these larger irrigant volumes into the myocardial interstitium have not been described in preclinical studies. In this multicentre prospective cohort study, 25 patients who had recurrent scar-related VT (80% had ischemic cardiomyopathy, mean ejection fraction 33.3 $\pm$ 8.6%, mean age 69.5 $\pm$ 6.4 years) were treated with saline-enhanced RF needle ablation. All patients had undergone at least 1 previous ablation procedure (24% had $\geq$ 2 procedures) and at least 1 class III antiarrhythmic drug had failed. Among these patients, 69 VTs were induced, of which 43 were thought to be clinically relevant, and 30 were hemodynamically stable and sustained enough to map. Each patient was treated with a mean of 10.6 needle ablation deliveries. Of the 43 VTs that were thought to be clinically relevant, 42 were rendered noninducible. During 6 months of clinical follow-up, 58% of patients had recurrent VT, but there was a 73% reduction in the overall number of implantable cardioverter defibrillator shocks delivered in the 6 months after the procedure compared with the previous 6 months. The investigators made important safety observations within this experience. One patient had presumed embolic complications and died from ischemic bowel, 2 had strokes, 2 had pericardial effusions, and 1 had an elevated pacing threshold. During the course of the study, the occurrence of emboli, which appeared to correlate with a higher volume of "microbubbles" on intracardiac echocardiography prompted the development and use of degassed saline as irrigant. This significantly reduced the number of times that RF delivery was interrupted because of the appearance of high-volume microbubbles. It will be interesting to see whether this innovation could carry benefit to conventional irrigated RF ablation.

The results of this initial human experience are reason for optimism. We do need therapeutic options when first- and second-line treatments fail. Needle ablation has the advantages of endocardial delivery via catheters, integration of physiologic data (recording of electrograms and pacing from the needle), and the ability to reach almost any ventricular site, delivering controllable, deep, and adequately large ablation lesions. The procedural safety and efficacy observed in this higher-risk cohort of treatment-refractory patients might improve with more experience and with some of the lessons learned in this study. It is also likely that ongoing development of other advanced techniques for VT suppression will result in effective and safe procedures. If these efforts are successful, we can be optimistic that in the future, some of these innovations could be considered for testing as first-line ablation procedures.

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