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Clinical Paper

Volume versus outcome: More emergency medical services personnel on-scene and increased survival after out-of-hospital cardiac arrest☆

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ABSTRACT

Background and aim: : The large regional variation in survival after treatment of out-of-hospital cardiac arrest (OHCA) is incompletely explained. Communities respond to OHCA with differing number of emergency medical services (EMS) personnel who respond to the scene. The effect of different numbers of EMS personnel on-scene upon outcomes is unclear. We sought to evaluate the association between number of EMS personnel on-scene and survival after OHCA.

Methods: We performed a retrospective review of prospectively collected data on 16,122 EMS-treated OHCA events from December 1, 2005 to May 31, 2007 from a combined population over 21 million people residing in an area of over 33,000 square miles in Canada and the United States. Number of EMS personnel on-scene was defined as the number of EMS personnel who responded to the scene of OHCA within 15 min after 9-1-1 call receipt and prior to patient death or transport away from the scene. Associations with survival to hospital discharge were assessed by using generalized estimating equations to construct multivariable logistic regression models.

Results: Compared to a reference number of EMS personnel on-scene of 5 or 6, 7 or 8 EMS personnel on-scene was associated with a higher rate of survival to hospital discharge, adjusted odds ratio [OR], 1.35 (95% CI: 1.05, 1.73). There was no significant difference in survival between 5 or 6 personnel on-scene versus fewer.

Conclusion: More EMS personnel on-scene within 15 min of 9-1-1 call was associated with improved survival of out-of-hospital cardiac arrest. It is unlikely that this finding was mediated solely by earlier CPR or earlier defibrillation.

1. Introduction

More than 400,000 out-of-hospital cardiac arrests (OHCA) occur annually in the U.S., representing 20% of all heart disease deaths.[1–3] Though there has been no uniform reporting mandate, significant and important variations in rates of survival to hospital discharge across communities have been observed.[2] Within the Resuscitation Outcomes Consortium (ROC) communities for whom OHCA

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data have been uniformly collected since December 2005, survival after OHCA ranged from 3.0% to 16.3%. For the subset who presented with ventricular fibrillation (VF) or ventricular tachycardia (VT), survival ranged from 7.7% to 39.9%.[2] Much of this variation in survival remains incompletely explained. In 2010, Rea and colleagues observed that the core Utstein data elements, a set of internationally recognized OHCA process of care variables believed to be associated with survival and explain geographic differences in outcome, collectively accounted for only 43.7% of the between-community survival difference among EMS-treated cardiac arrest.[4,5]

One way that community response to OHCA differs is in the number of emergency medical services (EMS) personnel dispatched to provide on-scene treatment.[6] This generally depends on EMS organizational structure. Accordingly, we sought to examine patterns of association between number of EMS personnel on-scene and survival to hospital discharge in adults with EMS-treated.

2. Methods

2.1. Design

We performed a retrospective review of prospectively collected data from 193 unique EMS agencies participating in the ROC Epistry-Cardiac Arrest, a multi-community registry of patients with OHCA. The study design and data collection of the ROC Epistry have been previously described.[7] An EMS-treated OHCA was defined as any patient with unresponsiveness, apnea, and the absence of a central pulse whom EMS responders attempted to revive. All data were abstracted by dedicated personnel from EMS records, hospital records, and death certificates. To encourage uniform reporting, definitions of data elements were referenced whenever possible to existing standardized National EMS Information System (NEMSIS) and Utstein reporting templates for cardiac arrest.[5,8] The accuracy of the data was ensured by training of personnel, data entry software with numerous built in data checks for missing or outlying values, and a centralized review of randomly selected records to confirm accuracy and consistency. The coordinating center also conducts annual site visits to spot check a portion of entered records, the data capture processes, and site specific measures of quality assurance.[7]

2.2. Population

Our study included EMS-treated OHCA events from December 1, 2005 to May 31, 2007 among adults from a combined population over 21 million people residing in an area of over 33,000 square miles in Canada and the United States. We excluded OHCA with traumatic injury as the primary cause, OHCA having occurred after EMS arrival to the patient, OHCA for which the number of EMS personnel on-scene was unavailable, OHCA with primary outcome unavailable, and OHCA for which the first arriving EMS vehicle was from an agency not participating in the ROC Epistry.

2.3. Measurements

The primary exposure of interest was the number of EMS personnel on-scene, which was pre-specified as the number of EMS personnel who responded to the scene of OHCA within 15 min after 9-1-1 call receipt and prior to patient death or transport away from the scene. The 15 min time frame was chosen with consideration for average EMS response times and published data regarding survival associations.[9–11] Number of EMS personnel on-scene was classified by categories: 0 personnel, 1 or 2 personnel, 3 or 4 personnel, 5 or 6 personnel, 7 or 8 personnel, and >8 personnel.

2.4. Statistical analysis

Baseline characteristics among categories of number of EMS personnel on-scene were summarized descriptively. To evaluate the association between number of EMS personnel on-scene and survival to hospital discharge, we constructed multivariable logistic regression models. Generalized estimating equations (GEE) with logit link, exchangeable correlation matrix, and a Huber–White robust variance estimator, were used to examine the association between number of EMS personnel on-scene and survival to hospital discharge, adjusted for patient and event characteristics and within-EMS agency correlation of OHCA cases.[12,13] For our independent variable, we chose the category of 5 or 6 personnel as our reference category, as it included the overall median and was the most frequent category observed. Effects were reported as odds ratios with 95% confidence intervals. *P*-values of less than or equal to 0.05 were considered to be significant. Analyses were performed using R, version 2.14.0 (R Foundation for Statistical Computing) or SAS, version 9.3 (SAS Institute, Cary, NC).

Covariates included in the adjusted models were chosen a priori based on their association with survival from prior studies of OHCA, biologic plausibility, and adequate ascertainment. Covariates missing more than 0.5% of values were assessed for differential distribution of missing data among categories of number of EMS personnel on-scene. Continuous covariates were included in the adjusted models either continuously or as categorical variables based on our a priori scientific understanding of the relationship between the covariates and the primary outcome.

Patient/event level covariates included were: age (years), sex, median income of census tract where cardiac arrest occurred, whether the arrest occurred in a public setting, whether the arrest was witnessed by bystanders, whether cardiopulmonary resuscitation was initiated by bystanders, first recorded rhythm (automated external defibrillator [AED] with no shock advised, asystole, pulseless electrical activity [PEA], ventricular fibrillation [VF], pulseless ventricular tachycardia [VT], cannot determine), and time (minutes) from 9-1-1 call receipt to first EMS vehicle arrival, and first arriving EMS agency. The following patient/event level covariates were excluded a priori from the primary regression model on the basis of their potential to mediate the association between number of EMS personnel on-scene and patient survival: time from arrival of first EMS agency to EMS CPR, time from arrival of first EMS agency to EMS defibrillation shock (for shockable cardiac rhythms), whether an advanced airway was used, and total dose (milligrams) of epinephrine administered during EMS resuscitation efforts.

EMS agency level covariates were included for each cardiac arrest's first responding EMS agency. These were: population density served, annual EMS runs per ALS capable vehicle, paid ALS full-time equivalents (FTE) per 100k service population, and paid basic life support (BLS) FTE per 100k service population. Median EMS personnel number per EMS vehicle was excluded a priori from the primary regression model on the basis of its anticipated collinearity with other variables of interest.

A secondary analysis was performed by repeating the above analyses, stratified by whether the first identifiable rhythm was shockable (VF or pulseless VT) or non-shockable (asystole or PEA). Additional secondary analyses were performed using three alternate independent variables: EMS personnel on-scene within 10 min of the 9-1-1 call, EMS personnel on-scene beyond 30 min after the 9-1-1, and EMS personnel on-scene any time prior to patient death or transport.

Potential effect modification by the first responding EMS agency's overall survival statistic ranking was assessed, since it was intuitive to the authors that any positive association found between OHCA survival and number of EMS personnel on-scene could be

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