Chest-compression-only versus standard cardiopulmonary resuscitation: a meta-analysis

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Summary

Background In out-of-hospital cardiac arrest, dispatcher-assisted chest-compression-only bystander CPR might be superior to standard bystander CPR (chest compression plus rescue ventilation), but trial findings have not shown significantly improved outcomes. We aimed to establish the association of chest-compression-only CPR with survival in patients with out-of-hospital cardiac arrest.

Methods Medline and Embase were systematically reviewed for studies published between January, 1985, and August, 2010, in which chest-compression-only bystander CPR was compared with standard bystander CPR for adult patients with out-of-hospital cardiac arrest. In the primary meta-analysis, we included trials in which patients were randomly allocated to receive one of the two CPR techniques, according to dispatcher instructions; and in the secondary meta-analysis, we included observational cohort studies of chest-compression-only CPR. All studies had to supply survival data. The primary outcome was survival to hospital discharge. A fixed-effects model was used for both meta-analyses because of an absence of heterogeneity among the studies (P=0%).

Findings In the primary meta-analysis, pooled data from three randomised trials showed that chest-compression-only CPR was associated with improved chance of survival compared with standard CPR (14% [211/1500] vs 12% [178/1531]; risk ratio 1·22, 95% CI 1·01–1·46). The absolute increase in survival was 2·4% (95% CI 0·1–4·9), and the number needed to treat was 41 (95% CI 20–1250). In the secondary meta-analysis of seven observational cohort studies, no difference was recorded between the two CPR techniques (8% [223/2731] vs 8% [863/11 152]; risk ratio 0·96, 95% CI 0·83–1·11).

Interpretation For adults with out-of-hospital cardiac arrest, instructions to bystanders from emergency medical services dispatch should focus on chest-compression-only CPR.

Introduction The optimal method for out-of-hospital bystander cardiopulmonary resuscitation (CPR) is controversial.12 Recommended standard basic life support combines chest compression and rescue ventilation.14 During the last decade, evidence from studies in animals15–17 has questioned the usefulness of rescue ventilation during adult CPR. In these studies, chest-compression-only CPR was either equivalent or superior to standard CPR with chest compression plus rescue ventilation. However, the evidence was largely inconclusive, mostly because of the observational study design or small sample size.

In a trial published in 2000, 520 patients with out-of-hospital cardiac arrest were randomly assigned to receive either dispatcher-assisted chest-compression-only or standard CPR.18 Chest-compression-only CPR was associated with a survival benefit, although the difference was not significant (relative difference 40%; absolute difference 4·2%, p=0·18).18 Two subsequent randomised trials reported a similar benefit with dispatcher-assisted chest-compression-only CPR: Rea and colleagues19 recorded a 14% increase in survival to hospital discharge (1·5% absolute increase, p=0·31) in 1941 patients with cardiac arrest; and Svensson and co-workers20 reported a 24% improvement in 30-day survival (1·7% absolute increase, p=0·29) in 1276 patients with cardiac arrest. Despite results favouring chest-compression-only CPR in all three trials, assessment of which dispatcher-assisted CPR method is superior was inconclusive.

Therefore, we aimed to systematically review existing evidence regarding chest-compression-only CPR and compare the findings with standard CPR in a meta-analysis. In the meta-analysis, we followed the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guideline21 for randomised trials and the MOOSE (Meta-analysis Of Observational Studies in Epidemiology) guideline22 for observational cohort studies.

Methods

Search strategy and selection criteria We searched Medline and Embase for studies published between January, 1985, and August, 2010, with the search terms “chest compression-only”, “compression alone”, “hands-only”, and “bystander CPR”. Additionally, we manually checked the reference list of every article for further suitable studies. We considered articles published in English and German for inclusion in the analysis; despite this restriction, we did not identify studies published in any other languages.

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We separated the systematic review and meta-analysis into two parts: primary analysis of randomised trials, and secondary analysis of observational cohort studies. All studies that were eligible for inclusion compared chest-compression-only bystander CPR with standard bystander CPR by chest compression plus rescue ventilation, were done in adult patients with out-of-hospital cardiac arrest, and supplied survival data. In randomised trials that were eligible for inclusion, patients were randomly assigned to receive one of the two CPR techniques according to instructions from a dispatcher. Observational studies that were eligible for inclusion had a cohort design (no case series), and used an unstratified cohort (eg, arrests of non-cardiac origin only).

Data extraction

In addition to information about study design, characteristics, and sample size, we extracted actual numbers of survivors and corresponding cohort sizes and event rates. Survival to hospital discharge was the primary outcome variable, but we also obtained outcome data on return of spontaneous circulation, 30-day survival, and favourable neurological outcome. If data for survival to hospital discharge were not available, we used 30-day survival as the primary outcome.

### Statistical analysis

All analyses were done with Biostat Comprehensive Meta-Analysis software (version 2.2.050). Risk ratios (RR) and 95% CIs were calculated using a random-effects model with a DerSimonian-Laird estimate of variance, and absolute differences were calculated using Mantel-Haenszel weighted averages. For each outcome, a p<0.05 was considered statistically significant. 

<table>
<thead>
<tr>
<th>Study design</th>
<th>Patients receiving chest-compression-only CPR</th>
<th>Patients receiving standard CPR</th>
<th>Primary outcome</th>
<th>Secondary outcome</th>
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<td>Admission to hospital; survival to hospital discharge</td>
<td>–</td>
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</table>

Data are number or n/N (%). CPR=cardiopulmonary resuscitation. *In randomised studies, patients and the study investigators were masked to CPR technique, but the bystander, the emergency medical services team, and the dispatcher were not. †For consistency between the three randomised trials, survival to hospital discharge was assessed in the meta-analysis, but for the primary outcome of 30-day survival in Svensson and colleagues’ study,16 54/620 (9%) patients survived in the group receiving chest-compression-only CPR and 46/656 (7%) survived in the group receiving standard CPR. ‡Data for survival to hospital discharge were used for the meta-analysis except for studies in which this information was unavailable: 30-day survival was used for Bohm and colleagues study,7 and SOS-KANTO Study Group’s studies;11 1-week survival was used for Iwami and colleagues study;7 and awake after 14 days was used for Van Hoevegh en and colleagues study.18

Table: Study characteristics
95% CIs were calculated for every study and pooled in both fixed-effects and random-effects models. However, the heterogeneity within the primary and secondary meta-analyses was negligible, as indicated by an $I^2$ of 0%, so we report only the results of the fixed-effects model. Comprehensive Meta-Analysis software uses the inverse-variance method for weighting studies; other methods can be selected, such as Mantel-Haenszel, but the results in our meta-analyses did not differ between these methods. Heterogeneity among studies was formally assessed by the $Q$ and $I^2$ statistics. Publication bias was tested with the Egger’s regression test.

Role of the funding source
Both funding organisations had no role in study design, data collection, data analysis, data interpretation, writing of the report, or the decision to submit for publication. The corresponding author had full access to all the data and had the final decision to submit for publication.

Results
In the systematic review, we identified three randomised trials that were eligible for inclusion in the primary meta-analysis (figure 1, table). The quality of these trials was high; all trials reported outcomes in an intention-to-treat analysis, had few missing data, and had a low rate of intervention crossovers. For the primary outcome of survival to hospital discharge, all three trials individually showed a small benefit in patients who received chest-compression-only CPR, but the differences were not significant (figure 2). Meta-analysis of these studies showed a significantly increased chance of survival with chest-compression-only CPR compared with standard CPR (figure 2), with an absolute increase in survival of 2.4% (95% CI 0.1–4.9). The number needed to treat was 41 (95% CI 20–1250).

Systematic review also identified seven observational cohort studies that were eligible for the secondary meta-analysis (figure 1, table). Apart from one study, none of the observational studies showed a significant survival difference between the two CPR techniques (figure 3). Despite our intention to use survival to hospital discharge as the primary outcome in the meta-analysis, this outcome was not reported in four studies, so instead we used 30-day survival, 1-week survival, or awake after 14 days. In the meta-analysis of these studies, chest-compression-only CPR was not associated with a difference in survival compared with standard CPR (figure 3). Furthermore,
chest-compression-only CPR did not improve the rate of return of spontaneous circulation (figure 4).

Discussion
The results of this meta-analysis show that dispatcher-assisted chest-compression-only bystander CPR is associated with improved survival in adults with out-of-hospital cardiac arrest compared with standard CPR (chest compression plus rescue ventilation; panel).

Since meta-analyses are used to pool existing evidence, we should consider the strength of the evidence favouring chest-compression-only CPR. Despite the small number of trials included in this meta-analysis, the evidence favouring dispatcher-assisted chest-compression-only CPR seems to be robust since all randomised trials reported similar positive effects of this CPR technique on survival, although differences were not significant. The pooled effect size of about 22% might seem small, but rates of survival after out-of-hospital cardiac arrest have been about 4–8% for the past few decades, so our result could represent important progress. The incidence of cardiac arrest is about 0.5 cases per 1000 people per year in the USA and Canada. Extrapolation of this number to include the USA and Canada, and the European Union (combined population of about 850 million), with an absolute increase in survival of 2% as recorded in our meta-analysis (eg, from 10% to 12%, which is equivalent to a 20% relative increase), an additional 8000 lives could be saved per year.

None of the randomised trials individually showed a significant improvement with dispatcher-assisted chest-compression-only CPR compared with standard CPR, which was probably because of inadequate statistical power. The fact that only three randomised trials have been done is testament to the difficulties associated with well designed prospective studies in this setting, such as obtaining of informed consent, the little time available to randomise patients, adherence to the study protocol, tracking of patients and outcomes, and masking of investigators, study personnel, and patients from the allocated intervention. Because survival rates after out-of-hospital cardiac arrest are low and large treatment effects are unlikely, very large sample sizes are needed to show a significant survival benefit. No trial of chest-compression-only CPR had more than 125 events of survival in a study group, which is a fairly small number for statistical analyses.

We should also address the plausibility of our findings. Several independent lines of evidence support a survival benefit associated with dispatcher-assisted chest-compression-only CPR compared with standard bystander CPR in out-of-hospital cardiac arrest. The best CPR technique for survival is a controversial issue and has been intensively discussed over the past few years, so only the most pertinent explanations will be mentioned. First, uninterrupted, high-quality chest compression is very important for successful CPR. Minimal hands-off time, both for lay people and healthcare professionals, is an important predictor for improved survival after cardiac arrest. By avoidance of rescue ventilation during CPR, which is often fairly time consuming for lay bystanders, a continuous uninterrupted coronary perfusion pressure is maintained, which increases the probability of a successful outcome. These considerations were the main reason to increase the compression-to-ventilation ratio for standard basic life support from 15:2 to 30:2 in the 2005 resuscitation guidelines. All three dispatcher-assisted CPR trials used the 15:2 ratio, and whether use of the 30:2 ratio would have changed the results is unclear. Second, provision of oxygenation and ventilation during the first minutes after cardiac arrest, particularly witnessed cardiac arrest, might be less important than is high-quality chest compression. Third, chest-compression-only CPR is easier to teach, learn, and do than is the fairly complex standard CPR algorithm, thus increasing the probability that a bystander will intervene and provide CPR.

Although our secondary meta-analysis of observational cohort studies did not show any benefit of chest-compression-only bystander CPR compared with standard bystander CPR, these studies did not investigate dispatcher-assisted CPR. Chest-compression-only CPR had not been taught to bystanders in any of the studies; rather, the lay bystander made the deliberate decision to avoid mouth-to-mouth rescue ventilation. Although our findings

![Figure 4: Analysis of return of spontaneous circulation](https://www.thelancet.com)

CPR=cardiopulmonary resuscitation.
suggest that dispatcher-assisted chest-compression-only CPR increases survival compared with standard CPR in adults with out-of-hospital cardiac arrest, several circumstances exist in which this CPR technique might not be beneficial. Findings from a large-scale prospective cohort study suggest that standard CPR might actually improve survival compared with chest-compression-only CPR in cardiac arrest from non-cardiac causes (eg, drowning, trauma, or asphyxia).

Moreover, in children with out-of-hospital cardiac arrest, which is often of non-cardiac origin, standard CPR might confer a similar benefit. Therefore, the benefits of chest-compression-only bystander CPR seem to be largest in adult patients with sudden cardiac death.

Our findings support the idea that emergency medical services dispatch should instruct bystanders to focus on chest-compression-only CPR in adults with out-of-hospital cardiac arrest. However, whether chest-compression-only CPR should be recommended for unassisted lay bystander CPR is unclear.

Contributors
MH and PN were responsible for the study concept and design, and provided administrative, technical, or material support. PN was responsible for obtaining of funding, supervision of the study, acquisition of data, and statistical analysis. All authors contributed to analysis and interpretation of data. MH and PN drafted the report, and all authors contributed to revision of the report.

Conflicts of interest
PN’s institution has received research support from Roche Diagnostics, unrelated to this study; PN has received consultancy fees from Gerson Lehman Group; and PN and his institution have received grants from the US National Institutes of Health and American Heart Association. MH is receiving a salary and has received payment for development of educational presentations from St John’s Ambulance Service, Vienna, Austria; and has received research support, lecture fees, and travel support from Novo Nordisk. HFS declares that he has no conflicts of interest.

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