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Risks and Benefits of Catheter Ablation of Ventricular Tachycardia in Patients with an Implantable Cardioverter-Defibrillator

Gregory F. Michaud[1] *and Fred Morady*[2]
[1]*Rhode Island Hospital, Providence, RI.* [2]*University of Michigan Medical Center, Ann Arbor, MI*

*P*atients with an implantable cardioverter-defibrillator (ICD) may receive frequent shocks or antitachycardia pacing for monomorphic ventricular tachycardia despite suppressive drug therapy. Antitachycardia pacing is often well-tolerated but not always effective. High voltage cardioversion is usually painful and may cause severe, disabling anxiety for some patients. Therefore, catheter ablation is an important adjunct to medical therapy for patients with structural heart disease who have frequent shocks for episodes of ventricular tachycardia. In 56–100% of selected patients, hemodynamically-tolerated monomorphic ventricular tachycardia can be successfully ablated with radiofrequency energy and standard mapping techniques [1–6]. Herein we review the indications, benefits and risks of radiofrequency ablation of monomorphic ventricular tachycardia for patients with structural heart disease and an ICD.

Willems et al. [4] published the first series of patients with catheter ablation of monomorphic ventricular tachycardia as an adjunct to ICD therapy. Among 6 patients, 5 had monomorphic ventricular tachycardia originating in a healed myocardial scar related to coronary artery disease and the other patient had bundle branch reentry. Four of 6 patients had incessant monomorphic ventricular tachycardia at the time of the procedure and the remaining 2 had frequent ICD shocks. The monomorphic ventricular tachycardia in all patients was successfully ablated, but 2 of 6 patients continued to have relatively frequent ICD shocks during the follow-up period.

Results of RF Ablation for VT

Radiofrequency ablation of monomorphic ventricular tachycardia decreases ICD shocks and improves quality of life, as shown in a prospective study of 21 consecutive patients with coronary artery disease and a previous myocardial infarction [6]. Their mean ejection fraction was 22% and they had failed an average of 2.5 suppressive drugs; 16 of 21 were taking amiodarone at the time of the ablation procedure and 18 of 21 were on multiple antiarrhythmic drugs. Antiarrhythmic medications were continued through the procedure and indefinitely thereafter. The patients had received an average of 17 shocks for monomorphic ventricular tachycardia in the month before ablation and one patient had received 54 shocks. Fourteen of 21 patients had spontaneous monomorphic ventricular tachycardia(s) recorded on a 12-lead ECG and the ventricular tachycardia cycle length was available in the remainder of patients by stored electrogram analysis from the ICD. An induced monomorphic ventricular tachycardia was presumed to be clinically-important if it matched the morphology and cycle length recorded on a 12-lead ECG or the cycle length alone in those patients without 12-lead ECG documentation. Twenty-six ventricular tachycardias in 21 patients were felt to be responsible for clinical symptoms prior to the ablation procedure. A total of 85 ventricular tachycardias (range 1–15 per patient) were inducible with a mean cycle length of 430 ms. Twenty additional inducible ventricular tachycardias were targeted for ablation besides the 26 ventricular tachycardias felt to be responsible for the majority of clinical symptoms. The remaining 39 ventricular tachycardias were poorly-tolerated and could not be mapped.

The patients underwent an average of 1.4 procedures and 12 radiofrequency energy applications. The procedures lasted on average 93 minutes from the onset of mapping to the last radiofrequency application and averaged 50 minutes of fluoroscopy time. The mapping techniques have been previously described and do not require sophisticated mapping and recording systems [7,8]. Concealed entrainment was the most useful criterion for a successful radiofrequency application. Thirty-six of 46 targeted monomorphic ventricular tachycardias (78%) were successfully ablated. If the

Address correspondence to: Gregory F. Michaud, M.D., Assistant Professor of Internal Medicine, Brown University School of Medicine, 2 Dudley Street, Suite 360, Providence, RI 02905. E-mail: gmichaud@lifespan.org

monomorphic ventricular tachycardia was well-tolerated, the success rate was 89%. Sixteen of 21 patients had a successful procedure as defined by elimination of the clinically-important monomorphic ventricular tachycardia (76%). A significant complication occurred in only one patient who required a dual chamber pacemaker after a successful ablation of a high septal monomorphic ventricular tachycardia.

The average number of ICD therapies per month for patients with an average follow-up time of 1 year (range 1–32 months) was significantly decreased in the 16 patients who underwent a successful ablation procedure (59 ± 80 vs. 0.5 ± 1, $p = 0.01$). Among the patients with unsuccessful procedures, the difference in monthly ICD therapies did not reach statistical significance (358 ± 661 vs. 1.5 ± 2, $p = 0.3$). There were no predictors of a successful ablation. A quality-of-life questionnaire was distributed to all patients within 1 month of the last follow-up date. The quality-of-life score significantly improved for patients with a successful procedure but not for patients with a failed ablation.

Benefits of RF Ablation

The benefits of catheter ablation as an adjunct to ICD therapy for patients with hemodynamically-tolerated, and therefore, mappable monomorphic ventricular tachycardia are clear from the results of Strickberger et al. [6]. Patients with an acutely successful ablation had fewer ICD therapies and an improved quality of life. These patients were carefully selected, however, to avoid the pitfalls of attempting to ablate monomorphic ventricular tachycardia that is hemodynamically poorly-tolerated. Mapping the monomorphic ventricular tachycardia using standard techniques circuit requires hemodynamic stability for sustained periods while the catheter is manipulated to potential ablation sites.

Newer mapping technology, such as non-contact [9] or basket electrodes [10], may allow ablation of hemodynamically poorly-tolerated ventricular tachycardia by identifying a critical component of the reentrant circuit during a few beats of ventricular tachycardia. Since the last review, radiofrequency ablation of hemodynamically poorly-tolerated monomorphic ventricular tachycardia has also proven to be effective in patients with structural heart disease and an ICD during the baseline rhythm [11]. Using fluoroscopy and a magnetic mapping system (CARTO) to identify scarred endocardium, linear radiofrequency lesions were made between "dense scar" and either anatomic boundaries or normal myocardium. Twelve of 16 (75%) patients who had received multiple ICD shocks in the month prior to ablation were free of ICD shocks during a median of 8 months follow-up time. This technique required a relatively large number of mean lesions for acute success (mean = 55). The volume of tissue critical to maintaining a reentrant circuit, however, is small relative to the volume of scar tissue. Larger and deeper lesions with future catheter technologies, such as cooled radiofrequency energy [12], may also minimize the need for precise mapping, although the complication rate may be higher and the effects of large lesions on myocardial function have not been carefully examined. Hopefully, new technology or future refinements of existing technology will allow more precise location of critical circuits for hemodynamically poorly-tolerated ventricular tachycardia so that the volume of tissue requiring ablation is minimized.

One should consider catheter ablation for patients whose monomorphic ventricular tachycardia is felt to be hemodynamically stable. In general, these patients have a tachycardia cycle length >300 ms and/or an absence of symptoms to suggest profound hypotension, for example syncope. In experienced hands with appropriate technology, hemodynamically poorly-tolerated ventricular tachycardia also may be successfully ablated.

There are significant risks associated with catheter ablation of monomorphic ventricular tachycardia for patients with coronary artery disease. In the Strickberger series [6] no patients died as a direct result of the ablation, and the sole complication was heart block requiring a dual chamber pacemaker. An earlier report of 15 patients from the University of Michigan reported no deaths and no significant complications [1]. The mortality rate in other published reports is as high as 2% and other reported complications include cardiac perforation and tamponade, stroke, myocardial infarction, and femoral artery occlusion [3,5]. The technique most successful in identifying a critical portion of the monomorphic ventricular tachycardia circuit is concealed entrainment. The positive predictive value of a successful ablation is improved if concealed entrainment is accompanied by a stimulus-QRS interval/ventricular tachycardia cycle length ratio of $\leq 70\%$, a match of the stimulus-QRS and electrogram-QRS intervals, or isolated mid-diastolic potentials that cannot be dissociated from the ventricular tachycardia [8]. Post-pacing interval has also been shown to be effective [2]. Endocardial activation time distinct from isolated diastolic potentials and pace-mapping are generally of little additional benefit to the criteria mentioned above [8]. Multiple morphologies of monomorphic ventricular tachycardia are frequently induced in patients with coronary artery disease [1,3,6,7,11]. Although it is important to target the monomorphic ventricular

Table 1. *Indications for RFA of VT in patients with ICD's*

Patient characteristics	Frequent ICD shocks for VT refractory to AAD therapy Intolerance to effective AAD therapy Rhythms (e.g., sinus tachycardia) that overlap in rate with slow VT
VT characteristics	Hemodynamically-tolerated or possibly poorly-tolerated at specialized centers Inducible by programmed electrical stimulation Incessant Monomorphic

Abbreviations: RFA = radiofrequency ablation, VT = ventricular tachycardia, ICD = implantable cardioverter-defibrillator, AAD = antiarrhythmic drug.

tachycardia which has been documented to occur spontaneously, other hemodynamically-stable, monomorphic ventricular tachycardias induced in the electrophysiology laboratory are probably important to ablate since they may occur clinically [11]. However, this has not been systematically studied.

There is no information in the literature to guide antiarrhythmic drug use following successful catheter ablation of monomorphic ventricular tachycardia. For patients who underwent an acutely successful ablation in the University of Michigan series [6], very few shocks were experienced during the follow-up period. All of these patients, however, continued their antiarrhythmic drugs. Until further evidence is available, patients who are tolerant of appropriate antiarrhythmic drug therapy should continue drug therapy following an acutely successful procedure. Although not statistically significant, some patients also seemed to benefit despite an acute ablation failure. These patients had antiarrhythmic drugs modified, but it is possible that the myocardial substrate was favorably altered such that antiarrhythmic drug therapy was more efficacious.

Conclusion

Radiofrequency catheter ablation of hemodynamically-stable monomorphic ventricular tachycardia is an important adjunct to but not replacement for medical therapy in carefully selected patients with coronary artery disease and an implantable cardioverter-defibrillator (Table 1). The success rate is approximately 75% in experienced hands and is associated with a low complication rate, fewer ICD therapies and an improved quality-of-life.

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