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The effect of team-based cardiopulmonary resuscitation on outcomes in out of hospital cardiac arrest patients: A meta-analysis

Sola Kim, MD [a,b], Ki Ok Ahn, MD, PhD [c,*], Seungmin Jeong, MD [b,d]

[a] Department of Emergency Medicine, Seoul National University Hospital, Seoul, Republic of Korea
[b] Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Research Institute, Seoul, Republic of Korea
[c] Department of Emergency Medicine, Myoungji Hospital, Goyang-si, Republic of Korea
[d] Department of Preventive Medicine, Seoul National University Graduate School of Public Health, Seoul, Republic of Korea

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ABSTRACT

Objectives: The objective of this systematic review and meta-analysis was to determine the effects of team cardiopulmonary resuscitation (CPR) on outcomes of patients with out-of-hospital cardiac arrest (OHCA).
Methods: A systematic literature review was performed using PubMed, EMBASE, and the Cochrane database to identify relevant articles for this meta-analysis. All studies that described the implementation of team CPR performed by emergency medical services for OHCA patients with presumed cardiac etiology were included in this study. Outcomes included return of spontaneous circulation (ROSC), survival to hospital discharge, and good neurological recovery.
Results: A total of 2504 studies were reviewed. After excluding studies according to exclusion criteria, 4 studies with 15,455 OHCA patients were included in this study. The odds of survival and neurologic recovery for patients who received team CPR were higher than those for patients who did not (survival odds ratio [OR]: 1.68; 95% confidence interval [CI]: 1.48–1.91; neurologic recovery OR: 1.52; 95% CI: 1.31–1.77). There was no significant difference in the odds of ROSC between the two patient groups (OR: 1.59; 95% CI: 0.76–3.33).
Conclusions: In this meta-analysis, team CPR improved the outcomes of OHCA patients, consistently increasing their odds of survival to discharge and neurologic recovery.

1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a global public health concern with a high fatality rate. The incidence of OHCA assessed by emergency medical services (EMS) is >326,000 each year in the United States, with a survival rate of <10% [1]. Although the concept of "chain of survival" including timely and effective delivery of cardiopulmonary resuscitation (CPR) by bystanders and EMS on scene have been introduced [2], the survival rate of patients with OHCA has remained unchanged over decades [3].

As one of the strategies to improve survival among OHCA patients, the 2015 American Heart Association (AHA) Guidelines for CPR have updated and emphasized team-based resuscitation [4]. Team CPR is a choreographed approach whereby each provider has a predetermined role and emphasized on high quality CPR. To maximize the effects of CPR on the scene, a highly organized team is required to coordinate the efforts of out-of-hospital emergency providers. Several simulation studies have demonstrated that team CPR can improve CPR quality [5,6]. A couple of studies have shown that high-quality, minimally interrupted CPR is associated with more favorable outcomes for OHCA patients [7,8]. Recent studies have reported that team CPR is associated with improved outcomes of OHCA patients [9,10], but pooled effects of team CPR have yet not been reported. Therefore, the objective of this systematic review and meta-analysis was to determine the effects of team CPR on the outcomes of OHCA patients.

2. Methods

This study followed the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses [11].

2.1. Eligibility criteria

The inclusion criteria for this meta-analysis were as follows: (1) OHCA patients treated by emergency medical services (EMS); (2) OHCA with presumed cardiac origin; and (3) comparing any team CPR training with non-team CPR; team CPR training included team-centered psychomotor practice using scenario-based training or specific positioning and the role of each team member in a "pit crew" model of resuscitation. In this study, we restricted team CPR trainings to those provided

* Corresponding author at: 679-24 Hwajung-Dong, Deokyang-Gu, Goyang-Si, Gyeonggi-Do 412-270, Republic of Korea.
E-mail address: arenolt75@mjh.or.kr (K.O. Ahn).

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by EMS personnel. Patient outcomes were reported using Utstein guidelines [12]. The exclusion criteria were: (1) studies that provided training to in-hospital personnel; (2) simulation studies; and (3) studies that were adapted to change the response system, for example changing from a single-tiered to a two-tiered system.

2.2. Outcomes

We investigated OHCA outcomes following the Utstein guidelines, including the following: (1) return of spontaneous circulation (ROSC); (2) survival to hospital discharge; and (3) neurologic recovery as defined by Cerebral Performance Category (CPC). For this meta-analysis, we considered survival status and good neurologic recovery (i.e., CPC category 1 or 2) outcomes regardless of the time of the assessment.

2.3. Search strategy

We searched PubMed, EMBASE, and the Cochrane Database for articles that were published before June 30, 2016, and we included eligible studies regardless of language; we used Google Translate when we needed to. Two reviewers conducted independent searches using a standard review protocol to identify all relevant peer-reviewed articles and included articles in the press, correspondences, and short reports; we also performed back searches of the reference lists of relevant articles. We used the following search terms including medical subject headings (MeSH) terms and any keyword for team-centered training used in the literature such as those for the 2015 AHA CPR/CCC guidelines: cardiac arrest, heart arrest, out-of-hospital cardiac arrest, cardiopulmonary resuscitation, team, simulation, leadership, debriefing, pit crew, and quality improvement. We applied function for truncation as the search strategy. We first reviewed the abstracts of selected articles, and if the inclusion criteria were met, we reviewed the entire article. We selected the final list of articles used for this meta-analysis based on consensus between the two reviewers. If a mismatch occurred, a third reviewer intervened to resolve the controversy.

2.4. Data extraction

The data extraction was conducted independently by the two authors to identify the following characteristics: study name, study year, demographics of OHCA patients, witness status, bystander resuscitation, crude numbers of OHCA patients who received team CPR or not, and outcomes. We extracted the measured treatment effects for team CPR vs non-team CPR as odds ratios (ORs) with 95% confidence intervals (CIs) for each outcome. In addition to raw outcomes, we also extracted outcomes after adjusting ORs using regression analysis when available. We extracted pilot data to establish a data extraction protocol. We resolved disagreements by arbitration and ultimate consensus. When studies did not demonstrate ORs for outcomes, we calculated ORs using data extracted from the studies.

2.5. Quality of evidence

We assessed the quality of the studies using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) system [13]. Two reviewers independently scored the evidence on four levels of quality: high, moderate, low, and very low. The GRADE system consists of the following six 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. We ultimately analyzed the final quality of the studies by consensus.

2.6. Statistical methods

We transformed the treatment effects to log ORs with 95% CIs, and we combined them for each outcome using a random-effects model. We assessed heterogeneity using Cochran's Q test based on corresponding I^2, with $I^2 > 50\%$ indicating significant heterogeneity. We conducted meta-analyses to compare the outcomes between team CPR and non-team CPR groups.

3. Results

3.1. Demographic findings of articles

The primary search strategy produced 2504 titles for review, and after we removed duplicates, we screened the titles of 2379 articles. We then assessed 122 articles for eligibility and excluded 55 studies because team CPR training was provided in hospital settings. Our screening of the abstracts yielded 67 articles, of which we reviewed 7 fully. Based on our exclusion and inclusion criteria, three before-and-after studies were admissible. We excluded two studies because they only presented team CPR data without data for comparison, and we included two studies in the change-of-response system. These studies used a team approach with higher levels of EMS service, and members of the higher service-level teams consisted of physicians or critical-care paramedics. These studies utilized newly trained teams as second-tier responses [14,15]. Additional back-searching of references and expert communications provided one additional study (Fig. 1), and ultimately there was no discrepancy between the reviewers for including or excluding studies.

We included a total of four studies spanning three years with sample sizes ranging from 105 to 14,129 OHCA patients, with 10,801 who received team CPR and 4654 who did not; all studies reported survival discharge, and three presented neurological recovery as an outcome. The raw outcomes reported in these included studies are summarized in Table 1. Baseline demographics, witness statuses, bystander CPR, and raw outcomes varied significantly across studies. The definitions of team CPR and additional interventions of each study are summarized in Table 2.

3.2. Meta-analysis

Based on full random-effects models, patients who received team CPR had higher odds of survival and neurological recovery than did patients who did not (survival OR: 1.68; 95% CI: 1.48–1.91; neurological recovery OR: 1.52; 95% CI: 1.31–1.77, Figs. 3 and 4). There was no significant difference in the odds of ROSC between team and non-team CPR patient groups (OR: 1.59; 95% CI: 0.76–3.33, Fig. 2), and we observed significant study-level heterogeneity in ROSC ($I^2 = 82\%$).

3.3. Quality of evidence

Given that all four articles reported community-intervention before-and-after studies, we considered the overall quality of evidence low or very low for all studies based on the GRADE system (Table 3). The main cause of bias was the study designs of these studies; all four had been designed as before-and-after studies without controls. Moreover, three studies presented imprecise survival to discharge results.

4. Discussion

This study is the first meta-analysis to establish an association between team CPR and the outcomes of OHCA patients. Our meta-analysis of four studies showed that team CPR was associated with consistently better outcomes after OHCA than those following non-team CPR, including better odds of survival to discharge and of neurologic recovery.

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