

Simultaneous Use of Two Defibrillators for the Conversion of Refractory Ventricular Fibrillation

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THE SIMULTANEOUS use of two defibrillators to deliver higher energy levels for the treatment of refractory arrhythmias is currently not a component of standard advanced cardiac life support (ACLS) guidelines.¹ As a result, it is an underappreciated and underutilized therapy, despite case reports and series demonstrating its efficacy and safety in refractory atrial and ventricular arrhythmias.²⁻⁷ This brief report describes the utility of double-dose defibrillation in refractory ventricular fibrillation (VF) and further publicizes its efficacy.

CASE REPORT

A 66-year-old male with a past history of tobacco abuse, hypertension, and diabetes presented to a community hospital with 45 minutes of substernal chest pain and diaphoresis. Physical examination revealed a pulse of 97 beats per minute, blood pressure 174/98 mmHg, respiratory rate of 20 breaths per minute, pulse oximetry of 96% on room air, and temperature of 35.9°C. He weighed approximately 200 pounds. Electrocardiogram (ECG) (Fig 1) showed a normal sinus rhythm with ST-segment elevations in the inferior leads consistent with an acute inferior ST-elevation myocardial infarction.

Initial therapy included aspirin, sublingual nitroglycerin, intravenous (IV) heparin, IV morphine, and IV fluids. His pain increased, and frequent premature ventricular contractions were noted on his bedside monitor. He then developed pulseless ventricular tachycardia (VT). This episode of VT was treated with transthoracic biphasic defibrillation of 200 joules (J). The defibrillator used was a HeartStart-XL (Philips Medical Systems, Andover, MA). Defibrillation was performed with the hand-held paddles connected to the defibrillator (one over the left anterior chest adjacent to the sternum and the other over the left lateral chest wall). The patient regained consciousness with a sinus rhythm and frequent premature ventricular complexes. Amiodarone, 150 mg IV, was given. He then developed ventricular fibrillation (VF) and lost consciousness again. A set of adhesive defibrillator pads (ZOLL Stat-padz, ZOLL Medical Corporation, Chelmsford, MA) were placed over the left anterior and left posterior chest (Fig 2). Defibrillation at 200 J via the adhesive pads was performed followed by an additional dose of amiodarone, 150 mg IV, as well as epinephrine, 1 mg IV. Cardiopulmonary resuscitation (CPR) was initiated. For the next 72 minutes, the patient remained in VF despite ACLS guideline driven care. Defibrillation at 200 J with the originally applied set of adhesive defibrillation pads was attempted an additional 13 times for VF. The position of this first set of pads was kept unchanged throughout the resuscitation. The patient was given the thrombolytic agent, tenecteplase, 50 mg IV, approximately 27 minutes into the resuscitation. During the resuscitation, he also underwent endotracheal intubation and was administered an additional dose of amiodarone, 300 mg IV, 16 doses of epinephrine, 1 mg IV, sodium bicarbonate, 4 ampules IV, and magnesium sulfate, 4 g IV. During CPR, the patient intermittently regained some neurologic function and had evidence of adequate perfusion (end-tidal CO₂ values of 27-28 mmHg, arterial oxygen saturation between 80%-99%). Despite ACLS-driven care and a total of 15 defibrillation attempts at 200 J, the patient remained in VF.

After 72 minutes of refractory VF, a second defibrillator (the same make and model as the first) with a separate set of pads (the same brand and style as the first) was applied to the patient and both defibrillators were charged to 200 J. The second set of defibrillator pads were placed

adjacent to the initial set of pads also in an anterior-posterior fashion (Fig 2). A single operator was tasked with pushing the shock buttons of each machine as simultaneously as possible. After the first attempt with each defibrillator delivering 200 J (400 J total) and 2 minutes of CPR, the patient remained in VF. A second double-dose defibrillation attempt was conducted, followed by 2 minutes of CPR, after which the patient was found to have a return of spontaneous circulation (ROSC) with a sinus rhythm at a rate of 70 beats per minute. He was then emergently transported to a tertiary medical center for cardiac catheterization, with a transport time of 15 minutes. During transport the patient was reported to have made purposeful attempts to extubate himself.

At the receiving facility, the patient underwent emergent left heart catheterization. He was found to have significant one-vessel coronary disease with an 80% stenosis involving a thrombotic ruptured plaque in the proximal right coronary artery, which was treated with a bare metal stent. Angiography after stenting demonstrated complete reperfusion of the right coronary artery. Heparin and clopidogrel were administered, and he was transferred to the cardiac intensive care unit (ICU) to undergo therapeutic hypothermia. After catheterization, transthoracic echocardiogram demonstrated preserved left ventricular systolic function. Repeat ECG (Fig 3) showed a normal sinus rhythm with inferior ST elevations. His serum troponin peaked at 307 ng/mL 6 hours after initial presentation. Once in the ICU, the patient was found to have a severe metabolic acidemia (arterial lactic acid range 17.00-20.00 mmol/L; arterial pH range 7.01-7.23). Also, a lack of neurologic response was felt to be consistent with anoxic brain injury secondary to the long duration of his CPR. A decision was made to withdraw care and the patient died 9 hours after presentation.

DISCUSSION

Multiple case reports^{2,3,5-7} described double-dose external cardioversion for refractory atrial fibrillation. The use of double-dose defibrillation for refractory VF is a relatively new concept with a lack of any large retrospective or observational data. It is well established that the duration of VF increases the defibrillation threshold.⁸ Based on this knowledge, it follows that the maximum defibrillation energy required also may be elevated. It is important to note that the use of greater than 200 J of defibrillation energy is not Food and Drug Administration approved and should be considered an "off-label" modality.

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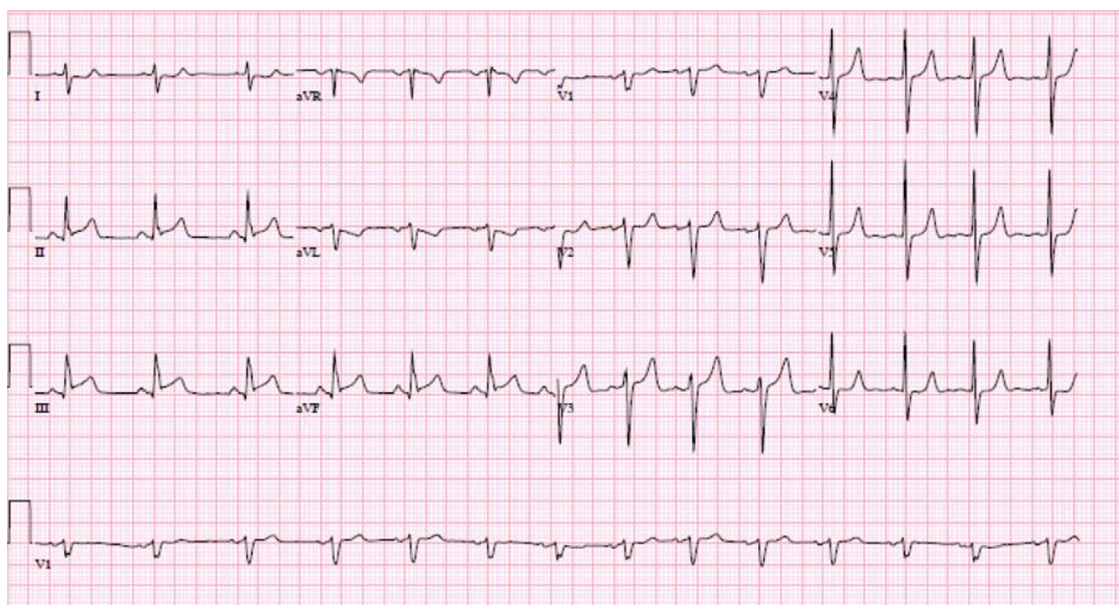


Fig 1. Presenting electrocardiogram.

Because of the extreme refractory nature of this VF presentation, double-dose defibrillation was attempted. A case series from 1994 describing this technique in refractory VF involved 5 patients in an electrophysiology lab setting with monophasic transthoracic defibrillators using 2 sets of pads.⁴ In this series, the number of shocks preceding the double-dose defibrillation ranged from 7 to 20, and the double-dose was delivered in a sequential fashion with a range of 0.5 to 4.5 seconds between shocks. All patients were converted successfully out of VF.⁴ Additionally, there are anecdotal reports of emergency medical systems using double-dose biphasic defibrillation for refractory VF.⁹

Multiple mechanisms have been postulated as to why greater than 200 J of defibrillating current (with 2 sets of

paddles or pads) is beneficial. First, the delivery of current from multiple vectors is superior to a single vector.⁹ It is possible that most of the left and right ventricles may not underlie a single vector of current; hence, by adding a second vector the total amount of myocardium shocked is increased. In the setting of a refractory lethal arrhythmia, it could be beneficial to alter the defibrillation current vector by using a second set of pads (ie, moving a second set of pads from an anterior-posterior position to a right-left lateral position or conversely). Second, two defibrillators do not release their energy in a perfectly synchronized fashion but rather in quick series, thus resulting in a defibrillation of longer duration.⁹ A computer simulation model of electrical defibrillation indicated that a minimal separation in time (about 85 msec)

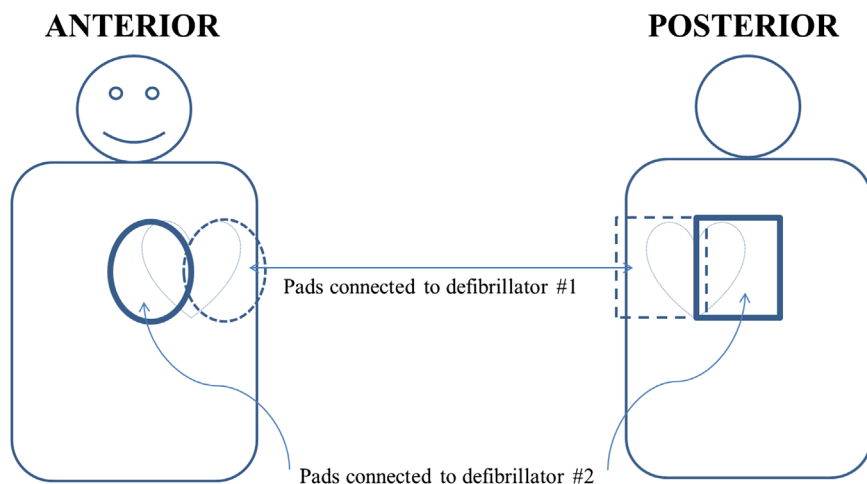


Fig 2. Schematic of defibrillator pad orientation.

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