



HTA

## HEALTH TECHNOLOGY INQUIRY SERVICE (HTIS)

### **Title: Mechanical Cardiopulmonary Resuscitation Versus Manual Cardiopulmonary Resuscitation for Cardiac Arrest in Pre-Hospital and Hospital Settings**

**Date:** 30 May 2008

#### **Context and policy issues:**

Each year, approximately 40,000 Canadians experience a cardiac arrest when breathing fails and the heart stops pumping.<sup>1</sup> It is estimated that 80% of cardiac arrests occur outside of the hospital setting with only a 5% to 10% survival rate.<sup>1,2</sup> The incidence of cardiac arrest treated by emergency medical services (EMS) ranges from 36/100,000 to 81/100,000.<sup>3</sup> Of those treated by EMS, 5% to 10% survive; of those with ventricular fibrillation, 15% survive to hospital discharge.<sup>2</sup>

Sudden cardiac arrest can be lethal unless promptly intervened with cardiopulmonary resuscitation (CPR) comprising chest compressions and rescue breaths. Canadian health care professionals refer to the American Heart Association Guidelines for CPR, recommending 100 chest compressions be given per minute with minimal interruptions to optimize blood flow to vital organs.<sup>2</sup> However, the number and depth of manual chest compressions given both out-of-hospital and in-hospital tend to decline with rescuer fatigue.<sup>2</sup> The fraction of time without chest compressions increases during transport of out-of-hospital cardiac patients.<sup>4</sup> Few cardiac arrest patients receive high-quality CPR.<sup>5</sup> Even when multiple rescuers alternate, chest compressions induce fatigue and compromise optimal CPR performance.<sup>2</sup> The Heart and Stroke Foundation of Canada suggests that an additional 4,800 lives could be saved by improving bystander CPR rates, the quality of CPR, and EMS response times.<sup>1</sup>

Mechanical chest compression devices have been developed in an effort to improve the effectiveness of CPR.<sup>6</sup> The Lund University Cardiac Assist System (LUCAS™; Jolife, Lund, Sweden), licensed as a class two device by Health Canada,<sup>7</sup> is a gas-driven device that provides automatic chest compression and active decompression.<sup>8</sup> It is a plunger-like device driven by a pneumatic cylinder attached to a back plate.<sup>8</sup> In accordance with clinical practice guidelines for CPR published by the American Heart Association and European Resuscitation

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Council, LUCAS™ is preset to deliver chest compressions to a depth of 4 cm to 5 cm at a fixed rate of 100 per minute, allowing full chest recoil between compressions.<sup>8</sup> While mechanical CPR devices hold the potential to improve efficiency and reduce rescuer fatigue, controversy exists regarding their ability to reduce mortality and improve neurological outcomes compared to manual CPR. A review of available evidence was conducted to compare the clinical and cost-effectiveness of mechanical CPR versus manual CPR for cardiac arrest in pre-hospital and hospital settings.

### Research questions:

1. What are the guidelines for use of mechanical CPR devices for cardiac arrest in pre-hospital and hospital settings?
2. What is the clinical effectiveness of mechanical CPR versus manual CPR for cardiac arrest in pre-hospital and hospital settings?
3. What is the cost effectiveness of mechanical CPR versus manual CPR for cardiac arrest in pre-hospital and hospital settings?
4. What is the ease of application of mechanical CPR devices?

### Methods:

A limited literature search was conducted on key health technology assessment (HTA) resources, including OVID Pre-Medline, MedLine and Embase, Pubmed, The Cochrane Library (Issue 2, 2008), University of York Centre for Reviews and Dissemination (CRD) databases, ECRI, EuroScan, international HTA agencies, and a focused Internet search. Results include articles published between 2003 and April 2008, and are limited to English language publications only. Filters were applied to limit the retrieval to health technology assessments, systematic reviews, meta-analysis, clinical guidelines, randomized clinical trial (RCT) studies, observational and non-randomized studies, and economic evaluations.

One reviewer (LM) independently screened citations and selected guidelines, health technology assessments (HTAs), systematic reviews, randomized controlled trials (RCTs), and non-randomized trials on mechanical CPR devices for cardiac arrest in pre-hospital and hospital settings. Studies of mixed populations and those involving devices powered by hand, electricity or battery were excluded. HTAs, systematic reviews and RCTs were included if they reported on the clinical or cost effectiveness of mechanical versus manual CPR. Only observational studies that employed mechanical CPR independent of, or following manual CPR were selected for inclusion in this report. One reviewer (LM) critically appraised the evidence.

HTIS reports are organized so that the higher quality evidence is presented first. Therefore, HTA reports, systematic reviews and meta-analyses are presented first. These are followed by economic evaluations, RCTs, observational studies and evidence-based guidelines.

**Summary of findings:**

The literature search yielded one systematic review,<sup>9</sup> a technology brief,<sup>10</sup> a prospective randomized trial,<sup>11,12</sup> a non-randomized controlled trial,<sup>13</sup> and a case series study for evaluation.<sup>14</sup> The systematic review and technology brief reported the clinical efficacy of active chest compression-decompression CPR (ACD CPR) compared to manual CPR for cardiac arrest in pre-hospital and hospital settings.<sup>9,10</sup> The observational studies reported on the clinical efficacy of mechanical CPR using LUCAS™ for out-of-hospital cardiac arrest.<sup>4,11-14</sup> Study details are provided in Appendix A.

No HTAs, meta-analyses, RCTs, or economic evaluations were identified that specifically addressed the use of mechanical CPR for cardiac arrest in pre-hospital or hospital settings. No clinical practice guidelines making recommendations regarding the use of mechanical CPR devices were identified.

*Systematic reviews*

A Cochrane systematic review evaluated the clinical effectiveness and safety of ACD CPR compared to manual CPR.<sup>9</sup> Two reviewers independently selected and extracted data from RCTs involving adults experiencing out-of-hospital or in-hospital cardiac arrest that were randomized to ACD CPR or manual CPR by a trained paramedical or medical team.<sup>9</sup> Outcomes of interest included mortality (immediate, to hospital discharge, up to 12 months); neurological impairment (Glasgow-Pittsburgh Cerebral Performance scale, follow-up to 12 months); and complications (sternal rib fracture, hemothorax or pneumothorax, or internal organ damage).<sup>9</sup> Data were analyzed on an intention-to-treat basis. Pooled relative risks (RR) were estimated and subgroup analyses were performed based on setting (out-of-hospital or in-hospital) and team composition (with physician or paramedic only).<sup>9</sup>

Of the 10 included studies, eight were in out-of-hospital settings, one set in-hospital, and one was conducted in both settings.<sup>9</sup> Allocation concealment was adequate in four trials. While two in-hospital studies differed in quality and size, no differences between ACD CPR and manual CPR were found for any outcome.<sup>9</sup> Out-of-hospital trials involving 4162 patients showed no differences between ACD CPR and manual CPR for mortality immediately (RR: 0.98; 95% CI 0.94, 1.03) or at hospital discharge (RR: 0.99; 95% CI 0.98, 1.01).<sup>9</sup> Mortality results were unchanged when trials were pooled by team (with physician or paramedic only).

Five trials involving 144 survivors contributed to neurological outcome data at hospital discharge. While not statistically significant, severe neurological damage was higher in the ACD CPR group compared to manual CPR recipients (RR: 3.11; 95% CI 0.98, 9.83).<sup>9</sup> This trend was apparent in trials with paramedics only (RR: 2.19; 95% CI 0.93, 5.13) and not apparent when a physician directed the team (RR: 1.14; 95% CI 0.59, 2.21).<sup>9</sup> The pooled relative risk of any neurological impairment was 1.71 (95% CI 0.90, 3.25) and there was no difference between groups regarding moderate neurological damage (RR: 0.98; 95% CI 0.34, 2.79).<sup>9</sup> No studies reported long term neurological outcomes. Six studies involving 3052 patients suggest complications were comparable between groups (RR: 1.09; 95% CI 0.86, 1.38); however, skin trauma was more frequent with ACD CPR.<sup>9</sup>

The reviewers concluded that among patients with cardiac arrest occurring in different settings and different teams, there is no clear evidence of benefit from the use of ACD CPR compared to manual CPR. A non-significant trend in the rate of severe neurological impairment was observed in ACD CPR recipients treated by paramedics alone. This finding is limited by small

sample size, unblinded assessors, lack of long-term follow-up, and imprecise measurement using the Glasgow Cerebral Performance Scale. Complications were similar between groups, with the exception of more frequent skin trauma in ACD CPR recipients. The authors noted that ACD CPR may not have a place in routine clinical practice, or may be used only by trained professionals in a controlled clinical trial. Future changes in device design may improve adherence to the chest wall. Future studies would benefit from longer-term follow-up of neurological outcomes and further study of the hemodynamic variables that contribute most to survival.<sup>9</sup>

### *Technology briefs*

A Best Evidence Topics (BETs) technology brief was conducted by the National Health Services Trust to compare the effectiveness of mechanical CPR to manual CPR.<sup>10</sup> A Best BETs technology brief is not as rigorous as an HTA but provides a critical appraisal of evidence by two reviewers. Literature was identified by searching electronic databases using keywords. Two reviewers screened results for studies involving out-of-hospital and in-hospital cardiac arrest patients receiving mechanical CPR versus manual CPR. Reviewers noted outcomes, key results and study weaknesses.<sup>10</sup>

The literature search yielded 429 articles, nine of which were relevant for analysis. Of the nine articles, three involved the LUCAS™ device, five involved the electrically powered AutoPulse, and one involved the older Thumper device.<sup>10</sup> In a case series by Larsen et al. 2007, (the patient population was a mix of cardiac arrests, hypertension and bradycardia), only three patients survived, and none were discharged from hospital.<sup>10</sup> Reviewers noted that in a prospective, multicentre, cluster-randomized trial by Axelsson *et al.* 2006, the LUCAS™ device was used in only 66% of cases randomized to the mechanical group.<sup>10</sup> Results of a case series by Steen et al. 2005 were limited by having no comparison group.<sup>10</sup> These studies are further discussed in the observational study section below.

Reviewers concluded that there is no evidence to support the routine use of mechanical CPR devices for patients suffering out-of-hospital cardiac arrest. No trials have attempted to compensate for any temporary improvement in behavior caused by observing worker performance (performance bias).<sup>10</sup>

### *Observational studies*

Early survival and injuries were reported, in abstract form, from a prospective pilot study.<sup>11,12</sup> As this trial has not yet been published, methods for randomization and determination of control participants cannot be verified. One hundred and forty-nine pre-hospital cardiac arrest patients were randomized to LUCAS™ CPR or manual CPR and the protocol was fulfilled with 138 patients, with 69 patients in each group. The mean time from alarm to start of CPR was 8.4 minutes in the LUCAS™ group versus 7.5 minutes in the manual group ( $p=0.29$ ).<sup>11</sup> It took an average of 2 minutes to apply the LUCAS™ device. Non significant differences were reported for restoration of spontaneous pulse (30 versus 22 patients;  $p=0.22$ ), arrival at hospital alive (18 versus 15 patients;  $p=0.69$ ), and number of patients discharged alive (6 versus 7;  $p$  value not reported) in the LUCAS™ and manual groups, respectively. In a subgroup of patients with witnessed cardiac arrest and immediate CPR, restoration of spontaneous pulse was achieved in 19 versus 13 patients ( $p=0.06$ ), arrival at hospital alive was reported in 14 versus 7 patients, and 5 versus 4 patients were discharged alive in the LUCAS™ and manual groups, respectively.<sup>11</sup> Of the 85 patients who underwent autopsy, 47 and 38 patients underwent manual CPR and LUCAS™ CPR, respectively. Sternal fracture and multiple costal fractures

were present in 10/47 versus 11/38 ( $p=0.46$ ) and in 13/47 versus 16/38 ( $p=0.18$ ) of the manual and LUCAS™ groups, respectively.<sup>12</sup> Bleeding in the ventral mediastinum (2/47 versus 3/38;  $p=0.65$ ), retrosternal bleeding (1/47 versus 3/38;  $p=0.32$ ), epicardial bleeding (1/47 versus 4/38;  $p=0.17$ ), and hemopericardial bleeding (4/47 versus 3/38;  $p=1.0$ ) were observed in the manual CPR and LUCAS™ groups, respectively.<sup>12</sup> Although differences in clinical outcomes and mortality were not significant, the authors concluded mechanical CPR may improve early survival without increasing injury compared to manual CPR.<sup>11,12</sup>

A non-randomized, controlled trial was conducted in two trained Swedish EMS systems to evaluate the outcome of out-of-hospital cardiac arrest patients after mechanical CPR compared to manual CPR.<sup>13</sup> The LUCAS™ device was exchanged between four advanced life support units within six months using a cluster method to create a control group.<sup>13</sup> Patients with witnessed out-of-hospital cardiac arrest were enrolled. Those under the age of 18 years, with trauma, pregnancy, hypothermia, intoxication, hanging, drowning, or terminal illness were excluded. A total of 328 patients were evaluated, 159 versus 169 for mechanical CPR and manual groups, respectively.<sup>13</sup> Patients had a mean age of 71 years, one third were female, and 50% had a history of coronary artery disease. The median delay between cardiac arrest and the start of mechanical CPR was 18 minutes.<sup>13</sup> The device was only used in 66% (105/159) patients allocated to the mechanical CPR group. The most common reasons for not using the device in 34% of cases were that the dispatchers interpreted the case as something other than a cardiac arrest and that there was no time to use the device as patients had a short delay from the time of arrival until return of spontaneous circulation. Return of spontaneous circulation and live hospital admissions occurred in 51% versus 51% and in 38% versus 37% of LUCAS™ and manual CPR groups, respectively.<sup>13</sup> In the subset of patients in whom the device was used return of spontaneous circulation occurred in 49% versus 50% of LUCAS™ and manual CPR recipients, respectively.<sup>13</sup> The percentage of patients discharged alive was 8% versus 10% for all patients, and 2% versus 4%, respectively for the subset where the device was used.<sup>13</sup> Authors concluded that the results do not support the hypothesis that mechanical CPR improves outcomes for those experiencing out-of-hospital cardiac arrest.<sup>13</sup>

Return of spontaneous circulation was evaluated in 100 consecutive out-of-hospital cardiac arrest patients receiving LUCAS™ CPR in Sweden.<sup>14</sup> Of the 71 patients with witnessed cardiac arrest, 39% received bystander CPR. In 28 patients where LUCAS™ CPR was initiated more than 15 minutes after the ambulance alarm and in 29 unwitnessed cases, there were no surviving patients at 30 days.<sup>14</sup> Of the 43 witnessed cases treated with LUCAS™ CPR within 15 minutes, 24 had ventricular fibrillation and 15 (63%) achieved return of spontaneous circulation.<sup>14</sup> Six patients (25%) survived with good neurological recovery after 30 days, 5 of 19 (26%) with asystole achieved return of spontaneous circulation, and 1 (5%) survived over 30 days.<sup>14</sup> Authors concluded that patients with witnessed cardiac arrest that received LUCAS™ CPR within 15 minutes had a 30 day survival of 25% in ventricular fibrillation and 5% in asystole, but if the interval was more than 15 minutes, there were no 30 day survivors.<sup>14</sup>

### *Guidelines*

No clinical practice guidelines were identified that specifically address the use of mechanical CPR for cardiac arrest in pre-hospital or hospital settings. Guidelines by the American Heart Association state that higher frequency CPR (up to 140 compressions per minute) using mechanical CPR showed no improvement in hemodynamics compared with 60 compressions per minute.<sup>2</sup>

## Assessment of quality:

### *Systematic reviews and technology briefs*

The Oxman and Guyatt index of scientific quality of research reviews was used to guide the quality assessment of the systematic review. The Cochrane review (2004) concluded that among patients with cardiac arrest occurring in different settings, there is no evidence of benefit from the use of ACD CPR compared to manual CPR and more severe neurological impairment was observed in ACD CPR recipients treated by paramedics alone. Neurological findings are limited by small sample size, unblinded assessors, lack of long-term follow-up, and imprecise measurement using the Glasgow Cerebral Performance Scale. The literature search used to identify the evidence may not have considered grey literature. Lack of grey literature searching may lead to an overestimate of effect. Two reviewers independently selected studies, extracted data, and assessed quality based on pre-specified selection criteria, extraction, and quality measures. Results were pooled and analyzed appropriately. The evidence cited supports the conclusions by the systematic reviewers.

The Best BETs technology brief concluded that there is no evidence to support the routine use of mechanical CPR devices for patients suffering out-of-hospital cardiac arrest. No trials have attempted to compensate for temporary improvements in behavior caused by observation. An overestimate in effect may occur due to lack of grey literature searching. It is also unclear whether there language restrictions were imposed in the searching or selection of studies. Details of the selection and data extraction process, and criteria for assessing the validity of studies was not explicitly reported in the methods. Conclusions by the reviewers are supported by cited evidence.

### *Observational studies*

The authors of a prospective pilot study involving 149 pre-hospital cardiac patients concluded that mechanical CPR may improve early survival without increasing injury compared to manual CPR.<sup>11,12</sup> As the results are reported in abstract form, little information is provided regarding methods and the study population may not be generalizable to a Canadian setting. Insufficient information is reported to determine the potential for selection bias. Detection bias and uncertainty exist regarding the validity of injury evaluation only in patients who underwent autopsy. The body may undergo various processes after death that could limit the relevance of these results in living patients. There is also the potential for performance bias in that workers were aware that CPR efforts were being observed and may have temporarily modified their behavior. Outcome evaluation would benefit from a consistent approach with all subjects and longer period of follow-up.

Authors of the non-randomized, controlled study concluded that the results do not support the hypothesis that mechanical CPR improves outcomes for those with out-of-hospital cardiac arrest.<sup>13</sup> These findings are limited in that only 66% of patients allocated to mechanical CPR received CPR using the device. There is also potential selection and performance bias. The study may not be generalizable, as few out-of-hospital cardiac arrests are witnessed and findings may not be generalizable to a Canadian setting. Longer-term outcomes through a well designed, multicentre, randomized controlled trial would be more informative.<sup>13</sup>

A case series concluded that patients with witnessed cardiac arrest that received LUCAS™ CPR within 15 minutes had a 30 day survival of 25% in ventricular fibrillation and 5% in asystole, but if the interval was more than 15 minutes, there were no 30 day survivors.<sup>14</sup> These

findings are limited in that fewer out-of-hospital cardiac arrests are witnessed and it may be difficult to ensure LUCAS™ CPR is administered within the 15 minute interval required for optimal results. The study does report longer-term outcomes compared to the other observational studies reviewed but it is limited as there is no comparison to manual CPR.

### **Conclusions and implications for decision or policy making:**

The Cochrane review (2004) of ten RCTs concluded that among patients with cardiac arrest occurring in different settings, there is no evidence of benefit from the use of ACD CPR compared to manual CPR and more severe neurological impairment may occur in ACD CPR recipients treated by paramedics alone. Neurological findings are limited by small sample size, unblinded assessors, lack of long-term follow-up, and imprecise measurement using the Glasgow Cerebral Performance Scale. Systematic reviewers recommended that ACD CPR may not have a place in routine clinical practice, or may be used only by trained professionals in a controlled clinical trial. Changes in device design may improve adherence to the chest wall. Future studies would benefit from longer-term follow-up of neurological outcomes and further study of the hemodynamic variables that contribute most to survival.<sup>9</sup> A recent Best BETs technology brief concurred with the results of the Cochrane review. There is no evidence to support the routine use of mechanical CPR devices for patients suffering out-of-hospital cardiac arrest and no trials have attempted to compensate for temporary improvements in behavior as a result of observation.<sup>10</sup> Authors of a prospective pilot study concluded that mechanical CPR may improve early survival without increasing injury compared to manual CPR but no significant differences were observed for clinical outcomes including mortality or complications.<sup>11,12</sup> Potential selection, performance and detection bias, coupled with lack of long term outcomes and injury data in all subjects limit the relevance of these findings. A non-randomized controlled trial suggested that mechanical CPR does not improve outcomes for out-of-hospital cardiac arrest patients compared to manual CPR.<sup>13</sup> Authors of a case series concluded that patients with witnessed cardiac arrest that received LUCAS™ CPR within 15 minutes had a 30 day survival of 25% in ventricular fibrillation and 5% in asystole, but if the interval was more than 15 minutes, there were no 30 day survivors.<sup>14</sup> There is an absence of information as to the ease of use of manual CPR devices in pre- and post-hospital settings. As a reflection of the paucity of good quality trials comparing mechanical CPR with manual CPR, no clinical practice guidelines endorse its use. There is currently no evidence for the cost effectiveness of mechanical CPR in comparison with manual CPR to guide purchasing decisions. Overall, one systematic review, a technology brief and three observational studies concur in concluding that there is no evidence of benefit from the use of mechanical CPR compared to manual CPR for cardiac arrest in different settings at this time.

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Appendix A: Clinical Efficacy of ACD CPR versus Manual CPR

Source	Objective	Inclusion and Exclusion Criteria	Results	Authors Conclusions and Limitations
<b>Systematic Reviews on ACD versus Manual CPR for Cardiac Arrest</b>				
<b>Cochrane 2004<sup>9</sup></b>	Assess the clinical effectiveness and safety of ACD CPR compared to manual CPR.	Population: pre-hospital or in-hospital cardiac arrest Intervention: ACD CPR Comparator: manual CPR Outcomes: mortality (immediate, to hospital discharge, up to 12 months); neurological impairment (Glasgow-Pittsburgh Cerebral Performance scale, follow-up to 12 months); and complications (sternal rib fracture, hemothorax or pneumothorax, internal organ damage). <sup>9</sup>	N=10 RCTs; 8 out-of-hospital, 1 in-hospital, 1 in both settings.  Two in-hospital studies showed no differences between ACD and manual CPR for any outcome. <sup>9</sup> Out-of-hospital showed no differences between ACD and manual CPR for mortality (RR: 0.98; 95% CI 0.94,1.03) immediately RR: 0.99; 95% CI 0.98,1.01 hospital). <sup>9</sup>  Five trials of 144 survivors showed severe neurological damage at discharge was higher with ACD compared to manual CPR (RR: 3.11; 95% CI 0.98, 9.83). <sup>9</sup> Apparent in trials with paramedics only (RR: 2.19; 95% CI 0.93, 5.13); not apparent with physicians (RR: 1.14; 95% CI 0.59, 2.21). <sup>9</sup> RR of any neurological impairment was 1.71 (95% CI 0.90, 3.25); no difference between groups regarding moderate neurological damage (RR: 0.98; 95% CI 0.34, 2.79)]. <sup>9</sup> Six studies of 3052 patients suggest comparable complications (RR: 1.09; 95% CI 0.86,1.38); however, skin trauma was more frequent with ACD CPR. <sup>9</sup>	Reviewers concluded there is no evidence of benefit from ACD compared to manual CPR; more severe neurological impairment occurs in paramedic treated patients. ACD CPR may not have a place in routine clinical practice, or may be used only by trained professionals in a CCTs. <sup>9</sup>  No studies reported long term neurological outcomes; small sample size, unblinded assessors, lack of long-term follow-up, allocation concealment in 4/10 studies, and imprecise measurement using the Glasgow Cerebral Performance Scale also limit these findings.  Evidence may have been missed as grey literature (not published in peer reviewed databases) was not searched. Potential overestimate of effect.

Source	Objective	Inclusion and Exclusion Criteria	Results	Authors Conclusions and Limitations
<b>Technology Briefs on ACP versus Manual CPR</b>				
<b>Best BETS, NHS Trust, United Kingdom 2008<sup>10</sup></b>	Assess mechanical versus manual CPR for cardiac arrest in pre-hospital and out-of-hospital settings.	Two reviewers screened results for studies involving out-of-hospital and in-hospital cardiac arrest patients receiving mechanical versus manual CPR. Reviewers noted outcomes, results and study weaknesses. <sup>10</sup>	3/9 studies assessed involved LUCAS™ <sup>10</sup> Only 3 patients survived in a case series by Larsen, 20007; none were discharged. <sup>10</sup> Reviewers noted that LUCAS™ was used in only 66% of cases randomized to the mechanical group of a cluster-randomized trial by Axelsson et al. 2006. <sup>10</sup> A case series by Steen et al. 2005 was limited by having no comparison group. <sup>10</sup>	<p>Reviewers concluded there is no evidence to support routine mechanical CPR devices for pre-hospital cardiac arrest. No trials have attempted to compensate for any temporary improvement in behavior caused by observing worker performance (performance bias).</p> <p>An overestimate of effect may occur due to lack of grey literature searching.</p> <p>It is also unclear whether language restrictions were imposed in the searching or selection of studies.</p> <p>Details of the selection and data extraction process, and criteria for assessing the validity of studies was not explicitly reported in the methods.</p>

Author, Year, Country	Study Design	Participants	Intervention Comparator Outcomes	Results	Conclusions and Limitations
<b>Observational Studies comparing LUCAS™ versus manual CPR</b>					
Rubertsson et al. 2007 Sweden <sup>11, 12</sup>	Prospective Randomized Pilot study	Pre-hospital cardiac arrest	<p>N= 138 n=69 LUCAS™ n=69 manual</p> <p>Outcomes Restoration of spontaneous pulse Arrival to hospital alive Discharged alive Sternum fracture Multiple costal fracture Bleeding</p>	<p>Restoration of spontaneous pulse (ROSC) was achieved in 30 versus 22 patients (p=0.22), arrival at hospital alive 18 versus 15 (p=0.69), and discharged alive 6 versus 7 in the LUCAS™ and manual groups, respectively. In patients with immediate CPR, ROSC was achieved in 19 versus 13 patients (p=0.06), arrival at hospital alive 14 versus 7, and discharged alive in 5 versus 4 patients in the LUCAS™ and manual groups, respectively.<sup>11</sup></p> <p>Of the 85 patients autopsied 47 and 38 patients underwent manual and LUCAS™ CPR, respectively. Sternal fracture and multiple costal fractures were present in 10/47 versus 11/38 (p=0.46) and in 13/47 versus 16/38 (p=0.18) in the manual and LUCAS™ groups, respectively.<sup>12</sup> Bleeding in the ventral mediastinum 2/47 versus 3/38 (p=0.65), retrosternal bleeding 1/47 versus 3/38 (p=0.32), epicardial 1/47 versus 4/38 (p=0.17) and hemopericardial bleeding, 4/47 versus 3/38 (p=1.0) was found in the manual and LUCAS™ groups, respectively.<sup>12</sup></p>	<p>Authors concluded mechanical CPR may improve early survival without increasing injury compared to manual CPR.<sup>11,12</sup></p> <p>Little information is provided regarding methods; full text publications may differ from abstract results.</p> <p>Potential selection bias. Detection bias and uncertainty exist regarding the validity of injury evaluation only in autopsied patients; generalizability and relevance limited.</p> <p>Potential for performance bias as workers may have modified efforts during observation.</p> <p>Outcome evaluation would benefit from a consistent approach with all subjects and longer follow-up.</p>

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<p><b>Axelsson et al. 2006 Sweden<sup>13</sup></b></p>	<p>Non-randomized Controlled</p>	<p>Witnessed pre-hospital cardiac arrest; excluded age &lt;18 years. N=397 n=159 LUCAS™ n=169 manual</p> <p>Patients had a mean age of 71 years, one third were female, and 50% had a history of coronary artery disease.</p>	<p>LUCAS™ CPR versus manual CPR</p> <p>Return of spontaneous circulation (ROSC) Hospital admission alive</p>	<p>ROSC and live hospital admissions occurred in 51% versus 51% and in 38% versus 37% of LUCAS™ and manual CPR groups, respectively.<sup>13</sup> In the subset of patients in whom the device was used ROSC occurred in 49% versus 50% of LUCAS™ and manual CPR recipients, respectively.<sup>13</sup> The percentage of patients discharged alive was 8% versus 10% for all patients, and 2% versus 4%, respectively for the subset where the device was used.<sup>13</sup></p>	<p>Authors concluded that the results do not support the hypothesis that mechanical CPR improves outcomes for those with out-of-hospital cardiac arrest.<sup>13</sup></p> <p>Only 66% of those allocated to mechanical CPR received the device.</p> <p>There is potential for selection and performance bias.</p> <p>Longer follow-up is needed.</p> <p>Few pre-hospital cardiac arrests are witnessed.</p> <p>May not be generalizable to Canadian setting.</p>

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<b>Steen et al. 2005 Sweden<sup>14</sup></b>	Case series	100 consecutive out-of-hospital cardiac arrests  Only witnessed cardiac arrests were included (n=71)	LUCAS™ CPR n=71	In 28 patients where LUCAS™ CPR was initiated more than 15 minutes after the ambulance alarm and in 29 unwitnessed cases, no patients survived for 30 days. <sup>14</sup> Of the 43 witnessed cases treated with LUCAS™ CPR within 15 minutes, 24 had ventricular fibrillation and 15 (63%) achieved ROSC. <sup>14</sup> Six patients (25%) survived with good neurological recovery after 30 days, 5 of 19 (26%) with asystole achieved ROSC, and 1 (5%) survived over 30 days. <sup>14</sup>	Authors concluded that patients with witnessed cardiac arrest that received LUCAS™ within 15 minutes had a 30 day survival of 25% in ventricular fibrillation and 5% in asystole, but if the interval was more than 15 minutes, there were no 30 day survivors. <sup>14</sup>  Fewer out-of-hospital cardiac arrests are witnessed and it may be difficult to achieve LUCAS™ CPR within the optimal 15 minute interval for best outcomes.  While longer-term outcomes are reported, results are limited as there is no comparison group.  May not be generalizeable to Canadian setting.