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# Comparing the prognosis of those with initial shockable and non-shockable rhythms with increasing durations of CPR: Informing minimum durations of resuscitation☆,☆☆

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ABSTRACT

*Aim:* There is little data to inform the appropriate duration of resuscitation attempts for out-of-hospital cardiac arrest (OHCA). We assessed the relationship of elapsed duration since commencement of resuscitation and outcomes, highlighting differences between initial shockable and non-shockable rhythms.
*Methods:* We examined consecutive adult non-traumatic EMS-treated OHCA in a single health region. We plotted the time-dependent accrual of patients with ROSC, as well as dynamic estimates of outcomes as a function of duration from commencement of professional resuscitation, and compared subgroups dichotomized by initial rhythm. Logistic regression tested the association between time-to-ROSC and outcomes.
*Results:* Of 1627 adult EMS-treated cases of OHCA, 1617 patients were included; 14% survivors and 10% with favorable neurological outcomes. Time-to-ROSC (per minute increase) was independently associated with survival in those with initial shockable (aOR 0.95, 95% CI 0.92–0.97) and non-shockable (aOR 0.83; 95% CI 0.78–0.88) rhythms. Similar associations were seen with favorable neurologic outcome. The elapsed duration at which the probability of survival fell below 1% was 48 and 15 min in the shockable and non-shockable groups, respectively. Median time-to-termination of resuscitation was 36 and 26 min in the shockable and non-shockable groups, respectively.
*Conclusion:* The subgroup of initial shockable rhythms showed a less pronounced association of time-to-ROSC with outcomes, and demonstrated higher resilience for neurologically intact survival after prolonged periods of resuscitation. This data can guide minimum durations of resuscitation, however should not be considered as evidence for termination of resuscitation as survival in this cohort may have been improved with longer resuscitation attempts.



## Introduction

Out-of-hospital cardiac arrest (OHCA) is common; emergency medical services (EMS) in the United States attend 134 cases per 100,000 adult citizens annually,[1] yielding survival rates between 3 and 16%.[2] Despite this, although termination of resuscitation (TOR) rules may assist with certain patient subgroups, data outlining the appropriate duration of resuscitation prior to termination

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of efforts are lacking for both pre-hospital and emergency department clinicians.[3,4] Previous data has demonstrated that an initial shockable rhythm is a predictor of survival,[2,5] however, it is unclear if initial rhythm continues to impact the probability of a good outcome after prolonged durations of resuscitation, and whether initial rhythm should influence the duration of resuscitation.

The primary objective of this study was to assess the relationship between clinical outcomes and the elapsed duration since commencement of professional resuscitation, comparing differences between those with initial shockable and non-shockable rhythms. We hoped to inform decisions regarding the optimal duration of resuscitation efforts and to explore whether this should be influenced by initial cardiac rhythm. In addition, we sought to describe the characteristics of patients with favorable outcomes who achieved return of spontaneous circulation (ROSC) after prolonged resuscitations, and the elapsed duration beyond which the point estimate for the probability of survival declined to below 1%.

## Methods

The institutional review boards and affiliated ethics committees of Providence Health Care, the University of British Columbia, and Vancouver Coastal Health approved this study.

### *Study setting*

We examined data from cases of OHCA in the city of Vancouver, British Columbia and surrounding areas, with a population of approximately one million persons.[6] The provincial British Columbia Ambulance Service (BCAS) and individual municipal fire departments provide pre-hospital emergency medical care through a coordinated 9-1-1 service. BCAS policy stipulates the circumstances in which pre-hospital personnel are not obligated to provide resuscitative efforts (Appendix 1). There was no structured termination of resuscitation protocol during the study period. Four hospitals within the region, all affiliated with the University of British Columbia, receive patients with OHCA.

### *Selection of participants*

This study was a post hoc analysis of consecutive non-traumatic OHCA patients within the region, who were prospectively enrolled as part of the Resuscitation Outcomes Consortium database[7] from September 2007 to December 2011. Patients were excluded from the analysis if:(1) there was no attempt at resuscitation or (2) the patient was less than 18 years of age.

### *Data collection*

All pre-hospital data, including patient characteristics, time-stamped diagnostics, treatments administered, and pre-hospital outcomes, were prospectively collected by EMS via standardized template charting. Hospital-level data was prospectively collected through chart review with vital status and cerebral performance category (CPC) assessed at hospital discharge. Data abstractors were unaware of this post hoc study purpose and hypothesis. Cases with missing or conflicting data prompted a full chart review by the primary investigator. A second independent chart review, performed at the time of this post hoc analysis by a research assistant blinded to study purpose and hypothesis, examined the records of 100 randomly selected study subjects who were transported to hospital, to assess the inter-rater reliability of neurological outcome assessment (Cohen's Kappa statistic).

### *Outcome measures and variable definitions*

The co-primary endpoints were survival and favorable neurological outcome at hospital discharge (defined as CPC 1-2).[8] The primary independent variable of interest was time-to-ROSC, defined as the duration from the initiation of chest compressions by a professional rescuer until initial ROSC. ROSC was defined as a palpable pulse in any vessel for any length of time. We pre-specified initial cardiac rhythms as: (1) "shockable", including ventricular fibrillation, pulseless ventricular tachycardia, and unknown rhythms that were shocked with the AED and (2) "non-shockable" including pulseless electrical activity, asystole, and unknown rhythms not shocked by the AED. "Hospital admission" was defined as admission to a hospital admitting service from the emergency department.

### *Data analysis*

We used Microsoft Excel 2008 (Microsoft Corp, Redmond, WA, USA), Statistica™ (Dell Corp, Round Rock, TX, USA), and EGRET™ (Cytel Corp, Cambridge, MA) for data entry and analysis. Dichotomous variables are reported as percentages and 95% confidence intervals. Continuous variables are presented as means with standard deviations (if normally distributed) or medians with interquartile ranges.

Logistic regression was used to assess the association between time-to-ROSC and clinical outcomes for the entire cohort and among the subgroups of initial shockable and non-shockable rhythms. We calculated odds ratios and 95% confidence intervals, adjusting for covariates known to be associated with outcomes in OHCA patients (age, sex, arrest in a public location, witnessed arrest, bystander CPR, interval from dispatch to EMS arrival, arrest witnessed by EMS, and initial rhythm).[5,9] For continuous variables (time-to-ROSC, time from dispatch to EMS arrival, and age) the assumption of linearity of the logit was satisfied. Overall fit of the multiple variable models was tested with Hosmer–Lemeshow goodness of fit chi-square. Among those with favorable neurological outcomes, time-to-ROSC durations for those with initial shockable versus non-shockable rhythms were compared using the Mann–Whitney *U* test.

We created two types of curves describing time-dependent patient outcomes. The first curve examined the proportion of patients who achieved ROSC prior to consecutive 1-min incremental time junctures of professional resuscitation, and demonstrated comparisons between those with favorable and unfavorable outcomes (Fig. 1A), as well as initial shockable vs non-shockable rhythms (Fig. 1B). The second curve demonstrated the dynamic probability of survival (Fig. 2A) and favorable neurologic outcome (Fig. 2B) at hospital discharge among all attempted resuscitations, stratified by initial cardiac rhythm; at each 1-min interval the numerator was the number of pulseless patients with positive outcomes at hospital discharge and the denominator was the total number of pulseless patients at this time juncture. For each proportion a 95% confidence interval was calculated, and data points were joined. Curves were compared using the log-rank test. Curve smoothing was not performed.

Using previous established guidelines for futility,[4,10] we determined the time juncture at which the point estimate for the probability of survival among those in refractory cardiac arrest was <1%. We described the characteristics of patients with survival and favorable neurological outcomes who achieved ROSC after "prolonged" (defined as 30 min) professional resuscitation. Although the most recent guideline of the National Association of EMS Physicians opted not to indicate a time at which TOR should