Cardiac Electrophysiology Review 1998;2:291–293

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

Gregory F. Michaud and Fred Morady
University of Michigan Medical Center, Ann Arbor, MI

Patients with an implantable cardioverter-defibrillator (ICD) may receive frequent shocks or antitachycardia pacing for monomorphic ventricular tachycardia (MVT) 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 in patients with coronary artery disease (CAD) who have frequent shocks for episodes of MVT. In 56–100% of selected patients, hemodynamically-tolerated MVT can be successfully ablated with radiofrequency energy [1,2,3,4,5,6]. Herein we review the indications, benefits and risks of radiofrequency ablation of MVT in patients with CAD and an ICD.

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

Radiofrequency ablation of MVT decreases ICD shocks and improves quality of life, as shown in a prospective study of 21 consecutive patients with CAD 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 MVT in the month before ablation and one patient had received 54 shocks. Fourteen of 21 patients had their spontaneous MVT(s) recorded on a 12-lead ECG and the MVT cycle length was available in the remainder of patients by stored electrogram analysis from the ICD. An induced MVT 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 MVT's in 21 patients were felt to be responsible for clinical symptoms prior to the ablation procedure. A total of 85 MVT's (range 1 to 15 per patient) were inducible with a mean cycle length of 430 ms. Twenty additional inducible MVT's were targeted for ablation besides the 26 MVT's felt to be responsible for the majority of clinical symptoms. The remaining 39 MVT's 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 recording systems [7,8]. Concealed entrainment was the most useful criterion for a successful radiofrequency application. Thirty-six of 46 targeted MVT's (78%) were successfully ablated. If the MVT was well-tolerated, the success rate was 89%. Sixteen of 21 patients had a successful procedure as defined by elimination of the clinically-important MVT (76%). A significant complication occurred in only one patient who required a dual chamber pacemaker after a successful ablation of a high septal MVT. The average number of ICD therapies per month for patients followed for an average of 1 year (range 1 to 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. This score significantly improved in patients with a successful procedure but not in patients with a failed ablation.

The benefits of catheter ablation as an adjunct to ICD therapy in patients with hemodynamically-tolerated MVT are clear from the results of Strickberger et.al. [6]. Patients with successful ablation had fewer

Address correspondence to: Gregory F. Michaud, M.D., Assistant Professor of Internal Medicine, University of Michigan Medical Center, 1500 East Medical Center Drive, B1F228, Ann Arbor, MI 48109-0022. E-mail: michaudg@umich.edu

ICD therapies and an improved quality of life. These patients were carefully selected, however, to avoid the pitfalls of attempting to ablate MVT that is hemodynamically poorly-tolerated. Mapping the MVT circuit requires hemodynamic stability for sustained periods while the catheter is manipulated to potential ablation sites. Mapping in sinus rhythm has not proven to be effective because, although the boundaries of a myocardial scar can be identified in sinus rhythm by fragmented, low amplitude electrograms, the volume of tissue critical to maintaining a reentrant circuit is small relative to the volume of scar tissue. Newer mapping technology, such as noncontact [9] or basket electrodes [10], may allow ablation of hemodynamically-unstable ventricular tachycardia by identifying a critical component of the reentrant circuit during a few beats of ventricular tachycardia. Larger lesion size with future catheter technologies may also abrogate the need for precise mapping, although the effects of large lesions on myocardial function need to be examined. Given the current technology and experience, one should consider catheter ablation in patients whose MVT is felt to be hemodynamically stable. In general, these patients have a tachycardia cycle length >300ms and/or an absence of symptoms to suggest profound hypotension, for example syncope.

There are significant risks associated with catheter ablation of MVT in patients with CAD. 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 may be 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 MVT 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 ≤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 is generally of little additional benefit to the criteria mentioned above [8]. More than one morphology of MVT can frequently be induced in patients with CAD [1,3,6,7,11]. Although it is important to target the MVT which has been documented to occur spontaneously, other hemodynamically stable, induced MVT's 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 MVT. In 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 during follow-up. 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.

In conclusion, radiofrequency catheter ablation of hemodynamically-stable MVT 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.

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
	Inducible by programmed electrical stimulation
	Incessant
	Monomorphic

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

References

1. Morady F, Harvey M, Kalbfleisch SJ, El-Atassi R, Calkins H, Langberg JJ. Radiofrequency catheter ablation of ventricular tachycardia in patients with coronary artery disease. *Circulation* 1991;84:558–566.
2. Stevenson WG, Khan H, Sager P, Saxon LA, Middlekauf HR, Natterson PD, Weiner I. Identification of reentry circuit sites during catheter mapping and radiofrequency ablation of ventricular tachycardia late after myocardial infarction. *Circulation* 1993;88:1647–1670.
3. Kim YH, Sosa-Surez G, Trouton TG, O'Nunain SS, Osswald S, McGovern BA, Ruskin JN, Garan H. Treatment of ventricular tachycardia by transcatheter radiofrequency ablation in patients with ischemic heart disease. *Circulation* 1994;89:1094–1102.
4. Willems S, Borgreffe M, Shenasa M, Chen X, Hindricks G, Haverkamp W, Wietholt D, Block M, Beithardt G. Radiofrequency catheter ablation of ventricular tachycardia follow-

ing implantation of an automatic cardioverter defibrillator. *PACE* 1993;16:1684–1692.
5. Gonska BD, Cao K, Schaumann A, Dorszewiski A, von zur Muhlen F, Kreuzer H. Catheter ablation of ventricular tachycardia in 136 patients with coronary artery disease: Results and long-term follow-up. *J Am Coll Cardiol* 1994:1506–1514.
6. Strickberger SA, Man KC, Daoud EG, Goyal R, Brinkman K, Hasse C, Bogun F, Knight BP, Weiss R, Bahu M, Morady F. A prospective evaluation of catheter ablation of ventricular tachycardia as adjuvant therapy in patients with coronary artery disease and an implantable cardioverter-defibrillator. Circulation. 1997;97:1525–1531.
7. Morady F, Kadish A, Rosenheck S, Calkins H, Kou WH, de Buitleir M, Sousa J. Concealed entrainment as a guide for catheter ablation of ventricular tachycardia in patients with prior myocardial infarction. *J Am Coll Cardiol* 1991;17: 678–689.
8. Bogun F, Bahu M, Knight BP, Weiss R, Paladino W, Harvey M, Goyal R, Daoud E, Man KC, Strickberger SA, Morady F. Comparison of effective and ineffective target sites that demonstrate concealed entrainment in patients with coronary artery disease undergoing radiofrequency ablation of ventricular tachycardia. *Circulation* 1997;95:183–190.
9. Strickberger SA, Man KC, Daoud EG, Goyal R, Hasse C, Knight BP, Weiss R, Bahu M, Zivin A, Souza J, Morady F. A computerized system for noncontact mapping of cardiac rhythms in humans. *Circulation* 1997;96:suppl 1–318#1776.
10. Greenspon AJ, Hsu SS, Datorre S. Successful radiofrequency ablation of sustained ventricular tachycardiapostmyocardial infarction in man guided by a multielectrode "basket" catheter. *J Cardiovasc Electrophysiol* 1997;8:565–570
11. Rothman SA, Hsia HH, Cossu SF, Chmielewski IL, Buxton AE, Miller JM. Radiofrequency catheter ablation of postinfarction ventricular tachycardia: Long-term success and the significance of inducible nonclinical arrhythmias. *Circulation* 1997;96:3499–3508.