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Original Article

Long-term outcomes of catheter ablation of ventricular tachycardia in patients with structural heart disease

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ABSTRACT

Background: Catheter ablation of ventricular tachycardia (VT) is feasible. However, the long-term outcomes for different underlying diseases have not been well defined.
Methods: Eighty-eight consecutive patients who underwent catheter ablation of VT using a three-dimensional mapping system were analyzed. The primary endpoint was any VT or ventricular fibrillation (VF) recurrence. Secondary endpoints were a composite of death or any VT/VF recurrence. Underlying heart diseases were remote myocardial infarction (remote MI) in 51 patients and non-ischemic cardiomyopathy in 37 (arrhythmogenic right ventricular cardiomyopathy [ARVC] in 18 patients, and dilated cardiomyopathy [NIDCM] in 19).
Results: Acute success was achieved in 82 of 88 (93%) patients. During a follow-up period of 39.2 ± 4.6 months, VT recurred in 26 of 87 (30%), and VT/VF recurrence or death occurred in 39 of 87 (45%) patients. ARVC had better outcomes than NIDCM for the primary ($p < 0.05$) and secondary endpoints ($p < 0.05$). Remote MI-VT revealed a midrange outcome.
Conclusions: The long-term outcomes after catheter ablation of VT varied according to the underlying heart disease. ARVC-VT ablation was associated with better long-term prognosis than NIDCM. Remote MI-VT demonstrated a midrange outcome.

1. Introduction

Patients with structural heart disease have an increased risk of sudden cardiac death, secondary to ventricular tachyarrhythmias in most cases. Implantable cardioverter–defibrillators (ICDs) are the treatment of choice. However, ventricular tachyarrhythmias cannot be prevented by ICD itself. Moreover, ICD shocks reduce quality of life, and episodes of ventricular tachycardia (VT) predict an increased risk of death and heart failure despite effective treatment with ICD [1–3]. Catheter ablation has been proven to be an effective choice of treatment for VT and may be indicated for some patients as either a primary therapy or an adjunct to an ICD implantation.

Although VT ablation is feasible, multiple morphologies of VT, hemodynamic instability, and non-inducibility limit the success of VT ablation. Recently, ablation of unmappable VTs has become feasible by mapping during sinus rhythm and with energy applications targeting delayed potentials or by creating ablation lesions using a three-dimensional (3D) mapping system [4].

After successful ablation, long-term recurrence of ventricular arrhythmias is not uncommon but the outcomes for different diseases are incompletely defined. This study aimed to clarify the outcomes of VT ablation for patients with different forms of structural heart disease.

2. Materials and methods

2.1. Patients

Between September 2004 and September 2012, endocardial catheter mapping and radiofrequency (RF) current ablation were performed using a 3D mapping system in 88 consecutive patients with clinically documented sustained monomorphic VT. All patients had ischemic (remote myocardial infarction; 51 patients) or non-ischemic heart disease (37 patients). Non-ischemic heart

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disease was divided into 2 groups: arrhythmogenic right ventricular cardiomyopathy (ARVC, 18 patients) and non-ischemic dilated cardiomyopathy (NIDCM, 19 patients). ARVC was defined based on the Task Force criteria [5]. Non-ischemic DCM was defined as a myocardial disorder in which there is evidence of structurally and functionally abnormal heart muscle, in the absence of significant coronary artery disease.

Written informed consent was obtained from all patients before the procedure.

2.2. Electrophysiological study

A conventional computerized electrophysiological system and CARTO (Biosense Webster, Diamond Bar, CA, USA) or Ensite NavX (St Jude Medical, Minneapolis, MN, USA) electroanatomical mapping system were used. The standard access to the left ventricle was retrograde across the aortic valve. In some patients, an antegrade transseptal access was used because of severe atherosclerosis of the aorta or peripheral arteries.

Programmed ventricular stimulation with up to 2 extra-stimuli at 2 different sites (right ventricular apex and outflow tract) was performed to induce clinical VT and/or any other non-clinical VT. VT was considered clinical if either the 12-lead morphology matched the previously documented VT or if the cycle length was within a range of 30 ms of the VT cycle length documented by the ICD.

2.3. Mapping and ablation

Mapping and ablation were performed using 7F steerable catheters with either a conventional 4-mm tip (NaviStar, Biosense-Webster) or a 3.5-mm irrigated tip electrode (NaviStar ThermoCool, Biosense-Webster) in patients in whom the CARTO systems used. In patients in whom the Ensite NavX system was used, a Celsius Thermocool (Biosense-Webster), Ablaze (8 mm tip, Japan Lifeline, Tokyo, Japan), or Coolflex (St Jude Medical) catheter was inserted.

Briefly, hemodynamically stable VTs were mapped and ablated during VT [6]. VT mapping was combined with conventional entrainment pacing at sites with diastolic potentials according to the methods for entrainment previously described [7–10]. Mapping for hemodynamically unstable VTs was performed during sinus rhythm or right ventricular pacing. The target of the ablation was putative channels and exits within the low-voltage area as identified from a paced QRS morphology similar to the QRS morphology of VT, fractionated potentials, or isolated late potentials during sinus or paced rhythm [11–16]. As for the patients included in the later part of the study period, RF energy was applied targeting all delayed potentials toward dechanneling [17]. Furthermore, when target sites were adjacent to the electrical barriers or a region of electrically unexcitable scar, the ablation lesions were extended to the unexcitable area [18,19]. We placed the mapping catheter at a potential target site during sinus rhythm or pacing. Then, if the VT was inducible and hemodynamically unstable, the RF current was applied as soon as any diastolic activity was recorded. If the endocardial mapping and ablation failed, we switched to epicardial mapping and ablation [20].

Conventional RF applications were delivered using a temperature-controlled mode (maximum 60 °C; maximum 180 s; 30–50 W; Stockert: Biosense-Webster or CABL-IT: Japan Lifeline). For the irrigated tip catheters, RF applications at 30–50 W were applied with a temperature limit of 43 °C.

The endpoint of the RF applications in the VT mapping group was non-inducibility of the clinical VT or all hemodynamically stable VTs, and the elimination of the targeted potentials in the substrate mapping group. The endpoint for linear ablation was the completion of the designed lines. Acute success was defined as the achievement of the ablation endpoint, but allowed for the induction of non-clinical hemodynamically unstable VTs or ventricular fibrillation (VF) [6]. In both groups, chronic success during the follow-up period was defined as the absence of any sustained VT, VF, or ICD therapy.

2.4. Follow-up

Follow-up started after hospital discharge and was performed every 3 months in the ICD outpatient clinic or by the referring physician. The primary endpoint was any VT/VF and the secondary endpoints were any VT/VF or death.

2.5. Statistical analysis

The continuous variables are expressed as the mean ± SD, and were compared using the Student's *t*-test. The categorical variables were compared using a chi-square test or Fisher's exact test. An overall chi-square test for a $2 \times n$ table was performed when comparisons involved >2 groups. A p value <0.05 was considered significant. In the comparisons among the types of cardiomyopathies, survival curves were created using the Kaplan–Meier method, and comparisons between groups were based on the Wilcoxon test.

3. Results

3.1. Patient characteristics

The patient characteristics are shown in Table 1. Between September 2004 and September 2012, 105 ablation procedures were performed in 88 consecutive patients (15 women; age, 64.8 ± 14.5 years). There were significant differences in age between the remote MI and ARVC ($p<0.01$), and remote MI and NIDCM ($p<0.01$) groups. Further, the left ventricular ejection fraction (LVEF) was better in the ARVC group than in the remote MI ($p<0.01$) or NIDCM group ($p<0.01$). VT storms were more prevalent in the remote MI group ($p<0.05$). In addition, there was a statistically significant difference in the concomitant diseases, medications, and device implantations.

Table 1
Patient characteristics.

	Remote MI	ARVC	NI-DCM	*P* value
Patients (*n*)	51	18	19	
Age (years)	70.0 ± 11.5*†	55.9 ± 16.2*	60.2 ± 15.5†	<0.01* <0.01†
Sex (male %)	45 (88)	12 (67)	16 (84)	NS
LVEF (%)	33.2 ± 9.5*	58.1 ± 10.4*†	33.8 ± 10.2†	<0.01* <0.01†
VT storm (%)	12 (24)	0 (0)	8 (42)	<0.05
DM (%)	15 (29)	1 (6)	2 (11)	<0.05
HT (%)	24 (47)	5 (28)	4 (21)	N.S.
Class 1 AAD (%)	4 (8)	6 (33)	7 (37)	<0.05
ACEI/ARB (%)	37 (73)	4 (22)	16 (84)	<0.01
β-Blocker (%)	37 (73)	5 (28)	16 (84)	<0.01
Amiodarone (%)	26 (51)	1 (6)	13 (68)	NS
Sotalol (%)	3 (6)	6 (33)	3 (16)	NS
ICD/CRTD (%)	43 (84)	8(44)	19 (100)	<0.01

Remote MI=remote myocardial infarction; ARVC=arrhythmogenic right ventricular cardiomyopathy; NIDCM=non-ischemic dilated cardiomyopathy; LVEF=left ventricular ejection fraction; VT=ventricular tachycardia; DM=diabetes mellitus; HT=hypertension; AAD=antiarrhythmic drug; ACEI=angiotensin-converting enzyme inhibitor; ARB=angiotensin receptor blocker; ICD=implantable cardioverter defibrillator; CRT=cardiac resynchronized therapy.
Data are presented as the mean ± SD or *n* (%).