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Original Contribution

Prehospital endotracheal intubation and survival after out-of-hospital cardiac arrest: results from the Korean nationwide registry☆,☆☆

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ABSTRACT

Purpose: Optimal out-of-hospital cardiac arrest (OHCA) airway management strategies are still controversial. Recent studies reported survival was higher among patients who received bag-valve-mask (BVM) than those receiving endotracheal intubation (ETI) or supraglottic airway (SGA). The aim of this study was to compare neurologically favorable survival outcomes among adult nontraumatic OHCA patients by prehospital airway.
Methods: We used the Korean nationwide OHCA cohort database from 2010 to 2013. The inclusion criteria were all OHCA adults with presumed cardiac etiology, resuscitated by level-1 emergency medical technician. Patients were excluded if their information about the method of prehospital airway or clinical outcomes at hospital discharge could not be captured. The primary outcome was neurologically favorable survival to discharge. We compared the outcomes among 3 groups (ETI, SGA, or BVM) by prehospital airway using multivariable logistic regression with interaction model.
Results: Of 98 896 patients with OHCA, 32 513 were included in analysis. Patients receiving BVM were 29 684 and 2829 underwent advanced airway management including 1634 with SGA and 1195 with ETI. The odds of neurologically favorable survival to discharge was significantly higher in the ETI group compared to the BVM group (adjusted OR, 1.405; 95% CI, 1.1001-1.971). In the interaction model by witnessed status, the effect of ETI on good clinical outcomes was shown only in the patients whose arrest was unwitnessed.
Conclusion: In this Korean nationwide, population-based OHCA cohort, neurologically favorable survival to hospital discharge rates was significantly higher among patients who received ETI than those receiving BVM or SGA.
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1. Introduction

Endotracheal intubation (ETI) has long been considered the optimal method for airway management during cardiopulmonary resuscitation (CPR). Although some studies have reported that out-of-hospital cardiac arrest (OHCA) patients who receive ETI have a significantly higher chance of surviving to hospital admission than those who do not [1,2], recent large-scale studies have reported that both ETI and supraglottic airway (SGA) insertion are associated with a reduced probability of neurologically favorable survival compared with conventional bag-mask ventilation (BVM) [3–6].

Despite this evidence, the optimal prehospital airway strategy for OHCA patients is still under debate. Few data exist in support of the routine use of any specific approach to airway management during cardiac arrest. The optimal technique is dependent on the competence of the rescuer, the precise circumstances of the cardiac arrest, the patient's condition, and the characteristics of the emergency medical service (EMS) or health care system [7,8]. In the United States, ETI is the most common airway intervention; however, most Asian countries have a single-tiered EMS system, and less than 10% of OHCA patients receive ETI by emergency medical technicians (EMTs) in the prehospital setting [9,10].

The aim of this study was to compare neurologically favorable survival outcomes among adult nontraumatic OHCA patients in the Korean nationwide OHCA cohort database according to the prehospital airway management technique used (ETI, SGA, and BVM). In addition, we aimed to investigate whether an interactive effect of airway management technique on survival outcome was present among patients with or without a witness.

2. Methods

2.1. Study design

This study was a population-based, retrospective cohort study approved by the institutional review board of the study hospital, and

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informed consent was waived. We conducted secondary analysis of the cardiovascular disease surveillance (CAVAS) database.

2.2. Data source

The CAVAS project began in 2006, and it was conducted by the Ministry of Health and Welfare in collaboration with the National Emergency Management Agency (NEMA) and the Korean Centers for Disease Control and Prevention to improve the outcome of cardiovascular disease in Korea. The CAVAS database consists of 3 disease entities, including acute myocardial infarction, acute stroke, and a nationwide EMS-assessed OHCA cohort that was obtained from EMS run sheets for demographic and Utstein information. After acquiring this information for the OHCA cohort from the database, a hospital medical record review was performed to assess hospital resuscitation and postresuscitation care and clinical outcomes.

All patient information from EMS run sheets is inputted by EMTs immediately after the transport of OHCA patients, and it is stored in the NEMA electronic server. Hospital medical records are reviewed and captured by experts from the Korean Centers for Disease Control and Prevention using a structured survey form. All of the items, including the definitions, inclusion and exclusion criteria, examples, and warnings, are defined in the medical record review guidelines and were developed by the project quality management committee (QMC). The QMC is composed of emergency physicians, epidemiologists, statistical experts, cardiologists, and medical record review experts.

2.3. Study setting

The Korean EMS system is a single-tiered, government-based system operated by 16 provincial headquarters of the National Fire Department, covering a population of approximately 50 million. Ambulance personnel cannot declare death at the scene or terminate CPR unless return of spontaneous circulation (ROSC) occurs. Thus, all patients with OHCA are transported to an emergency department (ED). EMTs in Korea are classified into 2 levels: level-1 and level-2 EMTs (comparable to EMT-intermediate and EMT-basic in the United States, respectively). Provision of prehospital advanced airway management and administration of limited medications, such as epinephrine or atropine, are only to be performed by level-1 EMTs under direct or indirect medical control.

According to the Emergency Medical Service Act, level-1 EMTs should have graduated from an EMT school (a 3- to 4-year curriculum) of a university or college and have passed a national certification examination composed of written and skills tests. The curriculum of the EMT school for advanced airway management should include 6 courses and 147 hours of education, with lectures and skill laboratories. After passing the national certification examination, certified level-1 EMTs can apply for the Fire Service Academy during recruitment.

The Fire Service Academy provides class or distance learning to all recruited EMTs. A life-saving technique course, including advanced airway management, is provided for EMTs' skill enhancement by the national Fire Service Academy or the nineteen provincial academies. To maintain knowledge and skills, continuing medical education comprising a 4-hour didactic session every year and a 2-month comprehensive clinical training course held at an ED every 4 years are mandatory. Level-1 EMTs must abide by the NEMA's internal regulation, which states that 1 attempt should be performed within a single 30-second duration, and up to 2 total advanced airway management attempts can be made on the scene.

Ambulance crews are usually composed of 3 members (level-1 and level-2 EMTs and a first-responder) in most metropolitan provinces, whereas 2 members (a level-1 or level-2 EMT and a first-responder) are on board in some rural provinces. In Korea, all EDs are designated as level 1, 2, or 3 by the government, with the level designation being based on the human resources, intensive care units, instruments, and equipment available at each ED. Level-1 ($n = 19$) and level-2 ($n = 110$) EDs have more resources and better facilities for emergency care and must be covered by emergency physicians 24 hours a day. All EDs are subject to annual evaluation by the government audit committee.

2.4. Study population

The data were extracted between January 2010 and December 2013. The inclusion criteria were all OHCA adults older than 18 years old with a presumed cardiac etiology who were resuscitated by a level-1 EMT. Patients were excluded if information about the method of prehospital airway management or the clinical outcomes at discharge could not be obtained.

The etiology of cardiac arrest was identified by medical record reviews, and we excluded cases with a primary noncardiac etiology. We assumed the primary cardiac etiology if there was no description of a definite noncardiac etiology, such as trauma (mainly motor vehicle accidents and falls from height), exsanguination, drowning, poisoning, burns, asphyxia, or hanging, in the medical records.

2.5. Outcomes and variables

The primary outcome was neurologically favorable survival to hospital discharge, defined *a priori* as a Glasgow-Pittsburgh cerebral performance category (CPC) of 1 or 2 [11], and the secondary outcome was survival to hospital discharge. The CPC score was determined by the medical record reviewers based on the discharge summary or documentation in the medical records.

The main exposure variable was the airway management technique performed by EMTs, classified as ETI, SGA, or BVM. The selection of the airway management technique was completely dependent on the preference of the level-1 EMT at the scene. We used the Utstein-defined co-variables, including gender, age, witnessed status, bystander CPR, initial electrocardiogram rhythm, prehospital defibrillation, arrest location, elapsed time interval from call to ambulance arrival at the scene (EMS response time), elapsed time interval from arrival at the scene to departure (EMS on-scene time), elapsed time interval from departure to arrival at the ED (EMS transport time), and prehospital ROSC. In addition, we added the following co-variables: the level of the ED (level 1-3) to adjust for ED performance and community urbanization (metropolitan or not) to adjust for geographical variations in community performance and resources.

2.6. Statistical analysis

We compared the patient demographics, arrest characteristics and EMS time intervals among those receiving ETI, SGA or BVM using the χ^2 test, 1-way analysis of variance or the 1-way Kruskal-Wallis test, as appropriate.

Afterward, we compared the outcomes among the 3 groups according to the airway management methods used. Multivariable logistic regression analyses were conducted to estimate the effect sizes of the prehospital airway management techniques on survival to discharge and good neurologic outcome and to calculate the adjusted odds ratios (ORs) and 95% confidence intervals (CIs) after adjusting for the potential confounders (the 13 co-variables mentioned above).

Finally, we applied interaction terms for airway management technique and witnessed status to the multivariable logistic regression model to estimate the effects of the airway management techniques according to the witnessed status on the primary and secondary outcomes. If an interactive effect was detected between an airway management technique and witnessed status, then the adjusted ORs for the airway management technique on the study outcomes differed between the patients with or without a witness. All statistical analyses were performed using SAS-version 9.4 software (SAS institute Inc, Cary, NC, USA).

3. Results

During the study period, 98 896 patients with OHCA were detected in the CAVAS OHCA database. We excluded 2475 children younger

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