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Clinical paper

Age-specific differences in prognostic significance of rhythm conversion from initial non-shockable to shockable rhythm and subsequent shock delivery in out-of-hospital cardiac arrest☆

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ABSTRACT

Background: Early rhythm conversion from an initial non-shockable to a shockable rhythm and subsequent shock delivery in patients with out-of-hospital cardiac arrest (OHCA) has been associated with favourable neurological outcome (Cerebral Performance Category score 1 or 2; CPC 1–2). We hypothesized that the prognostic significance of rhythm conversion and subsequent shock delivery differs by age and time from initiation of cardiopulmonary resuscitation (CPR) by emergency medical service (EMS) providers to first defibrillation (shock delivery time).
Methods: We analysed 430,443 OHCA patients with an initial non-shockable rhythm using a prospective Japanese Utstein-style database from 2011 to 2014. The primary endpoint was 1-month CPC 1–2.
Results: Multivariate logistic regression revealed that rhythm conversion and subsequent shock delivery is positively associated with 1-month CPC 1–2: the adjusted odds ratio was 6.09 (95% confidence interval: 3.65–9.75) for shock delivery time <10 min and 3.34 (2.58–4.27) for 10–19 min in patients aged 18–64 years, and 3.16 (1.45–6.09) for <10 min and 2.17 (1.51–3.03) for 10–19 min in patients aged 65–74 years. However, it is negatively associated with 1-month CPC 1–2 for shock delivery time of 20–59 min in patients aged 75–84 years (0.55; 0.27–0.98) and ≥85 years (0.17; 0.03–0.53).
Conclusions: Early rhythm conversion from an initial non-shockable to a shockable rhythm and subsequent shock delivery is associated with increased odds of 1-month CPC 1–2 in OHCA patients aged 18–74 years but not in those aged ≥75 years.

Introduction

Studies investigating the prognostic significance of subsequent shock delivery for patients with out-of-hospital cardiac arrest (OHCA) that had rhythm conversion from an initial non-shockable to a shockable rhythm have reported inconsistent results.[1–7] Recently, two studies evaluating the time from initiation of cardiopulmonary resuscitation (CPR) by emergency medical service (EMS) providers to first defibrillation revealed that early rhythm conversion from an initial non-shockable to a shockable rhythm and subsequent shock delivery is associated with increased survival with favourable neurological outcome.[6,7] Furthermore, younger age is significantly associated with the presence of rhythm conversion and subsequent shock delivery in OHCA patients with an initial non-shockable rhythm.[7] On the other hand, advanced age is independently associated with worse outcome, and the proportion of initial shockable rhythm decreases with age.[8–10] However, it is unclear whether age affects the prognostic significance of rhythm conversion and subsequent shock delivery in OHCA patients with an initial non-shockable rhythm. Therefore, we investigated whether the prognostic significance of rhythm conversion and subsequent shock delivery differs by age and time from initiation of CPR by EMS providers to first defibrillation.

Methods

Study design and data source

In January 2005, the Fire and Disaster Management Agency (FDMA) of Japan launched a prospective, nationwide, population-

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based registry based on the Utstein-style that includes all OHCA patients.[9,11] Using this registry, the present observational study enrolled adults (age ≥18 years) for whom resuscitation was attempted after OHCA between January 2011 and December 2014. Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation. The cause of arrest was presumed to be cardiac unless evidence suggested an external cause, 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 EMS providers.

This study was approved by the ethics committee of Kanazawa University with informed consent waived because of the anonymous nature of the data (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.[9] Briefly, municipal governments provide EMS through approximately 800 fire stations with dispatch centres. The FDMA of Japan supervises the national EMS system, whereas each local EMS system is operated by the local fire station. In general, an ambulance crew consists of 3 EMS staff members, including at least 1 emergency lifesaving technician (ELST). ELSTs can use various resuscitation methods, including automated external defibrillation (AED), insertion of a supraglottic airway device, insertion of a peripheral intravenous line, and administration of Ringer's lactate solution. Since July 2004, only specially trained ELSTs have been permitted to insert a tracheal tube. Since April 2006, they have been permitted to administer intravenous adrenaline in the field under the supervision of an online physician. All EMS providers perform CPR according to Japanese CPR guidelines.[12] When EMS providers arrive at the scene, the initiation of CPR and initial rhythm assessment using an AED are generally performed simultaneously as soon as possible. An AED delivers a shock only when it detects a shockable rhythm. If a non-shockable rhythm is detected, the AED instructs the EMS provider to resume CPR immediately. Rhythm detection is performed every two minutes by the AED during CPR. Electrocardiography (ECG) data collected from AEDs are reviewed by the regional medical control committee. Rhythm interpretation was then entered into the Utstein-style database.

Since EMS providers in Japan are legally prohibited from termination of resuscitation in the field, most OHCA patients who receive CPR from EMS providers are transported to hospitals, except in cases where fatality is certain.

Data collection and quality control

Data were collected prospectively for variables such as sex, age, cause of arrest, bystander witness status, bystander CPR with or without AED use, initial cardiac rhythm, bystander category, whether adrenaline was administered, whether advanced airway management techniques were used, whether return of spontaneous circulation (ROSC) was achieved before hospital arrival, time of the emergency call, time of vehicle arrival at the scene, time of CPR initiation by EMS providers, time of ROSC, time of vehicle arrival at the hospital, time of adrenaline administration, time of shock delivery by 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. We defined rhythm conversion from an initial non-shockable rhythm to a shockable rhythm and subsequent shock delivery as the delivery of shocks by EMS providers for a patient with an initial non-shockable rhythm during EMS resuscitation; we used shock

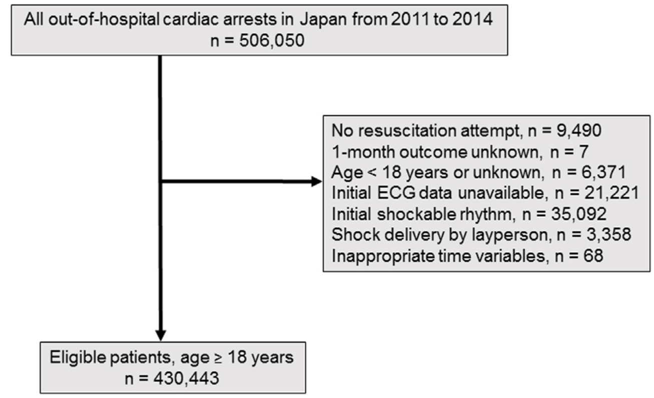

Fig. 1. Flowchart of the patient selection process.
ECG indicates electrocardiography.

delivery as a surrogate for rhythm conversion. Shock delivery time was defined as the time interval between the initiation of CPR by EMS providers and the first EMS-administered defibrillation.[6,7]

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.[11] CPC categorization was performed by the physician in charge.

Endpoint

The primary study endpoint was 1-month survival with favourable neurological outcome, defined as a CPC score of 1 or 2 (CPC 1–2).

Statistical analysis

Categorical variables were expressed as counts (%), and differences between groups were compared using the χ^2 test. Continuous variables were expressed as medians (interquartile range) or means and standard deviations and compared with the Wilcoxon and Kruskal–Wallis tests. We classified the following 2 covariates into several categories, defined in parentheses: age (18–64 years, 65–74 years, 75–84 years, and ≥85 years) and rhythm conversion and subsequent shock delivery (shock delivery time [<10 min, 10–19 min, and 20–59 min] and no). Outcomes were compared by age group and shock delivery time category using the Cochran–Armitage trend test or exact Cochran–Armitage trend test. Multivariate logistic regression models that included potential confounding factors based on biological plausibility and previous studies was used to identify factors associated with 1-month CPC 1–2 for overall and each age group; odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated.

All statistical analyses were performed using the JMP Pro version 12.2.0 (SAS Institute, Cary, NC, USA). All tests were two-tailed, and p values of <0.05 were considered statistically significant.

Results

Patient and EMS characteristics

During the 4-year study period, 506,050 OHCA events were documented. Of 496,560 OHCAs with attempted resuscitation, 430,443 patients aged ≥18 years (86.7%) with an initial non-shockable rhythm were eligible for analysis (Fig. 1). Patients were divided into two groups by presence of rhythm conversion and subsequent shock delivery: subsequent shock (n = 14,352; 3.3%) and no subse-