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ORIGINAL ARTICLE

# The role of catheter ablation in the management of patients with implantable cardioverter defibrillators presenting with electrical storm

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**KEYWORDS**
Electrical storm;
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**Abstract** *Objective:* Electrical storm (ES) is not uncommon among patients with an implantable cardioverter defibrillator (ICD) in situ. Catheter ablation (CA) may suppress the arrhythmia in the acute setting and prevent ES recurrence.
*Methods:* Nineteen consecutive patients with an ICD in situ presenting with ES underwent electrophysiologic studies followed by CA. CA outcome was classified as a complete success if both clinical and non-clinical tachycardia were successfully ablated, partial success if ≥1 non-clinical tachycardia episodes were still inducible post–CA, and failure if clinical tachycardia could not be abolished. Patients were followed for a median period (IQR) of 5.6 (1.8-13.7) months. The primary endpoint was event-free survival from ES recurrence. The secondary endpoint was event-free survival from a composite of ES and/or sustained ventricular tachycardia (VT) recurrence.
*Results:* Clinical arrhythmia was successfully ablated in 14 out of 19 (73.7%) cases after a single CA procedure. A completely successful CA outcome was associated with significantly increased ES-free survival compared with a partially successful or failed procedure (Log rank P=0.039). Nevertheless, patients with acute suppression of all tachycardia episodes (n=11), relative to those with a partially successful or a failed CA procedure (n=8), did not differ in incidence of the composite endpoint of sustained VT or ES (Log rank P=0.278).

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*Conclusion:* A single CA procedure can acutely suppress clinical arrhythmia in three-quarters of cases. A completely successful CA outcome can prolong ES-free survival; however, sporadic ICD therapies cannot be abrogated.


## 1. Introduction

The introduction of implantable cardioverter defibrillators (ICDs) to the clinical armamentarium has resulted in a paradigm shift in the management of patients with structural heart disease, both in primary[1] and secondary[2] sudden death prevention. The use of ICDs has enabled patients to survive multiple sustained ventricular tachycardia/fibrillation (VT/VF) episodes that otherwise might have proved fatal. However, the use of ICDs has also paved the way for the emergence of another clinical entity: electrical storm (ES), defined as three or more distinct VT/VF episodes within 24 hours.

ES is not uncommon among ICD recipients[3] and has been reported at 23% over a one year follow-up,[4] ranging from 10%[5] to 40%.[6] ES events have been associated with increased hospitalization rates[4] and increased cardiac and all-cause mortality.[7] ES events adversely impact survival in ICD patients irrespective of the causative arrhythmia.[5] The same applies to Cardiac Resynchronization Therapy-Defibrillator (CRT-D) patients with ES who experience increased heart failure-related hospitalization and mortality rates relative to those with no ES.[8] In most cases, there is no clear precipitant, and medical therapy alone may be inadequate to control the arrhythmia. Electrophysiologic studies followed by catheter ablation (CA) may acutely suppress the arrhythmia[9] and modify the arrhythmogenic substrate or eliminate potential triggers, such as ventricular ectopics, and thereby prevent future episodes.[10,11]

In the present study, we aimed to assess the short-term efficacy of CA in suppressing clinical arrhythmia underlying ES in a cohort of patients presenting with a cluster of multiple appropriate ICD therapies. Furthermore, we sought to investigate which patient characteristics and/or procedural aspects define event-free survival from recurrent ES and/or sustained VT episodes.

## 2. Methods

### 2.1. Study population

All patients (n = 19) with complete follow-up data who presented at our center between April 2008 and May 2015 with ES and had previously undergone defibrillator placement (ICD or CTR-D) were included in the study. ES was defined as three or more distinct episodes of VT or VF within 24 hours leading to appropriate defibrillator interventions. Consecutive ICD therapies following previously failed attempts to restore sinus rhythm were considered to be a single arrhythmic episode. Inappropriate ICD interventions for supraventricular tachycardia or due to device malfunction were not considered. Patients presenting with polymorphic VT or VF in the context of electrolyte abnormalities or an acute coronary syndrome were not included in the analysis. The study protocol was approved by our institution's ethics committee.

### 2.2. Electrophysiologic study and CA

On admission, all participants were transferred to the coronary care unit and were treated as per guidelines with intravenous beta-blockers, amiodarone, sedatives and device reprogramming. All patients underwent electrophysiologic studies during the index hospitalization as soon as hemodynamic stability was achieved. As per our institution's ventricular stimulation protocol, we aimed to reproduce the clinical arrhythmia by pacing the right ventricle at three different cycle lengths adding up to three extra stimuli at various coupling intervals. All inducible VTs were mapped using the Ensite-Navx® electro-anatomical mapping system.

All inducible VTs (clinical and non-clinical) were targeted for ablation using irrigated tip ablation catheters. In well-tolerated VTs, the exact location of the critical tachycardia isthmus was identified via activation mapping and further confirmed with entrainment maneuvers. In cases where the clinical VT was not inducible or not tolerated, CA was attempted during sinus rhythm. Substrate mapping was undertaken, and radio-frequency energy was delivered at areas exhibiting fragmented and late potentials as well as high pace-map scores (Figure 1).

Complete success was defined as complete suppression of all clinical and non-clinical VTs that were reproduced in the lab. In cases in which one or more non-clinical VTs remained inducible at the end of the study, the CA outcome was considered to be a partial success. The CA outcome was characterized as a failure if the clinical VT remained reproducible by the end of the study.

### 2.3. Follow-up and study endpoints

After hospital discharge, patients were reviewed after one month, three months and then twice a year (or sooner if clinically indicated) at our center's dedicated pacing clinic. Clinic visits involved history taking focused on arrhythmic episodes, a brief physical examination, an ECG and device interrogation using a programmer. The follow-up period ranged from the CA date to ES recurrence. For patients with an uneventful course, the follow-up period was terminated on the date of their last visit at the pacing clinic before

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