Do Mechanical Chest Compression Devices Compared With High-Quality Manual Chest Compressions Improve Neurologically Intact Survival of Patients Who Experience Cardiac Arrest?

TAKE-HOME MESSAGE

Mechanical chest compression devices are not superior to conventional, high-quality manual chest compressions in improving survival to hospital discharge with good neurologic function.

METHODS

DATA SOURCES

Authors searched the Cochrane Central Register of Controlled Trials, Ovid MEDLINE, Ovid EMBASE, Science Citation Index Expanded, Conference Proceedings Citation Index–Science, Science Citation abstracts on the Web of Science, ClinicalTrials.gov, the World Health Organization International Clinical Trials Registry Platform, Biotechnology and Bioengineering Abstracts, and bibliographies of included articles. Authors also contacted experts in mechanical chest compression devices to identify additional published and unpublished trials. Authors did not limit the search according to language.

STUDY SELECTION

The review included only randomized controlled trials comparing compressions delivered by powered, automatic mechanical chest compression devices versus manual chest compressions performed by a human being, with a primary outcome of survival to hospital discharge with good neurologic function equivalent to a

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This review does not reflect the views or opinions of the US government, Department of Defense, US Army, US Air Force, or SAUSHEC EM Residency Program.

Jestin N. Carlson, MD, MS, and Alan Jones, MD, serve as editors of the SRS series.

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Results

Results of included trials.

Outcome	Trials	No. of Patients	RR (95% CI) by Included Trial	Evidence Quality
Survival to hospital discharge with good neurologic outcome	Hallstrom, 2006[2]	767	0.41 (0.21–0.79)	Moderate
	Rubertsson, 2014[3]	2,589	1.07 (0.82–1.39)	
	Wik, 2014[4]	4,231	0.79 (0.60–1.04)	
Survival to hospital discharge	Gao, 2016[5]	133	3.01 (1.04–8.77)	Moderate
	Hallstrom, 2006	767	0.59 (0.36–0.97)	
	Lu, 2010[6]	150	2.21 (1.18–4.17)	
	Rubertsson, 2014	2,589	0.98 (0.77–1.25)	
	Smekal, 2011[7]	147	0.82 (0.29–2.33)	
	Taylor, 1978[8]	50	1.63 (0.30–8.90)	
	Wik, 2014	4,231	0.85 (0.71–1.02)	
Return of spontaneous circulation	Dickinson, 1998[9]	17	4.13 (0.19–88.71)	Low
	Gao, 2016	133	1.92 (1.15–3.21)	
	Halperin, 1993[10]	34	2.67 (0.85–8.37)	
	Lu, 2010	150	1.46 (1.02–2.08)	
	Perkins, 2015[11]	4,471	1.01 (0.92–1.10)	
	Rubertsson, 2014	2,589	1.02 (0.92–1.14)	
	Smekal, 2011	147	1.27 (0.82–1.96)	
	Wik, 2014	4,231	0.88 (0.81–0.97)	

Cerebral Performance Category score of 1 or 2.[1] Authors included patients experiencing out-of-hospital cardiac arrest or inhospital cardiac arrest who underwent resuscitation by trained medical personnel. The meta-analysis excluded trials with patients experiencing cardiac arrest from trauma, drowning, hypothermia, and toxic substances. Two authors used the predefined inclusion criteria to decide which trials to include, with disagreements resolved through consensus or discussion with a third author.

DATA EXTRACTION AND SYNTHESIS

Two authors abstracted data independently, with discrepancies resolved through consensus. Authors quantified the primary outcome of survival to hospital discharge with good neurologic function and dichotomous secondary outcomes by calculating risk ratios with 95% confidence intervals. Authors adjusted for clustering in cluster-randomized trials by calculating effective sample sizes. If trials used multiple comparator groups, authors combined data from all mechanical device groups into one comparator group. Authors contacted original trial investigators directly for missing or ambiguous data; if they did not receive a response within 1 month, they designated the data as missing. Two authors independently evaluated risk of bias and quality of evidence with the Grading of Recommendations Assessment, Development and Evaluation approach and quantified heterogeneity by calculating the I^2 statistic.

Continued.

Outcome	Trials	No. of Patients	RR (95% CI) by Included Trial	Evidence Quality
Survival to hospital admission	Dickinson, 1998	17	4.13 (0.19–88.71)	Moderate
	Perkins, 2015	4,471	0.98 (0.87–1.09)	
	Rubertsson, 2014	2,589	1.02 (0.90–1.15)	
	Smekal, 2011	147	1.15 (0.63–2.11)	

RR, Relative risk; *CI*, confidence interval

Authors screened 2,554 studies, from which they included 11 randomized trials (12,944 patients) in the final meta-analysis. Trial publication dates ranged from 1978 to 2015. Authors added 5 trials not featured in the last iteration of this meta-analysis, including 3 large-scale randomized controlled trials accounting for greater than 90% of patients in this review.[2-4] One added trial was a noninferiority randomized controlled trial.[12] An initial shockable rhythm was present in 13% to 47% of included patients. Patient mean age ranged from 45.5 to 71 years, and men accounted for 58% to 68% of patients. Mechanical compression device types varied significantly, including an unspecified piston device, a gas-powered external chest compressor, a pneumatic vest-type device, and the LUCAS and AutoPulse devices. Trial settings included the United States (3), China (2), Sweden (1), the Netherlands (1), and the United Kingdom (1). The remaining 3 trials were multinational. Three trials (7,587 patients) reported survival to hospital discharge with good neurologic function: 1 trial showed no benefit, 1 noninferiority trial showed equivalence, and 1 showed lower survival (Table). No trials reported differences in survival to admission, adverse events, or injury patterns. Two trials found benefit for survival to hospital discharge, 4 showed no difference, and 1 found harm with mechanical devices. Significant heterogeneity in regard to type of mechanical device, patient type, timing of device use, and publication year was present, with I^2 values ranging from 64% to 75%. This heterogeneity, along with considerable risk of bias and overall moderate evidence quality, precluded a priori planned pooled subgroup analyses and sensitivity analyses.

Commentary

Cardiac arrest is a major cause of mortality, with survival rates ranging from 5% to 50%,[13,14] and close to half of survivors have cerebral damage after cardiac arrest.[15,16] Management focuses on obtaining return of spontaneous circulation with good neurologic function.[13] This outcome requires high-quality chest compressions to ensure end-organ blood flow and maximize probability of survival.[13] Traditional cardiopulmonary resuscitation (CPR) includes manual compressions, but an alternative technique includes the use of a mechanical chest compression device. A variety of such devices exists, all of which are designed to provide continuous, high-quality compressions with minimal interruptions.

This meta-analysis sought to evaluate the effectiveness of mechanical compression devices versus traditional manual chest compressions. Two previous reviews concluded there was insufficient evidence from high-quality randomized controlled trials to determine whether mechanical compression devices optimize outcomes.[17,18] This current meta-analysis found that mechanical compression devices are not associated with improved patient outcomes compared with high-quality manual compressions. Mechanical devices may be useful in situations in which consistent, high-quality compressions are not possible or are dangerous for providers. Potential situations include limited rescuer availability, prolonged CPR, hypothermic cardiac arrest, CPR in a moving vehicle, and CPR while preparing for extracorporeal support or in the angiography suite. However, existing literature does not evaluate outcomes under these specific situations.

There are several limitations of this updated meta-analysis. A major limitation is clinical and statistical heterogeneity among trials, preventing pooling of results for full meta-analysis. Trials varied in out-of-hospital cardiac arrest versus inhospital cardiac arrest, causes of arrest, and timing of device application (immediate application compared with delayed after failure of traditional CPR). Devices used also varied, with more recent trials using the LUCAS and AutoPulse devices. Furthermore, individual trial results depend on the quality of manual compressions in comparator groups. Chest compression fraction often approximates 50%,[19] and the manual compression groups in this review may not reflect actual practice. Authors did not perform direct comparisons between different devices, and included trials did not report strong evidence of differences in long-term outcomes. Data were imprecise, with large confidence intervals, especially in regard to adverse events. Risk of bias was considerable across many aspects.

Current evidence suggests mechanical chest compression devices likely result in comparable but nonsuperior survival compared with high-quality, consistent manual compressions. Mechanical devices are likely most beneficial in scenarios in which consistent high-quality compressions are not possible or are dangerous to providers. Providers using these devices must minimize time without compressions and delays to defibrillation during device deployment and consider that compressions, whether mechanical or manual, are a bridge to therapy (defibrillation, extracorporeal support, etc) while providing end-organ perfusion. Further randomized controlled trial data are necessary in regard to potential adverse effects of mechanical compression devices, direct comparisons of different devices, evaluation of protocols limiting interruptions in compressions and delays to defibrillation, and, most important, situations in which high-quality manual compressions are not possible. The literature would also benefit from cost-effectiveness analyses[20] of mechanical devices and how their use might offset the costs of paramedic injury.

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