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Clinical paper

Timing of advanced airway management by emergency medical services personnel following out-of-hospital cardiac arrest: A population-based cohort study☆

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ABSTRACT

Background: Early prehospital advanced airway management (AAM) by emergency medical services (EMS) personnel has been intended to improve patient outcomes from out-of-hospital cardiac arrest (OHCA). However, few studies examine the effectiveness of early prehospital AAM. We investigated whether early prehospital AAM was associated with functionally favourable survival after adult OHCA.

Methods: We conducted a population-based cohort study of OHCA in Osaka, Japan, between 2005 and 2012. We included all consecutive, non-traumatic adult OHCA in which EMS personnel performed cardiopulmonary resuscitation (CPR) and AAM. Main exposure was time from CPR to AAM. Primary outcome was functionally favourable survival at one-month. As the primary analysis, we estimated adjusted odds ratio (OR) of time from CPR to AAM using multivariable logistic regression in the original cohort. In the secondary analysis, we divided the time from CPR to AAM into early (0–4 min) and late (5–29 min). We calculated propensity scores (PS) for early AAM and performed PS-matching.

Results: We included 27,471 patients who received prehospital AAM by EMS personnel. In this original cohort, time from CPR to AAM was inversely associated with functionally favourable survival (adjusted OR 0.90 for one-increment of minute, 95% confidence interval [CI] 0.87–0.94). In the PS-matched cohort of 17,022 patients, early AAM, compared to late AAM, was associated with functionally favourable survival: 2.2% vs 1.4%; adjusted OR 1.58 (95% CI 1.24–2.02).

Conclusions: Earlier prehospital AAM by EMS personnel was associated with functionally better survival among adult patients who received AAM.

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Introduction

Basic life support with laypersons using automated external defibrillators (AED) and advanced life support improve patient outcomes in out-of-hospital cardiac arrest (OHCA) [1–3], but OHCA mortality remains high, even in industrialized countries [4,5]. Advanced airway management (AAM), such as endotracheal intubation (ETI) or supraglottic airway (SGA) placement, is performed by emergency medical services (EMS) personnel during prehospital resuscitation, and is intended to increase favourable OHCA outcomes by improving oxygenation and the chest compression fraction during cardiopulmonary resuscitation (CPR) [6–8].

Previous studies have reported a general trend of AAM having worse survival than bag-valve-mask ventilation [9], but there are also conflicting results among nationwide registries. An observational study from the Korean nationwide OHCA registry reported that ETI was associated with functionally better survival than bag-valve-mask ventilation [10]. However, an observational study from the Japanese nationwide OHCA registry indicated that any prehospital AAM (SGA or ETI) was associated with worse outcomes compared to bag-valve-mask ventilation [11]. Although these studies examined nationwide registries, and the study from Japan used a sophisticated propensity score-matching statistical approach, neither study considered the timing of AAM. According to previous studies of in-hospital cardiac arrest (IHCA), the timing of AAM may be critical, and early AAM can be beneficial to improve outcomes after OHCA [12,13].

Therefore, we evaluated the effectiveness of early AAM using a population-based OHCA database, the Utstein Osaka Project Database, that contained detailed information including the exact timing of AAM by EMS personnel. The aim of this study was to investigate the effectiveness of early prehospital AAM compared to late AAM by EMS personnel for improving functionally favourable outcomes after adult OHCA.

Methods

Study design and setting

This population-based observational study reviewed the data of all consecutive OHCA patients in the Utstein Osaka Project Database, a prospective Utstein-Style population cohort conducted in Osaka Prefecture, Japan, from January 2005 through December 2012. Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation [14,15]. Osaka University organized this project, with the assent of the EMS authorities and local governments in the prefecture. Each EMS authority submitted anonymized data. The medical institutional review board of Osaka University approved this study and waived the need for informed consent because of de-identified data.

The EMS system in Osaka, Japan [16]

Osaka Prefecture has 8.8 million residents in an area of 1892 km^2 of both urban and rural communities. It has 34 fire stations with a corresponding number of emergency dispatch centres. Prehospital life support is provided 24 h each day by a fire-station-based EMS system, which is single-tiered in 32 stations and two-tiered in two stations.

Each fire ambulance has three EMS providers with at least one emergency life-saving technician (ELST), who are authorized to use an AED. Under on-line medical control direction, ELST are also authorized to insert an intravenous line, to administer adrenaline, and to place AAM devices for OHCA patients. In Japan, EMS providers are not permitted to terminate resuscitation on the field and all patients for whom resuscitation is attempted are transported to hospitals. SGA devices, such as laryngeal tubes and laryngeal masks, have been used in Japan since the ELST system started in 1991. Since 2004, specially-trained, certified ELST have been permitted to perform ETI under online medical control direction, but not all ELST are certified for ETI. When ELST decide to perform AAM for eligible OHCA patients, standard ELST can use only SGA on the scene whereas certified ELST can select either ETI or SGA.

To become a certified ELST able to perform ETI, each ELST must complete training that has been authorized by a regional medical control committee. The training period is composed of more than 62 terms, and each term takes 50 min to complete. The practical training is based on more than 30 successful ETI procedures for patients in hospital operating rooms under the guidance and supervision of attending physicians.

Study participants

We screened the data of all consecutive OHCA cases aged ≥18 years for whom EMS personnel attempted CPR. Of these, we included non-traumatic patients for whom EMS personnel performed AAM during prehospital CPR. We excluded patients whose time between the call to EMS and the start of CPR by EMS personnel was ≥60 min, whose time between the start of CPR by EMS personnel and the achievement of AAM by EMS personnel was ≥30 min, or whose Glasgow-Pittsburgh Cerebral Performance Category scale (CPC) at one-month after OHCA was unknown.

Data collection and main outcomes

Data for analyses included the year, the anonymised area (A–H) where the OHCA occurred within the Osaka Prefecture, age, sex, activities of daily living (ADL) prior to OHCA (intact or not), location of the OHCA (home, healthcare facilities, public locations, or others), OHCA cause (medical including cardiac and non-cardiac, or non-medical), witness status (no witness, by citizen, or by EMS personnel), bystander resuscitation by citizens, use of public access AED, presence of prehospital physician involvement, presence of ELST certified for ETI, time from call to CPR by EMS personnel (time from call to CPR), initially documented rhythm (PEA [pulseless electrical activity], asystole, VF [ventricular fibrillation], pulseless VT [ventricular tachycardia], or unknown), type of devices in AAM (SGA or ETI), time from CPR by EMS personnel to defibrillation by EMS personnel (time from CPR to defibrillation), time from CPR by EMS personnel to adrenaline administration by EMS personnel (time from CPR to adrenaline administration), and time from CPR by EMS personnel to hospital arrival (time from CPR to hospital arrival). We classified the timing of defibrillation and adrenaline administration into the following six categories: ≤4 min, 5–9 min, 10–14 min, 15–19 min, ≥20 min, or never on the field.

We collected functional neurologic outcomes at one-month from physicians in the hospitals who rated patients using the CPC as: 1: good performance, 2: moderate disability, 3: severe cerebral disability, 4: coma/vegetative state, and 5: death/brain death [14,15]. The primary outcome was functionally favourable survival at one-month, defined as a CPC of 1 or 2. We also collected one-month survival, hospital admission and prehospital return of spontaneous circulation (ROSC). For one-month survival, we only considered cardiac death to be non-survival according to the registry's definition [1].

Measure of main exposure and propensity score-matching

In the primary analysis, the main exposure was the time from CPR by EMS personnel to prehospital achievement of AAM by EMS personnel (time from CPR to AAM). For propensity score (PS) matching as the secondary analysis, we divided the time into early AAM (0–4 min from CPR) and late AAM (5–29 min from CPR), which was based on the methods of a previous study concerning AAM for IHCA patients [12].

To adjust for all measured, potential confounders, we performed PS