Resuscitation 96 (2015) 66–77

Contents lists available at ScienceDirect

Resuscitation

journal homepage: www.elsevier.com/locate/resuscitation

Review article

Cardiopulmonary resuscitation quality and patient survival outcome in cardiac arrest: A systematic review and meta-analysis☆

Milena Talikowska[a,*], Hideo Tohira[a], Judith Finn[a,b,c]

[a] Prehospital, Resuscitation and Emergency Care Research Unit (PRECRU), School of Nursing, Midwifery and Paramedicine, Curtin University, Bentley, WA, Australia
[b] St. John Ambulance, Western Australia, Belmont, WA, Australia
[c] School of Public Health and Preventive Medicine, Monash University, Melbourne, VIC, Australia

ARTICLE INFO

Article history:
Received 3 March 2015
Received in revised form 10 July 2015
Accepted 25 July 2015

Keywords:
Cardiac arrest
Cardiopulmonary resuscitation
Quality
Survival

ABSTRACT

Aim: To conduct a systematic review and meta-analysis to determine whether cardiopulmonary resuscitation (CPR) quality, as indicated by parameters such as chest compression depth, compression rate and compression fraction, is associated with patient survival from cardiac arrest.
Methods: Five databases were searched (MEDLINE, Embase, CINAHL, Scopus and Cochrane) as well as the grey literature (MedNar). To satisfy inclusion criteria, studies had to document human cases of in- or out-of hospital cardiac arrest where CPR quality had been recorded using an automated device and linked to patient survival. Where indicated (I^2 < 75%), meta-analysis was undertaken to examine the relationship between individual CPR quality parameters and either survival to hospital discharge (STHD) or return of spontaneous circulation (ROSC).
Results: Database searching yielded 8,842 unique citations, resulting in the inclusion of 22 relevant articles. Thirteen were included in the meta-analysis. Chest compression depth was significantly associated with STHD (mean difference (MD) between survivors and non-survivors 2.59 mm, 95% CI: 0.71, 4.47); and with ROSC (MD 0.99 mm, 95% CI: 0.04, 1.93). Within the range of approximately 100–120 compressions per minute (cpm), compression rate was significantly associated with STHD; survivors demonstrated a lower mean compression rate than non-survivors (MD −1.17 cpm, 95% CI: −2.21, −0.14). Compression fraction could not be examined by meta-analysis due to high heterogeneity, however a higher fraction appeared to be associated with survival in cases with a shockable initial rhythm.
Conclusions: Chest compression depth and rate were associated with survival outcomes. More studies with consistent reporting of data are required for other quality parameters.

1. Introduction

Several studies have investigated the link between the quality of cardiopulmonary resuscitation (CPR) provided to persons experiencing cardiac arrest and subsequent survival outcomes. Quality is commonly defined in terms of parameters such as chest compression depth, compression rate and compression fraction, along with others including ventilation rate, ventilation pause duration, peri-shock pause, duty cycle and incomplete chest release.

Compression depth, rate and fraction are most extensively described in the literature. A number of papers have reported a statistically significant relationship between compression depth and various survival outcomes, for example survival to emergency department (ED),[1] survival to hospital admission,[2] survival to hospital discharge (STHD)[3,4] and STHD with favourable functional outcome.[3] European Resuscitation Council (ERC) Guidelines for Resuscitation 2010 recommended pushing to a depth of between 50 and 60 mm.[5] Compression rate has likewise been linked to survival.[6,7] ERC Guidelines 2010 recommended a compression rate in the range of 100–120 compressions per minute (cpm).[5] Papers[3,8] have also linked compression fraction (the proportion of time spent delivering chest compressions during CPR)[8] to survival outcomes. ERC 2010 Guidelines advise that rescuers minimise interruptions to chest compressions.[5]

A systematic review investigating the effect of CPR quality on cardiac arrest outcome was previously undertaken by Wallace

☆ A Spanish translated version of the abstract of this article appears as Appendix in the final online version at http://dx.doi.org/10.1016/j.resuscitation.2015.07.036.

* Corresponding author at: Prehospital, Resuscitation and Emergency Care Research Unit, School of Nursing, Midwifery and Paramedicine, Curtin University, GPO Box U1987, Perth, WA 6845, Australia.
E-mail address: milena.talikowska@postgrad.curtin.edu.au (M. Talikowska).

http://dx.doi.org/10.1016/j.resuscitation.2015.07.036
0300-9572/

et al.[9] Since the time of that review, a number of papers[3,4,6,7,10–15] have been published, including several large studies[4,6,7,10,12,14] from the North American Resuscitation Outcomes Consortium (ROC).[16] By incorporating the most recent literature, the present review sought to answer the question of whether a relationship exists between individual CPR quality parameters and patient outcomes from cardiac arrest.

2. Methods

The protocol for this systematic review was registered with PROSPERO (CRD42014010125).[17]

2.1. Eligibility criteria

To be eligible for inclusion: (1) papers had to be original articles with a comparative design; (2) papers had to have been published within the last 20 years; (3) papers had to document human cases of either in-hospital or out-of-hospital cardiac arrest (IHCA or OHCA); (4) the quality of CPR has to have been recorded using a dedicated, automated CPR quality measurement device (for example the Philips HeartStart Monitor/Defibrillator with Q-CPR (Laerdal Medical AS) or the ZOLL AED Plus with Real CPR Help®); and (5) papers had to report on the association between at least one CPR quality parameter with at least one survival outcome or provide data that enabled reviewers to compute the relationship. The primary outcome of interest was return of spontaneous circulation (ROSC). Secondary outcomes were STHD and STHD with good neurological outcome (as defined by either a Cerebral Performance Category (CPC) score 1–2 or Modified Rankin Score $\leq$3). (Note – with reference to the outcomes listed on PROSPERO, the primary outcome was extended to cover all definitions of ROSC, not just ROSC at any time prior to hospital admission, to accommodate IHCA cases). Both adult and paediatric studies and all cardiac arrest aetiologies were considered. Database searches were restricted to articles published from January 1994 onwards. This was due to the fact that automated CPR quality measurement devices were not widely available prior to this time. No language restrictions were set.

The following studies were excluded: (1) editorials, commentaries, letters, case studies/case reports and conference abstracts; (2) animal and manikin studies; (3) studies where CPR quality was measured subjectively e.g. by an observer; (4) studies that featured a device that provided real-time guidance or feedback but did not store data for retrospective analysis (e.g. metronome); (5) studies that reported surrogate or physiological outcomes as a proxy for the abovementioned survival outcomes, for example, first shock success or failure[18]; and (6) studies that provided CPR quality data but did not relate it directly to survival outcome, e.g. they provided only the overall survival outcome for the entire patient cohort and did not stratify by CPR quality parameter.[19]

2.2. Information sources

Ovid MEDLINE, Ovid Embase, EBSCO CINAHL, Scopus and the Cochrane Library were searched up to 11 April 2015. MedNar was also used to search the grey literature. Reviewers consulted the reference lists of relevant papers to determine whether there were any additional relevant articles. Reviewers also examined other publications of the first authors of included papers.

2.3. Search

Our search strategy incorporated several key concepts and analogous terms: cardiac arrest, CPR and quality, including the individual parameters of CPR quality, and analogous terms of these keywords. A number of limits were placed upon the search in order to comply with the pre-specified eligibility criteria. A full electronic search strategy for MEDLINE is provided in Appendix A.

2.4. Study selection

One reviewer (MT) performed the database searching and selected potentially relevant papers based upon review of titles and abstracts. Two reviewers (MT, HT) then independently reviewed the full text versions of potentially relevant papers against the inclusion criteria to select relevant papers. Any uncertainties or disagreements amongst reviewers were referred to a third reviewer (JF) for resolution.

2.5. Data collection process

Data were collected from the relevant papers and entered into a pre-piloted form by MT. The form was developed with reference to the Cochrane Handbook.[20] Data extracted included: author(s), publication year, title, study location, number of cases, period over which cases were collected, study design, reported CPR quality parameters, devices used to collect data, reported survival outcomes and whether the study focused on OHCA, IHCA or both. In addition the reviewers noted the definition of ROSC used in the paper (where applicable), the time period over which CPR quality was measured during the resuscitation episode and the distribution of initial cardiac rhythms. This information was later used to facilitate subgroup analyses. All data used for meta-analyses were collated by one reviewer (MT) and independently checked by a second reviewer (HT).

2.6. Risk of bias in individual studies

The Newcastle-Ottawa Scale[21] was used by two reviewers (MT, HT) to assess bias in individual papers. Papers were considered of poor quality if they attained a score of 1–3, of intermediate quality with a score of 4–6 and of high quality with a score of 7–9.[22] Poor quality papers were not included in meta-analysis.

2.7. Studies with overlapping cohorts

Several papers featured overlapping cohorts. In these cases, for each individual quality parameter, the reviewers chose to preferentially include those papers that (1) were primarily designed to examine the relationship between the parameter of interest and survival, otherwise (2) contained data in a format that could be used in meta-analysis, otherwise (3) featured the largest sample size.

2.8. Summary measures

The summary measure used in the meta-analysis examining the relationship between individual CPR quality parameters and survival outcome was mean difference (MD). Where data were not available as mean (standard deviation (SD)) authors were contacted to request further information. Some articles included other measures such as Odds Ratio (OR). Although not used in meta-analysis, these alternative measures are described in tables that feature in the Results section of this review.

2.9. Synthesis of results

Compression depth, rate and fraction were the most frequently studied parameters in the literature; a table summarising the relationship of each with survival outcome is provided. *p*-Values were