WORKSHEET for Evidence-Based Review of Science for Emergency Cardiac Care

Worksheet author(s)

<table>
<thead>
<tr>
<th>Peter Morley</th>
<th>Date Submitted for review (Day Month Year)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>16 Sept 2012</td>
</tr>
</tbody>
</table>

Clinical question.

In adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA]), does the use of an ITD (I) compared with no ITD (C), improve any outcomes (e.g. ROSC, survival) (O)?

Population: adult cardiac arrest (prehospital [OHCA], in-hospital [IHCA])

Intervention: the use of an ITD

Comparison: compared with no ITD

Outcomes (key outcomes: critical 7-9, important 4-6, limited importance 1-3):

- Neurologically intact survival (critical 9)
- Discharge from hospital alive (critical 8)
- Return of spontaneous circulation (important 6)

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

State if this is a proposed new topic or revision of existing worksheet: Revision

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 [at least Medline, Embase, and Cochrane Central Register of Controlled Trials [Central]].)

PubMed: 06 Nov 2011 (30 hits, 7 studies included)


Cochrane Central Register of Controlled Trials (Central): 06 Nov 2011 (13 hits, no new studies identified)


Electronic search of EndNote database. Manual search of references of identified articles. 1 new study identified (term = ITV)

- State inclusion and exclusion criteria

Included all studies with concurrent controls. Excluded review articles, studies with historical controls, animal studies, and studies that did not specifically answer the question. Excluded unpublished studies, and studies only published in abstract form, unless accepted for publication.

- Number of articles/sources meeting criteria for further review:

### Characteristics of included studies (alphabetical)

#### Aufderheide 2005, 734

<table>
<thead>
<tr>
<th>Methods</th>
<th>Randomised Controlled Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>230 OOHCA (presumed ≥ 21 years), presumed cardiac, ventilat-able with facemask, then intubate-able with ETT. Milwaukee, WI, USA</td>
</tr>
<tr>
<td>Interventions</td>
<td>Impedance threshold device (facemask then ETT) plus standard CPR</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Sham ITD (facemask then ETT) plus standard CPR</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Primary: survival to ICU admission I 29/114 (25.4%) vs C 20/116 (17.2%) NS  Secondary: 24 hr survival I 19/114 (16.7%) vs C 14/116 (12.1%) NS; 1 year survival I 4/114 vs C 2/116. No hospital discharge data.</td>
</tr>
</tbody>
</table>

#### Aufderheide 2011, 301

<table>
<thead>
<tr>
<th>Methods</th>
<th>Multicentre Randomised Controlled Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>2470 OOHCA (presumed ≥ 18 years), presumed cardiac cause, no (pre-specified) airway problems</td>
</tr>
<tr>
<td>Interventions</td>
<td>Impedance threshold device (facemask then advanced airway) plus ACD CPR</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Standard CPR</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Primary: survival to hospital discharge with modified Rankin ≤ 3 I 75/840 (9%) vs C 47/813 (6%) 0.019. Secondary: Survive to hospital admission I 237/840 (28%) vs C 216/813 (27%). Hospital discharge I 104/840 (12%) vs C 80/813 (10%). NS. More pulmonary oedema I 94/840 (11%) vs C 62/813 (7%) 0.015.</td>
</tr>
<tr>
<td>Notes</td>
<td>Enrolled October 2005 to April 2009. ACD CPR provided metronome at 80/min, and force gauge to guide depth and recoil; 2 handed technique for ITD with facemask, ITD timing lights to guide ventilation. No feedback about quality CPR for standard group. Increased planned enrollments (sample size estimate) after midpoint analysis, then stopped early for funding reasons. Outcomes from third group of patients (ITD and SCPR) are not included. P values nominal and unadjusted. Excluded 817 patients (non-cardiac and inability to ventilate), before these exclusions results for primary endpoint are not significant (I 101/1269 (8%) vs C 71/1201 (6%) 0.057). Approx. 60% hospital mortality. Only 39% received hypothermia. No other outcome improved. Sponsor helped interpret data, write report and decide to submit for publication.</td>
</tr>
</tbody>
</table>

#### Aufderheide 2011, 798

<table>
<thead>
<tr>
<th>Methods</th>
<th>Multicentre Randomised Controlled Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>8718 non-traumatic OOHCA. 10 sites in USA/Canada (ROC)</td>
</tr>
<tr>
<td>Interventions</td>
<td>Impedance threshold device (facemask then advanced airway) plus standard CPR (4373)</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Sham ITD (facemask then advanced airway) plus standard CPR (4345)</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Primary: survival to hospital discharge with modified Rankin ≤ 3 I 254/4373 (5.8%) vs C 260/4345 (6.0%) NS  Secondary: no differences. Survive to hospital admission I 1140/4370 (26.1%) vs C 1139/4335 (26.3%). Hospital discharge I 357/4373 (8.2%) vs C 355/4345 (8.2%).</td>
</tr>
</tbody>
</table>
| Notes            | Large numbers so small differences in some parameters in Table 1 (“not clinically significant”). Multivariable analysis performed. Run in phase and retraining. June 2007 to Nov 2009. 2005 guidelines: 30:2 or 10:1. Similar adverse effects. Simultaneous study with early versus delayed rhythm analysis. High in-hospital
mortality. Only 48% received hypothermia. Modified intention-to-treat population, included all patients who had an ITD (active or sham) applied during the main trial but excluded those who had cardiac arrest due to hanging, drowning, electrocution, or strangulation or for whom the response time exceeded 15 minutes).

**Pirrallo 2005, 13**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Randomised Controlled Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>22 OOHCA (presumed ≥ 21 years), presumed cardiac, intubatable with ETT, able to monitor femoral BP for ≥ 2 mins. Milwaukee, WI, USA</td>
</tr>
<tr>
<td>Interventions</td>
<td>Impedance threshold device plus standard CPR (10)</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Sham ITD plus standard CPR (12)</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Primary: Femoral arterial BP: I higher SBP (initially 40 mmHg higher, but difference decreased with time) vs C. Secondary: oxygenation and ETCO2 not different. ROSC in I 2/10 (20%) vs C 3/12 (25%).</td>
</tr>
<tr>
<td>Notes</td>
<td>2000 guidelines: changed half way through to new model ITD with ventilation timing assist lights. Only 4 patients had new (active) ITD. Invasive BP after 34 mins. Similar adverse effects. No survival data. 11/22 patients in “pseudo-EMD”. Assume different patients to Aufderheide 2005, 734.</td>
</tr>
</tbody>
</table>

**Plaisance 2000, 989**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Randomised Controlled Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>21 OOHCA (≥ 18 years), haemodynamic monitoring within 10 mins. Paris, France</td>
</tr>
<tr>
<td>Interventions</td>
<td>Impedance threshold device plus ACD CPR</td>
</tr>
<tr>
<td>Comparisons</td>
<td>ACD CPR</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Higher maximal ETCO2, 70% higher mean coronary perfusion pressure with intervention group. Survival not different: 24hrs I 3/11 (27.3%) vs C 2/10 (20%); Hospital discharge I 1/11 (9.1%) vs C 1/10 (10%).</td>
</tr>
</tbody>
</table>

**Plaisance 2004, 265**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Randomised Controlled Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>400 OOHCA (&gt; 18 years). Paris, France</td>
</tr>
<tr>
<td>Interventions</td>
<td>Impedance threshold device plus ACD CPR</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Sham ITD plus standard care plus ACD CPR</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Primary: 24 hr survival I 64/200 (32%) vs C 44/200 (22%) 0.02 Secondary: Hospital discharge I 10/200 (5%) vs C 8/200 (4%)</td>
</tr>
</tbody>
</table>

**Plaisance 2005, 990**

<table>
<thead>
<tr>
<th>Methods</th>
<th>Randomised Controlled Crossover Trial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>12 Witnessed OOHCA (&gt; 18 years) with BLS by firefighters. Paris, France</td>
</tr>
<tr>
<td>Interventions</td>
<td>Impedance threshold device plus ACD CPR (facemask 2 mins, ETT 2 mins)</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Sham ITD plus standard care plus ACD CPR (facemask 2 mins, ETT 2 mins)</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Primary: Maximum negative intra-thoracic (Upper airway) pressure: I -4.6 (3.7) mmHg vs C -1.0 (0.73) facemask; I -7.3 (4.53) vs C -1.3 (1.25) ETT</td>
</tr>
<tr>
<td>Notes</td>
<td>ACD CPR, 15:2 (2000 guidelines), patients as own controls (crossover effects)</td>
</tr>
</tbody>
</table>

**Wolcke 2003, 2201**

| Methods                      | Randomised Controlled Trial |

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<table>
<thead>
<tr>
<th>Participants</th>
<th>210 OOHCA (≥ 18 years), presumed cardiac, hand ventilated via ETT. Mainz, Germany</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interventions</td>
<td>Impedance threshold device plus ACD CPR</td>
</tr>
<tr>
<td>Comparisons</td>
<td>Standard CPR</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Primary: survival 1 hour after hospital admission I 53/103 (51%) vs C 34/107 (32%) 0.006. Secondary: 24 hr survival I 38/103 (37%) vs C 24/107 (22%) 0.033; hospital discharge I 19/103 (18%) vs C 14/107 (13%) NS. More ecchymosis with ITD ACD.</td>
</tr>
</tbody>
</table>
## Risk of bias in individual studies

### All studies, alphabetical

<table>
<thead>
<tr>
<th>Study</th>
<th>Random -ization*</th>
<th>Allocation concealment*</th>
<th>Blinding*</th>
<th>Loss to follow-up, Intention to Treat (IT) analysis*</th>
<th>Any other risks</th>
<th>Outcomes to which these assessments apply</th>
<th>Overall risk of bias for outcome(s) for study**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aufderheide 2005, 734 ITD+SCPR vs ShamITD+SCPR</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Discontinued early. Indirectness: 2000 guidelines.</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>Aufderheide 2011, 798 ITD+SCPR vs ShamITD+SCPR</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Indirectness: 2005 guidelines</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>Aufderheide 2011, 301 ITD+ACD vs SCPR</td>
<td>Low</td>
<td>Unclear</td>
<td>High (only outcome assessors)</td>
<td>Unclear, some exclusions based on difficulty with airway, border on deviation from IT analysis.</td>
<td>High: Significant differences in real time feedback about CPR quality. Increase enrollment numbers then stop early.</td>
<td>All</td>
<td>High</td>
</tr>
<tr>
<td>Pirallo 2005, 13 ITD+SCPR vs ShamITD+SCPR</td>
<td>Low</td>
<td>Unclear</td>
<td>Low</td>
<td>Low</td>
<td>Changed device halfway into study. Equipment problems Indirectness: 2000 guidelines.</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>Plaisance 2000, 989 ITD+ACD vs ACD</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>No description primary outcome/power. Indirectness: 1992 guidelines</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>Plaisance 2004, 265 ITD+ACD vs ShamITD+ACD</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Automatic ventilator. Indirectness: 2000 guidelines.</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>Plaisance 2005, 990 ITD+ACD vs ShamITD+ACD</td>
<td>Low (order of use)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Crossover trial. Indirectness: 2000 guidelines</td>
<td>All</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

*For all: risk of bias = Low/Unclear/High

1. **Lack of allocation concealment**: Those enrolling patients are aware of the group (or period in a crossover trial) to which the next enrolled patient will be allocated (major problem in “pseudo” or “quasi” randomized trials with allocation by day of week, birth date, chart number, etc).

2. **Lack of blinding**: Patient, care givers, those recording outcomes, those adjudicating outcomes, or data analysts are aware of the arm to which patients are allocated (or the medication currently being received in a crossover trial).

3. **Incomplete accounting of patients and outcome events**: Loss to follow-up and failure to adhere to the intention-to-treat principle in superiority trials; or in noninferiority trials, loss to follow-up, and failure to conduct both analyses considering only those who adhered to treatment, and all patients for whom outcome data are available.

4. **Selective outcome reporting bias**: Incomplete or absent reporting of some outcomes and not others on the basis of the results.

5. **Other limitations**: Stopping early for benefit. Use of unvalidated outcome measures (e.g., patient-reported outcomes). Carryover effects in crossover trial. Recruitment bias in cluster-randomized trials.

**Overall risk of bias of study = Low, Moderate or High

“Low” risk of bias if most or all key criteria listed above are met, and any violations are not crucial.

“Moderate” risk of bias if have a crucial limitation in one criterion or some limitations in multiple criteria, sufficient to lower the confidence in the estimate of effect.

“High” risk of bias if have a crucial limitation in one or more criteria, sufficient to substantially lower the confidence in the estimate of effect.
### Impedance Threshold Device + Standard CPR (I) vs Standard CPR (C)

<table>
<thead>
<tr>
<th>Study</th>
<th>Random -ization</th>
<th>Allocation concealment</th>
<th>Blinding</th>
<th>Loss to follow-up, Intention to Treat (IT) analysis</th>
<th>Any other risks</th>
<th>Outcomes to which these assessments apply</th>
<th>Overall risk of bias for outcome(s) for study**</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITD+SCPR vs ShamITD+SCPR</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Pirallo 2005, 13</td>
<td>Low</td>
<td>Unclear</td>
<td>Low</td>
<td>Low</td>
<td>Changed device halfway into study, Equipment problems Indirectness: 2000 guidelines.</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>ITD+SCPR vs ShamITD+SCPR</td>
<td></td>
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</tr>
<tr>
<td>Aufderheide 2011, 798</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Indirectness: 2005 guidelines</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>ITD+SCPR vs ShamITD+SCPR</td>
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</tbody>
</table>

### Impedance Threshold Device + Active Compression Decompression CPR (I) vs Standard CPR (C)

<table>
<thead>
<tr>
<th>Study</th>
<th>Random -ization</th>
<th>Allocation concealment</th>
<th>Blinding</th>
<th>Loss to follow-up, IT principle observed or per protocol analysis</th>
<th>Any other risks</th>
<th>Outcomes to which these assessments apply</th>
<th>Overall risk of bias for outcome(s) for study**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaisance 2000, 989</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>No description primary outcome/power. Indirectness: 1992 guidelines</td>
<td>All</td>
<td>Low</td>
</tr>
<tr>
<td>ITD+ACD vs ACD</td>
<td></td>
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<td></td>
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<tr>
<td>ITD+ACD vs ShamITD+ACD</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Plaisance 2005, 990</td>
<td>Low (order of use)</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Crossover trial. Indirectness: 2000 guidelines</td>
<td>All</td>
<td>Moderate</td>
</tr>
<tr>
<td>ITD+ACD vs ShamITD+ACD</td>
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</table>

### Impedance Threshold Device + Active Compression Decompression CPR (I) vs Active Compression Decompression CPR (C)

<table>
<thead>
<tr>
<th>Study</th>
<th>Random -ization</th>
<th>Allocation concealment</th>
<th>Blinding</th>
<th>Loss to follow-up, IT principle observed or per protocol analysis</th>
<th>Any other risks</th>
<th>Outcomes to which these assessments apply</th>
<th>Overall risk of bias for outcome(s) for study**</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITD+ACD vs SCPR</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Aufderheide 2011, 301</td>
<td>Low</td>
<td>Unclear</td>
<td>High (only outcome assessor)</td>
<td>Unclear, some exclusions based on difficulty with airway border on deviation from IT analysis.</td>
<td>High: Significant differences in real time feedback about CPR quality. Increase enrollment numbers then stop early.</td>
<td>All</td>
<td>High</td>
</tr>
<tr>
<td>ITD+ACD vs SCPR</td>
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</tr>
</tbody>
</table>
### Evidence Profile tables

**Impedance Threshold Device + Standard CPR (I) vs Standard CPR (C)**

**Population:** Patients in cardiac arrest  
**Settings:** OOHCA  
**Intervention:** Use of Impedance Threshold Device in addition to standard CPR  
**Comparison:** Use of standard CPR

<table>
<thead>
<tr>
<th>Outcome</th>
<th>No of studies</th>
<th>Study Design</th>
<th>Risk of bias*</th>
<th>Inconsistency*</th>
<th>Indirectness*</th>
<th>Imprecision*</th>
<th>Other (including publication bias)**</th>
<th>Quality of evidence for outcome***</th>
</tr>
</thead>
</table>
| Outcome 1  
Neurologically intact survival  (survival to hospital discharge with modified Rankin ≤ 3)  
Critical (9) | 1  
Aufderheide 2011  
798 | RCT | No serious limitations | No serious limitations | No serious limitations | No serious limitations | Undetected | High |
| Outcome 2  
Survival to hospital discharge  
Critical (8) | 1  
Aufderheide 2011  
798 | RCT | No serious limitations | No serious limitations | No serious limitations | No serious limitations | Undetected | High |

* Classification across all studies for each outcome for: Risk of Bias/Inconsistency/Indirectness/Imprecision  
No serious limitations: Most information is from studies at low risk of bias. Do not downgrade  
Serious limitations: Most information is from studies at moderate risk of bias. Rate down one level  
Very serious limitations: Most information is from studies at high risk of bias. Rate down two levels  

** Classification across all studies for each outcome for Publication Bias: Undetected or Strongly suspected  
*** Quality of Evidence across included studies for outcome: High, Moderate, Low, Very Low
### Evidence Profile table

**Impedance Threshold Device + Active Compression Decompression CPR (I) vs Active Compression Decompression CPR (C)**

**Population:** Patients in cardiac arrest  
**Settings:** OOHCA  
**Intervention:** Impedance Threshold Device + Active Compression Decompression CPR  
**Comparison:** Active Compression Decompression CPR

<table>
<thead>
<tr>
<th>Outcome Description</th>
<th>No of studies</th>
<th>Study Design</th>
<th>Risk of bias*</th>
<th>Inconsistency*</th>
<th>Indirectness*</th>
<th>Imprecision*</th>
<th>Other (including publication bias)**</th>
<th>Quality of evidence for outcome***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologically intact survival</td>
<td>Nil</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Nil</td>
</tr>
<tr>
<td>Survival to hospital discharge</td>
<td>2 Plaisance 2000 989 Plaisance 2004 265</td>
<td>RCT</td>
<td>No serious limitations</td>
<td>No serious limitations</td>
<td>Serious limitations (1992/2000 guidelines)</td>
<td>Serious limitations (small number of events, N&lt;50)</td>
<td>Undetected</td>
<td>Low (rated down for indirectness &amp; imprecision)</td>
</tr>
</tbody>
</table>

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* Classification across all studies for each outcome for: Risk of Bias/Inconsistency/Indirectness/Imprecision
  - No serious limitations: Most information is from studies at low risk of bias. Do not downgrade
  - Serious limitations: Most information is from studies at moderate risk of bias. Rate down one level
  - Very serious limitations: Most information is from studies at high risk of bias. Rate down two levels

** Classification across all studies for each outcome for Publication Bias: Undetected or Strongly suspected

*** Quality of Evidence across included studies for outcome: High, Moderate, Low, Very Low
### Evidence Profile table

**Impedance Threshold Device + Active Compression Decompression CPR (I) vs Standard CPR (C)**

**Population:** Patients in cardiac arrest  
**Settings:** OOHCA  
**Intervention:** Impedance Threshold Device + Active Compression Decompression CPR  
**Comparison:** Standard CPR

<table>
<thead>
<tr>
<th>Outcome 1</th>
<th>No of studies</th>
<th>Study Design</th>
<th>Risk of bias*</th>
<th>Inconsistency*</th>
<th>Indirectness*</th>
<th>Imprecision*</th>
<th>Other (including publication bias)**</th>
<th>Quality of evidence for outcome***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neurologically intact survival (survival to hospital discharge with modified Rankin ≤ 3)</td>
<td>1</td>
<td>Aufderheide 2011 301</td>
<td>RCT</td>
<td>Very serious limitations (blinding, feedback about CPR quality, exclusions/IT analysis)</td>
<td>No serious limitations</td>
<td>No serious limitations</td>
<td>Serious limitations (ARR CI overlap 1%)</td>
<td>Undetected (sponsor involvement). More pulmonary oedema I 94/840 (11%) vs C 62/813 (7%) 0.015.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outcome 2</th>
<th>No of studies</th>
<th>Study Design</th>
<th>Risk of bias*</th>
<th>Inconsistency*</th>
<th>Indirectness*</th>
<th>Imprecision*</th>
<th>Other (including publication bias)**</th>
<th>Quality of evidence for outcome***</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survival to hospital discharge</td>
<td>2</td>
<td>Aufderheide 2011 301 Wolcke 2003 2201</td>
<td>RCT</td>
<td>Very serious limitations (blinding, feedback about CPR quality, exclusions/IT analysis)</td>
<td>No serious limitations</td>
<td>No serious limitations</td>
<td>Serious limitations (ARR CI overlap 1%)</td>
<td>Undetected (sponsor involvement). More pulmonary oedema I 94/840 (11%) vs C 62/813 (7%) 0.015.</td>
</tr>
</tbody>
</table>

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* Classification across all studies for each outcome for: Risk of Bias/Inconsistency/Indirectness/Imprecision  
  No serious limitations: Most information is from studies at low risk of bias. Do not downgrade  
  Serious limitations: Most information is from studies at moderate risk of bias. Rate down one level  
  Very serious limitations: Most information is from studies at high risk of bias. Rate down two levels  
** Classification across all studies for each outcome for Publication Bias: Undetected or Strongly suspected  
*** Quality of Evidence across included studies for outcome: High, Moderate, Low, Very Low
### Summary of findings tables

**Topic title:** Impedance Threshold Device + Standard CPR (I) vs Standard CPR (C)

**Patient or population:** Patients in cardiac arrest  
**Settings:** OOHCA  
**Intervention:** Use of Impedance Threshold Device in addition to standard CPR  
**Comparison:** Use of standard CPR

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Illustrative comparative risks* (95% CI)</th>
<th>Relative effect (95% CI)</th>
<th>No of Participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Outcome 1** Neurologically intact survival (survival to hospital discharge with modified Rankin ≤ 3) Critical (9) | Assumed risk  
Comparison: 260/4345 6.0%  
Corresponding risk  
Intervention: 254/4373 5.8%  
Difference: -0.1 (-1.1 to 0.8)  
NNT: 570 | OR 0.97 (0.81 to 1.16)                      | 8718 (1)**               | High                          | Single multicentre study in North America, based on 2005 guidelines                                      |
| **Outcome 2** Survival to hospital discharge. Critical (8)               | 355/4345 8.2%  
Comparison: 357/4373 8.2%  
Difference: 0.0 (-1.2 to 1.1) | OR 1.00 (0.86 to 1.16)                      | 8718 (1)**               | High                          | Single multicentre study in North America, based on 2005 guidelines                                      |

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI).  
CI: Confidence interval; OR: Odds ratio;  
GRADE Working Group grades of evidence  
**High quality:** Further research is very unlikely to change our confidence in the estimate of effect.  
**Moderate quality:** Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.  
**Low quality:** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.  
**Very low quality:** We are very uncertain about the estimate.  
**Footnotes**  
### Summary of findings tables

#### Topic title: Impedance Threshold Device + Active Compression Decompression CPR (I) vs Active Compression Decompression CPR (C)

- **Patient or population:** Patients in cardiac arrest  
- **Settings:** OOHCA  
- **Intervention:** Use of Impedance Threshold Device in addition to Active Compression Decompression CPR  
- **Comparison:** Use of Active Compression Decompression CPR

<table>
<thead>
<tr>
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<th>Relative effect (95% CI)</th>
<th>No of Participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Outcome 1**  
Neurologically intact survival  
Critical (9)  
| Assumed risk Comparison | Corresponding risk Intervention | OR 0.81 (0.33 to 2.01) | 421 (2)** | Low³ | Two small studies in Paris, France, based on pre-2005 guidelines |
| Not assessed | Not assessed | | | | |

| Outcome 2  
Survival to hospital discharge  
Critical (8)  
| | | | | | |
| 9/210 (4.3%) | 11/211 (5.2%)  
Difference 0.93% (-3.13 to 4.99) | NNT 107.8 | | | |

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). Data not weighted.

| CI: Confidence interval; OR: Odds ratio; |
|---------------------|---------------------|---------------------|---------------------|---------------------|---------------------|

**GRADE Working Group grades of evidence**

- **High quality:** Further research is very unlikely to change our confidence in the estimate of effect.
- **Moderate quality:** Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.
- **Low quality:** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.
- **Very low quality:** We are very uncertain about the estimate.

**Footnotes**

- **Studies:**

1. Downgraded from high to low because of indirectness (patients were treated with pre-2005 guidelines, so external validity decreased) and imprecision (small sample size, <<OIS)
### Summary of findings tables

**Topic title:** Impedance Threshold Device + Active Compression Decompression CPR (I) vs Standard CPR (C)

**Patient or population:** Patients in cardiac arrest  
**Settings:** OOHCA  
**Intervention:** Use of Impedance Threshold Device in addition to Active Compression Decompression CPR  
**Comparison:** Use of Standard CPR

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<th>No of Participants (studies)</th>
<th>Quality of the evidence (GRADE)</th>
<th>Comments</th>
</tr>
</thead>
</table>
| **Outcome 1**  
Neurologically intact survival (survival to hospital discharge with modified Rankin ≤ 3)  
Critical (9) |  
Assumed risk Comparison  
47/813 (5.8%)  
75/840 (8.9%)  
Difference 3.15% (0.64 to 5.66)  
NNT 31.8 |  
Corresponding risk Intervention  
OR 1.60 (1.09 to 2.33) | 2470 (1)** | Low<sup>1</sup> | Unblinded study with unbalanced control for quality of CPR. |
| **Outcome 2**  
Survival to hospital discharge  
Critical (8) |  
94/920 (10.2%)  
123/943 (13%)  
Difference 2.83% (-0.08 to 5.73)  
NNT 35.4 |  
OR 1.32 (0.99 to 1.75) | 2680 (2)** | Low<sup>1</sup> | Unblinded studies with unbalanced control for quality of CPR. |

*The basis for the **assumed risk** (e.g. the median control group risk across studies) is provided in footnotes. The **corresponding risk** (and its 95% confidence interval) is based on the assumed risk in the comparison group and the **relative effect** of the intervention (and its 95% CI). Data not weighted.

CI: Confidence interval; OR: Odds ratio;

**GRADE Working Group grades of evidence**

**High quality:** Further research is very unlikely to change our confidence in the estimate of effect.

**Moderate quality:** Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate.

**Low quality:** Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate.

**Very low quality:** We are very uncertain about the estimate.

**Footnotes**

**Studies:**


**Studies:**


1. Downgraded from high to low because of the very serious risk of bias: lack of blinding (unable to avoid), imbalance in guidance for CPR quality parameters, indirectness, imprecision and evidence of harm (pulmonary oedema).
There is published data to suggest that augmentation of negative intrathoracic pressure during the decompression phase of chest compressions can increase cardiac and cerebral perfusion in animals and people during CPR. The use of an Impedance Threshold Device (ITD) has been proposed to provide a simple way of delivering this augmentation of negative intrathoracic pressure. The use of this device has been originally been assessed in a number of animal studies and observational human studies, but has now been studied in a number of randomized controlled trials. The search strategy identified 8 RCTs (enrolling over 12,000 patients) which evaluate the impact of the use of the ITD. There are difficulties in combining the data from these studies because of variable control and intervention groups.

Three main groups of interventions were identified:
1) Standard CPR +ITD (I) vs Standard CPR (C)
2) ACD CPR+ITD (I) vs ACD CPR (C)
3) ACD CPR+ITD (I) vs Standard CPR (C)

The quality of the individual studies is outlined in the section entitled “Characteristic of included studies”. The summary of findings for each of the three intervention groups is listed in the three Summary of Findings tables according to the two key outcomes: neurologically intact survival, and survival to hospital discharge.

The use of sham ITD allowed blinding of treating clinicians in studies comparing ITD with no ITD. In contrast, the main limiting factor in comparisons between ACD CPR and standard CPR was the lack of blinding of the intervention, without implementing adequate techniques to minimize any differences between the quality parameters of CPR.

**Conclusion**

**CONSENSUS ON SCIENCE:**
- **Impedance Threshold Device + Standard CPR (I) vs Standard CPR (C)**: One RCT enrolling over 8000 OOHCAs was unable to demonstrate any improvements in survival to hospital discharge or neurologically intact survival when an Impedance Threshold Device was added to standard care (which included manual CPR).
- **Impedance Threshold Device + Active Compression Decompression CPR (I) vs Active Compression Decompression CPR (C)**: Two RCTs enrolling over 400 OOHCAs were unable to demonstrate any improvements in survival to hospital discharge when an Impedance Threshold Device was added to standard care (which included the use of manual Active Compression Decompression CPR).

**TREATMENT RECOMMENDATION (including direction, quality of evidence and strength of evidence grade*):**
- **Impedance Threshold Device + Standard CPR (I) vs Standard CPR (C)**: The addition of an Impedance Threshold Device when performing standard manual cardiopulmonary resuscitation is not recommended (strong recommendation, high quality of evidence).
- **Impedance Threshold Device + Active Compression Decompression CPR (I) vs Active Compression Decompression CPR (C)**: The addition of an Impedance Threshold Device when performing manual active compression decompression cardiopulmonary resuscitation is not recommended (weak recommendation, low quality of evidence).
- **Impedance Threshold Device + Active Compression Decompression CPR (I) vs Standard CPR (C)**: There is insufficient evidence to recommend the routine use of the combination of an Impedance Threshold Device and manual active compression decompression cardiopulmonary resuscitation instead of standard CPR (weak recommendation, low quality of evidence).

**Acknowledgements:**
- Eddy Lang

*Strength of Recommendation*
- Strong: the desirable effects of an intervention clearly outweigh the undesirable effects, or clearly do not.
- Weak: the trade-offs are less certain—either because of low quality evidence or because evidence suggests that desirable and undesirable effects are closely balanced.

For patients—most people in your situation would want the recommended course of action and only a small proportion would not; request discussion if the intervention is not offered.

For clinicians—most patients should receive the recommended course of action.

- □ Weak: the trade-offs are less certain—either because of low quality evidence or because evidence suggests that desirable and undesirable effects are closely balanced.

- □ For patients—most people in your situation would want the recommended course of action, but many would not.
- □ For clinicians—you should recognise that different choices will be appropriate for different patients and that you must help each patient to arrive at a management decision consistent with her or his values and preferences.

**Strength of Evidence Grade Definition**
High: We are very confident that the true effect lies close to that of the estimate of the effect
Moderate: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.
Low: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.
Very low: We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.
Citation List

Included studies (with abstracts)


OBJECTIVE: To determine whether an impedance threshold device, designed to enhance circulation, would increase acute resuscitation rates for patients in cardiac arrest receiving conventional manual cardiopulmonary resuscitation. DESIGN: Prospective, randomized, double-blind, intention-to-treat. SETTING: Out-of-hospital trial conducted in the Milwaukee, WI, emergency medical services system. PATIENTS: Adults in cardiac arrest of presumed cardiac etiology. INTERVENTIONS: On arrival of advanced life support, patients were treated with standard cardiopulmonary resuscitation combined with either an active or a sham impedance threshold device. MEASUREMENTS AND MAIN RESULTS: We measured safety and efficacy of the impedance threshold device; the primary end point was intensive care unit admission. Statistical analyses performed included the chi-square test and multivariate regression analysis. One hundred sixteen patients were treated with a sham impedance threshold device, and 114 patients were treated with an active impedance threshold device. Overall intensive care unit admission rates were 17% with the sham device vs. 25% in the active impedance threshold device (p = .13; odds ratio, 1.64; 95% confidence interval, 0.87, 3.10). Patients in the subgroup presenting with pulseless electrical activity had intensive care unit admission and 24-hr survival rates of 20% and 12% in sham (n = 25) vs. 52% and 30% in active impedance threshold device groups (n = 27) (p = .018, odds ratio, 4.31; 95% confidence interval, 1.28, 14.5, and p = .12, odds ratio, 3.09; 95% confidence interval, 0.74, 13.0, respectively). A post hoc analysis of patients with pulseless electrical activity at any time during the cardiac arrest revealed that intensive care unit and 24-hr survival rates were 20% and 11% in the sham (n = 56) vs. 41% and 27% in the active impedance threshold device groups (n = 49) (p = .018, odds ratio, 2.82; 95% confidence interval, 1.19, 6.67, and p = .037, odds ratio, 3.01; 95% confidence interval, 1.07, 8.96, respectively). There were no statistically significant differences in outcomes for patients presenting in ventricular fibrillation and asystole. Adverse event and complication rates were also similar. CONCLUSIONS: During this first clinical trial of the impedance threshold device during standard cardiopulmonary resuscitation, use of the new device more than doubled short-term survival rates in patients presenting with pulseless electrical activity. A larger clinical trial is underway to determine the potential longer term benefits of the impedance threshold device in cardiac arrest.


BACKGROUND: Active compression-decompression cardiopulmonary resuscitation (CPR) with decreased intrathoracic pressure in the decompression phase can lead to improved haemodynamics compared with standard CPR. We aimed to assess effectiveness and safety of this intervention on survival with favourable neurological function after out-of-hospital cardiac arrest. METHODS: In our randomised trial of 46 emergency medical service agencies (serving 2.3 million people) in urban, suburban, and rural areas of the USA, we assessed outcomes for patients with out-of-hospital cardiac arrest according to Utstein guidelines. We provisionally enrolled patients to receive standard CPR or active compression-decompression CPR with augmented negative intrathoracic pressure (via an impedance-threshold device) with a computer-generated block randomisation weekly schedule in a one-to-one ratio. Adults (presumed age or age >/=18 years) who had a non-traumatic arrest of presumed cardiac cause and met initial and final selection criteria received designated CPR and were included in the final analyses. The primary endpoint was survival to hospital discharge with favourable neurological function (modified Rankin scale score of <=3). All investigators apart from initial rescuers were masked to treatment group assignment. This trial is registered with ClinicalTrials.gov, number NCT00189423. FINDINGS: 2470 provisionally enrolled patients were randomly allocated to treatment groups. 813 (68%) of 1201 patients assigned to the standard CPR group (controls) and 840 (66%) of 1269 assigned to intervention CPR received designated CPR and were included in the final analyses. 47 (6%) of 813 controls survived to hospital discharge with favourable neurological function compared with 75 (9%) of 840 patients in the intervention group (odds ratio 1.58, 95% CI 1.07-2.36; p=0.019]. 74 (9%) of 840 patients survived to 1 year in the intervention group compared with 48 (6%) of 813 controls (p=0.03), with equivalent cognitive skills, disability ratings, and emotional-psychological statuses in both groups.
The overall major adverse event rate did not differ between groups, but more patients had pulmonary oedema in the intervention group (94 [11%] of 840) than did controls (62 [7%] of 813; p=0.015). INTERPRETATION: On the basis of our findings showing increased effectiveness and generalisability of the study intervention, active compression-decompression CPR with augmentation of negative intrathoracic pressure should be considered as an alternative to standard CPR to increase long-term survival after cardiac arrest. FUNDING: US National Institutes of Health grant R44-HL065851-03, Advanced Circulatory Systems.


BACKGROUND: The impedance threshold device (ITD) is designed to enhance venous return and cardiac output during cardiopulmonary resuscitation (CPR) by increasing the degree of negative intrathoracic pressure. Previous studies have suggested that the use of an ITD during CPR may improve survival rates after cardiac arrest. METHODS: We compared the use of an active ITD with that of a sham ITD in patients with out-of-hospital cardiac arrest who underwent standard CPR at 10 sites in the United States and Canada. Patients, investigators, study coordinators, and all care providers were unaware of the treatment assignments. The primary outcome was survival to hospital discharge with satisfactory function (i.e., a score of \( \leq 3 \) on the modified Rankin scale, which ranges from 0 to 6, with higher scores indicating greater disability). RESULTS: Of 8718 patients included in the analysis, 4345 were randomly assigned to treatment with a sham ITD and 4373 to treatment with an active device. A total of 260 patients (6.0%) in the sham-ITD group and 254 patients (5.8%) in the active-ITD group met the primary outcome (risk difference adjusted for sequential monitoring, -0.1 percentage points; 95% confidence interval, -1.1 to 0.8; \( P=0.71 \)). There were also no significant differences in the secondary outcomes, including rates of return of spontaneous circulation on arrival at the emergency department, survival to hospital admission, and survival to hospital discharge. CONCLUSIONS: Use of the ITD did not significantly improve survival with satisfactory function among patients with out-of-hospital cardiac arrest receiving standard CPR. (Funded by the National Heart, Lung, and Blood Institute and others; ROC PRIMED ClinicalTrials.gov number, NCT00394706).


BACKGROUND: In animals in cardiac arrest, an inspiratory impedance threshold device (ITD) has been shown to improve hemodynamics and neurologically intact survival. The objective of this study was to determine whether an ITD would improve blood pressure (BP) in patients receiving CPR for out-of-hospital cardiac arrest. METHODS: This prospective, randomized, double-blind, intention-to-treat study was conducted in the Milwaukee, WI, emergency medical services (EMS) system. EMS personnel used an active (functional) or sham (non-functional) ITD on a tracheal tube on adults in cardiac arrest of presumed cardiac etiology. Care between groups was similar except for ITD type. Low dose epinephrine (1mg) was used per American Heart Association Guidelines. Femoral arterial BP (mmHg) was measured invasively during CPR. RESULTS: Mean\( \pm \)S.D. time from ITD placement to first invasive BP recording was approximately 14 min. Twelve patients were treated with a sham ITD versus 10 patients with an active ITD. Systolic BPs (mean\( \pm \)S.D.) \( \text{[number of patients treated at given time point]} \) at \( T = 0 \) (time of first arterial BP measurement), and \( T = 2, 5 \) and 7 min were 85\( \pm \)/29 [10], 85\( \pm \)/23 [10], 85\( \pm \)/16 [9] and 69\( \pm \)/22 [8] in the group receiving an active ITD compared with 43\( \pm \)/15 [12], 47\( \pm \)/16 [12], 47\( \pm \)/20 [9], and 52\( \pm \)/23 [9] in subjects treated with a sham ITD, respectively (\( p < 0.01 \) for all times). Diastolic BPs at \( T = 0, 2, 5 \) and 7 min were 20\( \pm \)/12, 21\( \pm \)/13, 23\( \pm \)/15 and 25\( \pm \)/14 in the group receiving an active ITD compared with 15\( \pm \)/9, 17\( \pm \)/8, 17\( \pm \)/9 and 19\( \pm \)/8 in subjects treated with a sham ITD, respectively (\( p = \text{NS} \) for all times). No significant adverse device events were reported. CONCLUSIONS: Use of the active ITD was found to increase systolic pressures safely and significantly in patients in cardiac arrest compared with sham controls.


BACKGROUND: Blood pressure is severely reduced in patients in cardiac arrest receiving standard cardiopulmonary resuscitation (CPR). Although active compression-decompression (ACD) CPR improves acute hemodynamic parameters, arterial pressures remain suboptimal with this technique. We performed ACD CPR in patients with a new inspiratory threshold valve (ITV) to determine whether lowering intrathoracic pressures...
during the "relaxation" phase of ACD CPR would enhance venous blood return and overall CPR efficiency.

METHODS AND RESULTS: This prospective, randomized, blinded trial was performed in prehospital mobile intensive care units in Paris, France. Patients in nontraumatic cardiac arrest received ACD CPR plus the ITV or ACD CPR alone for 30 minutes during advanced cardiac life support. End tidal CO(2) (ETCO(2)), diastolic blood pressure (DAP) and coronary perfusion pressure, and time to return of spontaneous circulation (ROSC) were measured. Groups were similar with respect to age, gender, and initial rhythm. Mean maximal ETCO(2), coronary perfusion pressure, and DAP values, respectively (in mm Hg), were 13.1+/-0.9, 25.0+/-1.4, and 36.5+/-1.5 with ACD CPR alone versus 19.1+/-1.0, 43.3+/-1.6, and 56.4+/-1.7 with ACD plus valve (P<0.001 between groups). ROSC was observed in 2 of 10 patients with ACD CPR alone after 26.5+/-0.7 minutes versus 4 of 11 patients with ACD CPR plus ITV after 19.8+/-2.8 minutes (P<0.05 for time from intubation to ROSC).

Conclusions-Use of an inspiratory resistance valve in patients in cardiac arrest receiving ACD CPR increases the efficiency of CPR, leading to diastolic arterial pressures of >50 mm Hg. The long-term benefits of this new CPR technology are under investigation.

Not found with search strategy.


AIMS: The purpose of this multicentre clinical randomized controlled blinded prospective trial was to determine whether an inspiratory impedance threshold device (ITD), when used in combination with active compression-decompression (ACD) cardiopulmonary resuscitation (CPR), would improve survival rates in patients with out-of-hospital cardiac arrest. METHODS AND RESULTS: Patients were randomized to receive either a sham (n = 200) or an active impedance threshold device (n = 200) during advanced cardiac life support performed with active compression-decompression cardiopulmonary resuscitation. The primary endpoint of this study was 24 h survival. The 24 h survival rates were 44/200 (22%) with the sham valve and 64/200 (32%) with the active valve (P = 0.02). The number of patients who had a return of spontaneous circulation (ROSC), intensive care unit (ICU) admission, and hospital discharge rates was 77 (39%), 57 (29%), and 8 (4%) in the sham valve group versus 96 (48%) (P = 0.05), 79 (40%) (P = 0.02), and 10 (5%) (P = 0.6) in the active valve group. Six out of ten survivors in the active valve group and 1/8 survivors in the sham group had normal neurological function at hospital discharge (P = 0.1). CONCLUSION: The use of an impedance valve in patients receiving active compression-decompression cardiopulmonary resuscitation for out-of-hospital cardiac arrest significantly improved 24 h survival rates.


INTRODUCTION: Use of an inspiratory impedance threshold device (ITD) significantly increases coronary perfusion pressures and survival in patients ventilated with an endotracheal tube (ETT) during active compression-decompression cardiopulmonary resuscitation. We tested the hypothesis that the ITD could lower intrathoracic pressures when attached to either a facemask or ETT. METHODS: An active and sham ITD were randomly applied first to a facemask and then to an ETT during active compression-decompression cardiopulmonary resuscitation in 13 out-of-hospital cardiac arrest patients in a randomized, double-blinded, prospective clinical trial. The compression-to-bag-valve ventilation ratio was 15:2. Airway pressures (surrogate for intrathoracic pressure) were measured with a pressure transducer. A sham and an active ITD were used for 1 min each in a randomized order, first on a facemask and then on an ETT. Statistical analyses were made using Friedman's and Wilcoxon's rank-sum tests. RESULTS: For the primary end point, mean +/- sd maximum negative intrathoracic pressures (mm Hg) during the decompression phase of cardiopulmonary resuscitation were -1.0 +/- 0.73 mm Hg with a sham vs. -4.6 +/- 3.7 mm Hg with an active ITD on the facemask (p = .003) and -1.3 +/- 1.3 mm Hg with a sham ITD vs. -7.3 +/- 4.5 mm Hg with an active ITD on an ETT (p = .0009). Decompression phase airway pressures with the facemask and ETT were not statistically different. CONCLUSIONS: Use of an active ITD attached to a facemask or an ETT resulted in a significantly lower negative intrathoracic pressure during the decompression phase of active compression-decompression cardiopulmonary resuscitation when compared with controls. Airway pressures with an ITD on either a facemask or ETT were similar. The ITD-facemask combination was practical and enables rapid deployment of this life-saving technology.

BACKGROUND: Active compression-decompression (ACD) CPR combined with an inspiratory impedance threshold device (ITD) improves vital organ blood flow during cardiac arrest. This study compared survival rates with ACD+ITD CPR versus standard manual CPR (S-CPR).

METHODS AND RESULTS: A prospective, controlled trial was performed in Mainz, Germany, in which a 2-tiered emergency response included early defibrillation. Patients with out-of-hospital arrest of presumed cardiac pathogenesis were sequentially randomized to ACD+ITD CPR or S-CPR by the advanced life support team after intubation. Rescuers learned which method of CPR to use at the start of each work shift. The primary end point was 1-hour survival after a witnessed arrest. With ACD+ITD CPR (n=103), return of spontaneous circulation and 1- and 24-hour survival rates were 55%, 51%, and 37% versus 37%, 32%, and 22% with S-CPR (n=107) (P=0.016, 0.006, and 0.033, respectively). One- and 24-hour survival rates in witnessed arrests were 55% and 41% with ACD+ITD CPR versus 33% and 23% in control subjects (P=0.011 and 0.019), respectively. One- and 24-hour survival rates in patients with a witnessed arrest in ventricular fibrillation were 68% and 58% after ACD+ITD CPR versus 27% and 23% after S-CPR (P=0.002 and 0.009), respectively. Patients randomized > or =10 minutes after the call for help to the ACD+ITD CPR had a 3 times higher 1-hour survival rate than control subjects (P=0.002). Hospital discharge rates were 18% after ACD+ITD CPR versus 13% in control subjects (P=0.41). In witnessed arrests, overall neurological function trended higher with ACD+ITD CPR versus control subjects (P=0.07).

CONCLUSIONS: Compared with S-CPR, ACD+ITD CPR significantly improved short-term survival rates for patients with out-of-hospital cardiac arrest. Additional studies are needed to evaluate potential long-term benefits of ACD+ITD CPR.
**Excluded studies**

Not address question

Not address question

Not address question

Protocol only

Not specifically address question

Not address question

Systematic review only

Not specifically address question

Not specifically address question

Not specifically address question

Not address question

Not address question

Historical controls. Multiple confounders.
Not specifically address question

Animal study

Animal study

Animal study

Review only

Historical controls

Historical controls. Multiple confounders

Review article only

Not specifically address question

Not address question