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Chest Compression-Only CPR: A Meta-Analysis

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Summary

Background—Evidence suggests that dispatcher-assisted chest compression-only bystander CPR may be superior to standard CPR (chest compressions and rescue ventilation) in out-of-hospital cardiac arrest, yet recent clinical trials did not observe improved outcomes. The goal of the study was to determine the association between chest compression-only CPR and survival after out-of-hospital cardiac arrest.

Methods—Studies published until August 2010 were systematically searched and identified in MEDLINE and EMBASE databases. For the primary meta-analysis only clinical trials were included that prospectively randomized dispatcher instructions to chest compression-only versus standard bystander CPR in out-of-hospital adult cardiac arrest patients; for the secondary meta-analysis observational cohort studies were included that distinguished between standard CPR and chest compression-only CPR. All studies were required to contain survival data. Data on study characteristics, methods and outcomes (return of spontaneous circulation, survival to discharge, 30-day survival, and favourable neurologic outcome) were extracted. A fixed-effects model was used for both meta-analyses for lack of heterogeneity among the studies (I^2 0%).

Findings—All three published randomized clinical trials were included in the meta-analysis. The pooled analyses shows that dispatcher-assisted chest compression-only bystander CPR for adult out-of-hospital cardiac arrest was associated with a 22% improved chance of survival (risk ratio [RR] 1.22 [95% confidence interval {CI}, 1.01 – 1.47]; I^2, 0%) compared to standard CPR. The absolute increase in survival was 2.4%; the number needed to treat was 41. The secondary meta-analysis included seven observational studies of bystander-CPR (not dispatcher-assisted) and showed no difference between the two CPR techniques (RR, 0.96 [95% CI, 0.83 – 1.11]; I^2, 0%).

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Contributors
PN was responsible for study design, acquisition of data, statistical analysis and drafting of the manuscript. All authors contributed to the study concept, critical data interpretation and the preparation and revision of the manuscript.

Conflicts of Interest
PN is receiving research support from Roche Diagnostics, unrelated to this study. MH is receiving salary from St. John's Ambulance Service, Vienna, Austria and received research support, lecture fees and travel support from Novo Nordisk. HFS does not report a conflict of interest.

Interpretation—Dispatcher-assisted chest compression-only bystander CPR is associated with improved survival in adult patients after out-of-hospital cardiac arrest compared to standard CPR.

Introduction

The optimal method for bystander out-of-hospital cardiopulmonary resuscitation (CPR) is controversial.[1, 2] Recommended standard basic life support combines chest compressions and rescue ventilation.[3, 4] Over the course of the last decade, evidence from animal experiments[5, 6] and observational human studies[7–13] questioned the usefulness of rescue ventilation during adult CPR. These studies found chest compression-only CPR either equivalent to standard CPR with rescue ventilation or suggested even a benefit. However, the evidence was largely inconclusive mostly due to the observational study design or small sample size.

A single clinical trial published in 2000 randomized 520 patients with out-of-hospital cardiac arrest to either dispatcher-assisted chest compression-only or standard CPR and found a statistically non-significant survival benefit for chest compression-only CPR (relative difference: 40%, absolute difference: 4.2%, p=0.18).[14] Very recently, two additional randomized clinical trials reported a similar, albeit statistically non-significant, positive trend for dispatcher-assisted chest compression-only CPR. Rea *et al.*[15] found a 14% increased survival to hospital discharge (1.5% absolute increased survival, p= 0.31) among 1941 patients and Svensson *et al.*[16] report a 24% improved 30-day survival (1.7% absolute increased survival, p= 0.29) among 1276 patients with cardiac arrest. Despite a uniform trend favouring chest compression-only CPR in all three trials, the results were inconclusive as of which dispatcher-assisted bystander-CPR method is superior.

Therefore, the goal of this study was to summarize the existing evidence regarding chest compression-only CPR in a systematic review and to compare it to standard CPR in a meta-analysis.

Methods

We followed the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guideline[17] for randomized clinical trials and the MOOSE (Meta-analysis Of Observational Studies in Epidemiology) guideline[18] for observational cohort studies in this meta-analysis.

Search Strategy

Accessing MEDLINE and EMBASE databases, we performed a literature search for studies published between 1985 and August 2010 using the following search terms and key words: chest compression-only, compression alone, hands-only, bystander CPR. In addition, we manually checked the reference list of each article. The main focus of this study was on randomized clinical trials, but we also performed a secondary analysis of observational cohort studies.

Study Selection

We separated the systematic review and meta-analysis into two parts: in the primary analysis, randomized clinical trials were included and in the secondary, observational cohort studies. Only three randomized clinical trials have been conducted where adult patients suffering from out-of-hospital cardiac arrest received randomized instructions by a dispatcher for either chest compression-only CPR or standard CPR, and all three trials were included in the systematic review and meta-analysis. For observational studies, the

following eligibility criteria were required for inclusion: (1) observational cohort studies (no case series); (2) comparison between chest-compression-only CPR and standard CPR; (3) survival data available; (3) adult population; (4) unstratified cohort (e.g., arrests of non-cardiac origin only); (5) bystander CPR; (6) out-of-hospital arrest. Articles were considered if published in English and German; this notwithstanding, no other foreign language study was found.

Data Extraction

Besides information about study design, characteristics, and sample size, we extracted the following data from the articles: actual numbers of survivors and non-survivors and corresponding cohort sizes and event rates. Survival to discharge was the primary outcome variable, but we also obtained outcome data on: return of spontaneous circulation (ROSC); 30-day survival; favourable neurologic outcome. If survival to discharge data were not available, we used 30-day survival as the primary outcome.

Statistical Analysis

We performed the analysis with the Comprehensive Meta Analysis software, version 2.2.050 (Biostat, Englewood, NJ). Risk ratios (RR) and 95% confidence intervals were (re-)calculated for each study and pooled in both a fixed-effects and random effects model. However, since the heterogeneity of within all meta-analyses was negligible, as indicated by an I^2 statistics of 0%, we report only the results of the fixed-effects model. The Comprehensive Meta Analysis software uses the inverse variance method for weighing studies; however other methods can be selected, such as Mantel-Haenszel. The results in our meta-analyses did not differ between each method. The primary analysis included only randomized controlled trials, and the secondary analysis observational cohort studies.

Heterogeneity among studies was formally assessed by the Q and I^2 statistics. Publication bias was tested with the Egger's regression test.

Results

The systematic review identified three randomized clinical trials where adult patients suffering from out-of-hospital cardiac arrest received dispatcher-assisted bystander CPR that was randomized to either chest compression-only CPR or standard CPR including rescue ventilation.[14–16] The quality of these trials was high; all reported their outcomes on an intention-to-treat analysis, had scarce missing data and had a low rate of intervention cross-overs. All three trials were included in the meta-analysis and we used survival to discharge as primary outcome in our analysis (Figure 1). Uniformly, each of the three clinical trials showed individually a small, but statistically non-significant, survival benefit for patients who received chest compression-only CPR. After pooling the studies in a meta-analysis, chest compression-only bystander CPR was associated with a statistically significant 22% improved chance of survival (risk ratio [RR] 1.22 [95% confidence interval {CI}, 1.01 – 1.47]) compared to standard CPR (Figure 2). The meta-analysis had no heterogeneity as indicated by an I^2 of 0. The absolute increase in survival was 2.4% and the number needed to treat was 41.

In a secondary systematic review, all observational cohort studies were identified that investigated chest compression-only bystander-CPR *versus* standard CPR (not dispatcher-assisted). After a comprehensive search, seven articles were identified that met the search criteria (Figure 1). Out of 74 articles with suggestive titles and abstract, 64 had to be excluded because they did not report any chest compression-only CPR data. It must be pointed out that none of these non-randomized studies investigated dispatcher-assisted CPR.

All seven studies investigated prospectively or retrospectively the association between the CPR method lay bystander performed (chest compression-only or standard CPR) and survival.

Except for one study,[12] all observational studies showed no statistically significant survival difference between the two CPR methods. It is of note that despite our intention to use survival to discharge as the primary outcome in the meta-analysis, we had to use 30-day survival for lack of reporting survival to discharge data in 2 studies.[7, 8] In the pooled meta-analysis of all observational cohort studies (Figure 3), chest compression-only CPR was not associated with a difference in survival compared to standard CPR (RR, 0.96 [95% CI, 0.83 – 1.11]; I^2, 0%). Furthermore, chest compression-only CPR did not improve the rate of return of spontaneous circulation (RR, 0.99 [95% CI, 0.88 – 1.12]; I^2, 0%; Figure 4).

Discussion

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

Since meta-analyses are statistical tools for pooling 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,[14–16] the evidence favouring dispatcher-assisted chest compression-only CPR appears to be robust since all randomized clinical trials found a similar, albeit statistically non-significant, positive effect of chest compression-only CPR on survival. The effect size may appear small (~22%), but rates of survival after out-of-hospital cardiac arrest have been stagnating around 4–8 % for the last decades and thus a 22% increase in survival may actually represent an important progress. The incidence of cardiac arrest is about 0.5/1000 in North America.[19] Extrapolating this number to include North America and the European Union (population: ~850 mio.), an absolute 2% increase of survival (as found in our meta-analysis), e.g. from 10% to 12% (20% relative increase), would mean an additional 8,000 lives saved per year.

The main reason why neither clinical trial showed a benefit of dispatcher-assisted chest compression-only CPR over standard CPR was probably because of lack of adequate power. The fact that only three clinical trials investigating dispatcher-assisted chest compression-only CPR have ever been conducted in out-of-hospital cardiac arrest, speaks for the difficulty of conducting well-designed prospective studies in this setting. Well identified challenges involve obtaining informed consent, the limited time to randomize patients, the fidelity of following the study protocol, the tracking of patients and outcomes and the difficulties in blinding the interventions. Because survival rates after out-of-hospital cardiac arrest are low and large treatment effects unlikely, very large sample sizes are required to show a statistically significant survival benefit. No chest compression-only clinical trial had more than 125 “events” (survivors) in a study arm, a number that may be considered fairly small for statistical analyses.

A second question that needs to be addressed is the plausibility of our findings. While being considered a controversial topic,[20, 21] several independent lines of evidence suggest that chest compression-only CPR, assisted by dispatchers but perhaps also for non-assisted bystander CPR, may indeed be superior to standard bystander CPR in out-of-hospital cardiac arrest. Because this topic has been intensively discussed over the last few years, only the most pertinent explanations will be mentioned. The importance of uninterrupted, high-quality chest compressions for CPR success has been repeatedly documented.[22–24] Limiting hands-off time, both for lay people and healthcare professionals, is an important predictor

for survival after cardiac arrest. By avoiding rescue ventilations during CPR, which are commonly fairly time-consuming for lay bystanders,[25] a continuous uninterrupted coronary perfusion pressure is maintained which increases the probability of a successful outcome.[6] It should be noted that these considerations were the main reason to increase the compression:ventilation ratio for standard BLS from 15:2 to 30:2 in the 2005 resuscitation guidelines. All three dispatcher-assisted CPR trials used the old 15:2 ratio. It is unclear if using the current 30:2 ratio would have changed the results. Secondly, particularly for witnessed cardiac arrest it may be of less importance to provide oxygenation and ventilation during the first minutes than to provide high-quality chest compressions. Thirdly, chest compression-only CPR is easier to teach, to learn and to perform compared to the fairly complex standard CPR algorithm, thus increasing the chances of bystander to intervene and provide any CPR.

It is an interesting observation that our secondary meta-analysis that included only observational cohort studies and not randomized controlled trials, did not show any benefit of chest compression-only CPR compared to standard CPR. It needs, again, be pointed out that these observational studies did not investigate dispatcher-assisted bystander CPR, but aimed to investigate the chances of survival after out-of-hospital cardiac arrest between chest compression-only and standard CPR. In none of these studies, chest compression-only CPR had been taught to bystanders; rather, it was a deliberate decision of the lay bystander to avoid mouth-to-mouth rescue ventilation. While evidence suggests now that dispatcher-assisted chest compression-only CPR may be superior to standard CPR in adult out-of-hospital cardiac arrest, several special circumstances exist where chest compression-only CPR may *not* be beneficial. Recent evidence from a large-scale prospective cohort study indicates that in cardiac arrest from non-cardiac causes, e.g., drowning, trauma, asphyxia, standard CPR may actually improve survival.[26] Moreover, in paediatric out-of-hospital cardiac arrest which is also commonly of non-cardiac origin, a similar benefit may be conferred by standard CPR as well.[27] Therefore, it appears that the benefits of chest compression-only bystander CPR are largest in adult patients suffering from “cardiac” arrest.

In summary, findings from this meta-analysis provide evidence that in adult out-of-hospital cardiac arrest dispatcher-assisted chest compression-only bystander CPR is associated with improved survival compared to standard CPR (chest compressions plus rescue ventilations). It is, however, unclear if unassisted chest compression-only bystander CPR provides similar survival benefits.

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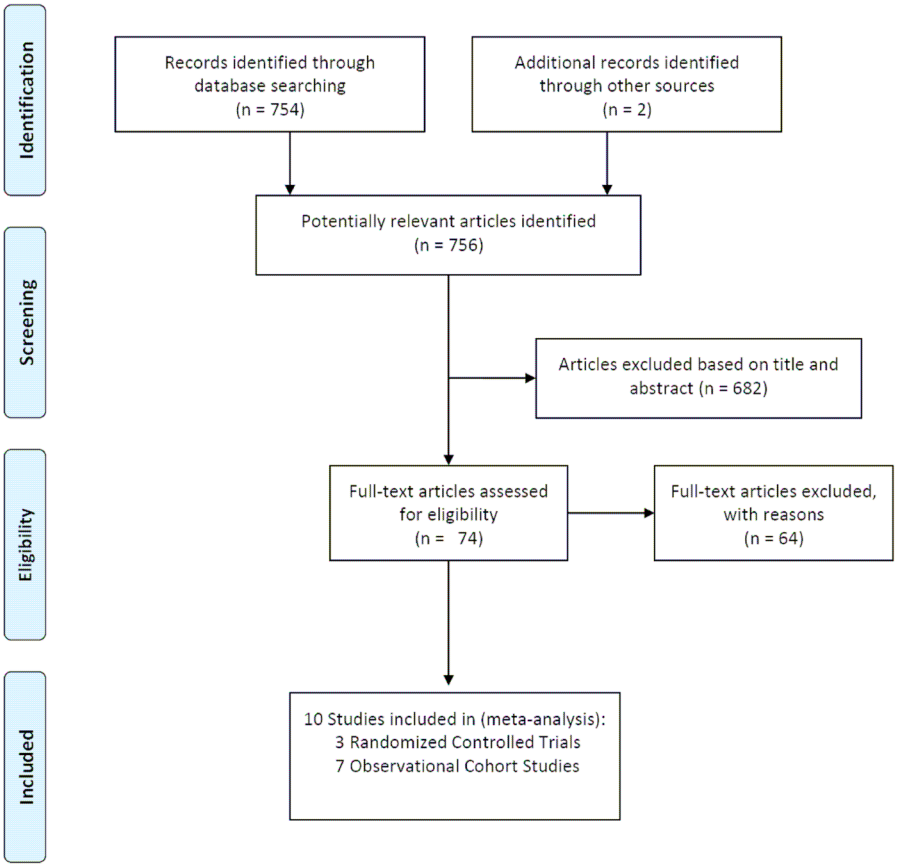

Figure 1.
Study Selection Process for Studies Included in Meta-Analysis (based on PRISMA guidelines).[17]

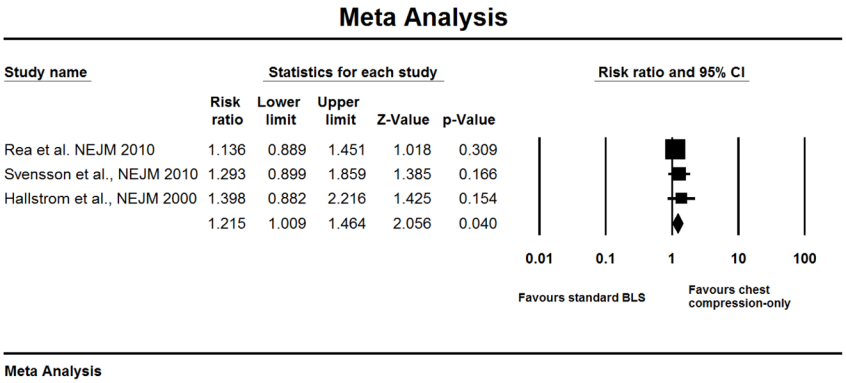

Figure 2.
Primary Analysis of Randomized Controlled Trials in Chest Compression-Only CPR

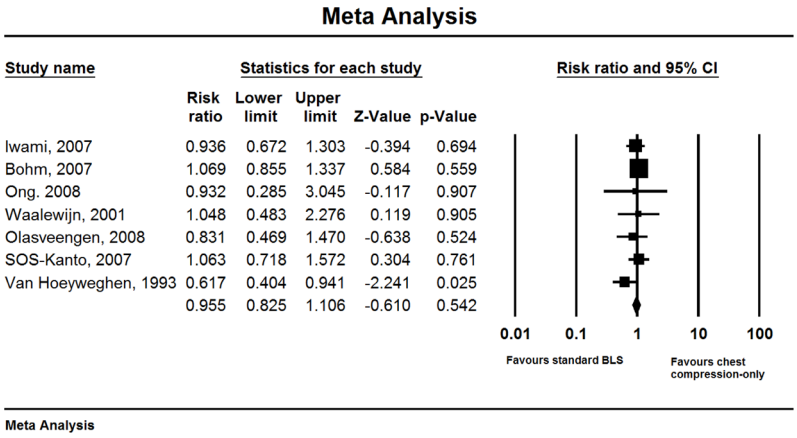

Figure 3.
Secondary Analysis of Observational Cohort Studies in Chest Compression-Only CPR

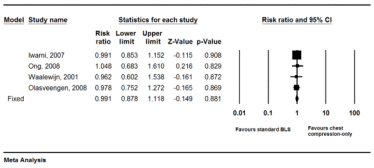

Figure 4.
Return of Spontaneous Circulation in Chest Compression-Only CPR

Table 1

Characteristics of Included Studies on Chest Compression-Only CPR

Source	Study Design	Number of Survivors/Patients Chest Compression Only	Number of Survivors/Patients Standard CPR	Missing Outcome data	Primary Outcome	Secondary Endpoints
Randomized Controlled Trials						
Hallstrom et al.,[14] 2000	RCT	35/240 (14.6%)	29/278 (10.4%)	2/520 (0.4%)	Survival to hospital discharge	Admission to hospital; neurologic status of survivors
Rea et al.,[15] 2010	RCT	122/978 (12.5%)	105/958 (11.0%)	7/1941 (0.4%)	Survival to hospital discharge	Favorable neurologic outcome at discharge
Svensson et al.,[16]2010	RCT	54/282 (19.1%)*	44/297 (14.8%)*	0/1276 (0%) [30-day] 697/1276 (54.6%) [survival to discharge]	30-day survival	1-day survival; Survival to hospital discharge
Observational Cohort Studies**						
Van Hoeyweghen et al.,[12] 1993	retrospective	26/263 (9.9%)	71/443 (16.0%)	Not reported	Awake 14 days after CPR	
Waalewijn et al.,[13] 2001	prospective	6/41 (14.6%)	61/437 (14.0%)	Not reported	Admission to hospital; Survival to hospital discharge	
SOS-Kanto study-group;[11] 2007	prospective	38/439 (8.7%)	58/712 (8.1%)	0/4068 (0%)	Favorable neurologic outcome 30 days after cardiac arrest	30-day survival
Bohm et al.,[7] 2007	retrospective	82/1145 (7.2%)	550/8209 (6.7%)	0/11275 (0%)	Admission to hospital; 30-day survival	
Iwami et al.,[8] 2007	prospective	52/544 (9.6%)	80/783 (10.2%)	25/23438 (0.1%)	Favorable neurologic outcome 1 year after cardiac arrest	ROSC; admission to hospital; 1-week, 30-day, 1-year survival
Olasveengen et al.,[9] 2008	retrospective	15/145 (10.3%)	35/281 (12.5%)	Not reported	Survival to hospital discharge	ROSC; admission to hospital
Ong et al.,[10] 2008	Prospective	4/154 (2.6%)	8/287 (2.8%)	Not reported	Survival to hospital discharge	30-day survival

*To ensure consistence between the three randomized clinical trials, we list survival to discharge in the study by Svensson et al. Their primary outcome (30-day survival) has 54/620 (8.7%) survivors in the chest compression-only CPR group and 46/656 (7.0%) in the standard CPR group.

**In the observational cohort studies, data used for the meta-analysis were survival to discharge, except when this information was unavailable (Van Hoeyweghen et al.: awake after 14 days; Bohm et al. and SOS-Kanto: 30-day survival; Iwami et al: 1 week survival).