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Termination of Hemodynamically Stable VT Storm *via* Double Sequential External Synchronization

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ABSTRACT

Ventricular Tachycardia (VT) is a clinical challenge for medical personnels. Even though the algorithm regarding management of tachycardia has been established, VT might progress to Electrical Storm (ES) despite adequate medical or electrical interventions. Critical complications such as cardiogenic shock or eventually cardiac arrest occur if the ES could not be stopped in a moment. Double Sequential External Defibrillation (DSED) might be an alternative solution for refractory Ventricular Fibrillation (VF) storms, which also could be applied on those with refractory ventricular tachycardia.

Keywords: Refractory ventricular tachycardia, Double sequential electrical synchronization, Electric storm.

INTRODUCTION

The management of VT could be pharmaceutical or electrical cardio version, which depends on whether the hemodynamic condition of patients is stable. However, sometimes VT couldn't be restored to normal cardiac rhythm with standard treatment. Refractory VT, also known as Electrical Storm (ES), is defined by over three episodes of VT during a 24-hr period, which lead to a high mortality rate. An algorithm for management of ES published and provided several effective treatments, like catheter ablation, neuraxial modulation and extracorporeal membrane oxygenation [1]. Based on a previous study, around 10%-20% of patients with ES required implantation of Implantable Cardioverter Defibrillators (ICD) [2].However, in the setting of the Emergency Department (ED) or at the hospital lacking resources; these tools might not be available. Therefore an alternative intervention to terminate the ES after failed attempt of pharmaceutical or traditional cardioversion is necessary. If the initial single-dose electrical cardio version couldn't terminate VT, increasing the energy dosage is recommended. However there is the maximum dosage of each defibrillator, which makes dual-dose cardio version an alternative

option while the termination with the maximum dosage failed. Nevertheless, the feasibility is in doubt regarding the safety and efficacy. In this article, we reviewed two cases of refractory unstable VT terminated by Double Sequential External Synchronization (DSES). DSES used to be applied to patients with VF or hemodynamically unstable patients with refractory VT. In this article, we also presented our case who suffered from refractory VT despite pharmaceutical and cardioversion intervention. Even though his hemodynamic status was stable, DSES was applied taking consideration of his previous myocardial infarction in the last 1 month. Tachycardia would compromise the blood flow to coronary arteries, which would lead to a vicious circle of ischemic heart.

CASE PRESENTATION

Gerstein, et al. presented a 41-year-old male with 10 days of upper respiratory infection symptoms. Relative hypotension (blood pressure: 91/61 mm Hg) and wide-complex tachycardia were found [3]. They delivered a combined 560-J shock and the other 720-J shock to the patient, but both attempts failed. However, one of the defibrillators malfunctioned the next day after a dual-dose cardio version attempt. Sheikh, et al. demonstrated a 79-year-old male with dyspnea, presyncope and nausea. He was tachycardia with undetectable blood pressure [4]. The first and the second single-dose electrical cardioversion (200-J shock) were unable to stop the VT storm, while it was successfully terminated after a combined 400-J shock. Elevated cardiac enzymes were found after the cardio version. A 56-year-old Asian man went to our Emergency Department (ED) with a complaint of palpitation ongoing for the entire day. His medical history revealed that he had a heart attack around 1 month ago, during which his percutaneous coronary intervention revealed 85% stenosis of the left anterior descending artery along with a drug-eluting stent to his right coronary artery. Upon arrival, the patient was fully conscious with normal blood pressure (SBP: 115 mm Hg). His heart rate was around 190 bpm, while the 12-lead electrocardiogram revealed monomorphic VT (Figure 1). He denied any hemodynamically unstable symptoms such as short of breath, dizziness or chest tightness. Considering the patient's stable hemodynamic condition, pharmacological cardioversion with amiodarone (150 mg) infusion was prescribed, which failed to convert the VT. The continuous amiodarone pump infusion was given thereafter. Refractory VT persisted despite our pharmaceutical intervention. Cardiologist was consulted who suggested electrical cardioversion considering persisted tachycardia would jeopardize his pre-existing ischemic heart condition, while neither catheter ablation nor ECMO was available in time. Therefore, we attempted synchronized electrical cardioversion with an initial single-dose biphasic 100-Joule (J) shock using a philips heart start XL monitor defibrillator (Philips Medical Systems, 3000 Minuteman Road Andover, MA USA 01810-1099). However, the initial shock was ineffective. Subsequently, we administered a single-dose 150-J shock and another 200-J synchronized biphasic cardioversion, which both attempts failed. Double Sequential External Synchronization (DSES) was considered. Two sets of defibrillation pads of philips heart start XL Monitor defibrillators were placed as the Figure 2. Total 350-J synchronized biphasic cardioversion was given by two emergency physicians simultaneously. The initial attempt failed, but a second DSES with a combined synchronized biphasic shock of 350 J restored normal sinus rhythm (Figure 3). Patient tolerated the whole procedure well without any discomfort, including chest pain or dyspnoea. The cardiologist performed catheterization a few hours later on the same day which revealed total occlusion of the left anterior descending artery. Thus, a second drug-eluting stent was implanted. The patient was discharged three days after catheterization; during the hospital stay, no complications or recurrent VT events took place (Figures 1-3).

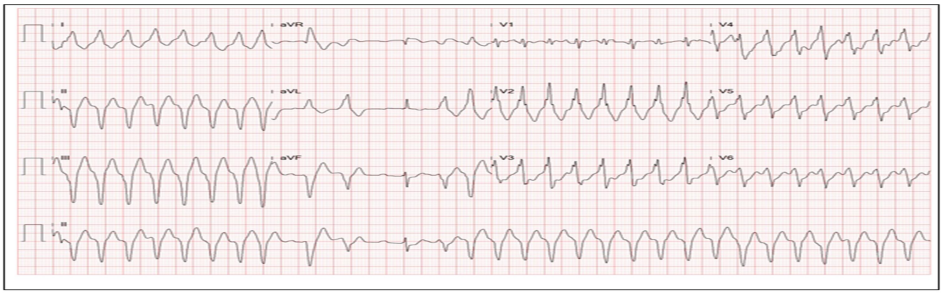

Figure 1: ECG upon visiting.

Figure 2: Position of paddles.

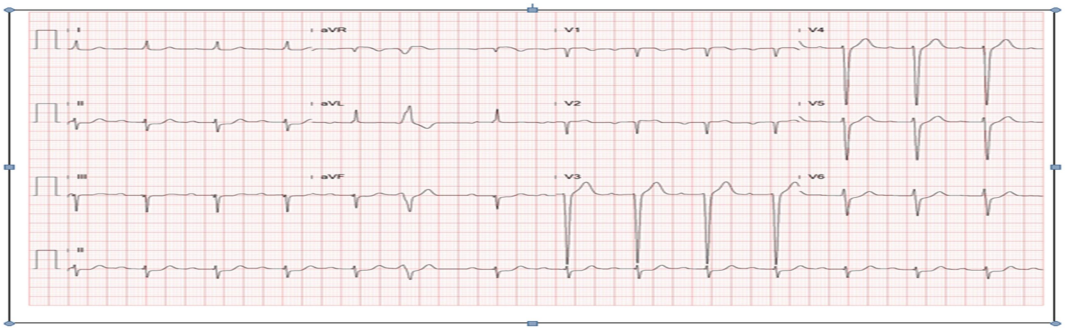

Figure 3: ECG after DSES.

RESULTS AND DISCUSSION

Management of ventricular tachycardia and electrical storm

Electrical storm is defined as the occurrence of more than three VT/VF episodes within 24 hours. Generally, the management of ES could be divided into pharmaceutical and non- pharmaceutical. Beta-blockers, amiodarone, sotalol and lidocaine are all capable of terminating ventricular arrhythmias. Deep sedation, Intra Cardiac Defibrillators (ICD), catheter ablation and autonomic modulation are considered as non-pharmacologic interventions, which ICD implementation could greatly change the survival rate. Meanwhile, Extra Corporeal Membrane Oxygenation (ECMO) and cardiac transplantation might be taken into consideration after the above treatments fail [5-8].

Advanced cardiac life support guidelines suggest that pharmacological cardioversion is the first-line management for hemodynamically stable VT. However, for patients with structural heart disease, the 2017 AHA guidelines [5] recommend electrical cardioversion (class I) over pharmacological cardioversion (class II a and II b). In this case, electrical cardioversion and catheter ablation are the preferred options, though catheter ablation may not always be feasible.

Therefore, initial single-dose cardio version with a biphasic 100-J is the preferable intervention for intractable hemodynamically stable VT. The guidelines also recommend that practitioners could deliver shocks with increasement in electric energy if the first attempt failed. The maximum energy of a single defibrillator is approximately 150–200 J depending on the manufacturer. However, VT may remain despite the fact that the maximum dose of a single defibrillator was applied.

Double sequential external defibrillation in refractory shockable rhythm

In 1994, Hoch, et al. introduced the concept of Double Sequential External Defibrillation (DSED) for refractory ventricular defibrillation [9]. DSED offers an alternative effective treatment for patients with intractable VF, though this is still considered an unapproved treatment

according to 2020 AHA guidelines (class II b). An on-going randomized controlled trial, double sequential external defibrillation for refractory ventricular fibrillation attempts to clarify benefits of DSED and Vector Change (VC) defibrillation compared to classical one [10].

Double sequential external synchronized cardioversion

Indication: Standard pharmacological or electrical cardioversion may fail to terminate ventricular tachycardia in certain groups. First, people with hereditary channelopathies, such as Brugada syndrome and long QT syndrome, without structure abnormalities, must be taken into consideration. Second, people with structural abnormalities such as coronary artery disease, on-going acute coronary syndrome, congestive heart failure, and cardiomyopathies. Third, for patients inapplicable or contraindicated to certain antiarrhythmic, such as allergy, pregnancy and lactation. For these groups, once the standard electrical cardioversion fails to convert to normal rhythm, DSES should be taken into consideration.

Complication: DSES may result in elevated cardiac enzymes, whether it could be the consequence of prolonged cardiac arrhythmia or the damage followed by electric defibrillation, according to previous reports.

Effect: Nowadays, the efficacy of DSES still remains uncertain due to lack of clinical trials. Devastating results may also occur due to lack of experience with DSES procedures. First, the mechanism was not well understood, while which group of patients would benefit the most from this intervention was still at debate. Second, due to the paucity of cases treated with this intervention, possible complications of DSES were also unclear. Further research is required to determine the benefits and potential harms of this procedure.

Back to our patient

To our knowledge, this is the first reported case of successful conversion of a hemodynamically stable VT storm to a normal sinus rhythm using DSES. For patients with structural heart diseases, including ischemic heart disease, uncontrollable VT may have severe consequences, Such as cardiogenic shock, acute heart failure, and eventually cardiac arrest. Given that our patient experienced a recent myocardial infarction, refractory VT might have aggravated myocardial ischemia.

Therefore, we had to terminate VT immediately despite our patient's relatively stable hemodynamic condition. Because our treatment with pharmacological cardioversion and single-dose electro cardioversion failed, we used DSES, despite a lack of precedence for its efficacy. Refractory VT or VF presents many challenges for clinicians, especially when treating patients' structural abnormalities. Devastating consequences (such as acute heart failure and cardiopulmonary failure) may occur suddenly in such patients.

CONCLUSION

Terminating VT in a timely manner is our first priority, and the clinical decision of intervention solely depends on a patient's hemodynamic status. Therefore, we present our case to raise awareness that DSES could play an important role in terminating refractory VT, even in patients with a stable hemodynamic condition. Refractory stable wide-complex tachyarrhythmia is a catastrophic event commonly encountered in the ED. However, when single-dose electrical cardioversion fails, alternatives are required one of which is DSES.

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