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Mohamed Ahmed Muharram
Department of cardiology, Faculty of Medicine, Al-Azhar University, mmoharam85@gmail.com

Mohammed Sami Abdel Samie
Department of cardiology, Faculty of Medicine, Al-Azhar University

Hatem Abdel Latief Kholief
Department of cardiology, Faculty of Medicine, Al-Azhar University

Ahmed Mohammed Fahmi El-Damaty
Department of Cardiology, Faculty of Medicine, Cairo University

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ORIGINAL ARTICLE

Efficacy and Safety of Catheter Ablation in Patients With Scar-related Ventricular Tachycardia

Mohamed Ahmed Muharram [a,*], Mohammed Sami Abdel Samie [a], Hatem Abdel Latief Kholief [a], Ahmed Mohammed Fahmi El-Damaty [b]

[a] Department of Cardiology, Faculty of Medicine, Al-Azhar University, Cairo, Egypt
[b] Department of Cardiology, Faculty of Medicine, Cairo University, Giza, Egypt

Abstract

Background: **In individuals with structural heart disease, catheter ablation of ventricular tachycardia (VT) is an important treatment option.**

The study aimed to evaluate the safety and outcomes of scar-related VT ablation in the Egyptian population.

Patients and methods: **This observational study included 22 male patients referred for scar-related VT ablation from November 2015 to December 2022. Ablation was done under general anesthesia using a three dimensional mapping system in three tertiary hospitals in Cairo, Egypt. Clinical, procedural, and follow-up data were reviewed. Substrate modification in sinus rhythm was the main ablation strategy.**

Results: **The mean age was 56.2 ± 13.9 yrs; 14 (63.6 %) patients had a previous myocardial infarction, six patients (27.2 %) were diagnosed as NICM, two (9 %) patients with previous surgical Fallot repair, and 20 (90.9 %) patients had implanted cardioverter defibrillator (ICD) therapy.**

Short-term outcomes: **Acute procedural success in 23 (76.6 %) procedures, VT modification in two (6.6 %) procedures, and failed ablation in five (16.6 %) procedures. Major complications occurred in three procedures (10 %). Nineteen patients were included in long-term FU, median FU time was 24 months (range 6−85 months), no sustained VT or implanted cardioverter defibrillator shocks in nine (47.6 %) patients, arrhythmia control was achieved in eight (42.1 %), and two patients (10.52 %) died.**

Conclusion: **Catheter ablation of scar-related VT is safe and effective.**

Keywords: Three dimensional mapping, Ablation, Outcome, Ventricular tachycardia

1. Introduction

Ventricular tachycardia (VT) is a leading cause of morbidity and mortality in individuals with structural heart disease (SHD), as well as a therapeutically problematic condition owing to its heterogeneous demographics and complicated electroanatomical substrates.[1]

Antiarrhythmic drugs (AAD), catheter ablation, and implanted cardioverter defibrillator (ICD) treatment are available to treat prolonged and recurrent VT.[2]

In patients with VT and SHD, AAD has limited options and many side effects, patients with ICD benefits from aborted arrhythmic events but may experience recurrent symptomatic VT leading to recurrent shocks, which was associated with poor outcomes.[3,4]

In patients with SHD, catheter ablation for VT has become a cornerstone in management; it reduces VT recurrence and ICD therapy compared with conventional therapy alone.[5]

We aimed to assess the safety and outcomes of scar-related VT ablation in a cohort of Egyptian population.

2. Patients and methods

2.1. Patients

This observational cross-sectional study involved 22 consecutive cases referred for scar-related VT

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* Corresponding author at: Cardiology Department, Al Hussin University Hospital, Cairo, Egypt.
E-mail addresses: mmoharam85@gmil.com, mohamedmuharram.206@azhar.edu.eg (M.A. Muharram).

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ablation from November 2015 to December 2022 in three tertiary health-care centers in Cairo, Egypt. The research procedure was approved by the Al-Azhar University Faculty of Medicine's Ethics Committee Fig. 1.

2.2. Preprocedural evaluation

All patients had thorough history taking and physical examination, reviewing resting ECG, clinical VT ECGs, and ICD episodes. Transthoracic echocardiography was used to assess EF, valvular affection, and wall motion abnormalities and to exclude intracardiac thrombi.

2.3. Procedure

All procedures were done under general anesthesia. ICD therapy was inactivated. An arterial line was obtained for blood pressure monitoring. Two venous sheaths were used from the right femoral vein for RV and CS catheters and preprocedural programmed electrical stimulation (PES) from RV apex (using up to 3 extra stimuli) was done except if hemodynamically unstable. VT was the presentation. The retrograde approach was preferable for left ventricular (LV) endocardial mapping. After left chamber access, IV heparin was administered guided by an activated clotting time greater than 300 s. Transseptal access was obtained in patients with the basal substrate at the operator's discretion. Epicardial access was done when the epicardial substrate was identified by late gadolinium enhancement cardiac magnetic resonance (LGE CMR), after no substrate in endocardial mapping and after failed previous endocardial ablation.

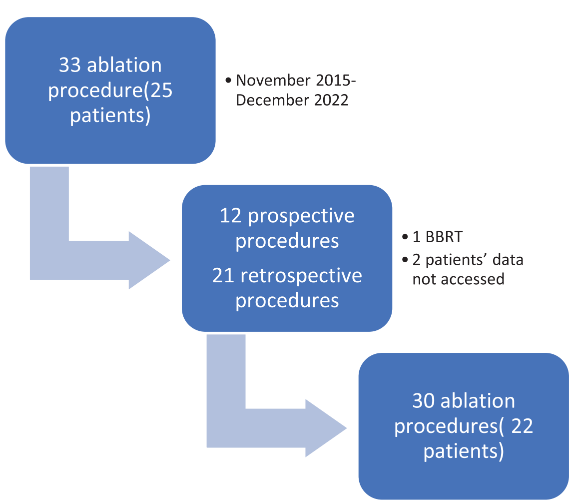

Fig. 1. Flowchart of patient selection: BBRT (bundle branch reentry tachycardia).

The CARTO 3 system (Biosense Webster, Diamond Bar, California) and NavX EnSite (Abbot) were used as mapping systems. VTs with stable hemodynamics were mapped and ablated. Ablation targets were sites with an isolated mid-diastolic potential, where pacing entrained the VT with hidden fusion and a post-pacing interval within 30 ms and a stimulus-to-QRS interval 70 % of the VT cycle duration. During sinus rhythm, mapping and ablation of unstable, unmappable VTs were done. Using a bipolar electrogram amplitude of 1.5 mV, scarred regions were found. Ablation of presumptive channels and exits within the scar area, as identified by a paced QRS morphology resembling the VT QRS morphology, wide-fractionated potentials, or isolated late potentials during sinus or paced rhythm where pacing captured, particularly if the stimulus-to-QRS interval was greater than 40 ms, consistent with abnormal conduction.

Ablation was performed with a power limit of 40–50 W and an irrigation rate of 30 ml/min (17 ml/min at the epicardium). Each application required between 30 and 60 s, based on the local electrogram reaction/abolition.

2.4. Outcomes

Outcomes were assessed immediately after ablation and 6 months later during the follow-up.

Immediately after ablation, one of the following should be obtained:

Acute complete success was defined as post-procedural non-inducibility of any monomorphic VT. VT modified was defined as no more induction of the clinical or presumed clinical VT, but other VTs remained inducible, and acute ablation failure was defined as still induced clinical or presumed clinical VT.

The long-term outcomes after 6 months included: Procedure success was defined as no VT during follow-up after single or multiple procedures; arrhythmia control was defined as any reduction in the number of VT episodes, ICD shocks, or number of antiarrhythmic drugs required for arrhythmia control during the follow-up, and overall survival.

The six-month long-term results included: arrhythmia control was defined as any decrease in the number of VT episodes, ICD shocks, or AADs necessary for arrhythmia control during the follow-up; and overall survival was defined as the absence of VT during the follow-up following a single or repeated surgeries.

2.5. Follow-up

Follow-up included arrhythmia recurrence as documented VT on a 12-lead ECG, 24-h Holter monitoring, and/or ICD interrogation, patient's symptoms, and medication, and follow-up of clinical data from patient files for retrospective patients, clinics FU, and by phone calls asking about ICD shocks, hospitalization, and survival.

2.6. Statistical analysis

SPSS version 23.0 (Inc., Chicago, Illinois, USA) was used for analysis of data. The quantitative data were reported as mean ± standard deviation and ranges. Also, qualitative variables were presented as numbers and percentages. We used the independent-samples t-test to compare between two means, paired sample *t*-test to compare related samples, and χ^2 test to compare qualitative parameters. Kaplan−Meier curve was used to examine the time-to-event variable distribution. The considered cutt-off for significance was *P* value less than 0.05.

3. Results

3.1. Study population

The mean age was 56.2 ± 13.9 yrs; all study populations were males, seven (31.8 %) patients were diabetics, eight (36.3 %) patients were hypertensives, four (18 %) patients had renal impairment, 14 (63.6 %) patients had previous myocardial infarction, six (27.2 %) patients were diagnosed as non ischemic cardiomyopathy (NICM), two (9 %) patients with previous surgical Fallot repair four (18 %) patients underwent previous VT ablation procedures, and 20 (90.9 %) patients had ICD therapy. Table 1 summarizes the clinical characteristics of the study population.

All patients received guideline-directed medical therapy and antiarrhythmic drugs; amiodarone as preprocedural AAD was prescribed in 73 % of procedures. The policy is to decrease AAD doses post-ablation and to gradually withdraw amiodarone if no recurrence.

3.2. VT and ablation strategy

Five (16.6 %) procedures were done after the VT storm and three (10 %) procedures after appropriate shocks for VF.

Preoperative echocardiography was done before procedures to exclude LV thrombi; the mean EF was 38.08 ± 13.01 % and the mean EF after exclusion of patients with post Fallot repair was 34.5 ± 8.2 %.

Table 1. Clinical data of study populations.

Patient characteristics	N (22)
Age (mean)	56.2 ± 13.9 yrs.
EF (%)	38.08 ± 13.01 %
Male sex	22 (100 %)
DM	7 (31.8 %)
HTN	8 (36.3 %)
Smoking	3 (13.6 %)
FH of IHD	1 (4.5 %)
Renal impairment	4 (18 %)
COPD	0 (0 %)
Previous MI	14 (63.6 %)
NICM	6 (27.2 %)
Post Fallot repair	2 (9 %)
Previous VT ablation	4 (18 %)
ICD therapy	20 (90.9 %)
	Single ICD 7 (31.8 %)
	Dual ICD 9 (40.9 %)
	CRT-D 4 (18.2 %)

Preoperative assessment of myocardial scar by MRI was performed on four patients (18.1 %), a small percentage due to most population having old defibrillator devices.

Preprocedural risk assessment was performed for all patients using the PAINESD score (mean 10.7 ± 4.4).

All procedures were done using a three dimensional mapping system under general anesthesia.

Retrograde LV access for endocardial mapping and ablation in 25 procedures (83.3 %) were done; in three procedures the operator preferred the transseptal approach for LV mapping using a deflectable sheath; in eight procedures the epicardial approach was done using a long sheath, and the percutaneous approach in seven procedures. Only one procedure needed a surgical epicardial window.

High-density mapping catheters were used only in 10 procedures (33.3 %); in the remaining procedures ablation catheters were used for mapping and ablation.

Programmed electrical stimulation from RV to induce clinical VT was performed in 14 (46.6 %) procedures, four (13.3 %) procedures had ongoing arrhythmia, in two (6.6 %) procedures clinical VT was spontaneously induced, and the mean induced VT CL was 376.31 ± 61.98 msec.

Mapping of the chamber of interest during sinus rhythm was done in all procedures to detect scar areas and tag local abnormal ventricular activation (LAVA). Activation mapping and entrainment of hemodynamically stable VT was done to delineate VT circuit and isthmus, using pace mapping to detect areas with best pace matching to exit the site of either induced or clinical VT. Table 2 shows the procedural data.

Table 2. Procedural data.

Procedures data	$N = 30$
3D mapping system	
CARTO 3	18 (60 %)
EnSite Precision	12 (40 %)
Access	
Retrograde LV access	25 (83.3 %)
RV (right ventricular) (venous access only)	4 (13.3 %)
Transseptal	3 (10 %)
Epicardial	8 (26.6 %) (1 epicardial window)
Chamber of interest	
LV endocardial	18 (60 %)
RV endocardial	4 (13.3 %)
Endocardial and epicardial	5 (16.6 %)
Epicardial	3 (10 %)
PES (programmed electrical stimulation)	14 (46.6 %)
Ongoing arrhythmia	4 (13.3)
Spontaneous induction	2 (6.6 %)
No PES	10 (33.3 %)
VT cycle length (msec)	376.31 ± 61.98 msec
Mapping:	
Dedicated high-density mapping catheters.	10 (33.3 %)
Voltage mapping	30 (100 %)
Pace mapping	25 (83.3 %)
Activation mapping	5 (16.6 %)
Entrainment	2 (6.6 %)
Ablation:	
LAVA/LP ablation	30 (100 %)
+Targeting VT isthmus	5 procedures (16.6 %)

Ablation of LAVA or late potential (LP) areas was the main ablation strategy.

3.3. Outcome and follow-up

Short-term outcomes: acute procedural success in 23 (76.6 %) procedures, VT modification in two (6.6 %) procedures, and failed ablation in five (16.6 %) procedures.

Two patients need another ablation procedure during index hospitalization after a successful first procedure.

Major complications occurred in three (10 %) procedures including intractable VT and VF in one redo procedure after VT storm, cerebrovascular stroke after one procedure and the patient died after a week, heart block during ablation of the basal septal substrate, and the patient passed away after a week by pneumonia. Table 3 summarizes the short-term outcomes.

In all, 19 patients were included in the long-term FU with a median FU time of 24 months (range 6–85 months), no sustained VT or ICD shocks in nine (47.6 %) patients, arrhythmia control in eight (42.1 %), and two (10.52 %) patients died.

Table 3. Short-term outcomes.

Short-term outcome	N (30) procedures
Acute success	23 (76.6 %)
VT modification	2 (6.6 %)
Failure	5 (16.6 %)
Complications	3 (10 %) 1 (3.3 %) Heart block. 1 (3.3 %) stroke. 1 (3.3 %) intractable VT, VF.
Redo ablation during the index hospitalization	**2 (6.6 %)**
Mortality	3 (10 %)
Cause of death (time after procedure)	Intractable VT, VF stroke (after 1 week), pneumonia (after 1 week)

Four patients underwent recurrent VT (6 procedures) ablation during long-term FU, three patients were with ICM, one patient with NICM and an RV endocardial substrate. Table 4 shows the long-term outcomes of the study population Figs. 2 and 3.

4. Discussion

In this research, catheter ablation of VT was effective, with an acute success rate of 76.6 %, and a safe, major complications rate of 10 %.

During long-term FU, no VT in 47.36 % of patients, VT recurrence in 42.1 %, and all-cause mortality was 10.52 % for 24 months median FU time.

Our results are compared with multiple observational trials as those of Jais et al., who studied 70 patients (ICM and NICM) referred for VT ablation with a mean EF of 35 ± 10 %, post-procedural non-inducibility achieved in 70 % of patients, complications' rate was 8.6 %, long-term FU over a median of 22 months, mortality rate was 10 %, and VT recurrence was found in 46 % (32 % of VT recurrence occurred in patients with post-procedural non-inducibility).[6]

Another study included 160 ICM patients with AAD refractory VT, who underwent mappable VT ablation and endocardial substrate ablation. Post-procedural VT non-inducibility was achieved in 88 %, and the recurrence rate in those groups was 46 % over a median FU of 82 days compared with 47.4 % VT recurrence in patients with no endpoints

Table 4. Long-term outcomes (N = 19 patients).

No VT	9 (47.36 %)
Arrhythmia control	8 (42.1 %)
Mortality	2/19 (10.52 %)
Cause of death (time after the procedure)	HF exacerbation (6 months) Atypical pneumonia (13 months).

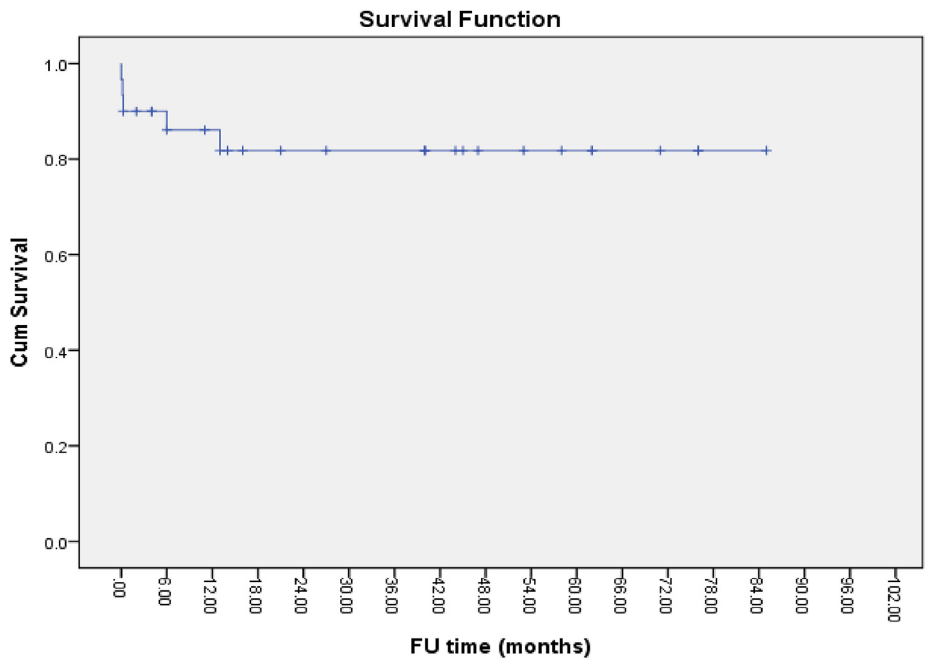

Fig. 2. Kaplan–Meier curve of all-cause mortality, all-cause mortality was 22.7 %, most of them in the first year after the procedure.

achieved (neither complete LP abolition nor post-procedural VT non-inducibility).[7]

Another study included 159 ICM patients, 25 % with previous CABG underwent mappable VT ablation endocardial/epicardial LAVA abolition, post-procedural VT non-inducibility was achieved in 94/110 tested patients (85.4 %), and VT-free survival was 55 % over an FU of 47 months (33–82 months).[8]

Another study included 72 patients, 69.4 % of the study population had ICM, patients underwent substrate ablation, acute success was in about 69 %, partial success was in about 10 %, and complications

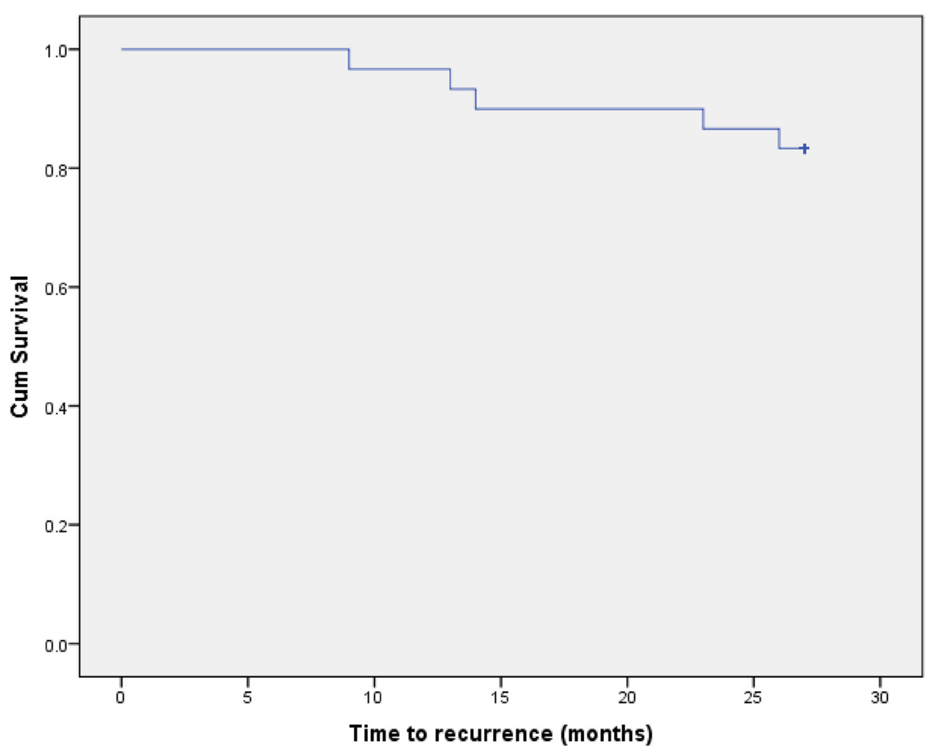

Fig. 3. Kaplan–Meier curve of Ventricular tachycardia recurrent ablation during long-term FU.

occurred in about 4 %. During long-term FU (28.9 ± 22.8 months), overall mortality was 22.1 %, and VT recurrence was 35.3 %.[9] The lesser VT recurrence rate was because of the gradual withdrawal of amiodarone after ablation compared with cessation of AAD after ablation in major trials.

Retrospective observational studies of VT ablation have demonstrated multiple VT recurrence rates in the long-term, which varied from 16 up to 66 % in ICM patients, and VT recurrence rate in NICM ranges from 14 to 74 %.[1]

Major complications rate after VT ablation were reported to be 8−10 %[10] and the overall major complications in patients with SHD were reported to be 3.8−11.4 %,[11] which was compared with our study.

There was no significant difference between those with no VT at FU and those with recurrent VT as regards etiology (ICM Vs NICM) and post-procedural VT non-inducibility.

This contrasts with the common concept of lesser procedural success and more VT recurrence after ablation of VT in NICM in comparison with ICM.[1]

However, a study in 2020 included 309 cases, who underwent catheter ablation for VT; the mean FU time was 34 ± 28 months, and found that there is no difference between ICM and NICM as regards short- and long-term outcomes.[12]

4.1. Limitations

This is an observational study, with a small sample size representing a single operator experience. High-density mapping catheters were not available in all procedures and lack of hemodynamic support, which limited mapping and ablation of unstable VT.

4.2. Conclusion

Catheter ablation of scar-related VT is safe and effective. Complications and VT recurrence were compared with internationally published data.

Conflicts of interest

None declared.

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