ISSN: 2634 - 6796

Journal of Cardiology Research Reviews & Reports

SCIENTIFIC Research and Community

Case Report

Open Access

Electrical Storm in the ICU – When all Options Run Out

Pedro Garcia Brás

Cardiology Department, Santa Marta Hospital, Central Lisbon Universitary Hospital Center, Rua de Santa Marta 50, 1169-024 Lisbon, Portugal

ABSTRACT

The management of patients with ischaemic cardiomyopathy presenting with refractory ventricular arrhythmias may be challenging and is associated with high morbidity and mortality. The authors present the case of a 72-year-old male patient with a known history of severe ischemic cardiomyopathy and impaired left ventricular function (LVEF 29%) with a previous episode of incessant ventricular tachycardia (VT), previously submitted to VT catheter ablation and implantable cardioverter-defibrillator (ICD) implantation in secondary prevention. Due to hyperthyroidism with amiodarone, he was under dofetilide therapy. In this case report, we detail the step-by-step approach undertaken in the management of a complex case of refractory electrical storm. The therapeutic approach included the use of several anti-arrhythmic drugs (amiodarone, lidocaine and esmolol), manual ICD anti-tachycardia pacing and cardioversion, sedation and mechanical ventilation, extracorporeal life support with VA-ECMO and VT catheter ablation under VA-ECMO support. Unfortunately, despite every measure undertaken, the patient developed incessant VT culminating in haemodynamic collapse and death. The role of mechanical circulatory support in haemodynamically unstable patients with refractory ventricular arrhythmias and undergoing VT catheter ablation is also explored, as well as other treatment options that may be considered in the management of electrical storm, such as early coronary angiography, autonomic modulation, and surgical VT ablation with electroanatomical mapping.

***Corresponding author**

Pedro Garcia Brás MD, Cardiology Department, Santa Marta Hospital, Central Lisbon Universitary Hospital Center Rua de Santa Marta 50, 1169-024 Lisbon, Portugal. E- mail: pedrobras3@gmail.com

Received: September 26, 2022; **Accepted:** September 28, 2022; **Published:** October 06, 2022

Keywords: Electrical Storm, Ventricular Tachycardia, Acute Cardiac Care, Ventricular Tachycardia Catheter Ablation, Va-Ecmo, Case Report

Introduction

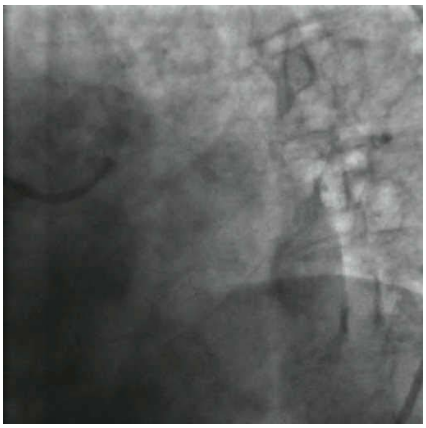
The management of patients with ischaemic cardiomyopathy experiencing recurrent ventricular arrhythmias and electrical storm may pose a daunting challenge. Ventricular tachyarrhythmias are a life-threatening complication of ischaemic cardiomyopathy, and implantation of an implantable cardioverter-defibrillator (ICD) is recommended in cases of severe left ventricular (LV) systolic dysfunction [1]. In patients with recurring symptomatic ventricular tachycardia (VT) despite anti-arrhythmic medication, VT catheter ablation should be considered [2]. In patients with electrical storm, while procedures are longer and more complex, VT catheter ablation was associated with a significant reduction in VT recurrence and improved 1-year survival [3]. In haemodynamically unstable patients with refractory ventricular arrhythmias, mechanical circulatory support may be considered [4].

We describe here a clinical case that illustrates the current recommendations for management of refractory electrical storm in patients with ischaemic cardiomyopathy, including from anti-arrhythmic medication, anti-tachycardia pacing, sedation and mechanical ventilation to Venoarterial Extracorporeal Membrane Oxygenation (VA-ECMO) support and VT catheter ablation.

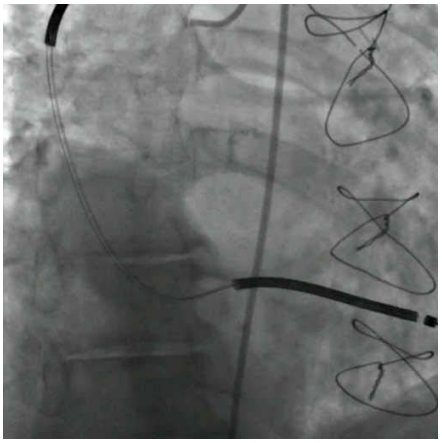
Case Report

The authors present the case of a 72-year-old male patient with medical history of atrial fibrillation, chronic kidney disease and multiple cardiovascular risk factors including type 2 diabetes mellitus, arterial hypertension, dyslipidaemia and prior smoking habits.

The patient had previous known history of ischaemic cardiomyopathy with multivessel disease previously submitted to coronary artery bypass graft and percutaneous coronary intervention of the left main and circumflex arteries (Supplementary Videos 1 and 2 for the live video link: **https://www.onlinescientificresearch.com/videos.php)**. His last echocardiographic evaluation showed a dilated LV with severe systolic dysfunction (LV ejection fraction of 29%).



Supplementary Video 1: Previous coronary angiography – left coronary artery Coronary angiography of left coronary artery showing final result after percutaneous coronary intervention (PCI) of the left main and circumflex arteries with 2 drug-eluting stents.



Supplementary Video 2: Previous coronary angiography – saphenous vein graft Coronary angiography of saphenous vein graft bypass to the right coronary artery showing patent flow (TIMI grade flow 3).

Due to episodes of syncopal VT, he had already undergone ICD implantation in secondary prevention seven years before. Two years prior the patient had an episode of incessant VT and was submitted to VT catheter ablation with successful modification of the arrhythmic substrate. Since then, he was started on dofetilide because of thyrotoxicosis caused by long-standing treatment with amiodarone. The patient's current medication was: dofetilide 250 µg BD, carvedilol 6.25 mg BD, sacubitril/valsartan 24/26 mg BD, spironolactone 25 mg OD, dapagliflozine 10 mg OD, furosemide 40 mg BD, apixaban 5 mg BD, clopidogrel 75 mg OD, atorvastatin 40 mg OD, pantoprazole 20 mg OD and linagliptin 5 mg OD.

The patient was admitted in the emergency room due to sudden onset of palpitations, chest pain and dyspnoea. The admission electrocardiogram (Figure 1A) showed a wide complex tachycardia with a heart rate of 180 beats per minute (bpm), consistent with monomorphic VT (positive QRS complexes in aVR, negative concordance in the precordial leads). He was swiftly submitted to external electrical DC cardioversion with 100 Joule (J) as haemodynamic instability was developing. After successful cardioversion he maintained frequent episodes of non-sustained VT so amiodarone perfusion was started and he was transferred to the cardiac intensive care unit (CICU).

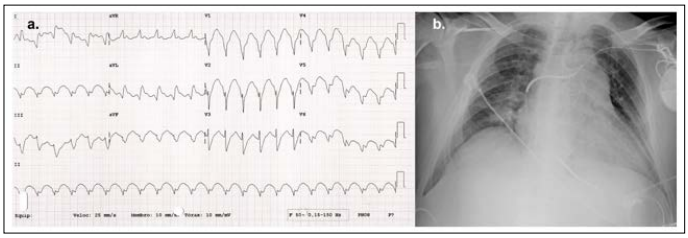
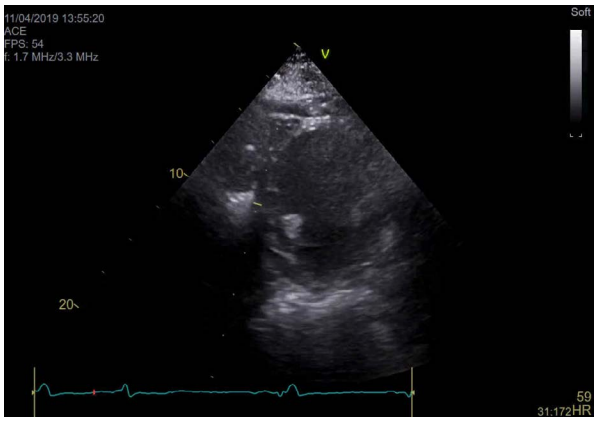
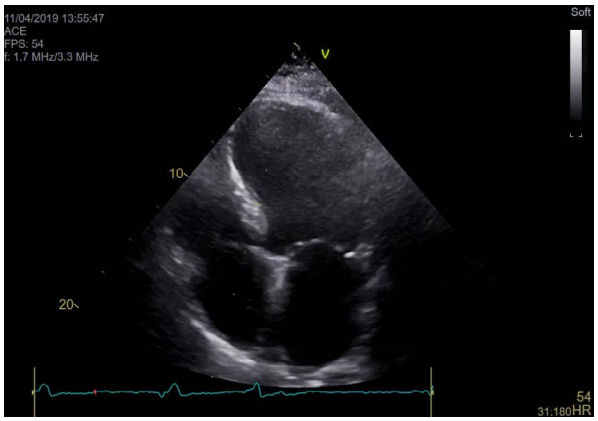


Figure 1: Admission 12-lead electrocardiogram (a) and chest x-ray (b)
A. Wide complex tachycardia with a heart rate of 180 bpm, positive QRS complexes in aVR, negative concordance in the precordial leads, suggestive of monomorphic ventricular tachycardia. B. The admission chest x-ray shows no ICD generator or lead displacement.

On CICU admission the patient was responsive and calm, haemodynamically stable, in sinus rhythm with a heart rate of 61 bpm. There were no relevant changes in physical examination, namely impaired mental status or peripheral perfusion. However, despite anti-arrhythmic medication and early stabilization, a few hours later the patient had a new episode of sustained monomorphic VT, with haemodynamic deterioration. Despite ICD therapies, both anti-tachycardia pacing (ATP) and 2 appropriate shocks, there was immediate VT recurrence. Initial laboratory results revealed normal complete blood count, absence of kidney, liver or thyroid dysfunction. Electrolyte levels, including potassium and magnesium, and arterial blood gas were also normal. The initial brain natriuretic peptide level was increased (1700 pg/mL) and there was no significant elevation of the creatine kinase or high sensitivity troponin I levels. A chest X-ray was performed (Figure 1B) revealing no ICD generator or lead displacement. Transthoracic echocardiographic (Supplementary videos 3 and 4 for the live video link:
https://www.onlinescientificresearch.com/videos.php) evaluation showed a severe systolic dysfunction (maintaining a LVEF of 29%), without de novo regional wall motion abnormalities.



Supplementary Video 3: Admission transthoracic echocardiogram – apical 4-chamber view Severe systolic dysfunction with akinesia of the septal and anterior wall segments.



Supplementary Video 4: Admission transthoracic echocardiogram – apical 4-chamber view Severe systolic dysfunction (LV ejection fraction of 29%) with akinesia of the mid-inferior septum and apical segments.

With the diagnosis of electrical storm in a patient with severe ischemic heart disease, the first therapeutic step was to attempt cardioversion with manual ATP via ICD. After several attempts with burst and ramp ATP therapies with no success, lidocaine and esmolol perfusions were started after initial bolus, while keeping the amiodarone perfusion started on admission.

Despite continuous attempts with ATP therapies via ICD and anti-arrhythmic therapy there was no success in converting the patient's tachyarrhythmia thus the next management option was electrical cardioversion via ICD after sedation with midazolam and etomidate. In spite of successful cardioversion to sinus rhythm with a 10J shock, there was immediate VT recurrence in the first ventricular complex. The ICD basal heart rate programming was adjusted, first to 90 bpm then to 40 bpm, yet the same result occurred after cardioversion – VT recurrence in the first pacing complexes (Figure 2A) After several attempts of electrical cardioversion (up to 36J) there was conversion to ventricular pacing rhythm (40 bpm) and afterwards to sinus rhythm (Figure 2B). Due to prolonged VT with haemodynamic instability, impaired mental status and signs of poor peripheral tissue perfusion we proceeded to patient sedation and intubation with subsequent mechanical ventilation and the patient was temporarily started on low dose noradrenaline perfusion.

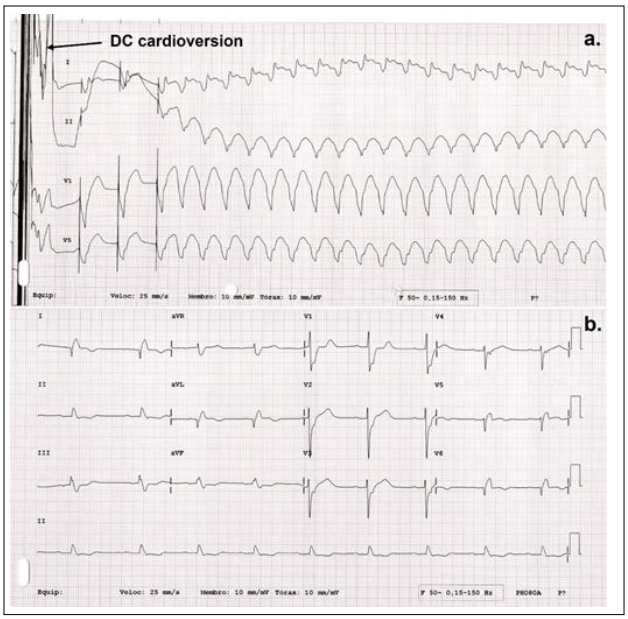


Figure 2: Rhythm strip after cardioversion (a) and 12-lead ECG after conversion to sinus rhythm (b)
A. DC cardioversion is noted in the start of the rhythm strip, followed by 3 ventricular pacing complexes and VT recurrence. B. Sinus rhythm at 58 bpm, first-degree AV block, intraventricular conduction delay, Q waves and T wave inversion in leads V5-V6, I and aVL, absence of R wave progression in precordial leads.

Further management was discussed in a Heart Team meeting with the Cardiothoracic Surgery team and the patient was submitted to VT catheter ablation under VA-ECMO support. With high-density mapping (with HD Grid mapping catheter), an extensive scar region in the apex was observed as well as sizable scarring in the lateral and basal portions. Activation mapping of one VT morphology showed a re-entry circuit dependent on 2 regions of slower activation, in the apical-anterior and the apical-mid-lateral region of the LV (Figure 3). However, there were more than 3 different VT morphologies observed during mapping. Despite achieving complete circumscription of the apical scar with radiofrequency (RF) energy application, there was modification of the VT morphology on several occasions (4 different morphologies identified, with cycle lengths of 390, 350, 360, 266 and 235 milliseconds). During RF application in the superior-anterior region of the apical scar there was conversion to sinus rhythm, yet there was VT recurrence after 15 minutes, with a different morphology, which was successfully converted to sinus rhythm with DC external cardioversion 200J.

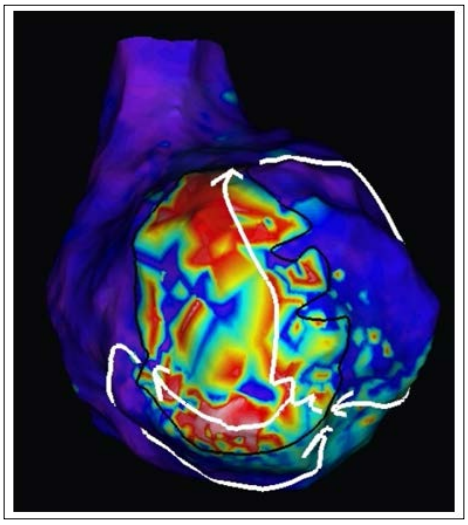


Figure 3: Electrophysiological study and VT catheter ablation
Activation mapping of one VT morphology showing a re-entry circuit dependent on 2 regions of slower activation, in the apical-anterior and the apical-mid-lateral region of the LV.

Discussion

Electrical storm can have a challenging management, refractory to every therapeutic measure undertaken. In this clinical case, several therapeutic steps were undertaken including anti-arrhythmic therapy (with amiodarone, lidocaine and esmolol), anti-tachycardia pacing and ICD basal heart rate programming, cardioversion (both external and via ICD), patient sedation and mechanical ventilation, extracorporeal life support with VA-ECMO, vasopressors, and finally VT catheter ablation under ECMO support (Figure 4).

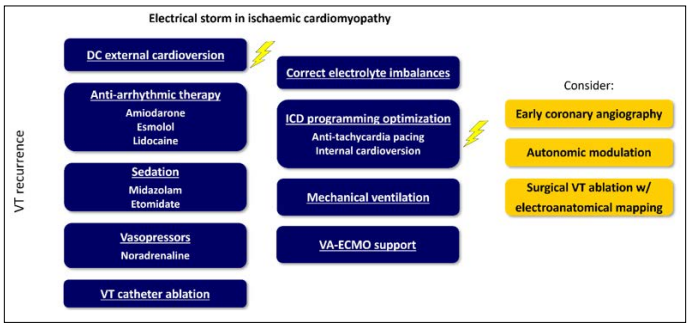


Figure 4: Step-by-step approach undertaken in the management of refractory electrical storm in this clinical case (graphical abstract)

According to the 2022 European Society of Cardiology Guidelines for the management of patients with ventricular arrhythmias, VT catheter ablation can acutely terminate VT and has been shown to decrease the rate of recurrent electrical storm episodes when compared with medical treatment only. Moreover, patients with VT related to post-myocardial scar tend to have a better outcome following catheter ablation than patients with VT due to non-ischaemic cardiomyopathy [1]. In patients with haemodynamic instability due to incessant VT, VA-ECMO can also safely provide the necessary haemodynamic support for the duration of the VT catheter ablation [5-6].

Despite all the aforementioned measures, in this case of severe ischaemic cardiomyopathy with extensive myocardial scar, the patient had a poor outcome with incessant VT leading to haemodynamic collapse. While progression of the ischaemic heart disease was a possible factor, due to the swift clinical deterioration and the history of severe coronary disease with multiple interventions, coronary angiography at admission was postponed. Another option that may be undertaken in patients refractory to anti-arrhythmic therapy is autonomic modulation, with percutaneous stellate ganglion blockade, thoracic epidural anaesthesia or renal sympathetic denervation [7-9]. In refractory cases, surgical VT ablation guided by intraoperative electrophysiology mapping may also be performed in experienced centres [10].

Statement of Consent: The patient's next of kin has provided informed consent for the submission of this manuscript, in accordance with COPE guidelines.

Funding: The authors report no funding, grants, contracts, or other forms of financial support. The authors report no relationships with industry or conflicts of interest.

Highlights:

- Review of the step-by-step approach of a patient with severe ischaemic cardiomyopathy admitted in refractory electrical storm
- Evidence-based management including anti-arrhythmic therapy, manual ICD programming optimization including anti-tachycardia pacing and cardioversion, sedation, mechanical ventilation and haemodynamic support
- Discussion of the role of VT catheter ablation in a severe case and VA-ECMO haemodynamic support in electrical storm

References

1. Baratto F, Pappalardo F, Oloriz T, Bisceglia C, Vergara P, et al. (2016) Extracorporeal Membrane Oxygenation for Hemodynamic Support of Ventricular Tachycardia Ablation. Circulation: Arrhythmia and Electrophysiology 9.
2. Do DH, Bradfield J, Ajijola OA, Vaseghi M, Le J, et al. (2017) Thoracic Epidural Anesthesia Can Be Effective for the Short-Term Management of Ventricular Tachycardia Storm. Journal of the American Heart Association 6: e007080.
3. Fudim M, Boortz-Marx R, Ganesh A, Waldron NH, Qadri YJ, et al. (2017) Stellate ganglion blockade for the treatment of refractory ventricular arrhythmias: A systematic review and meta-analysis. Journal of Cardiovascular Electrophysiology 28: 1460-1467.
4. Kunkel M, Rothstein P, Sauer P, Zipse MM, Sandhu A, (2021) Open surgical ablation of ventricular tachycardia: Utility and feasibility of contemporary mapping and ablation tools. Heart Rhythm 2: 271-279.
5. le Pennec-Prigent S, Flecher E, Auffret V, Leurent G, Daubert JC, et al. (2017) Effectiveness of Extracorporeal Life Support for Patients With Cardiogenic Shock Due To Intractable Arrhythmic Storm. Critical Care Medicine 45: e281-e289.
6. Mariani S, Napp LC, lo Coco V, Delnoij TSR, Luermans JGLM, et al. (2020) Mechanical circulatory support for life-threatening arrhythmia: A systematic review. International Journal of Cardiology 308: 42-49.
7. Sapp JL, Wells GA, Parkash R, Stevenson WG, Blier L, et al. (2016) Ventricular Tachycardia Ablation versus Escalation of Antiarrhythmic Drugs. New England Journal of Medicine 375: 111-121.
8. Vaseghi M, Barwad P, Malavassi Corrales FJ, Tandri H, Mathuria N, et al. (2017) Cardiac Sympathetic Denervation for Refractory Ventricular Arrhythmias. Journal of the American College of Cardiology 69: 3070-3080.
9. Vergara P, Tung R, Vaseghi M, Brombin C, Frankel D, et al. (2018) Successful ventricular tachycardia ablation in patients with electrical storm reduces recurrences and improves survival. Heart Rhythm 15: 48-55.
10. Zeppenfeld K, Tfelt-Hansen J, de Riva M, Winkel BG, Behr ER, et al. (2022) 2022 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death. European Heart Journal https://doi.org/10.1093/eurheartj/ehac262.