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Clinical paper

Use of double sequential external defibrillation for refractory ventricular fibrillation during out-of-hospital cardiac arrest☆

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ABSTRACT

Introduction: Survival from out of hospital cardiac arrest (OHCA) is highest in victims with shockable rhythms when early CPR and rapid defibrillation are provided. However, a subset of individuals present with ventricular fibrillation (VF) that does not respond to defibrillation (refractory VF). One intervention that may be a possible option in refractory VF is double sequential external defibrillation (DSD). The objective of this case series was to describe the outcome of prehospital victims with refractory VF treated with DSD in the out-of-hospital setting.

Methods: This evaluation is a retrospective chart review of VF patients treated with DSD in the prehospital setting from August 1st, 2010 through June 30th, 2014. Patients were excluded if less than 17 years of age. The outcomes we evaluated were the number of patients with return of spontaneous circulation, conversion from VF, survival-to-hospital discharge, and Cerebral Performance Category score.

Results: Total of 2428 OHCA events were reviewed with twelve patients treated with DSD. Median DSD and prehospital resuscitation times were 27 min (IQR 22–33) and 32 (IQR 24–38), respectively. Of the 12 patients treated, return of spontaneous circulation was achieved in three patients, nine patients were converted out of ventricular fibrillation, three patients survived to hospital discharge, and two patients (2/12, 17%) were discharged with Cerebral Performance Category scores of 1 (good cerebral performance).

Conclusions: Double sequential defibrillation may be another tool to improve neurologically intact survival from OHCA. Further studies are needed to demonstrate direct benefits to patient outcomes.

Introduction

Survival from out-of-hospital cardiac arrest (OHCA) has been found to be highest in patients who receive early, high quality cardiopulmonary resuscitation (CPR) and whose cardiac rhythms are amiable to defibrillation therapy.[1–3] Overall, cardiac arrest survival in individuals with a shockable rhythm (i.e., ventricular fibrillation (VF) or ventricular tachycardia (VT)) is approximately 30% in contrast to 2–3% and 9–10% for asystole and pulseless electrical activity rhythms, respectively.[4] When combined with high quality CPR in the setting of a strong coordinated system of care (public access to automated external defibrillators (AED), adoption of dispatch-assisted CPR, high bystander CPR rates), survival rates of OHCA with VF/VT can reach as high as 40–60%.[3–6]

There is a subset of individuals who have shockable rhythms that do not respond to CPR and defibrillation therapy, and are referred to as having refractory ventricular fibrillation.[7–9] This is a unique clinical entity with a paucity of literature addressing optimal treatment and management in the prehospital setting.[7,10] However, given the higher incidence of neurologically intact survival of ventricular fibrillation, patients in refractory ventricular fibrillation may be amendable to novel therapies not typically administered in the prehospital setting.[11,12]

One intervention that may be a possible option in refractory VF is the use of double sequential defibrillation. Animal studies have evaluated the use of sequential defibrillation demonstrating increased defibrillation efficiency with lower energy levels.[13,14] This theory has since been clinically applied in the treatment of atrial fibrillation with benefit.[15,16] Most recently, double sequential defibrillation has been theorized as a potentially effective treatment strategy for human patients experiencing refractory ventricular fibrillation in the prehospital setting.[10,17] The objective of this case series was to describe the outcome of prehospital patients

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with refractory VF treated with double sequential defibrillation with an established protocol for observation and management in the out-of-hospital setting.

Methods

Study design

This evaluation is a retrospective chart review of all patients in refractory ventricular fibrillation treated with double sequential defibrillation in the metropolitan area of Columbus, Ohio from August 1st, 2010 through June 30th, 2014. This area is serviced by the City of Columbus, Division of Fire, which is the primary EMS provider in the area. The study population included all patients with an OHCA with refractory VF treated with double sequential defibrillation. Double sequential defibrillation was utilized for all refractory VF consistent with Columbus Division of Fire Standard Operating Protocol. Similar to other prehospital definitions, refractory VF was defined as VF refractory to five single defibrillations.[10,18] Pad placement and the delivery of double sequential defibrillation were similar to previous descriptions.[10,18] The second set of pads were placed adjacent to, but not touching, the first set of pads from a second cardiac monitor. Both monitors were charged to maximum recommended energy, and as sequentially as possible, the defibrillation buttons on each cardiac monitor were pushed. Patients were excluded if double sequential defibrillation was not attempted, or patients were 17 years of age or younger.

Study setting

The Columbus Division of Fire is an urban, fire-based emergency medical services (EMS) system that serves a population of over 822,000 constituents covering 217 square miles. There are approximately 130,000 calls requesting EMS services per year. This EMS system includes 32 advanced life support (ALS) ambulances and 34 ALS engine vehicles. Ambulances and engine vehicles utilize Lifepak 15 or Lifepak 12 monitor/defibrillators (Physio-Control, Inc., Redmond, Washington). Each ambulance is staffed with two paramedics and each engine vehicle is staffed with at least one paramedic. There are seven EMS supervisors that oversee EMS operations in their respective battalions. Cardiac arrests are attended to by two ambulance paramedics, one paramedic and at least two emergency medical technicians (EMT), and an EMS supervisor.

Data analysis

Prehospital data were extracted from our electronic patient care report (Safety PAD, OPEN, Inc., Minneapolis, MN) and hospital data were obtained via EMS liaisons at each receiving hospital in Columbus, Ohio. Hospital-appointed EMS liaisons are trained personnel that work closely with the Columbus Division of Fire to facilitate our continuous quality improvement process.

A data sheet was created for study variables. Investigator blinding and inter-rater reliability were not performed. However, all extracted variables were present as discrete data points in the medical records and did not require interpretation by the abstractor. Analysis was performed using Microsoft Excel (Redmond, WA) and STATA v.12 (STATACorp, College Station, TX). Data were reported as medians with interquartile ranges (IQR) and proportions.

Outcome measures

The primary outcome was the proportion of refractory VF with return of spontaneous circulation (ROSC). Secondary outcomes were conversion from refractory VF, survival-to-hospital discharge, and Cerebral Performance Category (CPC) score.

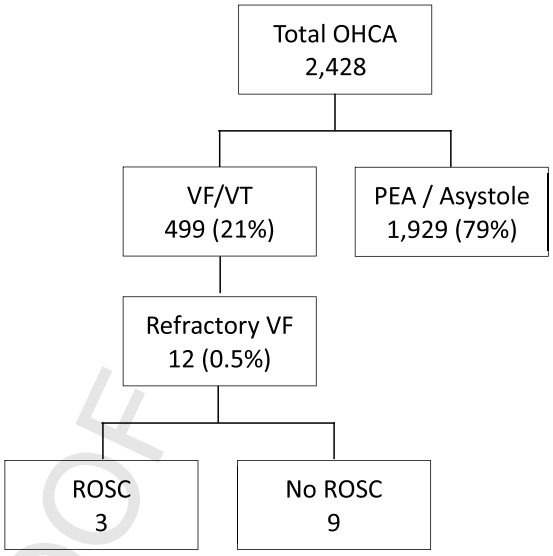

Fig. 1. Schematic of out of hospital cardiac arrests (OHCA) by cardiac rhythms during the study period. Abbreviations: PEA—pulseless electrical activity; ROSC—return of spontaneous resuscitation; VF—ventricular fibrillation; VT—ventricular tachycardia.

Results

Overall, 2428 OHCA occurred during the study period with 21% of these patients having a shockable rhythm (Fig. 1). Twelve patients developed refractory VF and were treated with double sequential defibrillation (Table 1). In this series of patients, 50% were witnessed arrests with 85% with the performance of bystander CPR. The majority of patients (92%) had an initial rhythm of ventricular fibrillation with one patient with PEA that converted to VF later.

Table 2 demonstrates the successful conversion of refractory VF by single or double sequential defibrillation along with timing of amiodarone administration. In this series, single defibrillation had no effect on conversion of refractory ventricular fibrillation whereas DSD demonstrated conversion of refractory VF in 9/12 cases. No definitive association with conversion of refractory VF with timing of amiodarone is noted in this small series.

The median prehospital resuscitation time was 31.5 min (interquartile range (IQR): 24–37.5) with median time to dual sequential defibrillation being 27 min (IQR: 22–33) (Table 3). Median single defibrillation attempts, as per protocol, were 5 (IQR: 5–6) with median dual defibrillation attempts being 2 (IQR: 1–2). Two of these patients (17%) received initial defibrillation by AEDs prior to arrival of EMS.

Return of spontaneous circulation was achieved in three patients (3/12, 25%) who all survived to hospital discharge (Table 3). Nine patients were converted out of ventricular fibrillation with double sequential defibrillation. Two patients (2/12, 17%) survived to discharge from the hospital with a CPC score of 1 with the third patient having a CPC of 3.

Discussion

Management of OHCA patients with potentially shockable rhythms who are refractory to traditional resuscitative efforts is challenging for prehospital providers. EMS caregivers recognize the potential survivability of shockable rhythms and provide high quality CPR coupled with excellent advanced cardiac life support.

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