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Review article

Systematic review of the effectiveness of prehospital critical care following out-of-hospital cardiac arrest☆

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ABSTRACT

Background: Improving survival after out-of-hospital cardiac arrest (OHCA) is a priority for modern emergency medical services (EMS) and prehospital research. Advanced life support (ALS) is now the standard of care in most EMS. In some EMS, prehospital critical care providers are also dispatched to attend OHCA. This systematic review presents the evidence for prehospital critical care for OHCA, when compared to standard ALS care.
Methods: We searched the following electronic databases: PubMed, EmBASE, CINAHL Plus and AMED (via EBSCO), Cochrane Database of Systematic Reviews, DARE, Cochrane Central Register of Controlled Trials, NHS Economic Evaluation Database, NIHR Health Technology Assessment Database, Google Scholar and ClinicalTrials.gov. Search terms related to cardiac arrest and prehospital critical care. All studies that compared patient-centred outcomes between prehospital critical care and ALS for OHCA were included.
Results: The review identified six full text publications that matched the inclusion criteria, all of which are observational studies. Three studies showed no benefit from prehospital critical care but were underpowered with sample sizes of 1028–1851. The other three publications showed benefit from prehospital critical care delivered by physicians. However, an imbalance of prognostic factors and hospital treatment in these studies systematically favoured the prehospital critical care group.
Conclusion: Current evidence to support prehospital critical care for OHCA is limited by the logistic difficulties of undertaking high quality research in this area. Further research needs an appropriate sample size with adjustments for confounding factors in observational research design.

Introduction

Improving survival after out-of-hospital cardiac arrest (OHCA) is a priority for many modern emergency medical services (EMS) and prehospital research.[1,2] Reported survival rates vary widely, ranging from 4.4% to 25%[3,4] and there is great interest in the influence of prehospital treatments on outcomes from OHCA. While short ambulance response times, coupled with EMS cardiopulmonary resuscitation (CPR) and early defibrillation can improve survival after OHCA,[5] there is little evidence to support advanced life support (ALS) interventions, such as intravenous adrenaline (epinephrine) and tracheal intubation.[6,7] Research examining ALS as a concept, rather than its individual components, has produced conflicting results.[2,8,9] Despite this lack of evidence, ALS has become the standard of care for OHCA in most modern EMS.[10] A number of further interventions, drugs and treatment modifications have been trialled, but have failed to improve outcomes consistently.[11]

Another focus of research has been the impact of the prehospital provider for OHCA, with a number of studies comparing physician and paramedic care.[12] A recent meta-analysis attributed the seemingly better outcomes associated with prehospital physician care to a higher quality of ALS provided.[12] However, we would argue that the quality of ALS is a matter of provider training and experience, rather than professional background.[13] Nevertheless, prehospital physicians in some EMS can undertake interventions and make decisions outside of or in addition to ALS algorithms, thus providing prehospital critical care.[10] In the UK, the availability of prehospital critical care is gradually increasing and provided by a combination of physicians and paramedics.[14,15] Without research to support the attendance of critical care teams at OHCA,[16,17] there is a large varia-

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Box 1: Inclusion criteria according to the PICOS system
Patients All cases of non-traumatic out-of-hospital cardiac arrest in adults.
Intervention Prehospital critical care by any provider group (paramedics or physicians) with interventional capacity beyond ALS algorithms and dedicated dispatch to critically ill patients.
Comparator Advanced life support (ALS) by any prehospital provider.
Outcomes Any patient-focused outcome such as short or long-term survival or quality of life; ROSC alone was not considered a patient-focused outcome.
Study designs Any comparative design such as randomized trials, but also observational studies with a comparative element.

tion in the dispatch of prehospital critical care services in the UK and worldwide. This review aims to identify and present existing evidence regarding prehospital critical care for OHCA, when compared to standard ALS care.

Methods

The review was carried out in accordance with the International Liaison Committee on Resuscitation (ILCOR) 2015 evidence evaluation process[18] and was registered with the International Prospective Register of Systematic Reviews (PROSPERO), registration number CRD42016039995.

We searched the following electronic databases between April and June 2016: PubMed, EmBASE, CINAHL Plus and AMED (via EBSCO), Cochrane Database of Systematic Reviews, DARE, Cochrane Central Register of Controlled Trials, NHS Economic Evaluation Database, NIHR Health Technology Assessment Database, Google Scholar and ClinicalTrials.gov. We excluded research published prior to 1990 as it was deemed very unlikely that it would be relevant to modern EMS. The search strategy reflects the fact that prehospital critical care is often provided by physicians or helicopter medical services (HEMS). Please see Table 1 for a detailed description of the search strategy. Also included were all cited and citing articles of publications which were retrieved for full text analysis during the review process. In addition we used social media (Twitter and Research Gate) to identify further grey literature.

Review of publications identified by the search followed a three-step approach. First, two independent researchers (JVVF and JBR) reviewed all study titles and remove all publications which were obviously not related to the study question as well as duplicate results. Next, the two researchers independently reviewed the abstracts of all remaining publications, removing those that did not fulfill the inclusion criteria outlined in Box 1. Finally, both researchers independently reviewed the full text of all remaining publications to assess for inclusion in the final analysis. If there were discrepancies in the researchers' opinions during step one or two, the publication in question was moved forward to the next step. If there were discrepancies in step three, consensus was sought between the two researchers. If no consensus was achieved, a third researcher (JB) was asked to review the publication. The final full analysis of all included manuscript was undertaken by one reviewer (JVVF).

All included studies were assessed for methodological quality and the risk of bias, using the STROBE checklist for observational studies as guidance.[19] Given the anticipated paucity of randomised controlled trials, we planned for a narrative analysis of the evidence.

Results

The search identified a total of 4554 publications. After excluding duplicates, 183 abstracts were reviewed of which 29 manuscripts were retrieved for further assessment. After review of the full text publications, six eligible papers remained for analysis; see Table 2.[17,20–24] Two conference abstracts also fulfilled the inclusion criteria and are presented in Table 3.[25,26] The authors of the conference abstracts were contacted but we were unable to obtain further information. Six full text publications did not include enough information to decide if EMS providers were practicing prehospital critical care and/or ALS. For five publications, we were successful in gaining this information by contacting the authors, resulting in two exclusions[27,28] and three inclusions in the review.[21,23,24] The remaining study was excluded after a consensus decision within the research group. Based on our best interpretation of the information provided and our knowledge of the EMS studied, we considered it unlikely that this publication from Taiwan compared prehospital critical care with ALS care.[4]

Reasons for exclusion of the other 18 publications were comparison of advanced treatment with Basic Life Support (4/18), all patients receiving critical care (3/18), non-experimental study designs such as systematic reviews (3/18) and publications classified as editorials (2/18), comparing paramedics and physicians providing ALS (2/18). Two studies reported ROSC as the only outcome, one was a secondary review of previous research, and a further study examined the effect of in-hospital emergency physicians. All four of these publications were therefore also excluded.

Evidence review

Only limited information is available from the conference abstracts summarised in Table 3.[25,26] We therefore provide a brief summary of key aspects for each abstract, all of which used observational study designs. Seki et al. included only cases of OHCA with non-shockable rhythm in their analysis and found no difference in 1-month survival between patients attended by prehospital physicians or paramedics.[25] Shiraishi and Otomo also compared physician and paramedic care in Japan.[26] In their propensity matched groups of 34 cases (68 patients in total), no difference in outcome was found.

All full text publications in this review are observational studies, four of which used prospective data collection whilst two were retrospective. Sample sizes ranged from 614 to 95,072 cases. In five publications, prehospital critical care was provided by physicians; one study describes a model of physician and paramedic-delivered prehospital critical care. The full text publications are described in chronological order.

The first publication by Mitchell et al. compares the EMS of Edinburgh (UK) and Milwaukee (USA) and their impact on survival to hospital discharge after OHCA.[20] In Edinburgh, prehospital critical care was provided by a physician-staffed mobile resuscitation team which responded to OHCA as a secondary response after initial resuscitation by BLS technicians or ALS paramedics. Physicians had access to 'full resuscitation equipment' including a mechanical chest compression device, central venous access and anti-arrhythmic medication. In contrast, Milwaukee provided a two-tier response to OHCA, with first response by BLS paramedics or firefighters, followed by ALS paramedics The ALS paramedics were able to intubate and administer intravenous drugs. They could also pronounce 'life extinct' after consultation with the directing physician. Survival to hospital discharge rates were significantly higher in the UK compared to the USA (12.4% and 7.2% respectively, $p < 0.01$). However, rates of witnessed cardiac arrests and bystander CPR were also significantly higher in the UK, compared to the USA (65.7% vs 25% and 42.3% vs 27.1%, respectively, $p < 0.001$). The rates