



## Management of Electrical Storm

### Key Articles

Hendriks AA, Szili-torok T. Editor's Choice-The treatment of electrical storm: an educational review. Eur Heart J Acute Cardiovasc Care. 2018;7(5):478-483.

### Background

- Patients may present to the ED after having multiple ICD shocks at home, with hemodynamic instability, or with recurrent episodes of wide complex tachycardia.
- Because this is an uncommon presenting illness, it's important that we can readily recognize and treat these patients.
- Effective management can often be complex involving antiarrhythmic medications, suppression of sympathetic tone, device management and in some cases emergent catheter ablation.
- In this discussion we are going start with patients who present with VT that fits in the "stable box" but will also address those who are refractory to medical treatment or in shock at the end.

### Definition and Mechanisms of Electrical Storm

- The most commonly accepted definition is 3 or more separate arrhythmia episodes leading to ICD shocks over a 24-hour time period.
  - **Sustained VT** is defined as any ventricular tachycardia that lasts for > 30 seconds or is symptomatic.
  - **Non-sustained VT** lasts for < 30 seconds and is asymptomatic.
  - Episodes must be separate, where each episode is terminated for at least 5 minutes by an ICD shock
  - This is slightly **different than persistent or sustained VT**, where the VT resumes within 5 minutes of successful ICD therapy.
- Mechanisms of electrical storm are often multifactorial but can include
  - Progressive ventricular scarring and LV remodeling in patients with advanced heart failure or from a previous MI
  - Volume overload causing ischemia due to an overstretched ventricular wall
  - Excessive sympathetic hyperactivity during heart failure exacerbations
- **Bottom line:** Every patient that presents with a single ICD shock should be considered as a possible electrical storm. While the patient may only report 1 known event, recent asymptomatic VT events may have occurred, but treated successfully with ICD/Pacemaker anti-tachycardia pacing (ATP)

## Initial workup and Treatment of Electrical Storm

- As we've all learned in the past – Stable v. Unstable is an important initial question
  - Active VT patients with hypotension (SBP < 90 or MAP < 65), complaints of ischemic chest pain, hypoxia or shortness of breath, altered mental status, or other clinical evidence of malperfusion should be treated with synchronized cardioversion at 200J.
    - **PEARL:** If you are going to attempt cardioversion, avoid placing electrical pads over the patient's ICD/PPM as this can reduce the effectiveness of the external shock. Anterior/posterior positioning may be more effective compared to AP/Lateral.
  - For the stable patient with intermittent episodes of sustained VT, a number of additional items should be considered
- **Reversible causes:** In a majority of cases, no clear cause for electrical storm is identified. Each of these will have a treatment specific to the inciting cause, but can help develop a quick differential to guide your initial work-up.
  - **The most common** reversible causes include:
    - Electrolyte imbalances
      - Abnormally low electrolytes can be caused by home diuretics, diet changes, and other medications.
      - Low potassium, magnesium, and calcium can prolong the patient's QT which leading to polymorphic VT
    - Ischemic VT due to a flow-limiting coronary lesion (\*\* Most common \*\*)
    - Volume overload 2/2 heart failure exacerbation
    - Changes or non-compliance with dosages of anti-arrhythmic medications
    - New biventricular pacemaker placement has also been associated with VT storm.
- First step for the patient with multiple ICD shocks:
  - Magnet placement
    - Will discontinue internal attempts at defibrillation
    - If patient has stable VT, will allow for medical management and also stop inappropriate/ineffective ICD shocks
- **Medical management with anti-arrhythmic drugs – focus on 3 main medications**
  - Beta-blocker therapy
    - Beta-blockers play a fundamental role in the management of electrical storm by blocking the sympathetic receptors that often trigger VT
    - Frequently the first step in the treatment of electrical storm ***in low-risk patients and those without cardiogenic shock***
      - **Risk Factor PEARL:** High risk factors that signal you should NOT use emergent beta blockers include: >70 years of age, acute ischemia on EKG, systolic blood pressure <120 mm Hg, and heart rate >110 beat/min

- **Metoprolol** is most commonly used: start with 5mg IV every 5 minutes up to 3 total doses
  - **Propranolol** (a lipophilic, unselective beta-blocker that penetrates the CNS) has been found to be effective in patients not responding to metoprolol or amiodarone.
  - **Esmolol**: 500 mcg/kg IV bolus with infusion starting at 50 mcg/kg/min
    - Benefit: You can usually see how the patient will respond quickly after an esmolol bolus dose, as it has a short half-life and its effect will go away quickly if the patient has a poor hemodynamic response.
- Lidocaine/Procainamide
    - Class 1 (Na<sup>+</sup> Channel blocker) antiarrhythmics
    - **Lidocaine**: in general, *preferred for patients with ischemic VT*
      - During ischemic VT, the altered cardiac membrane potential as well as pH reduction increase the rate of drug binding, making lidocaine more effective in terminating VAs
      - Dose: Bolus 1 mg/kg IV over 5 minutes up to 3mg/kg total
      - Infusion: 1-3 mg/min
    - **Procainamide**:
      - For *patients with recurrent, stable VT not in the setting of an AMI*, intravenous procainamide has been shown to be superior to lidocaine for terminating VT
        - PROCAMIO Study (2017): Compared procainamide vs. amiodarone in patients with VT storm *without* acute heart failure and severely depressed LVEF (<30%)
      - Complicated dosing: 20–50 mg/min x 30 minutes
      - Infusion: 1–4 mg/min
- **Amiodarone**
    - Class III or K<sup>+</sup> channel blocker that is commonly works best in patients with *structural heart disease* (post-MI scar, etc.)
      - Dose: Bolus 150 mg IV over 10 minutes, followed by an infusion of 1mg/min
    - NOTE: The incidence of IV-amiodarone-refractory electrical storm is approximately 30%(!) so it is important to have alternative treatments readily available
- **Persistent VT refractory to medical treatment**
    - In patients not responding to medical treatment or presenting with worsening shock, intubation and sedation can address a number of potential triggers by:
      - Decreasing sympathetic tone

- Reduce pain during cardioversion attempts or ICD shocks
  - Reduce myocardial ischemia and oxygen demand
- Peri-intubation considerations
  - High-risk intubation!!
  - Have vasopressors at the bedside or already running to prevent peri-intubation arrest
- Analgesia
  - Standard short acting opioids such as a fentanyl infusion in conjunction with sedation medications to suppress the sympathetic hyperactivity and provide analgesia without negative inotropic effects
- Sedation options and preferences
  - There is little evidence to recommend 1 medication over another, but medication side effects should be considered when being used in this patient population
  - **Benzodiazepines:** Probably preferred as it has minimal negative hemodynamic affects
  - **Propofol:** Has been reported to suppress electrical storm but has some *negative inotropic effects* that can worsen cardiogenic shock in patients with reduced ejection fraction
- **Invasive BP monitoring and access**
  - In patients with refractory VT, invasive blood pressure monitoring with a femoral arterial line and femoral venous access are extraordinarily helpful
  - Not only will these patients often require vasopressor/inotropic therapy, but early placement can also aid in the transition to mechanical circulatory support if needed.
  - **PEARL on site choice:** Femoral over radial artery access as the accuracy of peripheral arterial blood pressure can be significantly reduced in patients with cardiogenic shock.
- Advanced therapies and mechanical circulatory support
  - Persistent VT with evidence of shock should at a minimum prompt a call to the cath lab
  - More recent evidence suggests early initiation of mechanical circulatory support (VA-ECMO, Impella, IABP) may reduce early morbidity and mortality by increasing coronary perfusion, reducing afterload and therefore myocardial wall stress and prevent multiple organ failure guaranteeing and adequate cardiac output

## Summary

- Electrical storm and persistent VT are complicated conditions that often requires multiple clinical specialists to provide timely and effective treatment.
- Lidocaine is the preferred medication for patients with ischemic VT, the most common and reversible cause of VT storm.

- Beta-blocker therapy is the main stay of treatments in patients without shock whereas amiodarone may be preferred in those with structural heart disease
- Consider early intubation and sedation to reduce sympathetic surge in patients with refractory VT
- Place early invasive femoral access to facilitate advance therapies if needed.