Resuscitation 94 (2015) 91–97

Contents lists available at ScienceDirect

Resuscitation

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

Review article

Mechanical chest compression for out of hospital cardiac arrest: Systematic review and meta-analysis☆

Simon Gates[a,*], Tom Quinn[b,g], Charles D. Deakin[c,d], Laura Blair[e], Keith Couper[a,f], Gavin D. Perkins[a]

[a] Warwick Clinical Trials Unit, University of Warwick, Coventry CV4 7AL, UK
[b] School of Health Sciences, Faculty of Health and Medical Sciences, Duke of Kent Building, University of Surrey, Guildford GU2 7XH, UK
[c] South Central Ambulance Service NHS Foundation Trust, Otterbourne, UK
[d] NIHR Southampton Respiratory Biomedical Research Unit, University Hospital Southampton NHS Foundation Trust, Southampton, Hampshire, UK
[e] North East Ambulance Service NHS Foundation Trust, Bernicia House, Goldcrest Way, Newburn Riverside, Newcastle upon Tyne NE15 8NY, UK
[f] Academic Department of Anaesthesia, Critical Care, Pain and Resuscitation, Heart of England NHS Foundation Trust, Birmingham B9 5SS, UK
[g] Surrey Perioperative, Anaesthetic and Critical Care Collaborative Research Group, Surrey Health Partners, Egerton Road, Guildford GU2 8DR, UK

ARTICLE INFO

Article history:
Received 9 April 2015
Received in revised form 3 June 2015
Accepted 10 July 2015

Keywords:
Cardiac arrest
Cardiopulmonary resuscitation
LUCAS
AutoPulse
Mechanical chest compression

ABSTRACT

Aim: To summarise the evidence from randomised controlled trials of mechanical chest compression devices used during resuscitation after out of hospital cardiac arrest.
Methods: Systematic review of studies evaluating the effectiveness of mechanical chest compression. We included randomised controlled trials or cluster randomised trials that compared mechanical chest compression (using any device) with manual chest compression for adult patients following out-of-hospital cardiac arrest. Outcome measures were return of spontaneous circulation, survival of event, overall survival, survival with good neurological outcome. Results were combined using random-effects meta-analysis.
Data sources: Studies were identified by searches of electronic databases, reference lists of other studies and review articles.
Results: Five trials were included, of which three evaluated the LUCAS or LUCAS-2 device and two evaluated the AutoPulse device. The results did not show an advantage to the use of mechanical chest compression devices for survival to discharge/30 days (average OR 0.89, 95% CI 0.77, 1.02) and survival with good neurological outcome (average OR 0.76, 95% CI 0.53, 1.11).
Conclusions: Existing studies do not suggest that mechanical chest compression devices are superior to manual chest compression, when used during resuscitation after out of hospital cardiac arrest.

1. Introduction

Out of hospital cardiac arrest is a major cause of death and morbidity.[1] Survival rates are low; in the UK, only around 7% of patients in whom resuscitation is attempted, survive to discharge from hospital.[2] A key factor that improves survival is good quality cardiopulmonary resuscitation (CPR).[3,4]

The quality of CPR delivered at out-of-hospital cardiac arrest is often sub-optimal.[5] Fatigue and the need to deliver multiple tasks on arrival at a cardiac arrest likely limit the quality of CPR that paramedics can provide. Mechanical chest compression devices provide compressions of standard depth and frequency for prolonged periods without any decline in quality and remove the need for paramedics to provide chest compressions manually, enabling them to concentrate on other aspects of patient care.[6]

Several different types of mechanical chest compression device have been proposed, but the main technologies are piston devices and load-distributing bands. Piston devices such as LUCAS-2 (Jolife AB, Sweden) use a piston mounted on a frame that fits around the patient's chest. The piston is driven up and down by a power source such as compressed air or an electric motor, compressing the chest in a similar way to manual chest compressions. Load-distributing band devices, such as AutoPulse (Zoll Medical Corporation, Chelmsford, MA), work in a different way. They consist of a wide band that fits around the chest, whose circumference is alternately shortened and lengthened, providing rhythmic chest compressions.

☆ 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.2015.07.002.

* Corresponding author.
E-mail address: s.gates@warwick.ac.uk (S. Gates).

http://dx.doi.org/10.1016/j.resuscitation.2015.07.002

Three large randomised controlled trials that compared mechanical with manual chest compression, and evaluated their effects on clinically important outcomes, have recently been reported, but not yet included in systematic reviews. The aim of this paper is to combine, where appropriate, the results from randomised trials, to estimate the effects on important outcomes (especially survival and survival with good neurological outcome) of mechanical chest compression devices used to provide chest compressions for adult patients after out of hospital cardiac arrest.

2. Methods

Studies were eligible for inclusion if they were individually randomised or cluster randomised trials that compared the use of a mechanical chest compression device with standard manual chest compression in adult patients following out of hospital cardiac arrest. There was no restriction of eligibility based on language of publication. Quasi-randomised trials, for example, those randomised by birth date or days of the week, were excluded. Studies were not included in analyses if they reported insufficient information to allow assessment of their risk of bias. Screening, decisions about inclusion and data extraction were performed by one author and checked by a second author. The review protocol was not pre-registered or published.

We searched electronic resources (Medline, EMBASE and the Cochrane Central register from 1990 to February 2015) and the reference lists of studies and review articles (last search February 2015). We based our search strategies on that published by the Cochrane review of mechanical chest compression devices,[7] which used a combination of search terms to describe the condition (cardiac arrest), the intervention (mechanical compression devices) and the study design (randomised controlled trials).

For each eligible study, we extracted information about the study's population and methodology, and the following outcomes; return of spontaneous circulation (ROSC); survived event (sustained ROSC until handover to a hospital emergency department); survival to hospital discharge or 30 days; and survival with good neurological outcome. Good neurological outcome was defined as either a Cerebral Performance Category (CPC) score of 1 or 2, or Modified Rankin Scale (mRS) score of between 0 and 3.[8] Where studies presented a treatment effect estimate adjusted for important covariates (e.g. clustering, initial rhythm, bystander CPR, EMS response time, age) we used this estimate in meta-analyses in preference to unadjusted results.

We used the Cochrane Risk of Bias tool to assess studies' risk of bias. This assesses seven domains; generation of random allocation sequence, allocation concealment, blinding of participants and study personnel, blinding of outcome assessment, incomplete outcome data, selective reporting, and other sources of bias. For each study, we assessed the methods used to address each potential source of bias, and summarised them in tabular form. We did not produce an overall bias risk judgement or score, but assessed each domain separately.

We combined studies using the Review Manager (RevMan) software version 5.3. Because there may be differences in treatment effect between trials, especially those using different devices, we used a random-effects model. We used the generic inverse variance method in RevMan to estimate the average treatment effect (odds ratio) for each outcome, and the uncertainty around it, measured by the 95% confidence interval. We also calculated 95% prediction intervals,[9] to estimate the range of plausible treatment effects. We quantified heterogeneity in each analysis by the tau-squared and *I*-squared statistics. Studies were subgrouped by the type of mechanical compression device used, as different devices operate in different ways and hence could have different treatment effects. Our primary analysis compared mechanical compression with manual compression, and we performed a subgroup analysis by type of device, to explore whether there was any evidence that treatment effects differed between devices.

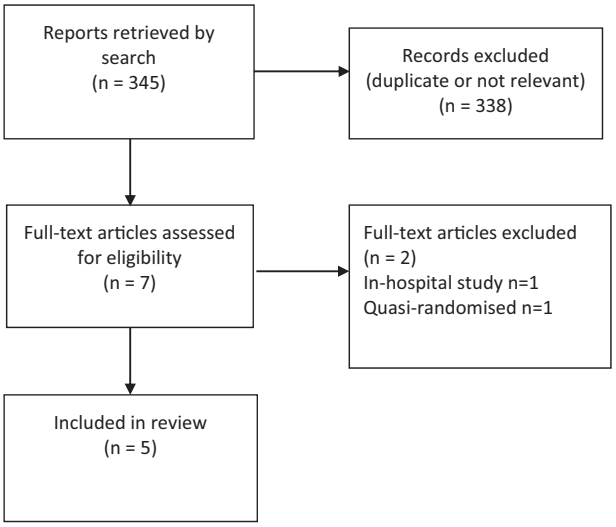

Fig. 1. Flow chart of studies.

Some of the included trials presented several results using different adjustments for covariates and design elements. We performed sensitivity analyses to explore the effects of using differently adjusted results for these trials. In addition, PARAMEDIC presented CACE (complier average causal effect) estimates, to estimate the treatment effect in the presence of non-compliance.[10,11] We performed additional sensitivity analyses to explore the effects of using these estimates.

3. Results

The search located five eligible studies[12–16] (Fig. 1). Two trials evaluated the AutoPulse device, and three evaluated the LUCAS device. Two of the studies used a cluster randomised design, one (PARAMEDIC) randomising by ambulance service vehicles, and the other (ASPIRE) using ambulance stations or groups of stations as the clusters; this study also incorporated crossovers at prespecified points between the intervention and control groups. The other three studies employed individual randomisation, using sealed envelopes or cards carried with the device, which were accessed by the paramedic at the time of the resuscitation attempt. Study characteristics and risk of bias are summaried in Table 1.

There were a number of differences between the studies in addition to the chest compression device used, which may have caused differences in treatment effects and hence introduce heterogeneity into the meta-analyses. In two studies the LUCAS device was used as part of a modified treatment algorithm,[13,14] whereas in the third LUCAS study mechanical chest compression was simply used to replace manual compression in the standard algorithm.[16] One of the trials of AutoPulse conducted extensive training to optimise the quality of manual CPR that was provided to the control group[17]; in contrast other trials did not provide extra training but the control group received CPR as it would be provided in standard clinical practice.

The randomisation methods of the studies appeared to be adequate, although four studies did not provide any information on the generation of the random allocation sequence. One concern with individual randomisation was that it would be possible for ambulance staff to open randomisation envelopes early and subvert the randomisation scheme. No studies reported any problems with