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Clinical paper

Impact of cardiopulmonary resuscitation duration on survival from paramedic witnessed out-of-hospital cardiac arrests: An observational study☆

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ABSTRACT

Background: Resuscitation guidelines often recommend ongoing cardiopulmonary resuscitation (CPR) efforts to hospital for out-of-hospital cardiac arrests (OHCA) witnessed by emergency medical service (EMS) personnel. In this study, we examine the relationship between EMS CPR duration and survival to hospital discharge in EMS witnessed OHCA patients.

Methods: Between January 2003 and December 2011, 1035 adult EMS witnessed arrests of presumed cardiac aetiology were included from the Victorian Ambulance Cardiac Arrest Registry. CPR duration was defined as the total sum of prehospital CPR time in minutes. Adjusted logistic regression analyses were used to assess the impact of EMS CPR duration on survival to hospital discharge.

Results: 382 (37.3%) patients were discharged alive. The median CPR duration was 12 min (95% CI: 11–13) overall, but was higher in non-survivors compared to survivors (24 min vs. 2 min, $p < 0.001$). The 99th percentile CPR duration in patients surviving to hospital discharge differed by the initial rhythm of arrest: 32 min (95% CI: 27–44) overall, 32 min (95% CI: 23–44) for ventricular fibrillation and pulseless ventricular tachycardia (VF/VT), 34 min (95% CI: 30–34) for pulseless electrical activity (PEA), and 28 min (95% CI: 21–28) for asystole. There were no survivors after 44 min for all rhythms. After adjusting for prehospital confounders, every minute increase in CPR duration was associated with a 13% reduction in the odds of survival to hospital discharge (OR 0.87, 95% CI: 0.84–0.89, $p < 0.001$). The multivariable model predicted no chance of survival at or after a CPR duration of 48 min for VF/VT patients, 47 min for PEA patients and 45 min for asystole patients.

Conclusion: Resuscitation efforts exceeding 32 min yielded less than 1% of survivors from EMS witnessed OHCA. On the basis of this data, EMS witnessed OHCA patients may benefit from ongoing CPR efforts up to 48 min in duration.

Introduction

Out-of-hospital cardiac arrest (OHCA) is a leading cause of death in developed countries, and is estimated to affect as many as 5 million people worldwide every year.[1] For patients who arrest before emergency medical service (EMS) arrival, the chance of surviving to hospital discharge is almost entirely determined by successful return of spontaneous circulation (ROSC) in the field.[2] Transport to hospital with ongoing cardiopulmonary resuscitation (CPR) has been associated with poor patient outcomes, and rarely leads to additional survivors.[3,4] As a result, some termination-of-resuscitation guidelines recommend withdrawing resuscitation efforts in the field after 20 min of advanced life support.[5,6]

However, specific OHCA populations may benefit from prolonged resuscitation efforts, including patients who develop a shockable rhythm, experience intermittent ROSC, or are witnessed to arrest by EMS personnel.[7,8] In particular, EMS witnessed arrests represent a significant proportion of OHCA patients and are known to experience favourable survival outcomes.[9–11] Although some

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EMS agencies recommend continuing resuscitation efforts to hospital after EMS witnessed arrests, the optimal duration of CPR efforts has not been evaluated in the medical literature. In this study, we examine the relationship between CPR duration and survival to hospital discharge in EMS witnessed OHCA patients.

Methods

Study design

The study methodology has been reported previously.[12] EMS witnessed OHCA patients were retrospectively identified from the Victorian Ambulance Cardiac Arrest Registry (VACAR).

Between 1st January 2003 and 31st December 2011, we included adult patients aged greater than 15 years who experienced an OHCA of a presumed cardiac aetiology and were witnessed to arrest by paramedics. Patients with a 'do not resuscitate' directive were excluded, as were patients whose arrest occurred on arrival at hospital.

Setting

The study was conducted in the Australian city of Melbourne, with a population of approximately 4.1 million people spanning an area of 7700 square kilometres. The state of Victoria operates a single state-wide EMS system which employs approximately 1800 advanced life support and 400 intensive care paramedics in the Melbourne region. Paramedics respond to life-threatening emergency incidents in a two-tiered fashion, with basic life support trained fire-fighters and community volunteers also dispatched for suspected cardiac arrest events. Prehospital treatment protocols for cardiac arrest patients follow the recommendations of the Australian Resuscitation Council.[13] Advanced life support paramedics are authorised to administer intravenous adrenaline and insert laryngeal airways, while intensive care paramedics can administer a wider scope of medications and can undertake endotracheal intubation (including rapid sequence intubation).

Victorian Ambulance Cardiac Arrest Registry

The VACAR is a population-based register of all OHCA events attended by EMS in the Australian state of Victoria. The registry methodology, including data capture and completeness, and quality assurance processes have been described previously.[14,15] The registry captures in-field treatment data electronically from computer tablets used by paramedics.[16] A highly sensitive search filter is used to identify potential cardiac arrest cases, which undergo manual review by registry personnel. Cases meeting the eligibility criteria are downloaded automatically from the organisation's clinical databases, populating most registry fields automatically with patient administrative and clinical data. Data are then subject to manual review and audit by registry staff. In total the registry collects over 150 data points, including the Utstein-style elements.[17,18] Arrests are presumed to be of cardiac aetiology unless an obvious cause of arrest is identified on the patient care record (e.g. trauma, hanging, overdose, etc.). In all transported cases, survival outcome and hospital discharge direction is verified from medical records, and later cross-validated against death records from the Victorian Registry of Births Deaths and Marriages.

Statistical analysis

Statistical analyses were undertaken using Stata Statistical Software 11 (StataCorp, 2009, College Station, TX). The main outcome measure was survival to hospital discharge. The duration of prehospital CPR was calculated as the sum of total resuscitation time, or total downtime, before arrival at hospital. For patients who experienced multiple arrests, we recorded the sum of resuscitation times of each arrest period.

To describe baseline characteristics and unadjusted survival outcomes, we stratified the population into 10 min intervals of CPR duration ($\leq$10, 11–20, 21–30, 31–40, >40 min) and compared differences using the χ^2 test and the Kruskal–Wallis test as appropriate. Significance tests used a two-sided p-value of <0.05. Differences in baseline characteristics and survival outcomes were also compared across major arrest locations, including private residence, aged care facility, public location and ambulance.

We computed median, 90th, and 99th percentiles of CPR duration (with 95% confidence intervals) for the overall population, and for subgroups with and without ROSC and survival to hospital discharge. The distribution of CPR duration was compared across subgroups using the Kruskal–Wallis test. To assess the contribution of CPR duration on survival to hospital discharge outcomes, we constructed a multivariable logistic regression model with the following covariates: age, gender, arrest rhythm, arrest location, number of arrests, and CPR duration. Curves for the predicted probability of survival to hospital discharge were generated for each arrest rhythm by holding model covariates at their mean response. Similarly, in the ventricular fibrillation and pulseless ventricular tachycardia (VF/VT) population, we constructed curves for the predicted probability of survival across the 25th, 50th, and 75th percentiles of age, and across the following arrest locations: private residence, aged care facility, public location and ambulance.

In a second multivariable model we included a categorical term denoting whether the patient was either: (1) resuscitated at scene, with or without achieving ROSC, or; (2) transported to hospital with ongoing CPR efforts. Patients who were declared deceased at scene after a failed prehospital resuscitation attempt were included in the first group. The variable was assessed in both the overall population and in patients who arrested in the ambulance. All models were adjusted for the above-mentioned covariates (i.e. age, gender, arrest rhythm, arrest location, number of arrests, and CPR duration).

Ethics approval

The study was approved by the Monash University Human Research Ethics Committee. The VACAR maintains independent ethics approval from the Victorian Department of Health Human Research Ethics Committee and over 100 participating hospitals for the collection and use of patient data.

Results

Between 2003 and 2011, we identified 1379 EMS witnessed arrests of presumed cardiac aetiology which received an attempted resuscitation. We excluded 344 (24.9%) cases because of missing treatment data (n = 153), the patient had a 'do not resuscitate' directive (n = 129), or; the patient arrested on arrival at hospital (n = 62). The analysis was conducted on 1035 EMS witnessed cases with available treatment data.

Population characteristics

Baseline characteristics of patients stratified across CPR duration groups are presented in Table 1. Longer CPR durations were associated with female gender, arrests in private residences, and an initial pulseless electrical activity (PEA) arrest rhythm. Intermittent ROSC and survival to hospital discharge decreased with increasing CPR duration. Only one of 108 (0.9%) patients receiving a resuscitation attempt >40 min (range 41–87 min) was discharged alive.