Resuscitation 92 (2015) 70–76

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Clinical paper

Managing cardiac arrest with refractory ventricular fibrillation in the emergency department: Conventional cardiopulmonary resuscitation versus extracorporeal cardiopulmonary resuscitation☆

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ARTICLE INFO

Article history:
Received 7 January 2015
Received in revised form 7 April 2015
Accepted 11 April 2015

Keywords:
Cardiac arrest
Refractory ventricular fibrillation
Cardiopulmonary resuscitation
Conventional cardiopulmonary resuscitation (C-CPR)
Extracorporeal membrane oxygenation (ECMO)
Extracorporeal cardiopulmonary resuscitation (E-CPR)

ABSTRACT

Aim: Refractory ventricular fibrillation, resistant to conventional cardiopulmonary resuscitation (CPR), is a life threatening rhythm encountered in the emergency department. Although previous reports suggest the use of extracorporeal CPR can improve the clinical outcomes in patients with prolonged cardiac arrest, the effectiveness of this novel strategy for refractory ventricular fibrillation is not known. We aimed to compare the clinical outcomes of patients with refractory ventricular fibrillation managed with conventional CPR or extracorporeal CPR in our institution.

Method: This is a retrospective chart review study from an emergency department in a tertiary referral medical center. We identified 209 patients presenting with cardiac arrest due to ventricular fibrillation between September 2011 and September 2013. Of these, 60 patients were enrolled with ventricular fibrillation refractory to resuscitation for more than 10 min. The clinical outcome of patients with ventricular fibrillation received either conventional CPR, including defibrillation, chest compression, and resuscitative medication (C-CPR, $n = 40$) or CPR plus extracorporeal CPR (E-CPR, $n = 20$) were compared.

Results: The overall survival rate was 35%, and 18.3% of patients were discharged with good neurological function. The mean duration of CPR was longer in the E-CPR group than in the C-CPR group (69.90 ± 49.6 min vs 34.3 ± 17.7 min, $p = 0.0001$). Patients receiving E-CPR had significantly higher rates of sustained return of spontaneous circulation (95.0% vs 47.5%, $p = 0.0009$), and good neurological function at discharge (40.0% vs 7.5%, $p = 0.0067$). The survival rate in the E-CPR group was higher (50% vs 27.5%, $p = 0.1512$) at discharge and (50% vs 20%, $p = 0.0998$) at 1 year after discharge.

Conclusions: The management of refractory ventricular fibrillation in the emergency department remains challenging, as evidenced by an overall survival rate of 35% in this study. Patients with refractory ventricular fibrillation receiving E-CPR had a trend toward higher survival rates and significantly improved neurological outcomes than those receiving C-CPR.

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1. Introduction

Cardiac arrest that is refractory to cardiopulmonary resuscitation (CPR) carries a high mortality rate, especially when the duration of resuscitation persists beyond 10 min.[1] The effect of conventional CPR (C-CPR) falls rapidly, with decreased survival beyond the first 10–15 min and only 2% patients achieve a favorable neurological outcome.[2] Although patients with cardiac arrest due to ventricular fibrillation tend to respond more favorably to C-CPR compared with other etiologies of cardiac arrest,[1,3] the clinical

Abbreviations: C-CPR, conventional cardiopulmonary resuscitation; E-CPR, extracorporeal cardiopulmonary resuscitation; OHCA, out-of-hospital cardiac arrest; IHCA, in-hospital cardiac arrest; ROSC, return of spontaneous circulation; ROSB, return of spontaneous beating; CPC, cerebral performance category; CPR, cardiopulmonary resuscitation; AHA, American Heart Association.

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2015.04.016.

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http://dx.doi.org/10.1016/j.resuscitation.2015.04.016
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outcome is poor if they fail to respond within the first 10 min.[4,5] Indeed, the reported survival rate is 20.4% in this scenario, with only 5.6% of patients regaining good neurological outcomes in out of hospital arrest.[6]

A previous study suggests that using extracorporeal membrane oxygenation (ECMO) in extracorporeal CPR (E-CPR) can improve the clinical outcomes in patients with prolonged cardiac arrest beyond 10 min.[4] However, the cost of ECMO is high and the patient characteristics that are likely to gain most from ECMO have not been established.[7,8] Ventricular fibrillation is considered refractory if no return of spontaneous circulation (ROSC) occurs after C-CPR for more than 10 min. Few case reports describe the use of ECMO in patients with prolonged cardiac arrest due to refractory ventricular fibrillation, particularly with excellent clinical outcomes.[9–13] Whether or not this unconventional strategy can be applied to the management of refractory ventricular fibrillation in the emergency department and improve patient outcomes is unclear.

In this study, we aimed to study the clinical outcomes of patients with refractory ventricular fibrillation. Specifically, we assessed the effects of C-CPR versus E-CPR in this patient group.

2. Patients and methods

A retrospective medical chart review at a medical center was performed between September 2011 and September 2013. The study was approved by our Institutional Review Board. We enrolled patients who fulfilled the following criteria: (1) age 18–75 years; (2) cardiac arrest with initial ventricular fibrillation and C-CPR initiated within 5 min (no flow duration <5 min); (3) refractory ventricular fibrillation defined as ventricular fibrillation resistant to at least three defibrillations, 3 mg of epinephrine, 300 mg of amiodarone, and no ROSC achieved after CPR for more than 10 min.[14]

Patients were excluded if they had (1) severe head trauma or severe acute active bleeding; (2) severe sepsis; (3) ventricular fibrillation that developed during resuscitation for initial asystole or pulseless electrical activity; (4) terminal stage of malignancy; and (5) any history of severe neurological deficits (including dementia, intracranial hemorrhage, or ischemic stroke and bedridden state).

2.1. Assessment of the resuscitation process and clinical outcome

We retrospectively reviewed the number of defibrillation attempts and drugs used, as well as the duration of resuscitation. Sustained ROSC was defined as more than 20 min of spontaneous circulation without recurrence of cardiac arrest. The CPR process was stopped when sustained ROSC was achieved. The decision to discontinue CPR was made if there was no ROSC after 30 min resuscitation. Neurological outcome was evaluated using the Glasgow–Pittsburgh cerebral performance category (CPC) scale. Good neurological outcome was defined as a CPC score of 1 or 2, poor cerebral function as a CPC score of 3 or 4, and brain death as a CPC of 5. Patients were followed to either discharge from the hospital or death.

2.2. The ECMO system and intervention

In our hospital, E-CPR was permitted as an option in prolonged CPR, according to the judgment of the attending physician. The ECMO system comprised a Bio-Pump® centrifugal blood pump (Medtronic Inc., Anaheim, CA), a Maxima Plus PRF hollow membrane oxygenator with an integral heat exchanger, and a heparin-bonded Carmeda Bioactive Surface circuit. The pump flow was controlled to maintain a minimum flow of 2.0 L min^{-1}. The activated clotting time was maintained at 180–220 s with heparin.

We performed E-CPR via femoral cannulation in the emergency department. Once the patient achieved sustained ROSB (return of spontaneous beating) after ECMO, they were transferred to intensive care. Therapeutic hypothermia is considered when the patients remain comatose after ROSC (C-CPR group) or ROSB (E-CPR group) and decided by the attending physician of the intensive care unit. Therapeutic hypothermia was provided as follows: the patient was cooled to 33 °C for 24 h and rewarmed at 0.5 °C every 4 h till tympanic temperature reached 37 °C. Emergency coronary angiography was performed by cardiologist if acute myocardial infarction was suspected.

2.3. Statistical analyses

Continuous variables were compared using Student's *t*-test or Mann–Whitney *U*-test as appropriate. Categorical variables were evaluated using the χ^2 test. Logistic regression modeling was used to evaluate factors associated with clinical outcome. Differences between the two groups were considered significant when the *P*-value was <0.05. Statistical analyses were performed using MedCalc software version 11.5 (MedCalc Software bvba, Broekstraat 52, 9030 Mariakerke, Belgium).

3. Results

3.1. Patient characteristics of refractory ventricular fibrillation

During the study period, we identified 209 patients with cardiac arrest due to ventricular fibrillation. Of these, 60 patients who had initial ventricular fibrillation that fulfilled the inclusion and exclusion criteria were enrolled (Fig. 1). The mean age was 58.37 years, with male predominance. Forty-one of the cases had out of hospital cardiac arrest (OHCA). The leading cause of cardiac arrest was acute myocardial infarction (46.67%).

The resuscitation process was illustrated in Fig. 2. The mean duration of resuscitation was 46.22 min, with a mean of 7.65 defibrillations performed. ECMO support was provided for 20 (33.33%) patients and successful cannulation achieved in 19 patients. 18 (30%) patients received therapeutic hypothermia. In our study, 38 (63.33%) patients achieved sustained ROSC/ROSB and all were transferred to intensive care. In total, 21 (35%) patients survived to discharged; however, only 11 (18.33%) had good neurological function at discharge.

3.2. Comparison of the C-CPR and E-CPR groups

We divided patients into C-CPR and E-CPR groups for further comparison (Table 1). Age, sex, amiodarone dose, co-morbidity disease, cause of cardiac arrest, location of cardiac arrest, serum lactate levels, and therapeutic hypothermia were similar in both groups. In the E-CPR group, patients had longer duration of resuscitation (E-CPR vs C-CPR: 69.90 min vs 34.38 min, $p = 0.0001$), more defibrillation attempts (E-CPR vs C-CPR: 9.72 vs 6.56, $p = 0.0001$), and more doses of epinephrine (E-CPR vs C-CPR: 11.17 mg vs 8.29 mg, $p = 0.032$). Patients in the E-CPR group also had significantly higher rates of sustained ROSC and survival to intensive care when compared with the C-CPR group (95% vs 47.5%, $p = 0.0009$). The overall survival rate was also higher in the E-CPR group compared with the C-CPR group at discharge (50% vs 27.5%) and one year after discharge (50% vs 20%), although this was not statistically significant. However, the rate of good neurological function was significantly higher at discharge in the E-CPR group than in the C-CPR group (40% vs 7.5%, $p = 0.0067$).

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