A cumulative meta-analysis of the effectiveness of defibrillator-capable emergency medical services for victims of out-of-hospital cardiac arrest

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Authors' objectives
To determine the relative effectiveness of differences in the defibrillation response time interval, proportion of bystander cardiopulmonary resuscitation (CPR), and type of emergency medical services (EMS) system on survival after out-of-hospital cardiac arrest.

Searching
MEDLINE (1966-Aug 1997) was searched using the following keywords: 'heart arrest' (with subheading 'therapy') and 'resuscitation' or 'cardiopulmonary resuscitation' combined with 'prognosis' or 'survival'. Searching the bibliographies of retrieved papers identified additional articles. Only English language literature was included. Unpublished studies and abstracts were excluded. Authors of included studies were not contacted.

Study selection
Study designs of evaluations included in the review
All published primary studies where the number of patients with cardiac arrest could be determined. Studies lacking patient data for the survival to hospital discharge were excluded. Where participants were included in more than one publication emanating from a single centre, only the report with the largest number of participants was included.

Specific interventions included in the review
Systems of emergency medical services (EMS) providing basic life support with defibrillation (BLS-D), advanced life support (ALS), basic life support (BLS) plus ALS, or BLS-D plus ALS. Services could be provided by either a 1- or 2-tier EMS systems, i.e. one provider responds to emergency calls in a 1-tier system and in a 2-tier system two levels of providers respond (e.g. fire service and ambulance) with usually the less-trained provider arriving first on the scene. Studies of 2-tier EMS systems were included regardless of whether the first responding unit was an ambulance or fire company. EMS systems where nurses or physicians arrived at the scene as ALS providers were excluded. The studies reported in the review described 39 EMS systems: 13 BLS-D, 12 ALS, 9 BLS+ALS, and 5 BLS-D+ALS.

Participants included in the review
Victims of out-of-hospital cardiac arrest.

Outcomes assessed in the review
Proportion of individuals surviving to hospital discharge.

How were decisions on the relevance of primary studies made?
Four individuals independently reviewed all studies and differences were resolved through discussion.

Assessment of study quality
Study quality was evaluated using a previously validated measure called the Cho scale (see Other Publications of Related Interest no.1). This consisted of 24-items relating to study validity (items not stated). Four individuals independently assessed the quality of all of the studies and differences were resolved through discussion. Each of the 24 scale items was assigned a predefined score. The total number of points for each study was then divided by the total possible number of points, to yield an overall score between 0 (lowest quality) and 1 (highest quality).

Data extraction
Data were extracted twice and checked for accuracy independently by four individuals. Any discrepancy in abstracted
data were drawn to the attention of the pair of reviewers. All differences were resolved through discussion. The following information was extracted from each study if available: number of arrests of presumed cardiac origin, survival to hospital discharge, response time interval, proportion of bystander CPR, type of EMS system, size of population, geographic area served by EMS, patient demographics. Bystander CPR was defined as CPR provided at the scene by laypersons. The defibrillation response time was defined according to Utstein criteria as the time between receipt of the call by dispatch and arrival on the scene of the first defibrillator-capable unit. For 2-tier systems the mean time intervals to arrival of both responding vehicles were used. The authors of primary studies were not contacted for additional data.

Methods of synthesis
How were the studies combined?
Studies were combined in primary analyses reporting odds ratios (ORs) and 95% confidence intervals (CI), using a generalised linear model to assess the effects of several independent variables (proportion of bystander CPR; defibrillation response time interval; and type of EMS system) on the proportion of individuals surviving to hospital discharge. This model estimated the maximum likelihood with an iteratively re-weighted least-squares algorithm as described in Chambers and Hastie (see Other Publications of Related Interest no.2). Possible random effects were addressed by means of dispersion estimation and goodness of fit was based on minimisation of the Akaike information criterion statistic. The response time data (continuous variables) were highly skewed and so were modelled using spline estimation as described in Chambers & Hastie (see Other Publications of Related Interest no.2). Studies missing values for one or more of the independent variables were omitted from the primary analyses. Funnel plots of effect sizes were performed to assess the potential for publication bias.

How were differences between studies investigated?
Sensitivity analyses adjusting for study quality and outliers were performed to assess the robustness of the primary analyses. Outlying studies were identified by calculating Cook's D statistic. Plotting study size against residual for each study identified potential overdispersion. Analyses were conducted without outliers or without influential studies that might support increasing overdispersion with increasing sample size.

Results of the review
Thirty-seven case series describing 39 EMS systems and including 33,124 patients were reported in the review.

All of the included studies were case series. The mean quality score was 0.47 (range 0.17-0.77). Four randomised controlled trials were identified but failed to meet all of the inclusion criteria. Median survival for all rhythm groups to hospital discharge was 6.4% (interquartile range, 3.7 to 10.3). Odds of survival were 1.06 (95% CI: 1.03, 1.09, P<0.01) per 5% increase in bystander CPR. Survival was constant if the defibrillation response time interval was <6mins (OR=1), decreased as the interval increased from 6 to 11 minutes (OR=0.85, 95% CI: 0.73, 0.99), and levelled off after 11 minutes (OR=0.53, 95% CI: 1.47, 3.62; P<0.01). Compared with BLS-D odds of survival were as follows: ALS OR=1.71 (95% CI: 1.09, 2.70, P=0.01), BLS+ALS OR=1.47 (95% CI: 0.89, 2.42, P=0.07), and BLS-D+ALS OR=2.31 (95% CI: 1.47, 3.62, P<0.01).

Similar results were obtained when the analyses were adjusted for differences in study quality (quality data not presented) or excluded the study that was identified as influential (results available from authors). After adjustment for differences in bystander CPR, type of EMS system, and defibrillation response time interval, there were no studies that were identified as outliers. The funnel plot did not demonstrate any evidence of publication bias.

Authors' conclusions
We confirm that greater survival after sudden cardiac arrest is associated with provision of bystander CPR, early defibrillation, or ALS. More research is required to evaluate the relative benefit of early defibrillation versus early ALS.

CRD commentary
This is a well-presented review with clearly defined inclusion criteria and methods. The studies reported in the review are subjected to a validity assessment and sensitivity analyses are performed to take into account differences in quality and the effects of outliers. However, the results of the validity assessment were not presented though they were used in the analysis. The authors did limit the review to published studies however they used funnel plots to demonstrate that the risk of publication bias was minimal. The inclusion of only MEDLINE and English-language literature may however have excluded relevant published data.

The authors provide detailed information regarding their analyses and highlight a number of limitations and problems with the review, not least the fact that no randomised controlled trials were identified and the findings were only based on case series. In view of these issues the authors’ conclusions should be treated with caution, as they themselves highlight.

Implications of the review for practice and research
Practice: The authors state that 'this analysis supports the need for strong links in the chain of survival to improve survival after cardiac arrest, as endorsed by the American Heart Association: early access, early bystander CPR, early defibrillation, and early ALS consisting of intubation and intravenous medication'. 'EMS directors should continue to attempt to shorten the time to defibrillation by improving use of dispatch, optimising deployment of vehicles, and introducing first-responder defibrillation by fire or police personnel'. The authors also suggest the following alterations to the current guidelines 'if a defibrillator is available near or at the scene, then the sequence of actions should be to call 911, defibrillate, and then initiate CPR. Otherwise, the sequence of actions should be to call 911, initiate CPR, and then defibrillate when the first defibrillator-capable unit arrives'.

Research: The authors state that 'future studies should adopt the data elements of the Utstein criteria and be of sufficient size to determine effectiveness in terms of survival to hospital discharge'. Also 'every effort should be made to encourage experimental or quasi-experimental designs by using some form of control group'. Finally, 'more methodologically rigorous studies are necessary for policy makers to confidently estimate the consequences of their decisions regarding funding and expansion of complex EMS systems', in particular 'more research is required to evaluate the relative benefit of early defibrillation versus early ALS'.

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Bibliographic details

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Other publications of related interest

This additional published commentary may also be of interest. Defibrillator use in out-of-hospital cardiac arrest. Bandolier 2000;77:7.

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This is a critical abstract of a systematic review that meets the criteria for inclusion on DARE. Each critical abstract contains a brief summary of the review methods, results and conclusions followed by a detailed critical assessment on the reliability of the review and the conclusions drawn.