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

**Worksheet author(s)**

| P M Middleton, S R Davies | Date Submitted for review: 28/09/09 |

**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)?

**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 of existing worksheet(s)

**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).**

**Medline (1950-September 2009)**

[“heart arrest” OR “cardiopulmonary resuscitation” as MeSH headings] OR [(heart or cardiac) and (massage or therapy or compression$)].ti,ab. OR [advanced or cardiac] and (life adj support).ti,ab. OR [CPR or (cardiopulmonary adj resuscitation) or (cardio-pulmonary adj resuscitation)].ti,ab] AND [ ((impedance adj threshold adj device) or ITD) or ((impedance adj threshold adj valve) or ITV)]

**Embase (1996 to Week 38 2009)**

[“resuscitation” OR “heart arrest” OR “heart massage” OR “heart stimulation” as Entree terms] OR [(heart or cardiac) and (massage or therapy or compression$)].ti,ab. OR (advanced or cardiac) and (life adj support).ti,ab. OR (CPR or (cardiopulmonary adj resuscitation) or (cardio-pulmonary adj resuscitation)].ti,ab] AND [ ((impedance adj threshold adj device) or ITD) or ((impedance adj threshold adj valve) or ITV)]

**AHA EndNote Master Library (March 2008)**

Search with the terms (impedance threshold device) OR (impedance threshold valve) in both title and abstract fields

**Cochrane Database of Systematic Reviews/ Cochrane Central Register of Controlled Trials (3rd Quarter 2009)**

Both searched with the combination of text words listed in the search strategies for Medline and Embase.

**Scopus**

Used for forward searching (citations) and backward searching (author-based)

**Google Scholar/Google**

Used for text word based searches of grey literature

**Reference Reviews**

Comprehensive revision of references from all relevant papers.

**State inclusion and exclusion criteria**

**Inclusion criteria:** Human cardiac arrest studies or animal models of cardiac arrest examining outcomes associated with the use of an ITD.

**Exclusion criteria:** Non-cardiac arrest studies (e.g., hypovolaemia studies or studies of spontaneously breathing patients), reviews, abstract-only studies, letters, studies not published in English

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

Eighteen (18) studies met the inclusion/exclusion criteria for further review. Of these, 7 were LOE 1 (RCTs or systematic reviews of RCTs), one was LOE 3 (historical control) and 10 were LOE 5 (porcine models of cardiac arrest).
# Summary of evidence

## Evidence Supporting Clinical Question

| Good   | Cabrini 2008 A,B,C  
|        | Pirrallo 2005 E  
|        | Plaisance 2004 ABC  
|        | Wolcke 2003 A B  
|        | Thayne 2005 B  
|        | Lurie 2001, E  
|        | Lurie 2002, B, D  
|        | Raedler 2000 E  
|        | Yannopoulos 2006 A E  
| Fair   | Plaisance 2002 A E  
|        | Aufderheide, 2005 BE  
|        | Plaisance 2005 E  
|        | Lurie 1995, A, E  
|        | Lurie 1998, E  
|        | Voelckel 2001 E  
| Poor   |  

### Level of evidence

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

Italics = Animal studies

## Evidence Neutral to Clinical question

| Good   | Cabrini 2008 D  
|        |  
|        |  
|        |  
|        |  
|        |  
| Fair   | Aufderheide 2005 A C D  
|        |  
|        |  
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|        | Mader 2008, A,B,E  
|        | Menegazzi 2007, E  
| Poor   |  
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A = Return of spontaneous circulation  
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### Evidence Opposing Clinical Question

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**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint  
*Herff data opposed the use of an ITD without assisted ventilation.

Italics = Animal studies
**REVIEWER’S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:**

The impedance threshold device (ITD) is a one-way valve that fits on an endotracheal tube or facemask. A pressure-sensitive silicon valve within the device impedes the flow of inspiratory gases during chest wall decompression, increasing negative intrathoracic pressure without impeding manual ventilation or exhalation. The vacuum thus created enhances venous return to the heart, thereby increasing cardiac output and coronary perfusion.

**Clinical Studies:**

To date, all human studies evaluating outcomes associated with the use of the ITD have been in the context of the EMS management of out-of-hospital cardiac arrest (OHCA) of presumed non-traumatic aetiology, including one meta-analysis of five OHCA studies. Human studies are equally divided into evaluations of ITD + S-CPR and evaluations of ITD + ACD-CPR, with some studies examining both. No studies examined the device in the management of IHCA. There is also a dearth of studies reporting long term or neurologically intact survival rates.

Many of the clinical study protocols included retraining in CPR techniques, with an emphasis on full chest wall recoil and appropriate ventilation rates (10 – 12/min). Currently available ITDs have ventilation timing assist lights. No studies differentiated improvements gained as a result of the CPR re-training from the effects of the device; therefore any recommendations for the device must include accompanying recommendations for CPR guideline adherence or refresher training for rescuers.

**Standard CPR (S-CPR):**

Two randomised controlled trials (LOE 1) comparing the ITD with either a sham-ITD or no ITD during S-CPR reported improved haemodynamics and short-term survival rates:

*Aufderheide (2005) in a prospective, double-blinded, randomised, sham-controlled trial of 230 adult OHCA patients demonstrated that the addition of an ITD during S-CPR improved the rates of ICU admission and 24 hour survival in patients with pulseless electrical activity.*

*Pirallo (2005) in a prospective, well-randomised, double-blinded, controlled trial (n=22) of ITD vs. sham-ITD in OHCA (analysed by intention-to-treat) reported significantly increased systolic blood pressure.*

*Thayne (2005) conducted a large (n=989) prospective case- historical control study (LOE 3) of the ITD vs. no ITD in S-CPR for OHCA. Patients treated with the device, irrespective of presenting rhythm, had significantly increased survival to ED admission rates.*

**Active compression-decompression CPR (ACD-CPR):**

All four human RCTs (all LOE 1) evaluating the ITD in combination with ACD-CPR reported improved haemodynamic and short-term survival outcomes.

*Plaisance (2002) in the first trial of the ITD in human cardiac arrest reported increased ETCO₂, systolic blood pressure, coronary perfusion pressure and shorter time interval to ROSC associated with the use of ACD-CPR + ITD for OHCA patients. (all patients presented in asystole - patients were excluded from the trial if they presented in VF, author states that defibrillation attempts interfered with femoral arterial access)*

*Wolcke (2003) compared S-CPR with ACD-CPR + ITD for OHCA in a randomised controlled trial (n=210) in one EMS system in Germany, demonstrating a statistically significant increase in ROSC, 1 hour survival rates and 24 hour survival rates for patients receiving ACD-CPR + ITD, irrespective of presenting rhythm. Of note in this study was the improvement in short term survival rate for patients with a witnessed arrest, presenting in VF (from 27% to 68%, p=0.002), and for patients where the interval from arrest to commencement of CPR exceeded ten minutes (from 14% to 44%, p=0.005)*

*Plaisance (2004) in a prospective, multicentre, blinded, randomised, controlled trial comparing the use of the ITD with a sham-ITD in ACD-CPR for OHCA reported increased ROSC rates, 24 hour survival rates, ICU admission rates and hospital discharge rates.*

*Plaisance (2005) reported an increase in maximum intratracheal pressure for adult OHCA patients treated with an ITD, compared to intratracheal pressures obtained for the same patients treated with a sham-ITD in prospective, randomised, blinded cross-over trial (n=13). Plaisance also reports the generation of comparable levels of negative intratracheal pressure between the ITD + facemask compared with the ITD + ETT. Plaisance reports intratracheal pressure as a surrogate for intrathoracic pressure.*
Cabrini (2008) in a systematic review and meta-analysis of 5 five studies of the ITD in OHCA (LOE 1) (n=833), reported increased ROSC and early survival for patients treated with an ITD compared with control treatment (sham or no ITD). No significant difference was detected in long-term survival (defined as the longest survival interval reported in each study) or neurologically intact survival between the treatment and control groups.

**Laboratory Studies:**

The remaining ten studies were LOE 5 studies conducted in a porcine model of induced VF. These were generally small studies with haemodynamic parameters as primary endpoints.


Menegazzi (2007) conducted a porcine case-control study (n=36) of S-CPR + ITD against S-CPR (this study was ‘nested’ within a primary study examining effects of selective A₁ antagonists). No difference in coronary perfusion pressure, and a decrease in ROSC and 20 minute survival were reported for the animals receiving S-CPR + ITD compared with those receiving S-CPR.

Herff (2007) in a modified randomised cross-over trial reported that the use of an ITD in pigs undergoing apnoeic ventilation and either S-CPR or ACD-CPR was associated with lower arterial oxygen partial pressure than that obtained in the same animals treated with S-CPR or ACD-CPR and no ITD. Authors conclude that assisted ventilation is required when using an ITD.

No studies (laboratory or clinical) reported any significant adverse effects or complications associated with the use of an inspiratory threshold device.

**Acknowledgements:**
Citation List


Level 1 study. Fair (underpowered). Supportive. (Positive for OHCA pts with PEA at any time during cardiac arrest)
Prospective, double-blinded, randomised, sham-controlled trial of 230 adult OHCA patients, in which standard CPR (S-CPR) plus sham ITD was compared with S-CPR plus ITD. Inclusion/exclusion criteria, outcome definitions, data collection and subsequent analysis appear to be consistent with the Utstein guidelines for OHCA. Analysis was on an ITT basis. Primary outcome was survival to ICU admission, two sub-group analyses (proposed a priori) were performed correlating rhythm and witnessed/unwitnessed arrest with ROSC, 1 hour survival, 24 hour survival, survival to ICU and survival to hospital discharge. Adverse events and complications from CPR were also recorded.
The trial was terminated early due to identification of possible harm through sub-standard performance of S-CPR by EMS personnel (notably excessive ventilation rates and incomplete chest wall recoil). This was identified in a separate, concurrent haemodynamic study performed in the same area (Milwaukee). Also, lower-than-predicted ICU admission rates in the control group meant that the study was underpowered to detect a statistically significant increase in the primary outcome. Aufderheide has subsequently published a proposed methodology for a well-powered RCT of ITD vs. sham-ITD in OHCA (Resuscitation 2008; 78(2):179-185)

The use of an ITD was associated with a higher admission rate to ICU than use of a sham ITD (25% vs. 17%), however, due to small sample size, this result was not significant (p=0.13, OR 1.64 95% CI 0.87 to 3.10).

Analysis by presenting rhythm (proposed a priori), demonstrated that S-CPR plus ITD significantly improved rate of survival to ICU admission for adult OHCA patients (of presumed cardiac aetiology) who present initially with PEA (OR 2.82, 95%CI 1.19 to 6.67, p=0.018). 52 of the 230 study subjects presented with PEA.

Patients who were identified as experiencing PEA at any time during the resuscitation had ICU and 24-hour survival rates of 20% and 11% in the sham (n=56) vs. 41% and 27% in the ITD groups (n=49) (p=0.037, OR 3.01, 95% CI 1.07 to 8.96)

No significant differences were identified for secondary outcomes (ROSC, discharge rates, neurological function). There were no significant differences in adverse events or complications between the control and treatment group.

KG Lurie (co-author) is co-inventor of the ResQPOD (ITD) and Chief Medical Officer at Advanced Circulatory Systems (manufacturing company).


Level 1 study (systematic review with meta-analysis). Good. Supportive.
Systematic review with meta-analysis of five small RCTs of ITD use in adult non-traumatic OHCA. Review inclusion criteria: random allocation to treatment, comparison of ITD vs. control treatment. Review exclusion criteria: cross-over trials, duplicate publications, non-human trials and trials with no outcome data. Although not stated as inclusion criteria, all studies included in the meta-analysis were of adult, non-traumatic cardiac arrest patients treated with either S-CPR or ACD-CPR (+/- ITD) in the out-of-hospital setting (this may reflect the nature of the existing studies, not an implicit inclusion criterion).

Total N=833, however not all patients were included in all meta-analyses, as not all studies reported all outcomes. No log of excluded studies (QUORUM – style flowchart included). RCTs were assessed for methodological quality – 4/5 reported as low risk of overall bias, 1/5 reported as moderate risk of bias. Baseline data reported and appeared comparable. Two studies compared (S-CPR + ITD) with (S-CPR + sham ITD), one study compared (ACD-CPR + ITD) with (ACD-CPR + sham ITD), one study compared (ACD-CPR + ITD) with S-CPR, and one study compared (ACD-CPR + ITD) with (ACD-CPR + sham ITD). Authors report that all studies ‘strictly followed’ ‘international basic and ALS guidelines for the implementation of CPR’ (?Aufderheide’s study - early termination due to non-compliance with CPR guidelines).
All included studies reported as demonstrating positive survival trends – although all underpowered. Egger test/funnel plot inspection for ROSC and early survival revealed no publication bias/ SSE.

ROSC: (5 studies) ITD increased ROSC compared with control treatment (202/438 vs. 159/438, RR=1.29 [1.10-1.51],
p for effect=0.004, p for heterogeneity= 0.79, $i^2=0\%$

**Early survival:** (4 studies - 24hr survival in 3 studies, ICU admission in one study). ITD significantly increased early survival compared with the control group (139/428 vs. 97/433, RR = 1.45 [1.16-1.80], p for effect =0.0009, p for heterogeneity = 0.93, $i^2=0\%$)

There was no significant effect of the ITD compared with a control, with regards to neurological outcome in survivors, or survival to the longest follow-up reported.


Level 5 (animal study), fair, opposing (for ITD without assisted ventilation)

Modified cross-over RCT in pigs (n=48), comparing ITD to no ITD during S-CPR and ACD-CPR. Beating-heart model of CPR, no assisted ventilation (apnoeic oxygenation). Study authors state that the ITV used in the study had a cracking pressure of 35cmH₂O, higher than the currently commercially available ITDs (generally ~15cmH₂O), which they hypothesis may have resulted in airway obstruction during CPR.

Recommendation that assisted ventilation or spontaneous breathing are required when using ITD.


Level 5 (porcine model), fair,(not blinded), supportive.

Small (n=17) controlled trial of ITD + ACD-CPR vs ACD-CPR alone in a porcine model of induced VF
Primary outcome ROSC following defibrillation; after 16 minutes of VF and 13 minutes of ACD-CPR, 6/8 pigs in the ITD group were successfully resuscitated with <3 successive 150-J shocks, whereas only 2/9 pigs with ACD-CPR alone were resuscitated with equivalent energy levels (P < .02)

ITD increased coronary perfusion pressure, myocardial flow and cerebral flow compared with no ITD

Insertion of the ITD led to significantly lower PO₂ and arterial pH after 7mins of ACD-CPR, however authors state that the values were within ‘normal physiological limits’

KG Lurie is co-inventor of the ResQPOD (ITD) and Chief Medical Officer at Advanced Circulatory Systems (manufacturing company).


Level 5 (porcine model), fair, supportive.

Small (n=15) cross-over trial (non-blinded) of ITD + S-CPR vs S-CPR in a porcine model of induced VF. Mechanical S-CPR (no active decompression), bag ventilation.

ITD significantly increased myocardial and cerebral flow compared with no ITD in S-CPR.

KG Lurie is co-inventor of the ResQPOD (ITD) and Chief Medical Officer at Advanced Circulatory Systems (manufacturing company).


Level 5 (porcine model), good, supportive (for CPP)

Small (n=22), prospective, randomised, double-blinded, controlled trial of ITD vs sham-ITD during S-CPR in porcine model of VF.
Study followed Utstein guidelines for laboratory CPR research. Mechanical CPR, bag ventilation, animals intubated. All animals defibrillated 17mins post cardiac arrest induction. Primary endpoint coronary perfusion pressure (CPP), other endpoints ROSC, 15 minute survival and vital organ perfusion.

After 2 min of CPR, mean +/- SEM CPP was 14 +/- 2 mm Hg with the sham valve versus 20 +/- 2 mm Hg in the ITD group (p < 0.006). CPP remained significantly higher for the ITD group post-CPR.

ROSC was achieved in 6/11 in the ITD group vs 3/11 in control group (not significant).

Cerebral blood flow was 75% of baseline value in ITD group vs 58% of baseline value in control group (p<0.05)

KG Lurie is co-inventor of the ResQPOD (ITD) and Chief Medical Officer at Advanced Circulatory Systems (manufacturing company).


Level 5 (animal study), good, supportive.
Prospective, randomised, double-blinded, controlled trial of ITD vs sham-ITD in S-CPR (n=40). Study followed Utstein guidelines for laboratory CPR research. Porcine model of induced VF. Animals intubated, mechanical CPR, ventilated with 100% O₂ via demand-valve resuscitator, defibrillated 12 minutes post VF induction. Primary end-points 24-hour survival and 24-hour neurological function, assessed by validated instruments (Swine Neurological Deficit Score, Cerebral Performance Score).

11 /20 animals (55%) in the control group versus 17/20 (85%) in the ITD group survived for 24 hours (p<0.05). Neurological scores were significantly higher with the ITD; the cerebral performance score (1=normal, 5=brain death) was 2.2+/-0.2 with the sham ITD versus 1.4+/-0.2 with the active ITD (p<0.05). A total of 1/11 in the sham versus 12 /17 in the active ITD group had completely normal neurological function, as assessed via Swine Neurological Deficit Score (p<0.05).


Level 5 (animal study), fair (underpowered), neutral
Small (n=30), randomised, double-blinded, controlled trial comparing the use of an ITD vs a sham-ITD in S-CPR, for a porcine model of prolonged (8 min) induced VF. Animals were intubated, mechanical S-CPR used, ventilated with 100% O₂ via a volume-cycled ventilator (30: 2). Adrenaline, vasopressin, propranolol and sodium bicarbonate were administered after the first three cycles of S-CPR (~1 min S-CPR). Animals received 150J rescue shock after 9 cycles of S-CPR + drugs. S-CPR/defib cycle continued while ever animal was in VF up to 20 minutes (=failed resuscitation). Outcomes were CPP, ABG values, ROSC, and 20 minute survival. Study detected no significant difference in any outcomes between the ITD group and the sham-ITD group.


Level 5 (animal study). Fair (not blinded, underpowered, selection bias?). Opposing.
A case-control study of 36 pigs, nested within an RCT examining the effects of a selective A₃ antagonist on VF and resuscitation. Animals for this study were selected sequentially from the RCT (non-random). Study used 15:1 compression: ventilation ratio (intrathoracic pressure ‘normalised’ every 15 compressions). Coronary perfusion pressure was measured over 15 compressions (giving lower ‘average’ CPP than measurement of CPP over last 3 compressions of a cycle). Authors conclude that ITD-CPR did not improve CPP compared with S-CPR, and that ROSC and 20 minute survival were significantly lower in the ITD-CPR group (estimates in abstract above).


Level I. Good, supportive.
Prospective, well-randomised, double-blinded, controlled trial of ITD vs. sham-ITD in OHCA, analysed by intention-to-treat (n=22)
Inclusion criteria: all adult OHCA patients of presumed cardiac aetiology who were attended by the study research team (EMS physician + paramedic) in Milwaukee EMS catchment area (Researchers were on call during weekday business hours only). Patients also needed to be successfully ventilated via an ETT at scene, and undergo at least two minutes of invasive femoral arterial blood pressure monitoring during CPR to be included. Patients who were resuscitated or had resuscitation terminated prior to monitoring equipment placement were excluded. The active/sham ITD was placed between the ETT and the bag-valve resuscitator (not used with the bag-valve mask).
Standard cardiac arrest treatment was provided by EMS personnel (BLS by initial responders, ALS by second-tier response). The study research team was responsible for collection of haemodynamic data. However, early recognition that EMS personnel were providing excessive ventilation rates and incomplete chest recoil during CPR resulted in the study research team taking on the additional role of CPR ‘monitors’.
This study was temporarily halted after approx 50% enrollment, in order to address the observation of excessive ventilation rates by EMS personnel. Ventilation timing lights (12 flashes/min) were added to the study device (both sham and active), and Milwaukee EMS personnel underwent CPR retraining. Study enrollment was resumed after these two interventions, and authors report no significant differences in terms of primary outcome measurements pre and post-modifications.
The primary endpoint of the study was invasive femoral arterial blood pressure. Authors report two previous studies supporting the use of blood pressure measurements as a suitable surrogate for short-term survival rates.
40 OHCA patients were randomised to receive the sham/active ITD, 18 were subsequently excluded due to ineligibility (exclusion log included). Data was incomplete for another 5 patients due to cessation of CPR (ROSC/death). Data was reported for twelve patients treated with a sham ITD and 10 patients treated with an active ITD. Data was collected and reported in accordance with the Utstein guidelines for OHCA.
The mean systolic blood pressure was significantly higher for the active ITD group for all measurements: Systolic BPs [mean+/−S.D.] [number of patients treated at given time point] at T = 0 (mean time of first arterial BP measurement 14 min post ITD placement), and T=2, 5 and 7 min were 85+/−29 [10], 85+/−23 [10], 85+/−16 [9] and 69+/−22 [8] in the group receiving an active ITD compared with 43+/−15 [12], 47+/−16 [12], 47+/−20 [9], and 52+/−23 [9] in subjects treated with a sham ITD, respectively (p < 0.01 for all times).

Diastolic blood pressures were higher for the active ITD group, but did not reach statistical significance. No clinically significant adverse events or complications were reported for either group. Of interest is the identification of 11/22 patients experiencing 'pseudo-PEA' - increasing blood pressure with each cardiac depolarization, presenting with unpalpable femoral pulses.


Level 1. Fair (underpowered for survival, no VF patients). Supportive
Prospective, well-randomised, double-blinded, controlled trial of ITD vs sham-ITD in ACD-CPR for OHCA (n=21). First trial of ITD in human cardiac arrest. Inclusion criteria: adult patients with OHCA (October 1997, Paris; France) who were treated by an ALS/EMS team accompanied by the study physician. Exclusion criteria: terminal illness, thoracic trauma, hypothermia, delay >30mins between cardiac arrest and commencement of CPR, patients presenting in VF (due to defibrillation attempts preventing femoral line insertion?). 33 consecutive OHCA patients were randomised to the active/sham ITD. 12 patients were subsequently excluded - generally due to inability to obtain femoral access (exclusion log included).

All patients in this study had an initial rhythm of asystole on arrival of ALS personnel (mean time to arrival 20mins post-arrest), were subsequently intubated, randomised to sham/active ITD, and 30 minutes of active compression-decompression CPR was performed. Adrenaline (1mg) was administered every 5 minutes. Outcomes were ETCO₂, SaO₂, coronary perfusion pressure (CPP), diastolic blood pressure and time to ROSC. Haemodynamic measurements were obtained via invasive femoral monitoring, recorded every 5 minutes (immediately prior to adrenaline administration). Haemodynamic measurements started approx 30 mins post arrest.

The mean time from intubation to ROSC was significantly shorter in the active ITD group (4/11 pts ROSC, 19.8+/−2.8mins) compared with the sham ITD group (2/10 pts ROSC, 26.5+/−0.7mins) (p=0.03). Only 1 patient from each group survived to hospital discharge (reported as ‘with no neurological impairment’ – not stated how this was assessed).

The mean maximal ETCO₂ was significantly higher in the active ITD group (19.1+/−1.0 mmHg) compared with the sham ITD group (13.1+/−0.9mmHg) [95% CI for difference 2.2 to 9.2mmHg, p<0.001]

The mean maximal diastolic blood pressure was significantly higher in the active ITD group (56.4+/−1.7mmHg) compared with the sham ITD group (36.5+/−1.5mm Hg) [95% CI for difference 14.3 to 23.8mmHg, p<0.001]

The mean maximal CPP was 70% higher in the active ITD group (43+/−1.6mmHg) compared with the sham ITD group (25.5+/−1.8mmHg) [95% CI for difference 12.4 to 22.8mmHg, p<0.001]. CPP was calculated as diastolic femoral arterial pressure – central venous pressure.

KG Lurie co-author.


Level 1. Good. Supportive.
Prospective, multicentre, blinded, randomised, controlled trial comparing the use of the ITD with a sham-ITD in ACD-CPR for OHCA. Trial conducted in 4 ‘two-tiered’ EMS systems in Paris, France between Sept 1999 and August 2009. Good randomization. Inclusion criteria: all adult OHCA patients treated by an ALS team. Pts were excluded if there was ROSC before ALS arrival, NFR orders, terminal illness, arrest to CPR time >30min or had sustained traumatic injuries.

Patients were randomised to active/sham ITD on arrival of ALS personnel (mean time to arrival 17min post-arrest). BLS was provided by first tier responders – comprised BVM ventilation and ACD-CPR. ALS personnel intubated pt and continued providing ACD-CPR for a minimum of 30min, administering 1mg adrenaline every 3-5 minutes. 200 patients were randomised to each arm of the study (total n=400). Primary endpoint was 24hour survival, other endpoints: ROSC, ICU admission, hospital discharge, neurological score at discharge.
Data collection complied with Utstein guidelines for OHCA reporting. Data was analysed on an intention-to-treat basis.

74.5% of patients had an initial rhythm of asystole on arrival of ALS (function of >17min response time?) 23% were in VF/pulseless VT and 2.5% were in PEA.

The 24-hour survival rates were significantly higher in the active ITD group (64/200) compared with the sham ITD group (44/200) (p=0.02)

The ICU admission rates were significantly higher in the active ITD group (79/200) compared with the sham ITD group (57/200) (p=0.02)

ROSC rates and hospital discharge rates were both higher in the active ITD group (96/200, 10/200 respectively) than in the sham ITD group (77/200, 8/200), but did not reach statistical significance (ROSC p=0.056, discharge p=0.63).

No significant difference between the sham and active device in respect to neurological scores on discharge or CPR complication rates. No adverse events related to the ITD were detected.

KG Lurie co-author


Level 1. Fair. Supportive.
Prospective, single-centre, randomised, blinded, controlled cross-over trial of active vs sham-ITD in OHCA.
Inclusion criteria: adult OHCA patients treated by ALS personnel in a single two-tiered EMS system in Paris, France. Patients were excluded if there was ROSC before ALS arrival, NFR orders, terminal illness, arrest to CPR time >30min or traumatic injuries.
Patients were enrolled on arrival of ALS personnel, who sequentially ventilated the patient with a sham ITD attached to a facemask (with added head-strap) for 1 minute, then an active ITD attached to a facemask for one minute, in computer-randomised order. ALS personnel were blinded to the sham/active status of the device. The patient was then intubated, and ventilated for 1 minute with both the sham and the active device (in random order/blinded). ACD-CPR was continuously performed. For the 4 minute procedure, a monitor continuously measured upper airway pressures as a surrogate for intrathoracic pressures. No reference supporting use of upper airway pressure as a surrogate measurement.
Primary endpoint was maximum negative upper-airway pressure (during decompression phase of ACD-CPR)
16 patients were enrolled; two excluded because of vomiting/pulmonary haemorrhage prior to intubation, a further two had ROSC during the study protocol.
Complete data was collected for n=12 patients. Data reported as intra-thoracic pressures (not upper-airway pressures)

The mean maximum negative ‘intrathoracic’ pressure (+/-SD) (during decompression phase of CPR) was significantly greater for the active ITD + facemask (-4.6 +/-3.7mmHg) compared with the sham ITD + facemask (-1.0 +/-0.73mmHg) (p=0.003)
The mean maximum negative ‘intrathoracic’ pressure (+/-SD) (during decompression phase of CPR) was significantly greater for the active ITD + ETT (-7.3 +/-4.5mmHg) compared with the sham ITD + ETT (-1.3 +/-1.3mmHg) (p=0.0009)

No vomiting/aspiration reported with either sham or active device.


Level 5 (animal study). Good. Supportive.
Small (n=14) randomised, controlled trial of ITD+ACD-CPR + vasopressin vs. S-CPR +vasopressin in a porcine model of hypothermic VF. Study end-points were coronary perfusion pressure (CPP) and common carotid blood flow.
Supportive for the use of ITD + vasopressin in hypothermic cardiac arrest to achieve increased CPP and common carotid blood flow without rewarming.

Level 3 (historical control). Good. Supportive.
Prospective case-control study of ITD in the pre-hospital management of OHCA in Staffordshire, England.
181 cases of adult OHCA treated with S-CPR + ITD were matched with 808 historical OHCA controls (no ITD) from the previous year. Exclusion criteria (cases and controls): likely traumatic cardiac arrest etiology, ROSC prior to intubation, age <21 yrs. EMS personnel were all trained in the use of the ITD and underwent ‘refresher’ training in CPR just prior to the study commencement, but were not formally ‘retrained’ to the study ITD model. The primary endpoint was survival (with spontaneous perfusing pulse) to ED admission (study authors were unable to access post-admission records for longer-term survival rates).

In all patients (irrespective of presenting rhythm), use of the ITD resulted in significantly higher percentage of patients surviving to ED admission, compared with the historical controls (61/181 [34%] vs. 180/808 [22%, p=0.005]

Survival to ED admission for patients presenting in asystole in the group receiving an ITD was significantly higher (26/76 [34%]) compared with historical controls (39/351 [11%], p=0.001)

For patients presenting in VF, pulseless VT or PEA, the use of the ITD was associated with increased rates of survival compared with the controls, however the differences did not reach statistical significance.

No clinically significant adverse events or complications were reported to result from the use of the ITD.

Authors report that the ITD was ‘easy to use, easy to teach and... readily integrated into standard cardiac arrest care’, based on observations of the prospective cases.


Level 5 (animal study). Fair (small, not blinded). Supportive.
Small (n=16) randomised, controlled trial of the effects of PEEP+ITD+ACD-CPR compared with ITD+ACD-CPR+IPPV in a porcine model of induced VF. Randomisation protocol not stated.
Mean +/- SEM arterial oxygen partial pressure decreased in the IPPV group from 150 +/- 30 at baseline after 8 min of CPR to 110 +/- 25 torr at 24 min, but increased in the PEEP group from 115 +/- 15 to 170 +/- 25 torr with increasing levels of PEEP (P <0.02 for comparisons within groups).
Coronary perfusion pressure reported as ‘comparable’ between groups.


Level 1 (RCT), good, supportive.
Randomised, controlled trial (n=210) of S-CPR vs. ACD-CPR +ITD in the prehospital management of cardiac arrest in Mainz, Germany.
All EMS personnel involved in the study completed training in the application of ACD-CPR and the ITD, as well as refresher training in S-CPR (to ensure compliance with AHA/ERC CPR protocols)
Adult OHCA patients were randomised upon arrival of ALS personnel (second tier response) Exclusions were: cardiac arrest of presumed traumatic aetiology, ROSC before intubation, unable to place ETT, NFR orders, time elapsed between arrest and commencement of CPR >15min. Exclusion log included. Data collected in accordance with Utstein OHCA guidelines.

Data demonstrated a statistically significant increase in ROSC (57/103), 1 hour (53/103) and 24hour (38/103) survival rates for all patients who were treated with ACD-CPR + ITD compared with all patients treated with S-CPR (40/107, 34/107, 24/107 respectively)(p=0.016, p=0.006, p=0.033).

The 1 hour survival rate for patients with a witnessed arrest presenting in VF were more than doubled when treated with ACD-CPR + ITD compared with S-CPR (68% vs 27%, p=0.002)
For OHCA patients where the time interval from arrest to CPR commencement was >10 minutes, the use of ACD-CPR + ITD resulted in a 1 hour survival rate of 44% compared with a rate of 14% for S-CPR (p=0.005)

No significant difference in complication/adverse effects (excepting superficial ecchymosis with ACD-CPR device)


Level 5 (animal study). Good. Supportive.
Randomised, controlled trial of 30:2 compression: ventilation (C:V) ratio with 15:2 C:V ratio, with and without ITD. Porcine model of induced VF (n=18).
Increasing C:V ratio from 15:2 to 30:2 increased the mean number of compressions delivered per minute (via mechanical CPR device) from 66+/−2 to 84+/−2 (p<0.0001), and reduced the mean off-chest time from 20.33+/−1.44 secs/min to 9.6+/−0.96 secs/min (p<0.0001)
Increasing the C:V ratio significantly improved coronary perfusion pressure, common carotid blood flow, end-tidal CO2 and venous oxygen saturation. These values also improved incrementally and significantly with the addition of an ITD (both for 15:2 ratio and 30:2 ratio). The greatest values were obtained for the combination of ITD + 30:2 C:V ratio.
ROSC was obtained in 1/9 pigs with 15:2 ratio + ITD and 6/9 pigs with 30:2 ratio + ITD (p<0.03)