

REVIEW

# The Role of Catheter Ablation of Ventricular Tachycardias in the Treatment of Patients with Electrical Storm

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## ABSTRACT

Electrical storm due to the development of repetitive sustained ventricular tachycardias (VT) is a potentially life-threatening clinical entity. Acute catheter ablation can be lifesaving. Electrical storm (ES) can be characterized as a period of severe cardiac electrical instability manifested by recurrent ventricular arrhythmias. ES adversely affects short and long term prognosis. The highest mortality risk is in the first 3 months after the occurrence of the index event as shown by the AVID trial. The appearance of a ventricular tachycardia (VT) storm is associated with a rather high mortality despite the presence of an internal cardioverter defibrillator. Catheter ablation (CA) in VT storm is evolving as a standard of care therapy. The increased utilization of CA is partly driven by data suggesting that ICD shocks may be associated with increased mortality, partly due to the limited possibilities and adverse events of medical therapy. The aim of this review is to summarize recent advances in CA of VTs in emergency setting.

**Keywords:** ablation, ventricular tachycardia, electrical storm

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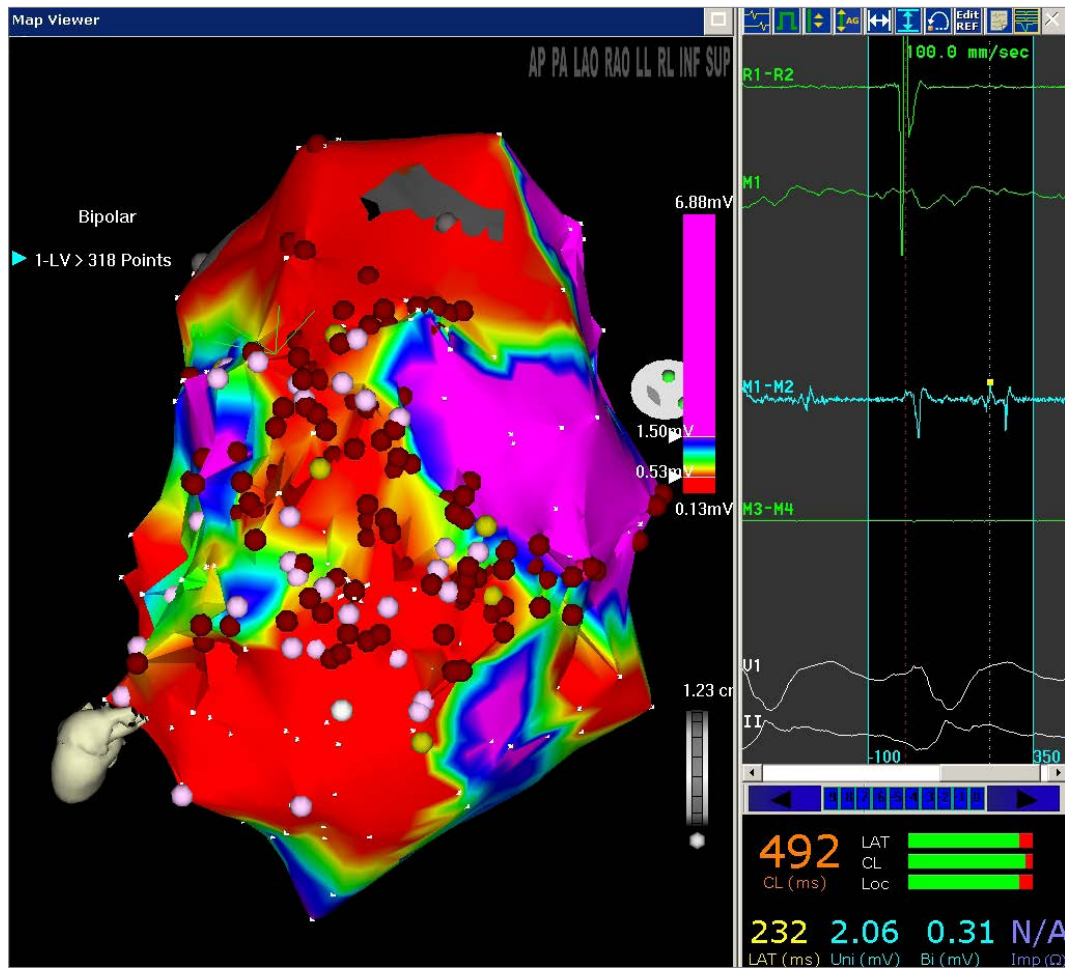
## BACKGROUND

Since electrical storm due to the development of life threatening sustained ventricular tachycardias is a cardiac emergency, acute catheter ablation can be lifesaving. Electrical storm (ES) can be characterized as a period of severe cardiac electrical instability manifested by recurrent ventricular arrhythmias [1]. The development of ES has a strong negative impact on the outcome of patients. The highest mortality risk is in the first 3 months after the occurrence of the index event as shown by the AVID trial [2]. Although the presence of implantable cardiac defibrillator decreases mortality, it is also not without risks. Indeed, the increased utilization of catheter ablation (CA) is partly driven by data suggesting that ICD shocks may be associated with increased mortality, partly due to the limited possibilities and adverse events of

medical therapy. Every defibrillator shock therapy multiplies the mortality risk by direct cell injury [3,4,5]. Other mechanisms how ES directly affects patient prognosis is by progressive deterioration of cardiac function from prolonged low-output states, and/or an adverse haemodynamic effect of antiarrhythmic medication [6] and thus, CA may become a life-saving procedure for these patients.

## MECHANISM OF VT IN ELECTRICAL STORM

The term "electrical storm" indicates a state of cardiac electrical instability manifested by several distinct episodes of VTs within a short period of time [1]. In patients with an ICD, ES is best defined as 3 appropriate VT detections in 24 hours, treated by antitachycardia pacing, shock or eventually untreated, but sustained in a VT monitoring



**FIGURE 1.** Three dimensional electro-anatomical map of a LV ventricle in a patient with a large scar (red). LAVAs (local abnormal ventricular activities) are tagged with white colors. The patient had multiple morphologies of ventricular tachycardias. Extensive scar ablation (dark red dots) in an emergency setting rendered all tachycardias non-inducible.

zone. Incessant VT, defined as VT starting shortly (after  $\geq 1$  sinus cycle and within 5 minutes) after a technically successful therapy, represents a serious form of electrical storm.

Ventricular monomorphic tachycardia is the most common arrhythmia in patients with an electrical storm, and reentry is the most common underlying mechanism [7]. Scarring—i.e. the development of fibrous tissue is the anatomical and electrophysiological substrate. It is therefore also the target for CA. Other targets can be premature ventricular contractions (PVC), since those can trigger sustained arrhythmias [8]. The study Hayashi et al. that investigated ES in acute heart failure, described PVC arising from the Purkinje fibers that not only triggered VF but also for about 30% of the monomorphic VTs [9]. Likewise early post-myocardial infarction (MI) incessant VT is mostly triggered by PVC [10,11]. In these patient categories targeting the PVCs resulted in a reasonable ablation success [9,10,11].

## VT ABLATION IN ELECTRICAL STORM

In electrical storm catheter ablation has been considered as a realistic and valid treatment option [7]. Carbuccio et al. [12] have shown the superiority of CA to conventional medical therapy (92% and 66%, respectively). CA is life-saving; it also improves quality of life and reduces the recurrent VA episodes [13]. A systematic review by Nayar et al. included 39 studies with 471 ventricular arrhythmia (VA) storm patients concluded that ventricular arrhythmia storm ablation has high acute success rates, with a low rate of recurrent storm [14]. They found high acute success rate of invasive management of VA storm, with 91% of patients having elimination of the clinical VA and 72% of patients having all inducible VA eliminated. Ninety-four percent of the patients were free from VA storm on follow-up.

For the better success rates sometimes multiple procedures ( $1.3 \pm 0.4$  per patient) are needed [14]. In the study

of Carbuccichio et al. one to three procedures were needed to suppress clinical VTs in 89% of patients [12]. Among the patients with all clinical VTs abolished during the ablation, no recurrence of electrical storm occurred during the follow-up period, and the mortality was significantly lower compared to those who showed persistent inducibility of  $\geq 1$  VT at the end of the procedure. Interestingly enough, Kozeluhova et al. found non-inducibility of the VT at the end of the study was not predictive of ES or VT recurrences during follow-up which might be explained by the inclusion of not only monomorphic VT but also polymorphic VTs [6].

Despite a remarkable initial success rate in VT ablation patients in ES, only a moderate long-term efficacy at follow-up has been reported [15]. Especially non-ischaemic dilated cardiomyopathy, is reported to be an independent predictor of failure of CA procedure in patients with ES [12]. Arya et al. reported an excellent survival rate after successful CA procedures in patients with non-ischemic dilated cardiomyopathy. Probably more aggressive ablation strategies targeting all inducible VTs may be appropriate as it improves long term freedom from VTs [16]. The same group evaluated long-term efficiency of CA using remote navigation in VT ablation in patients with ischemic heart disease and ES. During a mean follow-up of 7.8 months, 21 patients (70%) had no recurrence of VTs and received no appropriate ICD therapy. Multisite stimulation induction method was found very useful in assessment of the success of CA procedure [17]. The authors concluded that a significantly more aggressive ablation strategy, including epicardial mapping and ablation of all inducible VTs, may improve the ablation outcome especially among those who had an initially failed ablation procedures [17]. DiBiase et al. compared endocardial surface with limited substrate ablation to endocardial and epicardial scar homogenization in patients with an electrical storm and an underlying ischemic cardiomyopathy. A significant difference in outcome was observed after 25 months ( $p = 0.006$ ) in favour of the endo/epicardial homogenization group [13]. Limited substrate ablation abolishes circuits relevant to the arrhythmia burden at the time of the procedure, but more extensive ablation—endo- and epicardial substrate homogenization—may be more successful at long term [12].

### **CA FOR HEMODYNAMICALLY UNSTABLE VTs**

Acute cardiac decompensation can be either a cause or a consequence of ES. Unstable and decompensated patient is

an important sub-entity of ES [18]. Urgent radiofrequency catheter ablation in the setting of an acute heart failure (AHF) decompensation in patients with monomorphic VT was found safe, with the exception for a temporary exacerbation of pulmonary congestion in 20% of the patients [9]. Urgent RFCA for drug-resistant sustained ventricular tachyarrhythmias during AHF decompensations is a feasible therapeutic option [8]. In this study PVCs were found responsible for the ventricular arrhythmias and targeted for ablation. In monomorphic VT percutaneous left ventricular assist device-assisted VT ablation is a reasonable alternative to substrate mapping for haemodynamically unstable, medically refractory VT in high-risk patients [19]. Of all ES studies 23% of all patients required major invasive haemodynamic support during the procedure [14]. Hemodynamic support is crucial for this patient population. It can be achieved in the form of counter pulsation balloon pump, Impella device or by LVAD [19,20].

### **LONG-TERM PROGNOSIS AFTER CA OF ELECTRICAL STORM PATIENTS**

VT free long term survival may be improved by early invasive intervention. Deneke et al. performed catheter ablation within 24h after admission of the patient with electrical storm and showed a high cumulative mid-term survival (median 15 months) of 91% [21]. CA for VT in the early post infarction period may also be a feasible treatment [11]. In the study of Saggu et al. 5 patients short after myocardial infarction underwent catheter ablation within 48 hours for the treatment of VTs.

CA is fairly called a "lifesaving" approach with an acceptable efficacy and safety profile and a low complication rate (1%) [14]. The risk of death has been found the greatest at 3 months after ES [2]. Severely depressed LVEF, a higher degree of LV dilation, renal insufficiency, and ES recurrence after previous CA procedure were identified as predictors of adverse outcome within the first 6 months after the procedure [6]. In AHF decompensated VT patients, AHF after RFCA was ameliorated in 93% of the patients [9]. Nevertheless heart failure is the dominant cause of death in the long term in patients having a successful procedure [14]. In this subset of patients, the magnitude of the cardiac damage is too extensive and chronic heart failure far advanced [6]. Looking at it this way ES may rather be an epiphenomenon of progression of heart failure and even successful CA does not guarantee a good prognosis. High arrhythmia rate heralds pre-terminal pump failure, yet failure of the CA procedure carries an even higher mortality [14].

## CONCLUSION

In conclusion, progressively increasing number of studies support that CA is a very effective in suppressing of ES and it may be a life-saving therapy for a very troubled patient population.

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## LIST OF ABBREVIATIONS

<b>AHF</b>	acute heart failure
<b>CA</b>	catheter ablation
<b>ES</b>	electrical storm
<b>ICD</b>	implantable cardioverter defibrillator
<b>MI</b>	myocardial infarction
<b>PVC</b>	premature ventricular contraction
<b>RF</b>	radiofrequency
<b>VA</b>	ventricular arrhythmia
<b>VF</b>	ventricular fibrillation
<b>VT</b>	ventricular tachycardia