Prehospital Emergency Care

ISSN: 1090-3127 (Print) 1545-0066 (Online) Journal homepage: https://www.tandfonline.com/loi/ipec20

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Mark A. Merlin, Ammundeep Tagore, Robert Bauter & Faizan H. Arshad

To cite this article: Mark A. Merlin, Ammundeep Tagore, Robert Bauter & Faizan H. Arshad (2016) A Case Series of Double Sequence Defibrillation, Prehospital Emergency Care, 20:4, 550-553, DOI: 10.3109/10903127.2015.1128026

To link to this article: https://doi.org/10.3109/10903127.2015.1128026

Published online: 05 Feb 2016.

CASE CONFERENCE

A CASE SERIES OF DOUBLE SEQUENCE DEFIBRILLATION

Mark A. Merlin, DO, EMT-P, FACEP, Ammundeep Tagore, MBA, MSHA, Robert Bauter, MAS, NRP, Faizan H. Arshad, MD, MBA

ABSTRACT

Introduction: Double Sequence Defibrillation or Double Simultaneous Defibrillation (DSD) is the use of two defibrillators almost simultaneously at their highest allowed energy setting to treat refractory ventricular fibrillation (RVF). One set of pads is placed in the Anterior-Posterior position and the other set of pads is placed in the Anterior-Lateral Position. Both defibrillation buttons are pressed simultaneously. We sought to determine ROSC and survival rates in a large EMS system when DSD is routinely utilized for RVF. **Method:** A retrospective case series was performed of all patients who received DSD from January 1, 2015 to April 30, 2015. During the four month period, we requested physicians to instruct paramedics to use DSD on patients after three refractory episodes of VF. All Advanced Cardiac Life Support (ALS) patients treated by paramedics are discussed via telephone communication with a physician in the system of 100 ALS treated patients per day. **Results:** From January 1, 2015 to April 1, 2015, a total of 7 patients were treated with DSD. The mean age was 62 (Range: 45–78), with mean resuscitation time of 34.3 minutes before first DSD (Range: 23–48). The mean number of single shocks was 5.4 prior to DSD (Range: 3–9), with a mean of 2 DSD shocks delivered. VF converted after DSD in 5 cases (57.1%). Four patients survived to admission (43%). Three patients survived to discharge with no or minimal neurologic disability (28.6%). The mean Cerebral Performance Category Scale was 3.4 with 1 indicating good cerebral performance and 5 indicating Brain Death. **Discussion:** The correct amount of energy in joules for VF remains unknown. In this case series, significant patients converted out of VF. The reason for improved VF conversion may be several factors including additional defibrillation vectors, increased energy, more energy across myocardium, and unknown variables. Additional research is underway to determine if routine DSD will result in improved survival compared to standard defibrillation techniques. **Key words:** defibrillation; ventricular fibrillation; cardiac arrest; double sequence defibrillation; double defibrillation

PREHOSPITAL EMERGENCY CARE 2016;20:550–553

INTRODUCTION

Despite decades of cardiac arrest research, the majority of patients still do not obtain return of spontaneous circulation (ROSC). Recently, small increases in prehospital ROSC have been demonstrated for victims of cardiac arrest.[1] There is a minimal amount of evidence and data supporting the most effective method for defibrillation energy level selection or optimum pad placement.[2–5] Increased survival most likely results from improved bystander CPR, increased emphasis on uninterrupted compressions, de-emphasis on endotracheal intubation, widespread focus on early defibrillation methods, and early access to the 9-1-1 system.[1]

Double Sequence Defibrillation or Double Simultaneous Defibrillation (DSD) is the use of two defibrillators simultaneously at their highest allowed energy setting to treat refractory ventricular fibrillation (RVF). One set of pads is placed in the Anterior-Posterior position and second set of pads (second defibrillator) is placed in the Anterior-Lateral Position. Both defibrillation buttons are pressed simultaneously.

Several small case reports and case series of DSD have appeared in the literature.[2,6,7] Cabanas et al. created a prehospital protocol to use DSED after 5 unsuccessful ventricular fibrillation (VF) shocks.[6] Over three years, they reported 10 cases with successful defibrillations after failed single defibrillation. However, none of the 10 patients survived to hospital discharge. Based on limited data, we describe a case series of seven patients who received DSD. It is possible that Cabanas et al. did not have significant VF conversion because

Received June 14, 2015 from Newark Beth Israel Medical Center, Emergency Medicine, Newark, New Jersey (MAM, AT, FHA); Jet911, AirMedical, Kew Gardens, New York (MAM); Emergency Medical Associates, Parsippany, New Jersey (MAM); MONOC, EMS, Neptune, New Jersey (RB). Revision received November 14, 2015; accepted for publication November 18, 2015.

Address correspondence to Dr. Mark A. Merlin, DO, Newark Beth Israel Medical Center, Emergency Medicine, 201 Lyons Avenue, Newark, NJ 07112, USA. E-mail: markamerlin@gmail.com

doi: 10.3109/10903127.2015.1128026

the DSD was conducted too late into the resuscitation.[6] We employed a routine prehospital protocol permitting DSD after 3 unsuccessful first responder shocks is a system where every ALS unit has a readily available second defibrillator We implemented by a standing protocol increased defibrillation to an organized rhythm earlier into the resuscitation may improve clinical outcomes.

Methods

Institutional Review Board approval was granted at our hospital. A retrospective case series was performed of all patients who received greater than 360 joules as a defibrillation dose from January 1, 2015 to April 30, 2015. All attempted resuscitations treated by paramedics are discussed via telephone communication with a physician as part of the on-line medical control system (OLMC). Defibrillators were Lifepack 15 (Physiocontrol, Redmond, WA).

The two-tiered EMS system responds to 168,000 requests for emergency and medical transport services. The system has 26 ALS units with 22 that are specifically for 9-1-1 response. EMS provides coverage to 3.4 million residents in 1,800 square miles. In the previous year, the system had 226 cases of VF with 146 patients obtaining prehospital return of spontaneous circulation (68%). Physician authorization to use DSD was at their discretion; paramedics must call OLMC at some time during the cardiac arrest. In general most patients in cardiac arrest are not transported however patients in sustained VF or pulseless VT are transported. All ALS units have two defibrillators such that DSD could always be performed.

The protocol indication for DSD was any patient that has been in refractory VF, had received at least 3 (three) defibrillations, either by an AED or an ALS monitor/defibrillator, had been administered epinephrine and an antiarrhythmic during the process of the resuscitation and remains in VF. The procedure consisted of the following: After the first 3 (three) defibrillations is unsuccessful for a patient in refractory VF, a second ALS monitor/defibrillator is attached to the patient either in the anterior/posterior position or the anterior/lateral position opposite of the existing pads. Both defibrillators are charged to 360 joules by the same person as compressions are being continued on the patient. The patient is then cleared in a safe manner once the monitor/defibrillators are charged and the same person hits the shock buttons simultaneously on the monitor/defibrillator. After the delivery of the shock, CPR resumes immediately. If the patient remains in VF, all shocks after the first DSED are done by DSED.

We instructed physicians that any shock by an AED should be included in the three shocks before DSD; however, none of the patients in our study had an AED by first responders. Additionally, an e-mail was sent to all physicians, residents, fellows, and paramedic educators, requesting any knowledge of a DSD during this four month time period. Two physicians reviewed all DSD charts separately to assure reliability.

During the four month period, we requested the physicians to instruct paramedics to use DSD on patients after three refractory episodes of VF. A chart review on the electronic medical record was completed during the study period to verify all cases were captured in the case series (Rescue Net ID, Smithtown, IL). Of the 12,275 ALS patients treated during the four month time period, 7 patients received DSD in the prehospital setting for refractory VF. All 7 of the patients had CPR started by ALS and continued by BLS who arrived simultaneously or within 5 minutes.

Results

From January 1, 2015 to April 1, 2015, a total of 7 patients were treated with DSD. The mean age was 62.9 (Range: 45–78), with mean resuscitation time of 34.3 minutes before first DSD (Range: 10–48). The mean number of single shocks was 5.4 prior to DSD (Range: 3–9), with a mean of 2. DSED shocks delivered. VF converted after DSD in 5 cases (57.1%). Four patients survived to admission (43%). Three patients survived to discharge with no or minimal neurologic disability (28.6%) Table 1 reviews patient demographic and patient outcome including Cerebral Performance Cate-

Table 1. Patient demographic

Case	Age	Sex	Weight	Witnessed vs Not Witnessed Arrest	EMS Disposition	Final Disposition AND CPC*
1	78	M	100 kg	Witnessed	ROSC/ STEMI	Discharged Home, No Neuro Deficit, Awaiting CABG x3 CPS=1
2	63	M	80 kg	Witnessed	Pronounced	Died in ED CPC=5
3	45	M	79 kg	Not Witnessed	CPR in Progress	Died in ED CPC=5
4	55	M	90 kg	Witnessed	Pronounced	Died in ED CPC=5
5	59	F	72 kg	Witnessed	ROSC/STEMI	Died in ED CPC=5
6	71	F	60 kg	Witnessed	ROSC/ STEMI	S/P Stent, Severe GI Bleed 18 days after arrest. Died 21 days post arrest CPC=1 (initial)
7	62	F	109 kg	Witnessed	ROSC/ STEMI	Downtime 45 min, 100% RCA occlusion, EF 20-30% AOx2 with severe dysphagia with PEG CPC=3

CPC=Cerebral Performance Categories Scale

TABLE 2. Number of defibrillations and times

Case	Single Defibrillation	DSED	Single Defibrillation after DSED	Time from determination of arrest to First DSED	On Scene Time	EMS Response Times
1	5	1	0	26 min	12 min	4 min
2	9	2	0	45 min	32 min	9 min
3	3	1	0	28 min	28 min	5 min
4	6	4	0	44 min	36 min	7 min
5	7	3	0	48 min	42 min	7 min
6	4	4	0	26 min	33 min	9 min
7	4	3	2	23 min	27 min	6 min

All initial rhythms were VF. All rhythms for transported patients were VF.

gories Scale (CPC).[8] Table 2 reviews total number of defibrillations during the resuscitation.

DISCUSSION

The correct amount of energy in joules for VF remains elusive. Multiple case reports exist describing double external cardioversion for refractory atrial fibrillation.[9–11] Double Defibrillation for refractory VF is a newer concept, but several cases are currently in the literature (Table 3). The duration of VF increases the defibrillation threshold; therefore, more current may be needed for prolonged VF.[12] One potential mechanism for DSD is the delivery of current from multiple vectors is superior to a single vector.[13] It is possible that most of the ventricular myocardium may not underlie a single vector of current. If additional vectors are added, the total amount of ventricular myocardium being shocked is potentially increased. Additional defibrillated myocardium could result in increased chance of conversion out of VF. Additionally, it is possible that the current has an additive effect resulting in easier defibrillation. Lastly, because DSD is not perfectly synchronized but mildly sequential, two defibrillators did not release their energy in a perfectly synchronized fashion but rather in quick series, resulting in a defibrillation of longer duration. Improved defibrillation out of VF may occur because of this prolonged defibrillation pattern

Cabanas et al., in the first reported case series, demonstrated a 70% termination rate of refractory VF; however, no patients survived.[6] A contributing factor may be the delayed use of the intervention too late into the resuscitation. However, no consensus exists as to a definition of refractory VF in the literature. A total of 6.5 single shocks were given prior to DSD and in 6 of those cases, DSD was performed 35 minutes or greater into resuscitation. In our case series, all but one of our survivors received DSD within 26 minutes; however, we had hoped for better adherence to the protocol of DSD after three DSD. Instead, only one patient received DSD after three shocks and four patients received DSD in 5 or less shocks; most likely this represents physicians and paramedics getting used to a new protocol. Additionally, paramedics can determine for themselves the most appropriate time to call for medical control. It is possible that earlier contact with medical control results in earlier use of double defibrillation.

We picked DSD after three shocks, because it is known that the more rapid is the defibrillation out of VF, the better is the likelihood of neurological intact survival. Many questions remain unanswered. We do not know if DSD is appropriate after three shocks or less. Additionally, we do not know the importance of additional vectors versus an increase amount of Joules.

Improved VF defibrillation with DSD is likely multifactorial including techniques to help clinicians manage refractory VF: the addition of more defibrillation vectors, the increase of overall joules helping overcome variable impedance, and a higher dose of defibrillation energy delivered to the myocardium. A host of potential variables exists with this relatively new modality and further research is required to describe the physiologic changes associated with DSD. We anticipate 60 total cases over the next 12-month period upon which we will report. This pilot study enlightened us to retrain physicians and paramedics to strict protocol adherence.

TABLE 3. Human studies of double sequence defibrillation

Author	Type of Research	Outcomes
1. Lybeck et al. 2015[14]	Case Report	Pt survived after DSD on 8th attempt
2. Cabanas et al. 2014[6]	Case Series	ROSC in 7 of 10 patients. No Survivors
3. Hoch et al. 1994[3]	Subgroup Analysis	5 patients converted in EP lab after refractory VF. All survived
4. Leacock 2014[7]	Case Report	Pt survived after DSD on 5th attempt (400J)
5. Gerstein et al. 2014[15]	Case Report	Pt had ROSC after 400J with DSD and failed single multiple defibs. Pt did not survive

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