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Original Contribution

The role of prehospital advanced airway management on outcomes for out-of-hospital cardiac arrest patients: a meta-analysis☆

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ABSTRACT

Objective: The objective of this meta-analysis was to compare the benefits of prehospital advanced airway management (AAM) and basic airway management (BAM) for out-of-hospital cardiac arrest (OHCA) patients.
Methods: Two investigators performed a systematic review of PubMed, EMBASE, and the Cochrane Database to identify all peer-reviewed articles relevant to this meta-analysis. We included all articles describing emergency medical system–treated nontraumatic OHCAs; specifically, all articles that described intervention of the prehospital AAM type were considered. The primary outcome was survival to discharge, whereas the secondary outcome was neurologic recovery after an OHCA event. For subgroup analysis, we compared the clinical outcome of endotracheal intubation (ETI), a specific type of AAM, vs BAM.
Results: We reviewed 1452 studies, 10 of which satisfied all the inclusion criteria and involved 17 380 patients subjected to AAM and 67 525 subjected to BAM. Based on the full random effects model, patients who received AAM had lower odds of survival (odds ratio [OR], 0.51; 95% confidence interval [CI], 0.29-0.90) compared with BAM. Subgroup analysis for ETI vs BAM showed no significant association with respect to survival (OR, 0.44; 95% CI, 0.16-1.23). There were no significant differences in the odds of neurologic recovery between AAM and BAM (OR, 0.64; 95% CI, 0.03-1.37).
Conclusions: Our results reveal decreased survival odds for OHCA patients treated with AAM by emergency medical service personnel compared with BAM. However, the role of prehospital AAM, especially ETI, on achieving neurologic recovery remains unclear.

1. Introduction

1.1. Background

Out-of-hospital cardiac arrest (OHCA) is a major public health concern owing to its high incidence and fatality rates [1-3]. In particular, prehospital emergency care has a major impact on outcomes of OHCA patients. Advanced airway management (AAM) methods such as endotracheal intubation (ETI) or supraglottic airway (SGA) devices have been commonly used for advanced emergency care for OHCA patients in prehospital settings during the past 3 decades [4], and more than 80% of OHCA patients in the United States receive AAM in prehospital locations [5]. AAM in prehospital settings serves to reverse hypoxia and provide airway protection [6]. Recently, large-scale cohort studies in the United States and Japan concluded that AAM for OHCA patients in prehospital settings did not influence patient outcomes [5,7]. Although previous meta-analyses of prehospital AAM in OHCA patients have been conducted, the type of AAM that best influences OHCA patient outcomes remains controversial [8].

1.2. Goal of this study

The objective of our meta-analysis was to investigate the benefits of prehospital AAM for OHCA patients and compare them with outcomes of basic airway management (BAM).

2. Materials and methods

This study followed Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines [9].

2.1. Eligibility criteria

The inclusion criteria for this meta-analysis were as follows: (1) OHCA patients on whom resuscitation was attempted by emergency

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medical services (EMS) personnel in a prehospital setting. (2) Presumed cardiac-origin OHCA patients presenting with any electrocardiogram (ECG) rhythm. (3) A comparison of BAM with any AAM technique was performed. *BAM* was defined as a noninvasive technique for airway management such as head-tilt, chin lift, and variations thereof and bag valve mask (BVM) use with or without inclusion of the nasopharyngeal airway and/or oropharyngeal airway. *AAM* was defined as an invasive technique for airway management such as ETI and all types of SGA and transtracheal airway devices. (4) Patient outcomes were reported using the Utstein guidelines as defined below [10].

Exclusion criteria were (1) studies that included restrictively involved subjects, such as those who witnessed an OHCA; (2) patients where airway management was primarily conducted by a physician; and (3) simulation studies. To confirm that a single OHCA event was not double counted, cardiac arrest databases were checked for overlap.

2.2. Outcomes

We investigated major long-term outcomes after OHCA as per the Utstein guidelines. These included (1) survival to hospital discharge and (2) neurologic recovery as defined by the Cerebral Performance Category or Glasgow Outcome Scale. We also examined any minor differences in how outcomes were defined by different studies. For this meta-analysis, the considered outcomes were survival status and full neurologic recovery (Cerebral Performance Category 1 or 2) regardless of the time point of assessment.

2.3. Search strategy

We searched PubMed, EMBASE, and the Cochrane Database up to August 30, 2015. Eligible studies were included regardless of language. Two reviewers conducted independent searches using a standard review protocol to identify all relevant peer-reviewed articles. We included articles in press, letters, correspondences, and short reports and also performed back-searches of reference lists for suitable articles. The following search terms, which included medical subject headings (MeSH) terms and any commercial names of airway management devices, were used: *prehospital*, *out-of-hospital cardiac arrest*, *airway*, *intubation*, *supraglottic airway*, *bag valve mask*, *laryngeal mask airway (LMA)*, and *I-gel*.

The abstracts of selected articles were then reviewed. If the inclusion criteria were met, the entire article was reviewed. The authors used consensus to determine the final list of articles that met all the necessary criteria. If a mismatch occurred between the 2 reviewers, a third reviewer intervened to resolve the dispute.

2.4. Data extraction

When reviewing the entire article, data extraction was performed independently by 2 authors to identify the following characteristics: study and year, demographics of the OHCA patients, circumstance of cardiac arrest including witness status, bystander resuscitation, crude numbers of AAM vs BAM, description of the type of interventions, and primary and secondary outcomes. Measured treatment effects for AAM vs BAM were extracted as odds ratios (ORs) with associated 95% confidence intervals (CIs) for each of the outcomes. Outcomes adjusted for covariates using regression analysis or propensity scoring, as well as raw outcomes, were extracted when available. Pilot data extraction on a single study was conducted for establishing a data extraction protocol. Disagreements in extracted data were resolved by arbitration and ultimate consensus between 2 authors.

2.5. Quality of evidence

The Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system was used for quality assessment [11]. Two reviewers scored the evidence according to 4 levels of quality by consensus: high, moderate, low, and very low. The GRADE system consists of following 6 items based on the study design: (1) risk of bias, (2) indirectness of evidence, (3) imprecision of results, (4) possibility of publication bias, (5) magnitude of effect, and (6) plausible influence of confounding factors.

2.6. Statistical methods

Treatment effects were transformed to log OR with 95% CIs and combined for each of the 2 outcomes using the random effects model. Heterogeneity was assessed using Cochrane *Q* test with corresponding I^2. An $I^2 > 50\%$ indicated significant heterogeneity. In the full model, preference was given to results adjusted for covariates over unadjusted data when both were available. Meta-analyses were conducted to compare the effects of AAM and BAM on survival and neurologic recovery, and subgroup analyses were also conducted to compare ETI with BAM.

3. Results

3.1. Demographic findings of articles

The primary search strategy produced 1452 titles for review. Screening of abstracts yielded 122 articles, of which 17 were fully reviewed. Nine observational studies were admissible according to our inclusion/exclusion criteria. Additional back-searching of references and expert communications provided 1 additional study (Fig. 1); hence, a total of 10 studies spanning 22 years, with samples ranging from 191 [12] to 32 5139 OHCA patients, were included. Study subjects included 17 380 patients with AAM and 67 525 patients with BAM. Three studies reported outcomes of AAM, including an analysis of EIT and SGA vs BAM. Seven studies compared the outcomes of ETI vs BAM, whereas 3 showed the outcomes of SGA vs BAM. Less than 50% of the studies reported neurologic recovery as an outcome. Table 1 shows the raw outcomes reported in the included studies. Baseline demographics and witness statuses, bystander cardiopulmonary resuscitation (CPR) administration, and raw outcomes varied significantly across the studies. (See Figs. 2–4.)

3.2. Meta-analysis

Based on the full random effects models, patients who received AAM had lower odds of survival compared with BAM (OR, 0.51; 95% CI, 0.29-0.90). Subgroup analysis for ETI vs BAM revealed no significant difference in survival (OR, 0.44; 95% CI, 0.16-1.23). Furthermore, there was no significant difference in the odds of neurologic recovery between AAM and BAM (OR, 0.64; 95% CI, 0.03-1.37). Significant study-level heterogeneity was observed in terms of survival and neurologic recovery (I^2 for both = 99%, $P < .001$). Meta-analysis with respect to neurologic recovery for either ETI vs BAM or SGA vs BAM was not conducted because of the small sample size (only 2-3 studies were included for each).

3.3. Quality of evidence

Given that all 10 articles reported observational cohort studies, the overall quality of evidence was considered “low” or “very low” for all studies based on the GRADE methodology (Table 2). The main causes of bias were residual confounders of OHCA outcomes; this occurred in 8 studies (Table 1). Moreover, 2 studies had very small sample sizes that yielded highly imprecise measurements.

4. Discussion

Our meta-analysis of 10 observational studies reveals that prehospital AAM in OHCA patients is associated with decreased survival when compared with BAM. Prehospital ETI, an AAM method, did not

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