Clinical question.
In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of mechanical compression full (eg. Lucas) or partial decompression (eg. US version) (I) compared with manual CPR (C), improve any outcomes (eg. ROSC, survival) (O)? ALS/BLS-CPR&A-085A

Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention/therapy

State if this is a proposed new topic or revision of existing worksheet: Revision (Mechanical (Piston) CPRW77A,W77B,W163B,W163E), Lund University Cardiac Arrest System CPRW77B,W163D)

Conflict of interest specific to this question
Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? No

Search strategy (including electronic databases searched).
PubMed (10 Nov 09):
#1 = LUCAS[All Fields] 10666
#2 = mechanical[All Fields] 188550
#3 = automat* 127066
#4 = "cardiopulmonary resuscitation"[MeSH Terms] OR ("cardiopulmonary"[All Fields] AND "resuscitation"[All Fields]) OR "cardiopulmonary resuscitation"[All Fields] 11703
#5 = "heart arrest"[MeSH Terms] OR ("heart"[All Fields] AND "arrest"[All Fields]) OR "heart arrest"[All Fields] 37023
#6 = compar* 3365783
#7 = "load distributing band"[All Fields] or "LDB"[All Fields] or “load-distributing”[All Fields] or “autopulse”[All Fields] 129
(#1 or #2 or #3) AND (#4 or #5) AND #6 NOT #7 No Limits: 122 hits

References of all articles searched for other relevant articles.

State inclusion and exclusion criteria
Include: human studies, peer-reviewed publications
Exclude: case reports (including < 5 patients), animal studies, abstract only, manual compression-decompression CPR (ACD-CPR or Lifestick), vest CPR or autopulse (load distributing band).

Number of articles/sources meeting criteria for further review:
12: 1 LOE 1, 5 LOE 2, and 6 LOE 4
Mechanical: 4: 1 LOE 1, 3 LOE 2
LUCAS: 8: 2 LOE 2, 6 LOE 4
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Evidence Supporting Clinical Question</th>
</tr>
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<tbody>
<tr>
<td>Fair</td>
<td>[Ward, 1993, 669-74]E1</td>
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<tr>
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<th>2</th>
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<th>5</th>
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</table>

**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E1 = ETCO2  
* = LUCAS  
*italics* = own controls
## Evidence Neutral to Clinical question

<table>
<thead>
<tr>
<th>Good</th>
<th>[Axelsson, 2006, 47-55]ABC*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>[Smekal, 2009, 1104-7]PM</td>
</tr>
<tr>
<td>[Larsen, 2007, 454-9]BC*</td>
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</tr>
</tbody>
</table>

**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
* = LUCAS  
D = Intact neurological survival  
E = Other endpoint  
Italics = own controls

## Evidence Opposing Clinical Question

<table>
<thead>
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<tr>
<td>Fair</td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>[Cohen, 1992, 2916-23]E2</td>
</tr>
</tbody>
</table>
| [Deakin, 2007, 53-9]CDE*  

**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E2 = haemodynamics  
Italics = own controls  
* = LUCAS
REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

**C2005:**
Mechanical (Piston) CPRW77A,W77B,W163B,W163E
Consensus on Science
One prospective randomized study and 2 prospective randomized crossover studies in adults (LOE 2) indicated improvement in end-tidal CO2 and mean arterial pressure when automatic mechanical (piston) CPR was undertaken by medical and paramedical personnel in the hospital or prehospital setting. In several studies in animals (LOE 6), mechanical (piston) CPR improved end-tidal CO2, cardiac output, cerebral blood flow, mean arterial pressure, and short-term neurologic outcome.

Lund University Cardiac Arrest System CPRW77B,W163D
Consensus on Science
The Lund University Cardiac Arrest System (LUCAS) is a gas-driven sternal compression device that incorporates a suction cup for active decompression. There were no published randomized human studies comparing LUCAS-CPR with standard CPR. A single study of pigs with VF showed that LUCAS-CPR improved hemodynamic and short-term survival rates compared with standard CPR (LOE 6). The LUCAS was also used in 20 patients, but incomplete outcome data was reported (LOE 6).

Treatment Recommendation
In the hands of some groups, novel techniques and adjuncts may be better than standard CPR. The success of any technique depends on the education and training of the rescuers or the resources available (including personnel). Because information about these techniques and devices is often limited, conflicting, or supportive only for short-term outcomes, no recommendations can be made to support or refute their routine use.

Since the C2005 document, a number of additional relevant articles have been published regarding use of the LUCAS in human cardiac arrests. There have been no further studies evaluating mechanical CPR.

**Mechanical CPR**
One randomized trial ([Taylor, 1978, 644-6]; LOE 1. Neutral. Fair) reported 50 patients with OOHCA, within 10 minutes of arrest, randomised to manual or mechanical CPR. Similar survival to discharge (3 mechanical, vs 2 manual) and ROSC for 1 hour (10 vs 10).

3 studies used patients as their own controls (LOE 2) and compared mechanical CPR with manual CPR.
- Cohen 1992 ([Cohen, 1992, 2916-23]) was an opposing poor quality study in a subset of study for ACDCPR. Manual CPR and Mechanical CPR compared with ACD CPR. 5 patients in cardiac arrest compared mechanical CPR (thumper) with manual CPR and ACD CPR. Mechanical Thumper CPR “consistently underperformed” both standard and ACD CPR.
- Ward 1993 ([Ward, 1993, 669-74]) was a supportive fair quality study involving 15 nontraumatic cardiac arrests in ED used as own controls (random order of manual or mechanical). ETCO2 (mech) 13.6 ±4.1 vs 6.9 ±2.4 (P<0.001). No survivors.
- Dickinson 1998 ([Dickinson, 1998, 289-92]) was a supportive poor quality small study in OOHCA. 14 patients in arrest after intubation pseudorandomised to mechanical or manual CPR. “Statistically higher” ETCO2 in mechanical group.

**LUCAS**
One study using prospective non-randomised controls ([Axelsson, 2006, 47-55]), in witnessed OHCA of presumed cardiac aetiology enrolled 328 patients in Göteborg and Södertalje, Sweden over 2 years (22 May 2003—25 May 2005). The median delay from cardiac arrest to the arrival of the ALS unit was 12 min. The median delay between cardiac arrest until the start of mechanical chest compression was 18 min (i.e. a delay between the arrival of ALS and the start of mechanical chest compression of 6 min). For patients allocated to the mechanical chest compression group (n = 159), the device was actually used in only 105 cases (66%). No difference in ROSC, survival to hospital admission or discharge in both intention to treat and actually received groups (matched controls). In LUCAS group, 51% had ROSC (primary end-point) versus 51% in the controls. The corresponding values for hospital admission alive (secondary end-point) were 38% and 37% (NS).

One post-mortem study (using concurrent controls: LOE 2, poor, neutral: [Smekal, 2009, 1104-7]) demonstrated a similar incidence and severity of injuries detected at post-mortem with LUCAS (38 patients), and controls (47 patients).
There are six published case series in the literature which individually report > 5 patients.
- Steen 2002 ([Steen, 2002, 285-99]) was a poor quality case series of 20 cases (after failure of standard CPR). One reported to survive.
- Steen 2005 ([Steen, 2005, 25-30]) was a good quality case series of 100 cases in OOHCA. Overall ROSC 31% and 30 day survival 7%. Of the 43 witnessed cases treated with LUCAS within 15 min, 24 had VF and 15 (63%) of these cases achieved a stable return of spontaneous circulation (ROSC) and 6 (25%) of them survived with a good neurological recovery after 30 days; 5 (26%) of the 19 patients with asystole achieved ROSC and 1 (5%) survived for over 30 days.
- Larsen 2007 ([Larsen, 2007, 454-9]) was a poor case series of 13 cases. Possibly not in arrest at the time of application of the device. All received angiography. 3/13 survived event. None discharged alive.
- Bonnemeier ([Bonnemeier, 2009, e39-50]) was a good case series of 5 survivors of PEA for in-hospital cardiac arrest using LUCAS.
- Wagner ([Wagner, 2009, Epub]) was a good case series of use of LUCAS in 43 patients during PCI for STEMI. 19 had IABP use as well. 21/43 died in cath lab (5 with myocardial rupture). 12/43 discharged from hospital. 11/43 good neurological outcome (CPC = 1). Useful ability to pause CPR during stenting.

**Acknowledgements:**

**Citation List**


LOE 2. Good. Neutral: ROSC, survival to hospital, survival to discharge. Compared with pre-2005 guidelines. Descriptive, non-randomised, controlled trial in Goteborg and Sodertalje, Sweden, 2 years (22 May 2003—25 May 2005) in Goteborg/Molndal and 1 year (1 September 2003—31 August 2004) in Sodertalje, LUCAS was exchanged between the four Advanced Life Support (ALS) units for approximate 6-month periods. Inclusion: witnessed OHCA of presumed cardiac aetiology were enrolled. Exclusion criteria were age <18 years, with trauma, pregnancy, hypothermia, intoxication, hanging and drowning, as the judged aetiologies of OHCA, Return Of Spontaneous Circulation (ROSC) before the arrival of the second tier and other reasons, such as terminal illness. The median delay from cardiac arrest to the arrival of the ALS unit was 12 min. The median delay between cardiac arrest until the start of mechanical chest compression was 18 min (i.e. a delay between the arrival of ALS and the start of mechanical chest compression of 6 min). For patients allocated to the mechanical chest compression group (n = 159), the device was actually used in only 105 cases (66%). No difference in ROSC, survival to hospital admission or discharge in both intention to treat and actually received groups (matched controls). In LUCAS group, 51% had ROSC (primary end-point) versus 51% in the controls. The corresponding values for hospital admission alive (secondary end-point) were 38% and 37% (NS).


LOE 2. Oppose. Poor quality.
Subset of study for ACDCPR. Manual CPR and Mechanical CPR compared with ACD CPR. 5 patients in cardiac arrest compared mechanical CPR (thumper) with manual CPR and ACD CPR. Mechanical Thumper CPR consistently underperformed both standard and ACD CPR.


Active compressions disabled. No patients survived (of 17).


LOE 2. Supportive Poor
Small study in OOHCA. 14 patients in arrest after intubation pseudorandomised to mechanical or manual CPR. Statistically higher ETCO2 in mechanical group.


LOE 2. Poor. Neutral. Concurrent controls (but only in patients who had died). No difference apparent in severity or incidence of injuries detected at post-mortem. Sternal fracture was present in 10/47 in the manual group and 11/38 in the LUCAS group (p=0.46), and there were multiple rib fractures (> or =3 fractures) in 13/47 in the manual group and in 17/38 in the LUCAS group (p=0.12). Similar incidence of bleeding in the chest cavity.


LOE 4. Good. Supportive. Case series of 100 patients. Of the 43 witnessed cases treated with LUCAS within 15 min, 24 had VF and 15 (63%) of these cases achieved a stable return of spontaneous circulation (ROSC) and 6 (25%) of them survived with a good neurological recovery after 30 days; 5 (26%) of the 19 patients with asystole achieved ROSC and 1 (5%) survived for over 30 days.


LOE 1. Neutral. Fair.
50 patients with OOHCA, within 10 minutes of arrest, randomised to manual or mechanical CPR. Similar survival to discharge (3 mechanical, vs 2 manual) and ROSC for 1 hour (10 vs 10).


LOE 4. Good, Supportive
Series of use of LUCAS in 43 patients during PCI for STEMI. 19 had IABP use as well. 21/43 died in cath lab (5 with myocardial rupture). 12/43 discharged from hospital. 11/43 good neurological outcome (CPC = 1). Useful ability to pause CPR during stenting.

LOE 2, Fair, Supportive (ETCO2)
15 nontraumatic cardiac arrests in ED used as own controls (random order of manual or mechanical). ETCO2 13.6 ± 4.1 vs 6.9 ± 2.4 (P<0.001). No survivors.
**Excluded studies**


Excluded. No autopulse outcomes published.
During 22/5/2003—25/5/2005, the Goteborg/Molndal emergency medical system (EMS) took part in a pilot study together with the Sodertalje EMS. The aim was to evaluate mechanical chest compressions made by the LUCAS device versus chest compressions made by the ambulance crew in witnessed OHCA.
The device was exchanged between four ALS-units for approximately 6-month periods and authors used a cluster method to create a control group. This report analysed only patients treated in Goteborg/Molndal. Inclusion: witnessed, non-traumatic out-of-hospital cardiac arrest, by either a bystander or the rescue team. The exclusion criteria were trauma, intoxication, the return of spontaneous circulation (ROSC) before the arrival of the ALS, hypothermia and pregnancy.
Focused on included vs excluded patients.


Excluded. Review only.


Excluded. Manikin study.

Excluded. Letter reporting harm detected at Post-Mortem after use of LUCAS.


Excluded. Assessed for fire hazard. No patients.


Excluded. Single case report.


Excluded. Animal study.


Excluded. Animal study.


Excluded. Case report of successful use of LUCAS on single pregnant patient with anaphylaxis.


Excluded. Case report of successful use of LUCAS for severe hypothermia.

Excluded. Case series of 3 patients having CT during resuscitation with LUCAS device.