Mechanical devices during CPR

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Deputy Chair Australian Resuscitation Council (ARC)
Chair ALS Committee ARC
ARC rep on International Liaison Committee on Resuscitation (ILCOR)
Evidence Evaluation Expert (AHA/ILCOR)
Other techniques & devices to perform CPR (ANZCOR)

- Several techniques or adjuncts to standard CPR have been investigated and the relevant data was reviewed extensively as part of the Consensus on Science process.
- The success of any technique depends on the education and training of the rescuers or the resources available (including personnel).
- Techniques reviewed include: Open-chest CPR, Interposed Abdominal Compression CPR, Active Compression-Decompression CPR, Open Chest CPR, Load Distributing Band CPR, Mechanical (Piston) CPR, Lund University Cardiac Arrest System CPR, Impedance Threshold Device, and Extracorporeal Techniques.
Other techniques & devices to perform CPR (ANZCQR)

- 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.

- While no circulatory adjunct is currently recommended instead of manual CPR for routine use, some circulatory adjuncts are being routinely used in both out-of-hospital and in-hospital resuscitation. If a circulatory adjunct is used, rescuers should be well-trained and a program of continuous surveillance should be in place to ensure that use of the adjunct does not adversely affect survival. [Class B; LOE IV]
Barrel method

Resuscitation of the Arrested Heart. Weil & Tang 1999
Trotting horse

Figure 1–10. Trotting horse method of chest compression.

Resuscitation of the Arrested Heart. Weil & Tang 1999
A NEW EVALUATION OF EMERGENCY METHODS FOR ARTIFICIAL VENTILATION

By

HANS NOLTE

Devices

• Quality of CPR
  – Consistency
  – Transport
  – Difficult geography
  – Interruptions

• Commercial
ACLs: adjuncts to circulation

Use of Adjunctive Devices in Cardiopulmonary Resuscitation

Panel Members:
Karl B. Kern, MD
Peter T. Morley, MD
Charles F. Babbs, MD, PhD
Henry R. Halperin, MD
Francisco J. de Latorre, MD
Keith G. Lurie, MD
Joseph P. Ornato, MD
Edison F. de Paiva, MD
Norman A. Paradis, MD


INTRODUCTION

During the past few decades, a number of different techniques and devices have been introduced to improve the performance of and outcomes associated with cardiopulmonary resuscitation (CPR). Many of these techniques and devices were developed and fine tuned in numerous animal studies.
Mechanical CPR
QUALITY OF CHEST COMPRESSION
Improved survival with better CPR

• 662 Patients - “Correct CPR” improved survival (OR = 3.9; 95% CI 1.1 - 14.0; P<0.04)

• 885 Patients - Survival with “Correct CPR” 16% vs 4% with incorrect CPR (p < 0.05)
  – Hoeyweghen, Resuscitation, 1993, 26:47-52

(Correct CPR 1.5 - 2 inches chest displacement)
Mechanical (Piston) CPR Outcomes

- variable haemodynamic results compared with other techniques
- limited clinical data with no improvement in survival

Summary

- adjunct to be used by trained personnel to reduce variability in technique and rescuer fatigue in prolonged resuscitative efforts
Piston CPR 2010

CoSTR: Consensus on Science: extract

“Data from one prospective cohort study comparing the use of a piston-CPR device with manual CPR documented that the use of a piston-CPR device increased interruption in CPR because time was required to set up and remove the device from patients during transportation in adult OHCA (LOE 2)”
Piston CPR 2010

CoSTR: Treatment recommendation

- There is **insufficient evidence to support or refute** the use of piston-CPR instead of manual CPR for adult victims of cardiac arrest.
CPR: The P Stands for Plumber’s Helper

To the Editor.—Though novel methods of cardiac resuscitation exist, the traditional cardiopulmonary resuscitation (CPR) techniques recommended by the American Heart Association have a proven track record.¹ This is not the case, however, in all families. We describe a 65-year-old Iranian man with severe triple vessel coronary artery disease had once again been successful, recommended that we place toilet plungers next to all the beds in our coronary care unit. We recommended that he take a basic CPR course but had to admit that it’s hard to argue with success.

Michael F. Cleary, MD
Scottsdale, Ariz

Keith G. Lurie, MD
Clinton Lindo, MD
Jerome Chin, MD
Medical Center
University of California
San Francisco

1. Standards and guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). JAMA. 1980;244:453-509.

Active Compression-Decompression CPR in animals

- beagles, anaesthetized
- ACD CPR with modified toilet plunger


- dogs, anaesthetised, non ventilated
- ACD CPR via suction cup head with handle
  - 3 beagles with flat chests
  - five mongrel dogs with keel shaped chests (needed CPR performed slightly off centre)

Active Compression-Decompression CPR in animals

- pigs, intubated, anaesthetised
- ACD CPR with glue and toilet plunger

Effects of simulated mouth-to-mouth ventilation during external cardiac compression or active compression-decompression in a swine model of witnessed cardiac arrest.

- pigs, intubated, anaesthetised and ventilated
- ACD with pad wired to midsternum

Effects of active compression-decompression resuscitation on myocardial and cerebral blood flow in pigs.
Circulation 1993;88(3):1254-63
Commercial device
Initial studies in small numbers of humans

<table>
<thead>
<tr>
<th>Design</th>
<th>ROSC</th>
<th>24 hr surv</th>
<th>Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cohen et al.</td>
<td>62% vs. 30%</td>
<td>45% vs. 9%</td>
<td>24% vs. 11%</td>
</tr>
<tr>
<td>NEJM 1993; 329:1918-21</td>
<td>p= .03</td>
<td>p= .004</td>
<td>p= .20</td>
</tr>
<tr>
<td>N=62</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tucker et al.</td>
<td>62% vs. 32%</td>
<td>48% vs. 21%</td>
<td>24% vs. 11%</td>
</tr>
<tr>
<td>JACC 1994; 24:201-9</td>
<td>p= .04</td>
<td>p= .04</td>
<td>p= .20</td>
</tr>
<tr>
<td>N= 53</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
ACD-CPR : the saga continues

– French multicentre study of 512 pts ALS-ACD-CPR
– odd/even day allocation, intensive teaching programme, unable to control for BLS ACD-CPR
– better ROSC, ICU admission, 24 hr survival
– 1 month survival same
– neurologically intact hospital discharge
  • 14/254 (5.5%) vs 5/258 (1.9%) p = 0.03
    (OR 0.34; 95% CI 0.2 - 1.14)
– more sternal haematomas, pulmonary haemorrhages and sternal dislodgements

Paris trial – Short term survival

Plaisance P et al. Circulation 1997;95;955-61

t-of-hospital (n= 512)
81% asystole
Paris, France

Odd/even day randomization

<table>
<thead>
<tr>
<th>Collapse to</th>
<th>Std</th>
<th>ACD</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPR</td>
<td>8</td>
<td>10</td>
</tr>
<tr>
<td>ACLS</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>ROSC</td>
<td>34</td>
<td>36</td>
</tr>
</tbody>
</table>

Minutes

p= .08
p= .05
p= .001
Paris trial ACD-CPR
Long-term survival

Plaisance P et al. NEJM 1999;341:569-75

Out-of-hospital (n= 750); 80% asystole; Paris and Thionville, France

![Graph showing comparison between Standard and ACD in survival outcomes.]

- Discharge intact: 2% (Standard), 6% (ACD), p = .01
- 1 yr survival: 2% (Standard), 5% (ACD), p = .03
# ACD-CPR

## Table 1.

Studies of ACD-CPR in human beings.

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome Measure</th>
<th>ACD-CPR (n)</th>
<th>Standard CPR (n)</th>
<th>P</th>
<th>95% CI of Difference*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nolan et al6</td>
<td>Hospital discharge</td>
<td>16/267 (6.0%)</td>
<td>16/309 (4.8%)</td>
<td>.6704</td>
<td>-2.5-4.9</td>
</tr>
<tr>
<td>Mauer et al5</td>
<td>Hospital discharge</td>
<td>17/106 (16%)</td>
<td>16/114 (14%)</td>
<td>.6777</td>
<td>-7.5-11.5</td>
</tr>
<tr>
<td>Plaisance et al7,8†</td>
<td>Hospital discharge (no neurologic impairment)</td>
<td>21/373 (5.6%)</td>
<td>7/377 (1.9%)</td>
<td>.006</td>
<td>3.8-26.5</td>
</tr>
<tr>
<td></td>
<td>Survival at 1 y</td>
<td>17/373 (4.6%)</td>
<td>7/377 (1.9%)</td>
<td>.036</td>
<td>0.0-5.2</td>
</tr>
<tr>
<td>Stiell et al10</td>
<td>Hospital discharge, out-of-hospital</td>
<td>23/501 (4.6%)</td>
<td>19/510 (3.7%)</td>
<td>.4908</td>
<td>-1.7-3.4</td>
</tr>
<tr>
<td></td>
<td>Hospital discharge, in-hospital</td>
<td>42/405 (10.4%)</td>
<td>42/368 (11.4%)</td>
<td>.6418</td>
<td>-5.6-3.5</td>
</tr>
<tr>
<td>Schwab et al9</td>
<td>Hospital discharge, Fresno</td>
<td>6/117 (5%)</td>
<td>10/136 (7%)</td>
<td>.4685</td>
<td>-8.2-3.7</td>
</tr>
<tr>
<td></td>
<td>Hospital discharge, San Francisco</td>
<td>14/297 (4.7%)</td>
<td>17/310 (5.5%)</td>
<td>.6666</td>
<td>-4.3-2.7</td>
</tr>
<tr>
<td>Lurie et al4</td>
<td>Hospital discharge, reported</td>
<td>12/53 (22.6%)</td>
<td>13/77 (16.9%)</td>
<td>.410</td>
<td>-8.3-19.8</td>
</tr>
<tr>
<td></td>
<td>Hospital discharge, intention to treat</td>
<td>9/61 (14.8%)</td>
<td>12/69 (17.4%)</td>
<td>.6835</td>
<td>-15.3-10</td>
</tr>
<tr>
<td>Luiz et al,13</td>
<td>Hospital discharge</td>
<td>3/26 (11.5%)</td>
<td>4/30 (13.3%)</td>
<td>1.0²</td>
<td>-19.1-15.5</td>
</tr>
<tr>
<td>Ellinger et al12</td>
<td>Hospital discharge</td>
<td>6/25 (24%)</td>
<td>3/28 (11%)</td>
<td>.2785</td>
<td>-7.34</td>
</tr>
<tr>
<td>Tucker et al3</td>
<td>Hospital discharge</td>
<td>5/25 (20%)</td>
<td>3/28 (11%)</td>
<td>.4527</td>
<td>-10.29</td>
</tr>
<tr>
<td>Cohen et al2</td>
<td>Hospital discharge</td>
<td>2/29 (7%)</td>
<td>0/33 (0%)</td>
<td>.2147</td>
<td>-2.3-16.1</td>
</tr>
</tbody>
</table>

CI, Confidence interval.

* Ninety-five percent CI of absolute risk reduction.
† Investigators could not control for use of ACD by basic life support personnel before arrival of the resuscitation team.
‡ Fisher exact test (otherwise χ² analysis was used).
Active Compression-Decompression (ACD) CPR


- early beneficial studies small, skillfully applied, “efficacy” trials, no complications
- later non-beneficial studies larger, widespread clinical use, “effectiveness” trials, complications reported, better estimate true clinical relevance

Evidence of harm : ACD CPR

• Study suggesting harm (Rabl, 1996, Int J Legal Med)
  – 31 consecutive post-mortems (dying after CPR)
  – more rib fractures and sternal fractures with ACD CPR

• Manikin studies
  – increased energy expenditure required (Shultz, 1995, Resuscitation)
  – duration of CPR before exhaustion shortened (Baubin 1996, Resuscitation)
To determine the effect of active chest compression-decompression CPR, compared to standard chest compression CPR on mortality and neurological function in adults with cardiac arrest treated either in-hospital or out-of-hospital.
Analysis 1.2. Comparison of Out-of-hospital cardiac arrests, Outcome 2 Mortality at hospital discharge.

Review: Active chest compression-decompression for cardiopulmonary resuscitation

Comparison: 1 Out-of-hospital cardiac arrests

Outcome: 2 Mortality at hospital discharge

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>ACD CPR n/N</th>
<th>STR n/N</th>
<th>Risk Ratio M-H,Fixed,95% CI</th>
<th>Weight</th>
<th>Risk Ratio M-H,Fixed,95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goralski 1998</td>
<td>73/76</td>
<td>72/74</td>
<td></td>
<td>4.6 %</td>
<td>0.99 [0.93, 1.05]</td>
</tr>
<tr>
<td>Luiz 1996</td>
<td>28/31</td>
<td>26/30</td>
<td></td>
<td>1.7 %</td>
<td>1.04 [0.87, 1.25]</td>
</tr>
<tr>
<td>Lurie 1994</td>
<td>48/61</td>
<td>57/69</td>
<td></td>
<td>3.4 %</td>
<td>0.95 [0.80, 1.13]</td>
</tr>
<tr>
<td>Mauer 1996</td>
<td>89/106</td>
<td>98/114</td>
<td></td>
<td>5.9 %</td>
<td>0.98 [0.87, 1.09]</td>
</tr>
<tr>
<td>Nolan 1998</td>
<td>287/304</td>
<td>354/370</td>
<td></td>
<td>20.1 %</td>
<td>0.99 [0.95, 1.02]</td>
</tr>
<tr>
<td>Schwab-Fresno 1995</td>
<td>111/117</td>
<td>126/136</td>
<td></td>
<td>7.3 %</td>
<td>1.02 [0.96, 1.09]</td>
</tr>
<tr>
<td>Schwab-S.Francisco 1995</td>
<td>283/297</td>
<td>293/310</td>
<td></td>
<td>18.0 %</td>
<td>1.01 [0.97, 1.05]</td>
</tr>
<tr>
<td>Skagoll 1999</td>
<td>139/159</td>
<td>130/147</td>
<td></td>
<td>8.5 %</td>
<td>0.99 [0.91, 1.07]</td>
</tr>
<tr>
<td>Stiell-Prehospital 1996</td>
<td>478/501</td>
<td>491/510</td>
<td></td>
<td>30.6 %</td>
<td>0.99 [0.97, 1.02]</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>1652</strong></td>
<td><strong>1760</strong></td>
<td></td>
<td><strong>100.0 %</strong></td>
<td><strong>0.99 [0.98, 1.01]</strong></td>
</tr>
</tbody>
</table>

Total events: 1536 (ACD CPR), 1647 (STR)

Heterogeneity: $\chi^2 = 2.30$, df = 8 ($P = 0.97$); $I^2 = 0.0$

Test for overall effect: $Z = 0.66$ ($P = 0.51$)
The pooled RR of neurological impairment, any severity, was 1.71 (95%CI 0.90 to 3.25), with a non-significant trend to more frequent severe neurological damage in survivors of ACD CPR (RR 3.11, 95% CI 0.98 to 9.83).
ACDCPR 2010

CoSTR: Consensus on Science:

Five randomised controlled trials (LOE 1) and three controlled trials (LOE 2) failed to show a difference in ROSC or survival with use of ACD-CPR compared with standard CPR.

Six studies (LOE 2) demonstrated improved ROSC or survival to hospital discharge although there were no statistically significant differences in neurologically intact survival.

A meta-analysis of two trials (826 patients) comparing ACDCPR with standard CPR after in-hospital cardiac arrest (IHCA) did not detect a significant increase in rates of immediate survival or survival to hospital discharge.
ACDCPR 2010

CoSTR: Treatment recommendation

• There is insufficient evidence to support or refute the use of ACD-CPR.
Clinical Data: Vest CPR
Hemodynamics (Level 3) and Short-Term Survival (Level 2)

• CPP (N = 15)
  Vest: 23 ± 11 mm Hg
  Manual: 15 ± 8
  p<0.003

• 6 Hr survival (N= 34)
  Vest: 6/17
  Manual: 1/17
  p=0.085

No significant trauma

Table 3.
Studies of the CPR vest in human beings (Level of Evidence 1): data on ROSC and survival.

<table>
<thead>
<tr>
<th>Study</th>
<th>Outcome Measure</th>
<th>Vest CPR (n)</th>
<th>Standard CPR (n)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halperin et al^{42}</td>
<td>ROSC</td>
<td>8/17 (47%)</td>
<td>3/17 (18%)</td>
<td>.14</td>
</tr>
<tr>
<td>Weston et al^{43}</td>
<td></td>
<td>22/41 (54%)</td>
<td>20/40 (50%)</td>
<td>NS</td>
</tr>
<tr>
<td>Both studies</td>
<td></td>
<td>30/58 (52%)</td>
<td>23/57 (40%)</td>
<td></td>
</tr>
<tr>
<td>Halperin et al^{42}</td>
<td>6-Hour survival</td>
<td>6/17 (35%)</td>
<td>1/17 (6%)</td>
<td>.03</td>
</tr>
<tr>
<td>Weston et al^{43}</td>
<td></td>
<td>12/41 (29%)</td>
<td>10/40 (25%)</td>
<td>NS</td>
</tr>
<tr>
<td>Both studies</td>
<td></td>
<td>18/58 (31%)</td>
<td>11/57 (19%)</td>
<td></td>
</tr>
<tr>
<td>Halperin et al^{42}</td>
<td>Hospital discharge</td>
<td>0/17 (0%)</td>
<td>0/17 (0%)</td>
<td>NS</td>
</tr>
<tr>
<td>Weston et al^{43}</td>
<td></td>
<td>7/41 (17%)</td>
<td>4/40 (10%)</td>
<td>NS</td>
</tr>
<tr>
<td>Both studies</td>
<td></td>
<td>7/58 (12%)</td>
<td>4/57 (7%)</td>
<td></td>
</tr>
</tbody>
</table>

NS, Not significant.
Load Distributing Band
High level evidence

• The sole RCT (LOE 1) that has been performed [Hallstrom, 2006, 2620-8] compared the load-distributing band with manual CPR in over 1000 patients with OOHCA, and demonstrated worse neurological outcomes, and a trend to lower hospital discharge (after being stopped early by the data and safety monitoring board).
How could this be?
Paradis 2010

- A post-hoc analysis of this study demonstrated significant heterogeneity between sites.
- One site (site C) had a substantive decrease in survival to hospital discharge, whereas the other sites did not reflect these “safety concerns,” and these sites appeared to demonstrate a steadily “improving four hour survival” with patient enrollment.
- All authors consultants/employees of manufacturer

<table>
<thead>
<tr>
<th></th>
<th>AutoPulse</th>
<th>M-CPR</th>
<th>p</th>
<th>Odds ratio (OR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All sites</td>
<td>40/555 (7.2%)</td>
<td>54/516 (10.5%)</td>
<td>0.060</td>
<td>0.665</td>
</tr>
<tr>
<td>Site C</td>
<td>11/96 (11.5%)</td>
<td>28/105 (26.7%)</td>
<td>0.006</td>
<td>0.356</td>
</tr>
<tr>
<td>Other 4 sites</td>
<td>29/459 (6.3%)</td>
<td>26/411 (6.3%)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Efficacy or effectiveness?
LDB CPR 2010

CoSTR: Consensus on Science: Extract

Evidence from both clinical (LOE 1) and simulation (LOE 5) studies suggested that site-specific factors may influence resuscitation quality and device efficacy.

A case report documented successful performance of a computed tomography (CT) scan while LDB-CPR was used (LOE 4)
LDB CPR 2010

CoSTR: Treatment recommendation

• There **are insufficient data to support or refute the routine use** of LDB-CPR instead of manual CPR.

• **It may be reasonable to consider** LDB to maintain continuous chest compression while undergoing CT scan or similar diagnostic studies, when provision of manual CPR would be difficult.
Clinical paper

Design of the Circulation Improving Resuscitation Care (CIRC) Trial: A new state of the art design for out-of-hospital cardiac arrest research

E. Brooke Lerner, David Persse, Chris M. Souders, Fritz Sterz, Reinhard Malzer, Michael Lozano Jr., Mark Westfall, Marc A. Brouwer, Pierre M. van Grunsven, Anne Whitehead, Jan-Aage Olsen, Ulrich R. Herken, Lars Wik
CIRC trial has six unique features:

1. Training of all EMS providers in a standardized deployment strategy that reduces hands-off time and continuous monitoring for protocol compliance.
2. A pre-trial simulation study of provider compliance with the trial protocol.
3. Three distinct study phases (infield training, run-in, and statistical inclusion) to minimize the Hawthorne effect and other biases.
4. Monitoring of the CPR process using either transthoracic impedance or accelerometer data.
5. Randomization at the subject level after the decision to resuscitate is made to reduce selection bias.
6. Use of the Group Sequential Double Triangular Test with sufficient power to determine superiority, inferiority, or equivalence.
Lifestick CPR

Figure 6-5. Phased chest and abdominal compression-decompression with a manually operated Lifestick Resuscitator.

Resuscitation of the Arrested Heart. Weil & Tang 1999
Impedance Threshold Device

Ventilation Port

Ventilation Timing Assist Lights
provide guidance to the rescuer on proper ventilation rate to optimize cardiac output and oxygenation.

Atmospheric Pressure Sensor System
augments blood flow to the heart when intrathoracic pressures are < 0 ATMs.

Resistance Regulator
enables inspiration if spontaneous respiration resumes.

Ventilation Guidance Switch
slide for use of the ventilation timing assist lights.

Single Use Only

Patient Port
allows fast and easy connection to an endotracheal tube or other airway adjuncts.
Goal to improve blood flow

Example of how inspiratory impedance enhances the intrathoracic vacuum (negative pressure [mmHg]) in humans undergoing ACD CPR with an active vs. sham ResQPOD on a facemask.

Multiple suggestive but conflicting studies both with and without the use of ACD-CPR
ITD CPR 2010

CoSTR: Treatment recommendation

• There are insufficient data to support or refute the use of the ITD.
What is coming soon for ITD?
The Resuscitation Outcomes Consortium (ROC) PRIMED Impedance Threshold Device (ITD) Cardiac Arrest Trial: A Prospective, Randomized, Double-Blind, Controlled Clinical Trial

- Partial factorial design
- ITD versus sham ITD
- Analyse Early - initial compressions 30 s versus 3 min
Modified Rankin Score (MRS)

0. No symptoms.
1. No significant disability. Able to carry out all usual activities, despite some symptoms.
2. Slight disability. Able to look after own affairs without assistance, but unable to carry out all previous activities.
3. **Moderate disability. Requires some help, but able to walk unassisted.**
4. Moderately severe disability. Unable to attend to own bodily needs without assistance, and unable to walk unassisted.
5. Severe disability. Requires constant nursing care and attention, bedridden, incontinent.
6. Dead.
The Resuscitation Outcomes Consortium ROC) PRIMED Impedance Threshold Device (ITD) Cardiac Arrest Trial: A Prospective, Randomized, Double-Blind, Controlled Clinical Trial

<table>
<thead>
<tr>
<th></th>
<th>Sham ITD (n = 4345)</th>
<th>Active ITD (n = 4373)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital Dis</td>
<td>260 (6.0)</td>
<td>254 (5.8)</td>
<td>0.61</td>
</tr>
<tr>
<td>MRS ≤ 3 n (%)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Resuscitation Guidelines 2011
Lund University Cardiac Arrest System
CoSTR: Science: extract

• There are no RCTs evaluating the LUCAS device in human cardiac arrest.

• Three adult human case reports (LOE 4), three adult human case series (LOE 4), and one animal study (LOE 5) reported that the use of a mechanical chest-compression device in cardiac arrest during percutaneous coronary intervention (PCI) maintained circulation and enabled the procedure to be completed. A small number of patients in the case series survived.

• Two case reports demonstrated that a CT scan could be performed during CPR with the LUCAS device (LOE 4).
Active compression—decompression CPR necessitates follow-up post mortem

In this letter we want to draw attention to the findings of atypical pathological tissue damage in some patients who did not survive after cardiopulmonary resuscitation with active mechanical compression—decompression, ACD-CPR.

In the south of Sweden, an ACD-CPR commercial device LUCAS®¹ was introduced into the prehospital setting from 2003, with the aim of improving CPR in the ambulance service and the outcome after prehospital CPR. The overall results have been encouraging so far. With the aid of this device, it

There were also a few infra-diaphragmatic injuries, which included a ruptured aneurysm of the abdominal aorta and liver haemorrhage. These injuries were thought to emanate from the device sliding from its original position; sliding however has not been reported to occur previously.

Most of these injuries have previously been reported at autopsy in those who did not survive conventional manual CPR.³ However, according to the most extensive report from regular autopsy focused on CPR complications,⁴ the number of injuries in dead patients after ACD-CPR markedly exceeded those injuries seen in patients not surviving conventional/manual CPR.
Automated CPR devices: Primum non nocere
(BJA: eletter M Fitzgerald March 2010)
"One postmortem study showed similar injuries with LUCAS-CPR and standard CPR (LOE 2)."
LUCAS CPR 2010

CoSTR: Treatment recommendation

• There are insufficient data to support or refute the use of LUCAS CPR instead of manual CPR.

• It may be reasonable to consider LUCAS CPR to maintain continuous chest compression while undergoing CT scan or similar diagnostic studies, when provision of manual CPR would be difficult.
In a prospective pilot study, from February 1, 2005, to April 1, 2007, 149 patients with out-of-hospital cardiac arrest in two Swedish cities were randomised to mechanical chest compressions or standard CPR with manual chest compressions.

Conclusions: In this pilot study of out-of-hospital cardiac arrest patients we found no difference in early survival between CPR performed with mechanical chest compression with the LUCAS device and CPR with manual chest compressions. Data have been used for power calculation in a forthcoming multicentre trial.
So if one doesn’t work, why not try more than one?
Substantive preliminary work
Standard cardiopulmonary resuscitation versus active compression-decompression cardiopulmonary resuscitation with augmentation of negative intrathoracic pressure for out-of-hospital cardiac arrest: a randomised trial

Tom P Aufderheide, Ralph J Frascone, Marvin A Wayne, Brian D Mahoney, Robert A Swor, Robert M Domeier, Michael L Olinger, Richard G Holcomb, David E Tupper, Demetris Yannopoulos, Keith G Lurie

Lancet 2011; 377: 301–11
Treatment of Out-of-Hospital Cardiac Arrest with an Impedance Threshold Device and Active Compression Decompression CPR: the RESQTrial

• Manual ACD + ITD versus standard CPR
• Randomised
• Primary endpoint – survival to hospital discharge MRS ≤ 3
• 2470 patients randomised; 827 (33%) excluded; 1653 enrolled
<table>
<thead>
<tr>
<th>Primary composite study endpoints</th>
<th>Standard CPR group (n=813)</th>
<th>Intervention* group (n=840)</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified Rankin scale score at hospital discharge†</td>
<td>727 (89%)</td>
<td>734 (87%)</td>
<td>0.039</td>
</tr>
<tr>
<td>0</td>
<td>3 (&lt;1%)</td>
<td>11 (1%)</td>
<td>...</td>
</tr>
<tr>
<td>1</td>
<td>8 (1%)</td>
<td>11 (1%)</td>
<td>...</td>
</tr>
<tr>
<td>2</td>
<td>26 (3%)</td>
<td>30 (4%)</td>
<td>...</td>
</tr>
<tr>
<td>3</td>
<td>10 (1%)</td>
<td>23 (3%)</td>
<td>...</td>
</tr>
<tr>
<td>4</td>
<td>10 (1%)</td>
<td>9 (1%)</td>
<td>...</td>
</tr>
<tr>
<td>5</td>
<td>16 (2%)</td>
<td>18 (2%)</td>
<td>...</td>
</tr>
<tr>
<td>6</td>
<td>727 (89%)</td>
<td>734 (87%)</td>
<td>0.039</td>
</tr>
<tr>
<td>Survival data for hospital discharge not available</td>
<td>6 (&lt;1%)</td>
<td>2 (&lt;1%)</td>
<td>...</td>
</tr>
<tr>
<td>Survived, but data for MRS not available</td>
<td>7 (&lt;1%)</td>
<td>2 (&lt;1%)</td>
<td>...</td>
</tr>
<tr>
<td>MRS ≤3 (primary study endpoint)</td>
<td>47 (6%)</td>
<td>75 (9%)</td>
<td>0.019</td>
</tr>
<tr>
<td>Secondary survival endpoints</td>
<td>Standard CPR group (n=813)</td>
<td>Intervention* group (n=840)</td>
<td>p value</td>
</tr>
<tr>
<td>Survived to 24 h after arrest</td>
<td>176 (22%)</td>
<td>197 (24%)</td>
<td>0.41</td>
</tr>
<tr>
<td>Data not available</td>
<td>9 (1%)</td>
<td>6 (&lt;1%)</td>
<td>...</td>
</tr>
<tr>
<td>Survived to hospital discharge</td>
<td>80 (10%)</td>
<td>104 (12%)</td>
<td>0.12</td>
</tr>
<tr>
<td>Data not available</td>
<td>6 (&lt;1%)</td>
<td>2 (&lt;1%)</td>
<td>...</td>
</tr>
<tr>
<td>Survived to 90 days</td>
<td>58 (7%)</td>
<td>87 (10%)</td>
<td>0.029</td>
</tr>
<tr>
<td>Data not available</td>
<td>15 (2%)</td>
<td>8 (1%)</td>
<td>...</td>
</tr>
<tr>
<td>Survived to 1 year</td>
<td>48 (6%)</td>
<td>74 (9%)</td>
<td>0.030</td>
</tr>
<tr>
<td>Data not available</td>
<td>19 (2%)</td>
<td>19 (2%)</td>
<td>...</td>
</tr>
</tbody>
</table>
Treatment of Out-of-Hospital Cardiac Arrest with an Impedance Threshold Device and Active Compression Decompression CPR: the RESQTrial

<table>
<thead>
<tr>
<th></th>
<th>SCPR (n = 813)</th>
<th>ACD-ITD (n = 840)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hosp Discharge</td>
<td>80 (9.8)</td>
<td>104 (12.4)</td>
<td>0.12</td>
</tr>
<tr>
<td>Hosp Discharge MRS ≤ 3 n (%)</td>
<td>47 (5.8)</td>
<td>75 (8.9)</td>
<td>0.019</td>
</tr>
<tr>
<td>CPC 1-2 90 days</td>
<td>47 (5.8)</td>
<td>72 (8.6)</td>
<td>0.036</td>
</tr>
</tbody>
</table>

Aufderheide TP.
But . . .

• What about the quality of CPR in controls
• You can’t blind the rescuers!
Hawthorne effect?
If you are convinced a technique works, and you are using it . . . ?
If you are convinced a technique works, and you are using the old fashioned (inferior) control . . . ?
Empirical Evidence of Bias

Dimensions of Methodological Quality Associated With Estimates of Treatment Effects in Controlled Trials

Kenneth F. Schulz, PhD, MBA; Iain Chalmers, MBBS, MSc; Richard J. Hayes, MSc; Douglas G. Altman

JAMA. 1995;273:408-412
Table 3.—Association Between Four Dimensions of Methodological Quality and Estimates of Treatment Effects in the 229 Adequately and Unclearly Concealed Trials*

<table>
<thead>
<tr>
<th>Measure of Methodological Quality</th>
<th>Ratio of Odds Ratios (95% Confidence Interval)</th>
<th>$\chi^2$ (df)</th>
<th>$P$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allocation concealment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adequate</td>
<td>1.00 (referent)</td>
<td>32.9 (1)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Unclear</td>
<td>0.70 (0.62-0.79)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sequence generation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adequate</td>
<td>1.00 (referent)</td>
<td>0.31 (1)</td>
<td>.58</td>
</tr>
<tr>
<td>Inadequate</td>
<td>0.95 (0.81-1.12)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusions</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>1.00 (referent)</td>
<td>0.99 (1)</td>
<td>.32</td>
</tr>
<tr>
<td>Yes</td>
<td>1.07 (0.94-1.21)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double-blinded</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1.00 (referent)</td>
<td>6.16 (1)</td>
<td>.01</td>
</tr>
<tr>
<td>No</td>
<td>0.83 (0.71-0.96)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Multiple logistic regression model with the dependent variable being binary outcome measures from each meta-analysis. The independent variables included a binary variable for treatment group (experimental vs control); indicator variables to control for the effects of each of the 229 trials; terms for the "meta-analysis by treatment group" interaction to control for the different summary odds ratios for the treatment effects in the 33 meta-analyses; and the four "quality measure by treatment" interaction terms displayed in this table to analyze their associations with estimates of treatment effects. Model deviance=325.3; df=192.
Empirical Evidence of Bias

JAMA. 1995;273:408-412

- Compared with trials in which authors reported adequately concealed treatment allocation, trials in which concealment was either inadequate or unclear (did not report or incompletely reported a concealment approach) yielded larger estimates of treatment effects (P<.001). **Odds ratios were exaggerated by 41% for inadequately concealed trials and by 30% for unclearly concealed trials (adjusted for other aspects of quality).**

- Trials in which participants had been excluded after randomization did not yield larger estimates of effects, but that lack of association may be due to incomplete reporting.

- **Trials that were not double-blind also yielded larger estimates of effects** (P=.01), with odds ratios being exaggerated by 17%. 

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Resuscitation Guidelines 2011
Why not succeed if so much potential for the power of good?

- Efficiency versus effectiveness
- Hard to maintain that broad enthusiasm for the technique
- Aimed at wrong endpoints
- Harder to titrate, more rigid in their application
- Improvements still occurring in devices
- Our baseline continues to improve
Active Compression-Decompression (ACD) CPR


• early beneficial studies small, skilfully applied, “efficacy” trials, no complications
• later non-beneficial studies larger, widespread clinical use, “effectiveness” trials, complications reported, better estimate true clinical relevance

In the hands of the expert proponents

- May provide opportunities during percutaneous coronary interventions
- Complex transport/extrication
So why not introduce a new technique which needs a lot of training costs a lot, and has no overall benefits?
Trade off

- Key is good CPR
- Minimise delays
- Attaching device adds delays
- Incremental benefit must be better than loss of flow
Opportunity cost!

- Limited time and resource channeled into studies of limited return
- Diverts resources away from other valuable studies
- Cost required to implement would take away from other opportunities
Barriers to translating evidence into practice
Sean Berenholtz, MD, MHS*, and Peter J. Pronovost, MD, PhD, FCCM†

• Curr Opin Crit Care 2003, 9:321–325
• “the most cost-effective opportunity to improve patient outcomes over the next quarter century will likely come not from discovering new therapies but from discovering how to deliver therapies that are known to be effective”
Other techniques & devices to perform CPR (ANZCOR)

- Several techniques or adjuncts to standard CPR have been investigated and the relevant data was reviewed extensively as part of the Consensus on Science process.

- The success of any technique depends on the education and training of the rescuers or the resources available (including personnel).

- Techniques reviewed include: Open-chest CPR, Interposed Abdominal Compression CPR, Active Compression-Decompression CPR, Open Chest CPR, Load Distributing Band CPR, Mechanical (Piston) CPR, Lund University Cardiac Arrest System CPR, Impedance Threshold Device, and Extracorporeal Techniques.
Other techniques & devices to perform CPR (ANZCOR)

• 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.**

• While no circulatory adjunct is currently recommended instead of manual CPR for routine use, some circulatory adjuncts are being routinely used in both out-of-hospital and in-hospital resuscitation. If a circulatory adjunct is used, rescuers should be well-trained and a program of continuous surveillance should be in place to ensure that use of the adjunct does not adversely affect survival. [Class B; LOE IV]