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ADVANCED

CASE REPORT: CLINICAL CASE

Bilateral Cardiac Sympathectomy and Extrapericardial Coil Implantation for the Management of Electrical Storm

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ABSTRACT

We present a novel multidisciplinary approach for the treatment of electrical storm combining bilateral cardiac sympathectomy, extrapericardial coil insertion, and implantable cardioverter defibrillator upgrade in a patient with nonischemic cardiomyopathy and ventricular arrhythmias refractory to conventional therapies. (**Level of Difficulty: Advanced.**)

HISTORY OF PRESENTATION

A 35-year-old male athlete presented to the hospital in August 2019 following his fourth out-of-hospital cardiac arrest (OHCA) caused by an episode of refractory ventricular tachycardia (VT) and ensuing electrical storm. Eleven minutes later, the arrhythmia was terminated by an external shock delivered by emergency medical responders before arrival at the emergency department.

On presentation, his blood pressure was 107/69 mm Hg, pulse was 63 beats/min, and resting oxygen saturation was 95%. There was no jugular venous distension, cardiac auscultation revealed no extra heart sounds or murmurs, and the remainder of the physical examination findings were within normal limits. His medications included bisoprolol 2.5 mg daily, mexiletine 100 mg thrice daily, amiodarone 200 mg daily, and candesartan 4 mg daily. Device interrogation showed wide complex tachycardia with 1 predominant morphology that degenerated to polymorphic VT despite 5 bursts of antitachycardia pacing (ATP) and 10 implantable cardioverter-defibrillator (ICD) shocks (**Figure 1**).

LEARNING OBJECTIVES

- To illustrate a novel approach in the management of patients with VAs refractory to standard therapy.
- To recognize the importance of multidisciplinary collaboration in the management of patients with complex heart failure.

MEDICAL HISTORY

The patient is known for a nonischemic cardiomyopathy awaiting heart transplantation, New York Heart Association functional class I. He initially presented in 2012 following an OHCA due to VT, for which a single-chamber ICD was inserted for

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ABBREVIATIONS AND ACRONYMS

AAD = antiarrhythmic drug

ATP = antitachycardia pacing

CSD = cardiac sympathetic denervation

ICD = implantable cardioverter-defibrillator

OHCA = out-of-hospital cardiac arrest

VA = ventricular arrythmia

VT = ventricular tachycardia

secondary prevention. In 2016, he experienced his third OHCA due to unstable ventricular arrythmia (VA) despite amiodarone and mexiletine and therefore underwent an endocardial and epicardial ablation, which was complicated by pericarditis and adhesions. Cardiovascular magnetic resonance imaging revealed a left ventricular ejection fraction of 43% and a pattern suggestive of either arrhythmogenic right ventricular dysplasia with left ventricular involvement or sequelae of previous perimyocarditis. Genetic testing was nondiagnostic.

DIFFERENTIAL DIAGNOSIS

Alternative causes of wide QRS complex tachycardia, such as supraventricular tachycardia with aberrancy and device malfunction (e.g., lead fracture), were ruled out following device interrogation in the emergency department.

INVESTIGATIONS

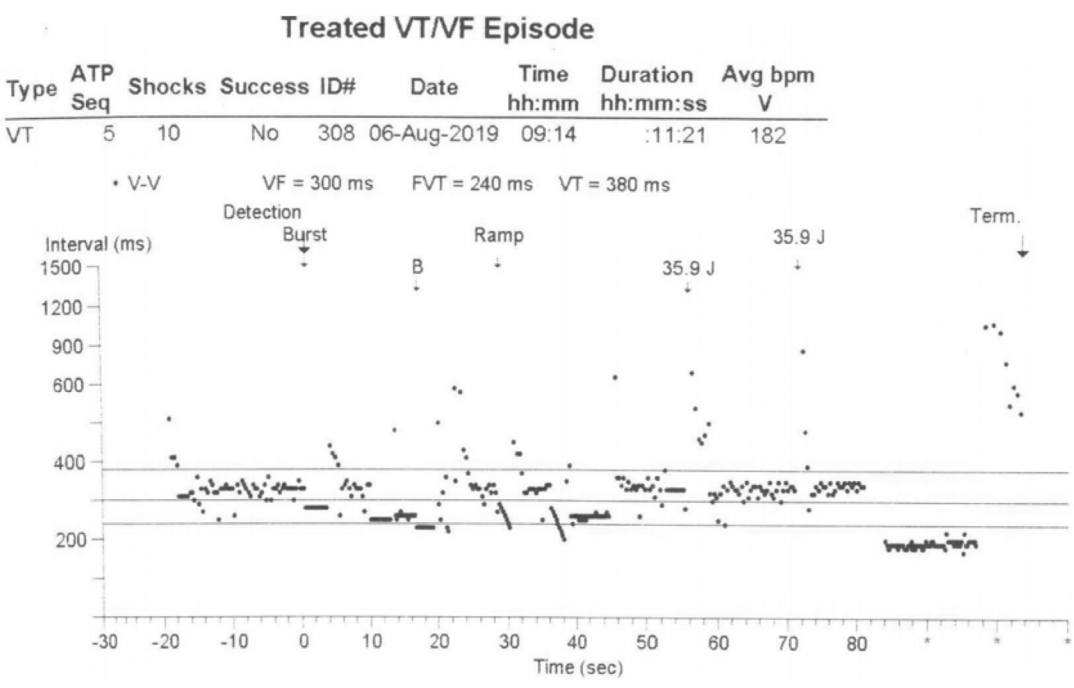
An interrogation of the patient's ICD showed an episode of VT that degenerated into ventricular fibrillation. Transthoracic echocardiography showed biventricular dysfunction and a left ventricular ejection fraction of 20%. Troponins and metabolic workup were unremarkable.

MANAGEMENT

After discussion between the cardiology, electrophysiology, and thoracic surgery teams, the patient was presented with the option of bilateral cardiac sympathetic denervation (CSD) and ICD device upgrade with the addition of an atrial lead. Furthermore, implantation of an extrapericardial defibrillator coil was suggested to improve the defibrillation threshold.

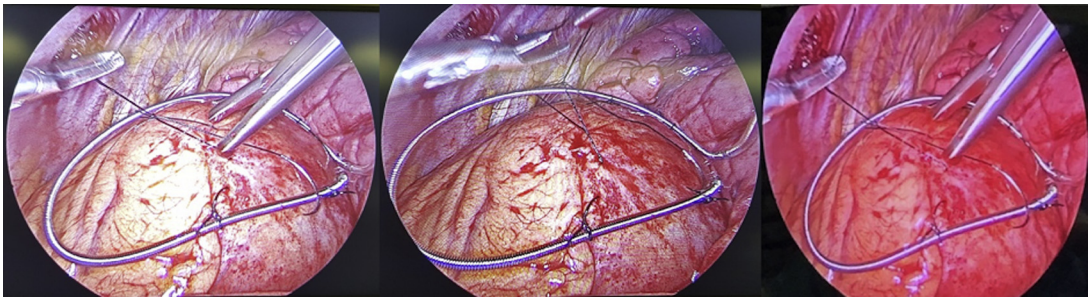
The patient consented to video-assisted thoracoscopic surgery under general anesthesia. A thoracic epidural catheter was placed at T3 to T4 and bupivacaine was administered to prevent arrhythmias during induction. Vascular access was secured in case of potential recurrence of VAs requiring extracorporeal membrane oxygenation. The left lung was deflated, and the patient was positioned in left lateral decubitus. The inferior third of the stellate ganglion and T1 to T5 sympathetic ganglia were transected on

FIGURE 1 Implantable Cardioverter-Defibrillator Dot Graph



Ventricular tachycardia (VT) episode that failed to terminate despite implantable cardioverter-defibrillator shock and required external defibrillation. ATP = antitachycardia pacing; B = burst; bpm = beats/min; FVT = fast ventricular tachycardia; ID = identification; V = ventricular rate; VF = ventricular fibrillation; VT = ventricular tachycardia; V-V = ventricular cycle length.

FIGURE 2 Insertion of an Extrapericardial Defibrillator Coil



The lung was mobilized to expose the lower aspect of the pericardium. The defibrillator coil was sutured on the outer pericardium in a circular fashion, ensuring good contact with the posterior aspect of the heart, away from the phrenic nerve.

the left side. This was followed by the implantation of a defibrillator coil in the pleural space, against the lateral wall of the left ventricle (**Figure 2**). The left lung was then reinflated, and the patient was placed supine. A right atrial pacing lead was added transvenously, the ICD generator was replaced, and the pleural coil was connected. Subsequently, a right-sided sympathectomy was completed. Defibrillation threshold testing was performed and confirmed a threshold of <25 J. The procedure was completed without complications (**Figure 3**). The epidural catheter infusion was continued for 48 h with a mixture of bupivacaine and fentanyl.

No recurrence of VAs was observed in the following days. There was no evidence of pneumothorax, bleeding, Horner syndrome, or compensatory hyperhidrosis. Five days later, the patient was discharged with follow-up in the heart failure, electrophysiology, and thoracic surgery clinics.

DISCUSSION

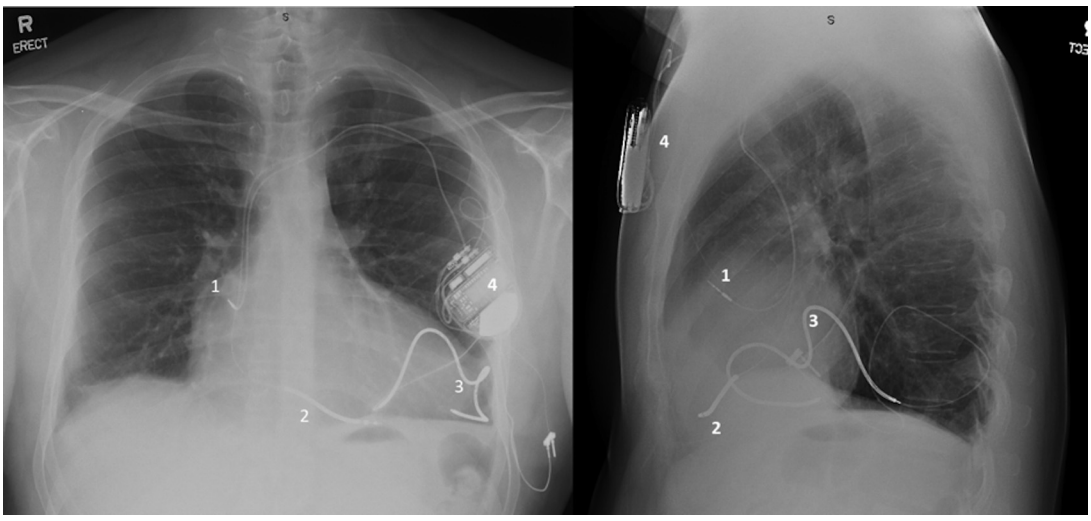
To our knowledge, this is the first reported case of a single procedure combining thoracoscopic bilateral CSD, implantation of an extrapericardial defibrillator coil, and ICD device upgrade in a patient with refractory VAs, structural heart disease, and an inaccessible pericardium.

Congestive heart failure is associated with autonomic dysregulation, which may lead to a higher VA burden, consequently increasing the risk of sudden cardiac death (1,2). Thus, CSD is increasingly recognized as an effective adjunct therapy to reduce the incidence of VAs refractory to antiarrhythmic drugs (AADs) and/or catheter ablation in patients with structural heart disease (3,4). Bilateral CSD was preferred over a left-sided one for this patient, given data showing more profound arrhythmia suppression, prolonged ICD shock-free periods, and transplant-free survival with this approach (4–6).

Given our patient's recurrent OHCAs despite endocardial and epicardial ablation, repeating an ablation was thought to be of limited yield, especially in the context of previous pericarditis and adhesions. Moreover, the patient's VAs failed to terminate despite maximal shock output from the ICD. Therefore, an extrapericardial defibrillator coil was implanted to maximize the area of the myocardium covered and improve the defibrillation vector, thereby reducing the defibrillation threshold. Video-assisted thoracoscopic surgery was chosen because it is a safe alternative to sternotomy and is associated with lower morbidity (7). In addition, an intrapericardial coil was not suitable in anticipation of future cardiac transplantation and, in this case, not possible due to previous adhesions. An alternative would have been inserting a tunneled subcutaneous coil as a separate procedure. However, given its uncertain effectiveness (8) and the suboptimal efficacy of the patient's pre-existing ICD, an extrapericardial coil was instead inserted at the same time as the CSD to maximize the chances of a successful outcome.

Finally, the patient's single-lead ICD was upgraded. Although the implantation of a single versus dual chamber device remains controversial (9), advantages of the latter approach include the ability to sense and pace the atrium. This was especially relevant to this patient, given his resting sinus bradycardia that could have been exacerbated by

FIGURE 3 Post-Procedure Posteroanterior and Lateral Chest X-Ray Films



1 = right atrial lead; 2 = ventricular lead; 3 = epicardial coil overlying the left ventricle; and 4 = defibrillator generator.

unopposed vagal tone after bilateral sympathectomy. Moreover, this upgrade allowed for atrioventricular synchrony, thereby facilitating up-titration of AADs.

FOLLOW-UP

After discharge, the patient reported shortness of breath. Transthoracic echocardiography findings were stable, but his heart rate failed to augment during a 6-m walk test. This was attributed to the bilateral sympathectomy and medications. He improved with the adjustment of his ICD's rate response feature. However, a chest computed tomography revealed amiodarone pulmonary toxicity. Following its discontinuation, episodes of slow nonsustained VT recurred but were successfully terminated by ATP. Therefore, sotalol was added to his pharmacotherapy. In July 2020, the patient was briefly admitted after receiving an effective ICD shock following unsuccessful ATP, and his AADs were uptitrated. One year following the procedure, no OHCAs have occurred.

CONCLUSIONS

This therapeutic innovation served as a bridge to heart transplantation and was made possible through a multidisciplinary collaboration. This approach may have resulted in fewer complications and in a shorter hospitalization compared to multiple serial procedures to achieve the same outcome. Future prospective studies with longer follow-up durations are needed to evaluate the long-term efficacy of such a multimodal approach.

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The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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REFERENCES

1. Lip GY, Heinzel FR, Gaita F, et al. European Heart Rhythm Association/Heart Failure Association joint consensus document on arrhythmias in heart failure, endorsed by the Heart Rhythm Society and the Asia Pacific Heart Rhythm Society. Europace 2016;18:12–36.

2. Santangeli P, Rame JE, Birati EY, Marchlinski FE. Management of ventricular arrhythmias in patients with advanced heart failure. J Am Coll Cardiol 2017;69:1842–60.

3. Bourke T, Vaseghi M, Michowitz Y, et al. Neuraxial modulation for refractory ventricular arrhythmias: value of thoracic epidural anesthesia and surgical left cardiac sympathetic denervation. Circulation 2010;121:2255–62.

4. Shah R, Assis F, Alugubelli N, et al. Cardiac sympathetic denervation for refractory ventricular arrhythmias in patients with structural heart

disease: a systematic review. Heart Rhythm 2019; 16:1499–505.

5. Ajijola OA, Lellouche N, Bourke T, et al. Bilateral cardiac sympathetic denervation for the management of electrical storm. J Am Coll Cardiol 2012; 59:91–2.

6. Vaseghi M, Barwad P, Malavassi Corrales FJ, et al. Cardiac sympathetic denervation for refractory ventricular arrhythmias. J Am Coll Cardiol 2017;69:3070–80.

7. Czapla J, Wellens F, Nijs J, La Meir M. Video-assisted thoracoscopic implantation of cardioverter-defibrillator systems. Ann Thorac Surg 2014;98:1855–7.

8. Aydin A, Hartel F, Schluter M, et al. Shock efficacy of subcutaneous implantable cardioverter-defibrillator for prevention of sudden cardiac death: initial multicenter experience. Circ Arrhythm Electrophysiol 2012;5:913–9.

9. Worden NE, Alqasrawi M, Krothapalli SM, Mazur A. "Two for the price of one": a single-lead implantable cardioverter-defibrillator system with a floating atrial dipole. J Atr Fibrillation 2016;8: 60–5.

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