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CASE REPORT

# Case Reports on Successful Use of Two Defibrillators Sequentially for Refractory Ventricular Fibrillation

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## ABSTRACT

Double Sequence Defibrillation (DSD) is a proposed management strategy for refractory ventricular fibrillation that involves using two defibrillators rapidly in sequence at their maximum permitted energy level. Two sets of defibrillator pads are positioned: one in the anterior-lateral position and the other in the anterior-posterior position. The two defibrillation buttons are pushed one after the other in quick succession.

Here we report two cases of in-hospital cardiac arrests due to refractory VF where Double Sequence Defibrillation was implemented. In the first case, a 23-year-old male presented with chest pain and had witnessed cardiac arrest, and after multiple defibrillation attempts including a double sequential defibrillation, he regained spontaneous circulation, ultimately leading to a full neurological recovery. The second case involved a 53-year-old male who, after experiencing a witnessed cardiac arrest, was successfully resuscitated using double sequential defibrillation after unsuccessful initial three single defibrillation attempts. These cases highlight the potential of double sequential defibrillation (DSD) as a promising intervention for patients with refractory VF, warranting further investigation into its role in improving outcomes.

## Introduction

More than 700,000 people die from sudden cardiac arrest each year in Europe and the USA, making it the third most common cause of death in developed countries. Almost one-third of these deaths are caused by ventricular fibrillation (VF) or pulseless ventricular tachycardia (pVT).[1] Patients who present with shockable rhythms, such as ventricular fibrillation and pulseless ventricular tachycardia (pVT), are key predictors of survival.[2,3] Therefore, improving survival rates with favourable neurological outcomes in these patients relies on recognizing and effectively managing VF. Despite advancements in resuscitation techniques and their widespread availability, some patients remain in VF even after receiving several standard defibrillations.[3] According to the current literature, VF is considered refractory if it persists after 3 or more shocks, and this definition has been incorporated into current guidelines.[4,5,6,7] Current estimated incidence of refractory VF is between 0.5 and 0.6 per 100,000 people.[6] Of all patients who present with ventricular fibrillation, it is estimated that about 20% of them could go into refractory VF.[7] When the defibrillation technique and overall management follows the traditional pathway, further defibrillations in these individuals typically fail, leading to higher mortality and poor neurological outcome in survival.[3,4,6]

Current Resuscitation Council guidelines suggest escalating the shock energy, changing the defibrillator pad position to anteroposterior position, also known as vector change defibrillation (VC), and administering anti-arrhythmic drugs such as Amiodarone or Lidocaine to manage such scenarios.[7, 8]

Double sequential defibrillation (DSD) is a technique where two defibrillators are used in two different planes (conventional anterolateral position and anteroposterior position) to deliver two defibrillations in quick succession.[3,5,6] Currently, there is only one randomized trial that has shown increased survival rates and improved neurological outcomes among out-of-hospital cardiac arrest patients who received double sequential defibrillation compared to those who underwent standard defibrillations.[3]

In our case reports, we describe two in-hospital cardiac arrests characterized by refractory VF, where patients received double sequential defibrillation and ultimately achieved good neurological outcomes at discharge.

## Case 1

A 23-year-old male presented to the emergency department with acute, severe chest pain characterized by a tightening sensation lasting for 20 minutes. The pain radiated to his neck and was accompanied by diaphoresis and nausea. The ECG performed within five minutes of arrival revealed massive hyperacute T waves in the anterior and lateral regions, raising the possibility of a hyperacute Left Anterior Descending (LAD) artery occlusion. Shortly after the ECG was recorded, the patient became unresponsive, and cardiac arrest was confirmed. CPR was initiated according to the Advanced Life Support algorithm. The initial rhythm was ventricular fibrillation (VF). The first three stacked DC shocks were administered at 150J, 240J, and 300J, respectively. Following the third shock, IV adrenaline (1:10,000, 1 mg) and IV amiodarone (300 mg) were administered. Given the initial ECG findings, the decision to administer thrombolysis was made. The patient received IV Enoxaparin 30 mg and IV Tenecteplase 35 mg. During the fifth cycle of CPR, the patient remained in VF. Therefore, a double sequential defibrillation was performed by two operators, using manual defibrillator paddles in the conventional antero-lateral position and disposable defibrillation pads in the antero-posterior position. A rhythm check at the end of the cycle revealed pulseless electrical activity. After five more cycles of CPR, spontaneous circulation was regained. The total downtime was 45 minutes. A subsequent coronary angiogram revealed 70-90% stenosis in the ostial to proximal portion of the Left Anterior Descending artery, which was successfully stented. The patient was discharged on day 17 with a full neurological recovery.

## Case 2

A 53-year-old male patient presented at the emergency department with symptoms of cardiac-type chest pain. Upon evaluation, the patient was found to be hemodynamically stable but experiencing acute pain and profuse sweating. The ECG on arrival demonstrated an inferoposterior ST elevation MI. He was promptly connected to a defibrillator and closely monitored. Initial treatment included the administration of 3 mg of IV Morphine as analgesia and 300 mg stat doses of Aspirin and Clopidogrel. Subsequently, the patient received 30mg of IV Tenecteplase for thrombolysis.

The patient then experienced a VF cardiac arrest, and he received three stacked defibrillations at 150 J each, followed by CPR as per standard ALS protocol. Despite two subsequent shocks at 300 J, the patient remained in ventricular fibrillation (VF) arrest. I the next cycle, a Double Sequential Defibrillation was performed with two operators. The defibrillator pads were placed at anterior-posterior and standard anterior-lateral locations. Return of spontaneous circulation (ROSC) was confirmed during the subsequent rhythm check. Following this, the patient underwent a rescue PCI which revealed an ulcerated plaque in proximal Right Coronary Artery, which was successfully stented. The patient remained hospitalized for 10 days and was ultimately discharged with a full neurological recovery.

## Discussion

The idea of double defibrillation for refractory VF is not particularly novel. Recently its popularity has increased, and several case reports and case series have been published.[14] Despite its emerging popularity, recent studies indicate no evidence supporting the routine use of double sequential defibrillation in clinical practice, as relevant confounders were not accounted for, leading to a serious risk of bias in those studies.[7,9]

A prehospital procedure for the application of DSD following five failed ventricular fibrillation (VF) shocks was employed by Cabanas et al. in 2014, where they reported on ten instances where patients were given a double sequential defibrillation after establishing that they were in refractory VF.[10] Seven of the ten patients had return of spontaneous circulation (ROSC). Nevertheless, none of these patients made it to the point of hospital discharge; Resuscitation time bias and other confounding factors might have complicated the outcome of these cases. However, it was suggested that increased rates of ventricular fibrillation termination may be linked to early DSD application.[11]

The DOSE-VF trial, which was released in 2022, is the first randomized controlled trial to directly compare DSD and vector change (VC) defibrillation to conventional defibrillation for adult patients who are still experiencing refractory VF during an out-of-hospital cardiac arrest.[3] It is a cluster-randomized trial with crossover among six Canadian paramedic services to evaluate DSD and VC defibrillation as compared with standard defibrillation in adult patients with refractory ventricular fibrillation during out of-hospital cardiac arrest. The survival to hospital release was the main outcome. VF termination, spontaneous circulation restoration, and survival with a satisfactory neurologic outcome—defined as a modified Rankin Scale score of <2 at hospital discharge—were secondary outcomes. Interestingly, compared to conventional defibrillation, DSD (RR 2.21; 95% CI 1.26–3.88) but not VC defibrillation was linked to a larger percentage of patients attaining a satisfactory neurological result (RR 1.48; 95% CI 0.81–2.71).[3]

It is believed that the shock defibrillates via changing the cardiac myofibers' transmembrane potential. According to certain mathematical models, the shock's effect on the transmembrane potential over much of the myocardium is linearly correlated with the extracellular potential gradient it creates.[12] Refractory VF frequently recurs in the area of the myocardium with the lowest voltage and current gradient when defibrillation is unable to stop it.[12]

Both DSD and vector change (VC) defibrillation strategies may be useful in treating refractory VF, based on several hypotheses. Firstly, changing the vector or multiple vectors may provide better intracardiac current flow than the traditional single vector. Since all of the left and right ventricles might not be covered by a single current vector, the overall quantity of myocardium defibrillated may be enhanced by adding a second vector. The left ventricle may not get enough defibrillation with the traditional anterior-lateral pad placement, because of its more posterior anatomical location; this is the area of the heart that is far from the straight line connecting the conventional anterior-lateral defibrillation pad position. Disorders like dilated cardiomyopathy or left ventricular hypertrophy may exacerbate this unfavourable placement of the left ventricle. Therefore, compared to typical anterior-lateral pad location, antero-posterior defibrillation may provide a greater voltage gradient over the posterior portion of the left ventricle, increasing the likelihood that the defibrillation will entirely terminate the arrhythmia. With more energy provided by the second defibrillator shock, DSD offers more potential advantage than the simple vector-change (VC) defibrillation.[13]

Secondly, defibrillation lasts longer because two defibrillators discharge their energy in brief series rather than in perfect synchronization. A minimal time lapse (about 85 msec) between the two shocks (hence sequential) may also lower the defibrillation threshold energy, according to older animal studies and more recent computer simulation models of electrical defibrillation.[5,14]

In the two cases we described, DSD was used after the fifth and third shock respectively. Both were witnessed in-hospital cardiac arrests with a clear reversible cause, namely ischaemia, which was addressed in form of thrombolysis while performing the advanced life support (ALS) algorithm. The patients were fairly young, therefore with presumed good physiological reserves. All of these factors may have contributed to the good neurological outcome in these two patients, along with timely application of Double Sequential Defibrillation.

Since it is well known that the earlier the VF is defibrillated, the higher the chance of neurologically intact survival, we employed DSD after three shocks in the second case. We believe the positive experience with the first case played a role in decision-making in the second. We were unable to locate any documented instances of negative consequences resulting from the usage of DSD in the current literature. However, there are still many unresolved questions with regard to this novel method. Firstly, we are unsure when applying a double sequential defibrillation would be suitable or optimal in a resuscitation; would it be after one single shock, three single shocks, or even later in the algorithm? Secondly, as we are currently using the maximum possible energy levels, we are unsure whether DSD would be feasible with low energy levels.

To further assess double sequential defibrillation (DSD) as a treatment method for refractory malignant arrhythmias and its possible inclusion as a recommendation to the guidelines, additional research is undoubtedly required.

## Conclusion

Patients with refractory VF may have a higher chance of survival if they use innovative techniques such as double sequential defibrillation, which has a theoretical justification.

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