Mechanical Cardiopulmonary Resuscitation Devices for Cardiac Arrest: Clinical Effectiveness and Cost-Effectiveness
Authors: Calvin Young, Lory Picheca


Acknowledgments:

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About CADTH: CADTH is an independent, not-for-profit organization responsible for providing Canada’s health care decision-makers with objective evidence to help make informed decisions about the optimal use of drugs, medical devices, diagnostics, and procedures in our health care system.
Research Questions
1. What is the clinical effectiveness of mechanical cardiopulmonary resuscitation devices for cardiac arrest in pre-hospital and hospital settings?
2. What is the cost-effectiveness of mechanical cardiopulmonary resuscitation devices for cardiac arrest in pre-hospital and hospital settings?

Key Findings
Two health technology assessments, ten systematic reviews (seven with meta-analysis), five randomized controlled trials, and 13 non-randomized studies were identified regarding the clinical benefits, harms, or cost-effectiveness of mechanical CPR devices for patients with cardiac arrest in pre-hospital and hospital settings.

Methods
A limited literature search was conducted on key resources including PubMed, The Cochrane Library (2017, Issue 5), University of York Centre for Reviews and Dissemination (CRD) databases, Canadian and major international health technology agencies, as well as a focused Internet search. No filters were applied to limit the retrieval by study type. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2012 and May 8, 2017. Internet links were provided, where available.

Selection Criteria
One reviewer screened citations and selected studies based on the inclusion criteria presented in Table 1.

Table 1: Selection Criteria

<table>
<thead>
<tr>
<th>Population</th>
<th>Patients with cardiac arrest in pre-hospital and hospital settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Mechanical CPR devices (e.g., AutoPulse, LUCAS, LUCAS-2)</td>
</tr>
<tr>
<td>Comparator</td>
<td>Manual CPR; Mechanical CPR devices compared with each other</td>
</tr>
</tbody>
</table>
| Outcomes                    | Q1: Clinical benefits and harms (e.g., survival [i.e., to hospital admission, discharge, and post-discharge] return of spontaneous circulation, rib or sternal fractures)  
                              | Q2: Cost-effectiveness outcomes (e.g., incremental cost per QALY or health benefit) |
| Study Designs                | Health technology assessments, systematic reviews, meta-analyses, randomized controlled trials, non-randomized studies, economic evaluations |
Results
Rapid Response reports are organized so that the higher quality evidence is presented first. Therefore, health technology assessment reports, systematic reviews, and meta-analyses are presented first. These are followed by randomized controlled trials, non-randomized studies, and economic evaluations.

Two health technology assessments, ten systematic reviews (seven with meta-analysis), five randomized controlled trials, and 13 non-randomized studies were identified regarding the clinical benefits, harms, or cost-effectiveness of mechanical CPR devices for patients with cardiac arrest in pre-hospital and hospital settings. No relevant economic evaluations were identified.

Additional references of potential interest are provided in the appendix.

Overall Summary of Findings
Two health technology assessments,\(^1\) ten systematic reviews\(^3,12\) (seven with meta-analysis),\(^4,6,8,15\) five randomized controlled trials,\(^13-17\) and 13 non-randomized studies\(^18-30\) were identified regarding the clinical benefits, harms, or cost-effectiveness of mechanical CPR devices for patients with cardiac arrest in pre-hospital and hospital settings. Detailed study characteristics are provided in Table 2.

Studies assessing the clinical effectiveness of mechanical CPR devices were varied in their conclusions. Thirteen of the 30 identified studies concluded that chest compressions with a mechanical CPR device had a clinical advantage over manual chest compressions for CPR. These studies included four systematic reviews,\(^3,4,7,10\) two randomized controlled trials,\(^13-14\) and seven non-randomized studies.\(^18,20,24,28-30\) Of note, one study which investigated the use of mechanical CPR devices while transporting patients by helicopter found them to be advantageous over manual CPR.\(^28\) Ten studies reported no difference in clinical effectiveness between mechanical CPR and manual CPR. These included two health technology assessments,\(^1-2\) four systematic reviews,\(^6,9,11-12\) three randomized controlled trials,\(^15-17\) and one non-randomized study.\(^23\) Finally, the authors of seven studies concluded that mechanical CPR was inferior to manual CPR. These included two systematic reviews\(^5,8\) and five non-randomized studies.\(^21,22,25-27\) Several studies agreed that there was often insufficient evidence to make a clear decision on whether the widespread implementation of mechanical CPR devices can be recommended and that future research is warranted.\(^4,7,9,12,25,30\)

<table>
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<tr>
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<tr>
<td>Gates, 2016(^1)</td>
<td>• Contains RCT, SR, and economic evaluation evidence</td>
<td>• LUCAS-2 mechanical CPR</td>
<td>• Manual CPR</td>
<td>• 30-day survival • EA</td>
<td>• RCT reported no benefit to 30-day survival with LUCAS-2 over manual CPR</td>
</tr>
</tbody>
</table>

Table 2: Summary of Included Studies on the Clinical Benefits, Harms, or Cost-Effectiveness of Mechanical CPR devices for Patients with Cardiac Arrest in Pre-Hospital and Hospital Settings
# Table 2: Summary of Included Studies on the Clinical Benefits, Harms, or Cost-Effectiveness of Mechanical CPR devices for Patients with Cardiac Arrest in Pre-Hospital and Hospital Settings

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<tr>
<td>NICE, 2015^2</td>
<td>Assessed clinical effectiveness, safety, and cost</td>
<td>AutoPulse mechanical CPR device</td>
<td>Manual CPR</td>
<td>Survival to hospital discharge, 24-hour survival, 4-hour survival, Cerebral performance, EA</td>
<td>Majority of included studies reported that outcomes with the AutoPulse device were at least non-inferior compared with manual CPR</td>
</tr>
</tbody>
</table>

### Systematic Reviews and Meta-Analyses

| Bonnes, 2016^3       | SR & MA 20 studies included (5 RCTs, 15 NRS) N = 21,363 | Mechanical chest compression devices | Manual chest compression | Survival to hospital admission, Survival to discharge, Favourable neurologic outcome | NRS pooling suggested that mechanical CPR devices may offer benefit for survival to admission. No difference observed for survival to discharge or neurological outcome between CPR strategies |

| Couper, 2016^4       | SR & MA 9 studies included N = 689 | Mechanical chest compression devices | Manual chest compression | Survival with good neurological outcome, Survival at hospital discharge, 30-day survival, Short-term survival (ROSC/1-h survival) | Mechanical chest compression device use led to improved hospital, 30-day, and short-term survival. Quality of reviewed evidence was low |

| Li, 2016^5           | SR & MA 12 studies included N = 11,162 | Mechanical chest compression devices | Manual chest compression | ROSC, Survival to admission and discharge, Neurological function | No differences between chest compression devices and manual resuscitation in survival to admission, |
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</table>
| Gates, 2015⁵       | • SR & MA            | • Mechanical chest compression devices | • Manual chest compression | • ROSC  
  • Survival of event  
  • Overall survival  
  • Survival with good neurological outcome | • No evidence that mechanical chest compression devices were superior to manual chest compression for the outcomes studied |
| Lameijer, 2015⁶    | • SR                 | • Mechanical chest compression devices | • Manual chest compression | • Survival rate  
  • Full neurological recovery | • Early start of mechanical chest compressions may improve patient outcomes over manual chest compressions |
| Tang, 2015⁷        | • SR & MA            | • Mechanical chest compressions | • Manual chest compressions | • Survival with good neurological outcome  
  • ROSC  
  • Long-term (≥6 months) survival  
  • Survival to hospital admission  
  • Survival to hospital discharge | • Mechanical chest compression did not significantly improve survival with good neurological outcomes, ROSC, or long-term survival  
• Mechanical chest compression was inferior for survival to hospital admission and hospital discharge  
• Widespread use of mechanical compression devices cannot be recommended |

discharge, and neurology function were observed
• Mechanical chest compression devices were inferior in their ability to achieve ROSC; therefore, cannot be recommended to replace manual CPR

Note: ROSE = Return of Spontaneous Circulation
N = NR = Number of participants not reported
### Table 2: Summary of Included Studies on the Clinical Benefits, Harms, or Cost-Effectiveness of Mechanical CPR devices for Patients with Cardiac Arrest in Pre-Hospital and Hospital Settings

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| Brooks, 2014<sup>9</sup> | • SR & MA  
• 6 studies included  
• N = 1,166 | • Mechanical chest compressions | • Manual chest compressions | • Survival to hospital discharge with good neurological outcome  
• ROSC  
• Survival to hospital admission | • Insufficient evidence to conclude that mechanical chest compressions during CPR are advantageous to manual chest compressions |
| Westfall, 2013<sup>10</sup> | • SR & MA  
• 12 studies included  
• N = 6,538 | • Load-distributing band and piston-driven chest compression devices | • Manual CPR | • ROSC | • ROSC achieved at a higher rate with mechanical compression devices |
| Gates, 2012<sup>11</sup> | • SR  
• 16 studies included  
• N = NR | • LUCAS mechanical chest compression device | • Manual chest compression | • ROSC  
• Survival  
• Injuries caused by resuscitation  
• Physiological parameters | • Human studies did not suggest a clinical advantage for the LUCAS device over manual chest compressions  
• Insufficient evidence to make recommendations for clinical practice |
| Ong, 2012<sup>12</sup> | • SR  
• 10 studies included  
• N = NR | • Mechanical CPR devices | • Manual CPR | • Quality of CPR  
• ROSC  
• Survival  
• Survival to hospital admission  
• Survival to discharge  
• Cerebral performance | • Insufficient evidence regarding the use of mechanical CPR devices for out-of-hospital cardiac arrest and during ambulance transport |

### Randomized Controlled Trials

| Gao, 2016<sup>13</sup> | • N = 133 | • AutoPulse automated chest compression device | • Manual chest compression | • ROSC  
• 24-hour survival  
• Hospital discharge rate  
• Cerebral performance | • AutoPulse device increases rate of ROSC and survival in patients with out-of-hospital cardiac arrest |
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<tr>
<td>Esibov, 2015^{14}</td>
<td>• N = 206</td>
<td>• LUCAS mechanical chest compression device</td>
<td>• Manual chest compression</td>
<td>• Chest compression fraction (the fraction of time during cardiac arrest that chest compressions were administered)</td>
<td>• LUCAS device reduced interruptions in chest compressions and enabled defibrillation during ongoing compressions without decreasing the quality of CPR</td>
</tr>
<tr>
<td>Perkins, 2015^{1b}</td>
<td>• N = 4,471</td>
<td>• LUCAS-2 mechanical CPR</td>
<td>• Manual CPR</td>
<td>• 30-day survival</td>
<td>• No statistically significant difference in the 30-day survival rates of the 2 groups • Widespread adoption of mechanical CPR devices for routine use does not improve survival</td>
</tr>
<tr>
<td>Rubertsson, 2014^{16}</td>
<td>• N = 2,589</td>
<td>• LUCAS mechanical CPR with defibrillation</td>
<td>• Manual CPR</td>
<td>• 4-hour survival • 6-month survival with good neurological outcome</td>
<td>• No difference in 4-hour survival for either treatment group • Mechanical CPR not clinically superior to manual CPR</td>
</tr>
<tr>
<td>Wik, 2014^{17}</td>
<td>• N = 4,231</td>
<td>• Integrated automated load distributing band CPR</td>
<td>• High-quality manual CPR</td>
<td>• Survival to hospital discharge</td>
<td>• Integrated automated load distributing band CPR and high-quality manual CPR resulted in statistically equivalent survival to hospital discharge</td>
</tr>
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Non-Randomized Studies

<table>
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<tr>
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<tr>
<td>Kim, 2017^{18}</td>
<td>• N = 31</td>
<td>• Mechanical CPR on a reducible stretcher</td>
<td>• Manual CPR on a standard stretcher</td>
<td>• Chest compression fraction</td>
<td>• Chest compression fraction significantly higher in the mechanical CPR group</td>
</tr>
<tr>
<td>Venturini, 2017^{19}</td>
<td>• N = 43</td>
<td>• Mechanical chest compression</td>
<td>• Manual chest compression</td>
<td>• ROSC • 30-day survival • Survival to hospital discharge</td>
<td>• Mechanical chest compression increased the rate of ROSC</td>
</tr>
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### Table 2: Summary of Included Studies on the Clinical Benefits, Harms, or Cost-Effectiveness of Mechanical CPR devices for Patients with Cardiac Arrest in Pre-Hospital and Hospital Settings

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<tr>
<td>Wagner, 2016&lt;sup&gt;20&lt;/sup&gt;</td>
<td>• N = 32</td>
<td>• Mechanical chest compressions</td>
<td>• Manual chest compressions</td>
<td>• Neurological outcome at hospital discharge</td>
<td>• Mechanical chest compressions associated with better neurological outcome at discharge</td>
</tr>
<tr>
<td>Youngquist, 2016&lt;sup&gt;21&lt;/sup&gt;</td>
<td>• N = 2,600</td>
<td>• Mechanical chest compressions</td>
<td>• Manual chest compressions</td>
<td>• Functional survival (cerebral performance)</td>
<td>• Mechanical chest compression group had a lower rate of functional survival</td>
</tr>
<tr>
<td>Koga, 2015&lt;sup&gt;22&lt;/sup&gt;</td>
<td>• N = 323</td>
<td>• AutoPulse automated chest compression device</td>
<td>• Manual CPR</td>
<td>• Post-resuscitation injuries</td>
<td>• AutoPulse CPR associated with higher rates of posterior rib fracture and abdominal injury</td>
</tr>
<tr>
<td>Lin, 2015&lt;sup&gt;23&lt;/sup&gt;</td>
<td>• N = 455</td>
<td>• Standard CPR followed by mechanical chest compression</td>
<td>• Standard CPR followed by manual chest compression</td>
<td>• ROSC</td>
<td>• No difference in early survival rates</td>
</tr>
<tr>
<td>Tranberg, 2015&lt;sup&gt;24&lt;/sup&gt;</td>
<td>• N = 696</td>
<td>• LUCAS-2 mechanical chest compression device</td>
<td>• Manual chest compressions</td>
<td>• Chest compression rate</td>
<td>• LUCAS-2 mechanical chest compressions reduced the no-flow fraction and provided an average compression rate more in conformity with the current Guidelines for Resuscitation</td>
</tr>
<tr>
<td>Zeiner, 2015&lt;sup&gt;25&lt;/sup&gt;</td>
<td>• N = 984</td>
<td>• Mechanical chest compressions</td>
<td>• Manual chest compressions</td>
<td>• Neurologic outcomes</td>
<td>• Mechanical chest compressions associated with worse neurologic outcomes (measured in cerebral performance category)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quality of CPR</td>
<td></td>
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</table>

**SUMMARY OF ABSTRACTS** Mechanical CPR Devices for Cardiac Arrest
# Table 2: Summary of Included Studies on the Clinical Benefits, Harms, or Cost-Effectiveness of Mechanical CPR devices for Patients with Cardiac Arrest in Pre-Hospital and Hospital Settings

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<tbody>
<tr>
<td>Smekal, 2014&lt;sup&gt;26&lt;/sup&gt;</td>
<td>• N = 222</td>
<td>• Mechanical chest compressions (with the LUCAS device)</td>
<td>• Manual chest compressions</td>
<td>• CPR-related injuries</td>
<td>• Mechanical chest compressions with the LUCAS device more likely to cause rib fractures during unsuccessful CPR • No CPR-related injuries were deemed to be fatal</td>
</tr>
<tr>
<td>Axelsson, 2013&lt;sup&gt;27&lt;/sup&gt;</td>
<td>• N = 2,401</td>
<td>• Mechanical chest compression</td>
<td>• Manual chest compressions</td>
<td>• Survival to hospital admission • 1-month survival</td>
<td>• The mechanical chest compression group had lower rates of survival • Results do not support widespread of mechanical chest compression</td>
</tr>
<tr>
<td>Omori, 2013&lt;sup&gt;28&lt;/sup&gt;</td>
<td>• N = 92</td>
<td>• AutoPulse CPR</td>
<td>• Manual CPR</td>
<td>• ROSC • Survival to hospital discharge</td>
<td>• Rates for ROSC and survival to hospital discharge were higher in the AutoPulse group • AutoPulse device might be recommended for use in patients transported by helicopter</td>
</tr>
<tr>
<td>Hock Ong, 2012&lt;sup&gt;29&lt;/sup&gt;</td>
<td>• N = 1,101</td>
<td>• Load-distributing band CPR</td>
<td>• Manual CPR</td>
<td>• Survival to hospital discharge • ROSC • Survival to hospital admission • Neurological outcome at discharge</td>
<td>• Load-distributing band CPR associated with improved neurologic outcomes and survival rate at discharge</td>
</tr>
<tr>
<td>Jennings, 2012&lt;sup&gt;30&lt;/sup&gt;</td>
<td>• N = 286</td>
<td>• Automated CPR using the AutoPulse device</td>
<td>• Conventional CPR</td>
<td>• Survival to hospital • Survival to hospital discharge</td>
<td>• Automated CPR resulted in higher rate of survival to hospital</td>
</tr>
</tbody>
</table>

Abbreviations: CPR = cardiopulmonary resuscitation; EA = economic analysis; LUCAS-2 = Lund University Cardiopulmonary Assistance System-2; MA = meta-analysis; NICE = National Institute for Health and Care Excellence; NR = not reported; NRS = non-randomized study; RCT = randomized controlled trial; ROSC = return of spontaneous circulation; SR = systematic review.
References Summarized
Health Technology Assessments


Systematic Reviews and Meta-Analyses


Randomized Controlled Trials


Non-Randomized Studies

PubMed: PM28467138

PubMed: PM28377296

PubMed: PM26795941

PubMed: PM27422305

PubMed: PM26335044

PubMed: PM25754453

PubMed: PM25898992

PubMed: PM26303569


Economic Evaluations
No literature identified.
Appendix — Further Information

Previous CADTH Reports

Non-Randomized Studies

Case Studies

Review Articles