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Clinical paper

Duration of cardiopulmonary resuscitation in patients without prehospital return of spontaneous circulation after out-of-hospital cardiac arrest: Results from a severity stratification analysis

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ABSTRACT

Background: The relationship between duration of cardiopulmonary resuscitation (CPR) and post-arrest outcomes based on severity stratification in out-of-hospital cardiac arrest (OHCA) patients without prehospital return of spontaneous circulation (ROSC) remains unclear.
Methods: We analysed 420,959 adult patients without prehospital ROSC in the All-Japan OHCA registry for 4 years. Prehospital CPR duration was defined as the time from CPR initiation by emergency medical service (EMS) providers to hospital arrival. The primary outcome was 1-month neurologically intact survival (cerebral performance category 1 or 2, CPC 1–2).
Results: The rate of overall 1-month CPC 1–2 was 0.45% (1899/420,959). Using recursive partitioning analysis to predict 1-month CPC 1–2, we stratified patients into 4 groups with 3 predictors: patients aged <75 years with initial shockable rhythm (1-month CPC 1–2 rate, 6.15%), those aged ≥75 years with initial shockable rhythm (1.32%), those with EMS-witnessed arrest and initial non-shockable rhythm (1.62%), and those with EMS-unwitnessed arrest and initial non-shockable rhythm (0.15%). Prehospital CPR duration was negatively associated with 1-month CPC 1–2 (adjusted odds ratio 0.94 per 1-min increment; 95% confidence interval 0.94–0.95). Prehospital CPR durations beyond which the dynamic probability of 1-month CPC 1–2 decreased to <1% were 26 min, 10 min, 7 min, and at all times in above-mentioned stratification, respectively.
Conclusions: In OHCA patients without prehospital ROSC, those aged <75 years with initial shockable rhythm had acceptable 1-month CPC 1–2 rate. However, CPR efforts lasting 26 min or over before hospital arrival could be futile.

Introduction

In many emergency medical service (EMS) systems in the United States and other Western countries, where termination of resuscitation (TOR) rule is applicable, patients with out-of-hospital cardiac arrest (OHCA) are declared dead at the scene after a predetermined cardiopulmonary resuscitation (CPR) duration of 20–30 min [1–3]. However, in Japan, almost all OHCA patients treated by EMS providers who did not achieve prehospital return of spontaneous circulation (ROSC) were transported to a hospital because EMS providers are legally prohibited from TOR in the field [4,5]. In this context, physicians in the emergency departments in Japan may use resuscitation duration in the absence of ROSC to justify prolonging or terminating CPR after a certain period of time has elapsed. However, despite advances in resuscitation knowledge, the appropriate CPR duration and when it is acceptable to terminate resuscitation efforts in these patients remains unclear [1–7]. Recently, several studies have investigated the relationship between CPR duration and outcomes, particularly in patients who achieved prehospital ROSC [8–17]. However, in OHCA patients without prehospital ROSC, there are no studies that focused on the relationship between prehospital CPR duration and post-arrest outcome based on severity stratification.

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Our objective was to investigate the impact of prehospital CPR duration and other prehospital variables on the probability of neurologically intact survival in OHCA patients without prehospital ROSC. We also performed severity stratification to determine whether patients with particular characteristics justified prolonging or terminating CPR.

Methods

Study design and data source

In January 2005, the Fire and Disaster Management Agency (FDMA) of Japan launched a prospective, nationwide, population-based registry based on the Utstein-style that included all OHCA patients [18,19]. Using this registry, the present observational study enrolled adults (age ≥18 years) for whom resuscitation was attempted by EMS providers after OHCA in January 2011–December 2014. Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by patient unresponsiveness and absence of normal breathing (e.g., not breathing or only gasping) [4,7]. The cause of arrest was presumed to be cardiac unless evidence suggested an external cause, such as respiratory disease, cerebrovascular disease, malignant tumour, or any other non-cardiac cause. The cause of arrest was determined by physicians in charge in collaboration with the EMS providers.

This study was approved by the ethics committee of Kanazawa University, and informed consent was waived because of the anonymous nature of the data used (2012-032).

The Japanese EMS system

Japan has approximately 127 million residents in an area of 378,000 km^2. Details of the Japanese EMS system have been described previously [18]. Briefly, the FDMA of Japan supervises the nationwide EMS system, and the local fire stations operate the local EMS systems. Emergency lifesaving technicians are EMS providers who are allowed to use several resuscitation methods, including automated external defibrillators (AED), insertion of an airway adjunct or a peripheral intravenous line, and administration of Ringer's Lactate solution. However, only specifically trained emergency lifesaving technicians are permitted to insert a tracheal tube and administer intravenous adrenaline in the field while receiving physician instruction on the phone. All EMS providers perform CPR according to Japanese CPR guidelines [4]. Since EMS providers in Japan are legally prohibited from TOR in the field, most OHCA patients who receive CPR by EMS providers are transported to hospitals, except in cases where fatality is certain. The duration of on-scene CPR by EMS providers before transport to a hospital is not predetermined.

Data collection and quality control

Data were collected prospectively for variables such as age, sex, cause of arrest, bystander witness status, bystander CPR with or without AED, initial cardiac rhythm, bystander category. Other variables included whether a) adrenaline was administered, b) advanced airway management techniques were used, c) ROSC was achieved before hospital arrival, together with time of a) the emergency call, b) vehicle arrival at the scene, c) CPR initiation by the EMS providers, d) ROSC, e) vehicle arrival at the hospital, f) adrenaline administration, g) shock delivery by the EMS providers; 1-month survival, and neurological outcome at 1 month after cardiac arrest. The EMS response time was calculated as the time from the emergency call to the time of vehicle arrival at the scene. Prehospital CPR duration was defined as the time from CPR initiation by the EMS providers to hospital arrival.

Neurological outcome was defined using the Cerebral Performance Category (CPC) scale: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death [19]. CPC categorization was performed by the physician in charge.

Outcome

The primary study outcome was 1-month neurologically intact survival, defined as a CPC score of 1 or 2 (CPC 1–2).

Statistical analysis

Continuous variables were expressed as medians (interquartile range) or means and standard deviations. Categorical variables were expressed as counts and percentages. We classified age into two categories: <75 and ≥75 years according to the latest definition of elderly by the Japan Gerontological Society and the Japan Geriatrics Society [20]. Multivariate logistic regression analysis using 12 prehospital variables including potential confounders based on biological plausibility and the previous studies were performed to identify factors associated with 1-month CPC 1–2; adjusted odds ratio (OR) and their 95% confidence interval (CI) were calculated. Twelve prehospital variables were age, sex, witnessed arrest, EMS-witnessed arrest, presumed cardiac aetiology, initial documented rhythm, bystander CPR, EMS response time (per 1-min increment), prehospital CPR duration (per 1-min increment), use of advanced airway management, adrenaline administration, and prehospital AED administration. Using 11 prehospital variables mentioned above excluding prehospital CPR duration, recursive partitioning analysis was performed to stratify patients into subgroups by patient characteristics to predict 1-month CPC 1–2. The dynamic probability of 1-month CPC 1–2 was calculated, for all patients and each subgroup, using the following formula: Dynamic probability of a 1-month CPC 1–2 (Y) [%] = {[(survivors with CPC 1–2 at 1 month after OHCA, for all patients or each subgroup) − Nx] × 100}/(all patients or each subgroup with OHCA), where Nx is the number of all patients or each subgroup who received prehospital CPR for 0 to x minutes and survived with CPC 1–2 for 1 month after OHCA [8–10]. The cumulative proportion of 1-month CPC 1–2, was also calculated, for all patients and each subgroup, using the following formula: Cumulative proportion of 1-month CPC 1–2 (Y)[%] = (Nx × 100)/(survivors with CPC 1–2 at 1 month after OHCA, for all patients or each subgroup), where Nx is the number of all patients or each subgroup who received prehospital CPR for 0 to x minutes and survived with CPC 1–2 for 1 month after OHCA [8–10]. On the basis of medical futility (<1% chance of 1-month CPC 1–2) [7,21], we determined 2 categories of prehospital CPR duration: that beyond which the dynamic probability of 1-month CPC 1–2 decreased to <1%, and that necessary to achieve >99% cumulative proportion of OHCA patients with 1-month CPC 1–2 [8–15]. All statistical analyses were performed using JMP Pro software, version 12.2.0 (SAS Institute, Cary, NC, USA). All tests were 2-tailed, and P values < 0.05 were considered statistically significant.

Results

During the 4-year study period, 506,050 OHCA events were documented. Out of 496,560 OHCAs with attempted resuscitation by EMS providers, 420,959 patients aged ≥18 years (84.8%) without prehospital ROSC were eligible for analysis (Fig. 1). Baseline patient characteristics and outcomes are shown in Table 1. The rate of 1-month CPC 1–2 was 0.45% (1899/420,959) in this study population. In multivariate logistic regression analysis, 10 variables except