BRIEF REPORT

Catheter Ablation in Patients with Electrical Storm. The Calm after the Tempest

Ablación por catéter en pacientes con tormenta eléctrica. La calma tras la tempestad

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ABSTRACT

Background: Catheter ablation (CA) has been shown to be effective in patients with recurrent ventricular tachycardia (VT); however, its role in patients with electrical storm (ES) has not been studied in randomized trials.
Objective: The aim of this study was to analyze ES cases treated with CA.
Methods: This was a retrospective analysis of patients treated with CA for ES due to sustained monomorphic VT (SMVT). Procedure success was defined as lack of inducible VT at the end of ablation, partial success as the induction of non-clinical VT and failure as inducible clinical VT.
Results: Sixteen procedures were performed in 14 patients: 10 successful, 3 partially successful and 3 failures. All patients were free from ventricular arrhythmia immediately after ablation. Ten patients (71.4%) were free from VT and 86.7% free from ES [8 (3-30)-month follow-up]. Five patients (35.7%) died from causes unrelated to arrhythmia.
Conclusions: Catheter ablation is associated with acute suppression of VT in all patients with ES due to SMVT and with a recurrence-free outcome in most of them.

Key words: Electrical Storm - Catheter Ablation - Ventricular Tachycardia

RESUMEN

Introducción: La ablación por catéter (AC) ha demostrado que es beneficiosa en pacientes con taquicardia ventricular (TV) recurrente, pero su rol en pacientes con tormenta eléctrica (TE) no se ha estudiado en ensayos aleatorizados.
Objetivo: Analizar los casos de TE tratados con AC.
Material y métodos: Análisis retrospectivo de pacientes con TE debida a TV monomorfa sostenida (TVMS) tratados mediante AC. Se definió éxito del procedimiento a la ausencia de TV inducible al final de la ablación, éxito parcial a la inducción de TV no clínica y no éxito a la inducibilidad de la TV clínica.
Resultados: Se realizaron 16 procedimientos en 14 pacientes: 10 exitosos, 3 éxito parcial y 3 no exitosos. Todos los pacientes evolucionaron sin arritmia ventricular inmediatamente posablación. Diez pacientes (71,4%) evolucionaron sin TV y el 86,7% sin TE [seguimiento 8 (3-30) meses]. Cinco pacientes (35,7%) murieron de causa no arrítmica.
Conclusiones: La AC se asocia con una supresión aguda de la TV en todos los pacientes con TE debida a TVMS y con una evolución sin recurrencia en la mayoría de ellos.

Palabras clave: Tormenta eléctrica - Ablación por catéter - Taquicardia ventricular

Abbreviations

AAD	Antiarrhythmic drugs	**ICD**	Implantable cardioverter defibrillator
AF	Atrial fibrilation	**LVEF**	Left ventricular ejection fraction
CA	Catheter ablation	**SMVT**	Sustained monomorphic ventricular tachycardia
ES	Electrical storm	**VT**	Ventricular tachycardia

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INTRODUCTION

The implantable cardioverter defibrillator (ICD) significantly improves survival of patients with sustained ventricular arrhythmia, but the recurrence of ventricular tachycardia (VT) or ventricular fibrillation (VF) still remains a cause of death. (1, 2) Electrical storm (ES) is characterized by ≥3 episodes of VT/VF (separated by >5 minutes) in 24 hours, requiring intervention for its interruption (usually ICD discharge). (3) It is more common in patients with ICD as secondary prevention and is associated with poor short- and mid-term prognosis. (4-6) It is a sometimes dramatic clinical situation, in which recurrent VT/VF episodes, the necessary discharges to interrupt them and the intravenous administration of antiarrhythmic drugs (AAD), detrimental to cardiac function, contribute to rapid clinical deterioration. Catheter ablation (CA) has proven to be beneficial in patients with recurrent VT, but its role in patients with ES has not been studied in randomized trials. The aim of this study was to analyze ES cases due to sustained monomorphic VT (SMVT) treated with CA.

METHODS

A review was done of all patients with structural heart disease who presented with ES due to SMVT treated with CA between December 2010 and November 2014. Ablation and follow-up clinical data were analyzed. Procedural success was defined as the absence of inducible VT at the end of the procedure; partial success as induced VT different only from clinical VT and no success as induced clinical VT (the term clinical VT refers to spontaneous VT presented by the patient before ablation).

Statistical analysis

Discrete variables were expressed as percentages and continuous variables as median and interquartile range (25%-75%). The paired-sample Wilcoxon signed-rank test was used to compare continuous variables. A p value <0.05 was considered statistically significant. SPSS v.20-Statistics software package was used for statistical analyses.

Ethical considerations

The protocol was assessed and approved by the Institutional Review Committee.

RESULTS

Fourteen patients (13 men) with mean age 64.5 years (56 to 71.2) and 27.5% (22-37) left ventricular ejection fraction (LVEF) were analyzed. The etiology of the heart disease was coronary (n=6), chagasic (n=4), hypertensive (n=2) and idiopathic (n=2). All patients had an implanted ICD (3 single chamber, 8 dual chamber and 3 biventricular) as secondary (13 patients) or primary (1) prevention of sudden death.

All patients had SMVT, with 475 ms cycle length (382-560). Two patients presented with 2 clinical VT with different morphology. Patients had 24.5 (15-29) stored VT episodes and received 9 (6-17) ICD discharges during the 5 days prior to CA, except for 1 patient who presented with ES one month before the procedure (Figure 1A).

Sixteen CA procedures were performed (2 patients needed a second procedure): 2 with fluoroscopic guidance and 14 with three-dimensional mapping system (13 EnSite-NAVX, St. Jude Medical, 1 CartoXP, Biosense-Webster). Cardiac ablation was performed with 8-mm-tip ablation catheter in 6 cases and 3.5-mm-tip externally irrigated catheter in 10 cases using retroaortic (12), transeptal (3) or double (1) approach. Ablation was guided by electrophysiological mapping during VT in 10 cases or by anatomical substrate due to poorly

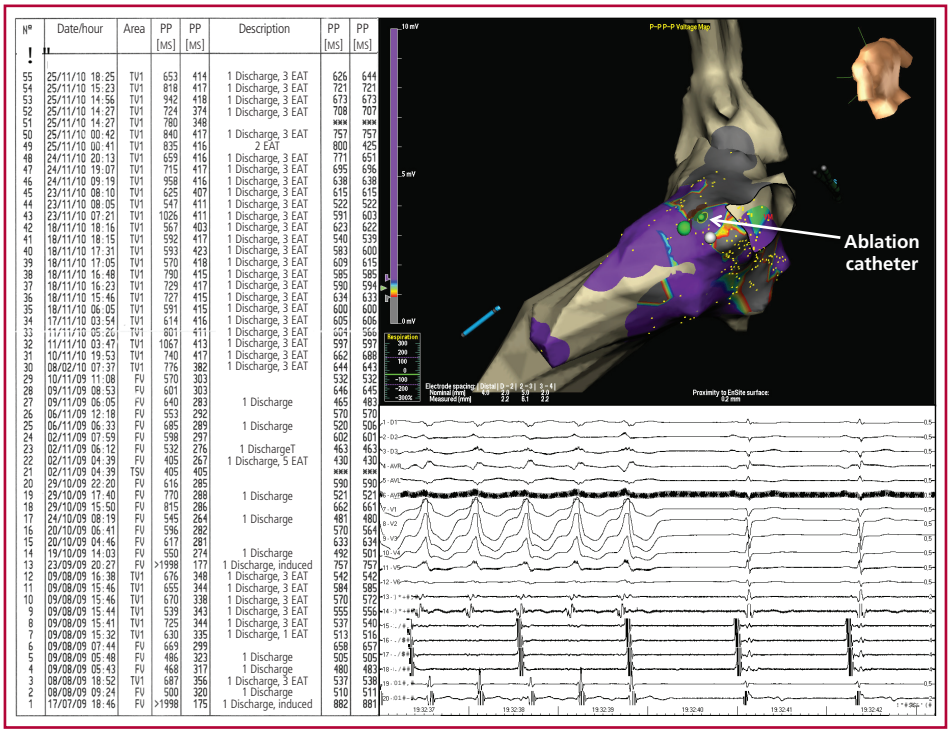

Fig. 1. A. List of VT episodes stored in the cardioverter defibrillator obtained at the end of follow-up (patient 3). Note the absence of arrhythmia after ablation performed on 11/26/2010. **B:** Voltage map (EnSite-Navx) showing scar area at baseline posterolateral level in patients with Chagas cardiomyopathy (patient 3). In the bottom panel VT disruption is observed during radiofrequency application in that region

tolerated VT in 6 cases. For substrate ablation, regions of diseased tissue (local electrocardiogram voltage between 0.5 mV and 1.5 mV) and scar tissue (<0.5 mV) were identified during sinus rhythm or continuous ventricular stimulation. Radiofrequency was applied in areas with scar-related tissue that topographically coincided with VT origin (according to ECG) and in which abnormal electrograms were recorded (late, fractionated). Although poorly accurate in reentrant arrhythmias, local stimulation (pacemapping) can reproduce VT morphology if the ablation catheter is positioned at the exit site of the VT circuit, thus guiding radiofrequency applications. Activation mapping was performed during VT to determine the VT circuit and its relationship with myocardial scars, and ventricular overstimulation during tachycardia to restore entrainment and evaluate its response. Entrainment maneuvers were performed when presystolic or mesodiastolic potentials were registered during VT. Sites where entrainment with concealed fusion was achieved (QRS during entrainment equal to QRS during VT) accompanied by a post-stimulation interval equal to the VT cycle±30 ms, and/or spike stimulation to QRS interval equal to the local electrogram to QRS interval during VT±20 ms, were considered suitable to apply radiofrequency. The two last parameters indicate that the ablation catheter is positioned within the VT circuit and the concealed fusion is consistent with a critical zone of the circuit, "surrounded" by scar tissue. (7) In 8/10 procedures guided by electrophysiological mapping (performed with three-dimensional navigation) substrate ablation was added before ending the procedure (Table 1).

Ten (62.5%) CA were successful, in 3 (18.8%) partial success was obtained and 3 (18.8%) were unsuccessful (2 of them were second procedures). Only one complication (femoral pseudoaneurysm resolved with mechanical compression) was observed. All patients recovered without ventricular arrhythmia immediately after ablation. (Figure 1 B)

Follow up

After 8 (3-30) follow-up months, 10 patients (71.4%) remain free from VT/VF. The remaining 4 patients presented VT recurrence at 10 days, and 6, 10 and 16 months. In 3 cases, CA was successful and 1 was unsuccessful. Two of them recurred as ES and underwent a second procedure, resulting in 85.7% of patients without ES at follow-up. A non-significant increase in LVEF after CA (43% vs. 27.5%; p=0.066) was observed.

Five patients (35.7%) died: 4 due to heart failure and 1 due to endocarditis 4 months post-ablation. Only one of them had presented recurrence and no death was caused by arrhythmia.

DISCUSSION

To our knowledge, this is the first report of a series of patients with ES treated with CA in our country. The results of this study show that CA allows immediate remission of the VT/VF episodes (main objective of ablation in patients with ES) in all patients with ES due to SMVT and a mid-term outcome without ES in 85.7% of cases, and without ventricular arrhythmia in 7 out of 10 patients. The detrimental effect of the incessant VT and ICD discharges on ventricular function worsens the hemodynamic status of these patients and promotes more arrhythmic events, creating a "vicious circle" effect. Suppressing acute episodes of VT/VF achieved with CA could contribute to stop the progression of the hemodynamic deterioration that may lead these patients to death in a few days. The mortality observed in our series (35% in the mid-term) reflects the severity of patients with ES and is similar to that published internationally. (6, 8, 9) Four patients had VT/VF during follow-up without arrhythmic mortality. This recurrence rate (28.6%) is comparable to that reported in other series (10, 11) and may be favored, in part, by the progression of the heart disease.

Table 1. Patient characteristics

Pt	Age (years)	Gender	Cardiac disease	LVEF (%)	ICD	Prevention	VT morphology	TV cycle (mseg)	Navigation	Approach	Catheter	Technique	Acute success	Follow-up (months)	Recurrence	Death
1	63	M	Chagas	30	VVI	Secondary	2 RBBB+right axis	383	Fluoroscopic	Retroaortic	8 mm	Mapping	Yes	49	-	-
2	66	M	HT	32	TRC	Secondary	RBBB+left axis	515	Fluoroscopic	Retroaortic	8 mm	Mapping	Yes*	19	6 months	-
3	54	M	Chagas	37	DDD	Secondary	2 RBBB+right axis	450	NAVX	Retroaortic	8 mm	Mapping	Yes	52	-	-
4	62	M	Chagas	40	DDD	Secondary	RBBB+left axis	404	NAVX	Retroaortic	Irrigated	Mapping	Yes	27	16 months	-
5	73	M	Coronary	22	TRC	Secondary	LBBB+left axis	575	NAVX	Retroaortic	Irrigated	Substrate	Yes	4	-	Endocarditis
6	58	F	Chagas	23	DDD	Secondary	2 RBBB+right axis	610	NAVX	Retroaortic	Irrigated	Substrate	Partial	1	-	HF
7	70	M	Coronary	25	VVI	Secondary	RBBB+left axis	555	NAVX	Transeptal	8 mm	Mapping	Partial	3	-	HF
8	71	M	Coronary	38	DDD	Secondary	RBBB+left axis	530	NAVX	Retroartic	8 mm	Mapping	Partial	10	-	-
9	67	M	Coronary	17	TRC	Secondary	RBBB+left axis	580	NAVX	Transeptal	8 mm	Mapping	Yes	5	-	-
10	56	M	Coronary	30	DDD	Secondary	LBBB+left axis	380	NAVX	Retroaortic	Irrigated	Substrate	Yes	43	-	-
11	79	M	Coronary	24	DDD	Secondary	RBBB	480	NAVX	Transeptal	Irrigated	Substrate	Yes	13 days	-	HF
12	72	M	Idiopathic	20	VVI	Primary	RBBB and LBBB	470	NAVX	Double	Irrigated	Substrate	Yes	39 days	8 days	HF
13	54	M	Idiopathic	22	DDD	Secondary	RBBB+left axis	310	NAVX	Retroaortic	Irrigated	Mapping	No*	16	10 months	-
14	56	M	HT	38	DDD	Secondary	RBBB+left axis	332	CARTO	Retroaortic	Irrigated	Substrate	Yes	4	-	-

Pt.: Patient. LVEF: Left ventricular ejection fraction. ICD: Implantable cardioverter defibrillator. VT: Ventricular tachycardia. M: Male. F: Female. HTN: Hypertension. CP: Cardiac pacemaker. RBBB: Right bundle branch block. LBBB: Left bundle branch block. HF: Heart failure.
* Second unsuccessful procedure.

Electrical storm has been identified as an independent risk factor for death, compared with patients with history of VT/VF without ES and patients without history of VT. (6) There are some communications about the benefits of CA in these patients, although with no reduction in mortality. Carbucicchio et al. reported a survival rate of 92% without ES and of 66% without VT in 95 patients treated with CA. (10) In another series of 50 patients treated with CA, 84% remained free from ES episodes and 48% with no VT recurrence with more than one ablation procedure. (8) In both studies, ES recurrence was associated with higher mortality.

As in our series, another study evaluated ES cases only due to VTMS, although in patients with nonischemic cardiomyopathy. (11) On longer follow-up, they reported 61.5% of patients free from VT. The recurrence rate was significantly higher after ablation with partial success. We found no relationship between the outcome of ablation and recurrence or death.

A recent study retrospectively compared CA or conservative treatment in 52 patients with ES due to SMVT. (9) Cardiac ablation reduced the recurrence of ES only in patients with LVEF >25%. Post-ablation AAD prescription was not associated with lower ES recurrence. Interestingly, the authors did not report ventricular arrhythmia-free survival during follow-up.

Limitations

This is a retrospective study of patients with ES only due to VTMS without comparing with a control group. We have no information regarding medically treated patients and those treated with polymorphic VT or VF. Follow-up time is short. However, we believe that the central objective of CA in these patients is to stop VT episodes and interrupt the ES status. In addition to achieving an immediate remission of arrhythmic events in all patients, 71.4% remains without VT/VF in the follow-up period.

Finally, although ICD programming was not standardized, a monitoring area for the detection of slow VT in all post-ablation patients was added. Notwithstanding, there have been episodes of VT ignored by the ICD, a fact which cannot be ruled out.

CONCLUSIONS

Cardiac ablation is associated with acute VT/VF suppression in all patients with ES due to SMVT and with recurrence-free outcome in most of them. Information from randomized studies is required regarding its use in patients with ES. Meanwhile, CA should be considered of great utility in the treatment of this serious clinical condition.

Conflicts of interest

None declared

(See the authors' conflict of interest forms in the web/ Supplementary material)

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