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

**Worksheet author(s)**

<table>
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<th>Dianne L. Atkins</th>
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**Date Submitted for review:** Sept 2008  
Revision May 2009  
August, 2009  
Jan 2010

**Clinical question.**

Peds-029 "In infants and children in cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of any specific paddle/pad size/orientation and position (I) compared with standard resuscitation or other specific paddle/pad size/orientation and position) (C), improve outcomes (e.g. successful defibrillation, ROSC, survival) (O)?"

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

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

**Conflict of interest specific to this question**

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? I have published on paddle size. I have no financial conflicts of interest

**Search strategy (including electronic databases searched).**

- Electric countershock/instrumentation electrodes (763 citations)
- Electric countershock/instrumentation electrodes NOT implanted, electrodes (281 Citations)
- Electric countershock/instrumentation electrode limits 0-18 years (55 citations)
- Electric countershock/* electrodes limits 0-18 years (80 citations)

**EMBASE search:**

- Electric countershock  2004-2008  105 citations

**Cochrane External**

- Defibrillation electrodes  9 articles

**AHA Endnote library:** Defibrillation electrodes

Search repeated on August 17, 2009 with no new articles

**State inclusion and exclusion criteria**

**Inclusion criteria:** Pediatric, adult, animal and manikin studies

**Exclusion criteria:** Abstracts, reviews, editorials  
Implanted cardioverter-defibrillators  
Rhythms other than cardiac arrest rhythms in adults (Did include one pediatric paper with supraventricular rhythms)

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

- 27
- 1 LOE 2; 3 LOE 4; 23 LOE 5
# Summary of evidence

## Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
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<tr>
<td>Atkins 88 E2</td>
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<td>Samson 95 E2</td>
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<td>Killingworth 02 A</td>
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<td>Kerber, 81 E2</td>
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<td>Hoyt 81 E2</td>
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<td>Lerman 1990 E</td>
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<td>Dalzell, 1981 E1</td>
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<td>Tibballs In Press A, E2</td>
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<td>Pagan-Carlo, 96 E2</td>
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<td>Deakin, 03 E2</td>
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<td>Dodd 2004 E2</td>
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<td>Schuder 87 E</td>
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<td>Weaver 1993 E2</td>
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<td>Perkins 2002 E3</td>
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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
- **E1** = Termination of VF
- **E2** = Transthoracic Impedance
- **E3** = Time to defibrillation

**Italics** = Animal studies
### Evidence Neutral to Clinical question

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**Kerber 84 E2, E1**  
**Pagan-Carlo 97 E**  
**Karlsson, 01 E1, E2**  
**Garcia 98 E2**  
**Drury, 2001 E2**  
**Deakin 98 E2**  
**Deakin 2001 E2**  
**Perkins 2007, E3**

**Caterine 97 E2**  
**Heames 01 E**  
**Adams 2005 E**  
**Perkins 2002 E3**

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### Evidence Opposing Clinical Question

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**Cornwall 05 E**

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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  
*Italics = Animal studies*  
E1 = Termination of VF  
E2 = Transthoracic Impedance  
E3 = Time to defibrillation
Successful transthoracic defibrillation is dependent on the myocardial current density which traverses the heart. During delivery of a shock, the operator chooses an energy level, which does not directly translate to current. Current delivery is dependent on transthoracic impedance and the amount of current shunted through the thorax. Transthoracic impedance is a function of the tissue, electrode surface area, pressure on the electrode and to a lesser extent body size. Current flow shunted through the thoracic cavity is dependent on chest geometry and relative resistivities of thoracic tissues and the location of the paddles. The range of transcardiac current fraction, defined as the ratio of transcardiac current to transthoracic current, is 1-10% with an average of 4% (Lerman, 1990). This transcardiac fraction can be greatly altered by clinical conditions such as pleural effusion or pneumothorax. Adding to the complexity of this is that measurement of myocardial current is difficult, requiring implantation of multiple electrodes and application of multiple shocks. Thus most studies are performed in animals (Hoyt, 1981, Pagan-Carlo 1997) or adults undergoing surgical implantation of ICDs (Lerman, 1990). One pediatric study measured delivered current in patients undergoing elective cardioversion for atrial arrhythmias. (Atkins 1994)

There is one study (Tibballs In Press, used with permission) position which evaluated ROSC in children, based on paddle position or paddle type and there was no difference between the two methods. Transthoracic impedance did not differ significantly between the two methods either. There is one study in adults where larger paddles improved defibrillation success in adults (Dalzell, 1989). Rather the surrogate outcome of transthoracic impedance is the usual measure.

**Electrode size**

There are many (Kerber 81, Dalzell 89, Samson 95, Atkins 88, Atkins 94, Hoyt 81, Pagan-Carlo 97, Killingsworth 02), studies which demonstrate that pad size alters transthoracic impedance, which by extrapolation may affect defibrillation success. Larger pads consistently have lower TTI than smaller. There is one human study that documents a higher defibrillation success with larger paddles (Dalzell 89). Large paddles are preferable to small paddles. However, hand-held paddles may not have good skin-to-paddle contact especially in the apical position. Large self-adhesive pad appear to provide the best success.

**Electrode type**

Self-adhesive pads have enjoyed increasing use in EMS and hospitals over the past two decades. Pads are disposable, allow operation “distant” from the patient, and can be kept on a patient for repeated use. Measured TTI is comparable to hand-held pads.(Kerber 1984, Samson 1995, Deakin, 1998, Deakin 2003) However, if pads are not applied firmly to the chest or remain on the chest for long periods of time, the TTI will increase. (Drury 2001, Deakin 2001) Self-adhesive pads may require more time to apply (open the package, connect to defibrillator and apply to patient) compared to hand-held paddles which are often kept attached to the defibrillator. (Adams 2005) However, Perkins (2002 and 2006) testing experienced providers, have shown that time to defibrillation in manikin studies does not differ if self-adhesive pads or hand-held paddles are used. There are minor differences of TTI among various manufacturers of self-adhesive pads, but these are probably not clinically significant. To date there are no studies comparing hand-held or self-adhesive pads to defibrillation success, ROSC or survival. Tibballs et al (In Press) found no difference in ROSC between pads or paddles during pediatric defibrillation.

**Electrode position**
The AHA has recommended three positions for defibrillation electrodes: Anterior-apex, anterior-posterior and anterior-anterior. The goal is the position the pads to that the heart is between the pads, orienting the current flow through the heart. Pad position is classically apex-anterior or anterior-posterior. Polarity of the pads is usually anode is anterior and cathode apex, so current goes from the apex to the anterior paddle. Typically the orientation of the pad is longitudinal (long axis of the pad parallel to long-axis of the patient). There is no evidence that position affects transthoracic impedance in adults, (Garcia 1998, Dodd 2004) children (Atkins, 1988) or defibrillation success in animals (Killingsworth, 2002). However, placing the pads too close together (< 3 cm apart) (Caterine 1997) over the adult female breast (Pagan-Carlo, 1996) increases transthoracic impedance while placing the apical pad in a horizontal position rather than a vertical one lowers transthoracic impedance (Deakin 2003). Additionally, polarity does appear to alter TTI (Karlsson, 2002). Tibballs et al (In Press) found no difference in ROSC between anterior-posterior or anterior-lateral position during pediatric defibrillation.

### Acknowledgements:

### Citation List


*LOE 5 Neutral Fair design. Manikin study comparing ease of connecting and time required to connect two different electrode adaptors to the defibrillator. These are used with self-adhesive pads. Both took over 60 seconds to achieve defibrillation but one was significantly longer than the other. Subjects were resident physicians with little experience in CPR. Not randomized to paddle or pad application. Time to defibrillation with hand-held paddles was not compared.


*LOE 3 Supporting Good First paper to look at TTI in children. TTI measured with validated technique. Crossover design with each TTI measured in each patient (except infants) with both sized paddles. Pediatric hand-held pads have very high impedances and should be limited to children < 10-15 kg (current recommendation)


*LOE 5 Supporting Good Pediatric study confirming that TTI is very high in the standard size hand-held “ pediatric electrodes” during actual shock delivery. Rhythms were atrial flutter and SVT, not cardiac arrest. Authors recommend using large “adult” paddle as soon as they fit on the chest.


*LOE 5 Neutral Fair This is a small study, and supports the current AHA recommendation. Only looked at TTI and not actual defibrillation successes

**Cornwell, L, Mukherjee R, Kelsall AWR.** Problems with the use of self-adhesive electrode pads in neonates
LOE 4 Opposing Poor Case report of two premature infants where self-adhesive pads were too large to place on chest.


LOE 5 Supportive Good Larger pad sizes are associated with higher defibrillation rates. Only clinical study to document improved defibrillation in humans


LOE 5 Neutral Good quality. TTI measured using both hand-held paddles and self-adhesive pad in adult males. Although statistical differences were found, the differences are probably not enough to make a clinical difference. One set of self-adhesive pads had a mean TTI approximately 50% higher, which illustrates the problem of pad composition.

Deakin CD, Petley GW, Drury NE, Clewlow F. How often should defibrillation pads be changed?: the effect of evaporative drying. Resuscitation. 2001 Feb;48(2):157-62

LOE 5 Neutral Good quality. Not directly related to question, so not used in CoS statements. But shows that self-adhesive pads begin to dry out within 30 minutes and this is accompanied by a rise in TTI.


LOE 5 Supportive Good Small study, using hand-held paddles. TTI measured with validated technique is both positions in each subject. The transverse position with hand-held paddles probably increases the surface area of skin to paddle contact, which decreases TTI. This is probably not as important with self-adhesive pads. Only looked at TTI and not actual defibrillation successes


LOE 5 Fair design TTI measured with self-adhesive pads and hand-held paddles on the anterior-apex and anterior-posterior positions. Adult patients. TTI lower in both AP and AA positions with hand-held pads compared to self-adhesive pads. electrode position. Difference is probably related to pressure applied when holding hand-held pads rather than a difference in the pads or the position.

Drury NE, Petley GW, Clewlow F, Deakin CD. Evidence-based guidelines for the use of defibrillation pads Resuscitation. 2001 Dec;51(3):283-6

LOE 5 Neutral Good quality. Not directly related to question, so not used in CoS statements. But shows that self-adhesive pads begin to dry out within 30 minutes and this is accompanied by a rise in TTI. This drying is not altered by passage of electrical current through the pads.

Garcia LA, Pagan-Carlo LA, Stone MS, Kerber RE. High perimeter impedance defibrillation electrodes reduce skin burns in transthoracic cardioversion Am J Cardiol. 1998 Nov 1;82(9):1125-7

LOE 5 Neutral Good Small study looking at skin burns with high impedance electrodes. No shock delivery Not used in review

LOE 5  (Good) No position was superior to another. Only looked at TTI using a validated test technique and not during shock delivery or actual defibrillation successes.


LOE 5  Neutral Fair Study evaluating correct pad placement among physicians at all levels (experienced and trainee). There was a high frequency of incorrect pad placement especially with the apical pad. There was no relationship to experience or a CPR course within 3 years of the study.


LOE 5  Supportive Good Excellent animal study measuring intracardiac current in dogs with VF. Larger paddle size increase intracardiac current. 12 cm paddles produced the highest intracardiac current. Increasing shock energy increased Intramyocardial current.


LOE 5  Supportive Good Electrode polarity or position had no effect on defibrillation. Adult population. Defibrillation success measured, but this was short duration.


LOE 5  Supportive Good Paddle decreased TTI during defibrillation for VF. Defibrillation success not compared between paddle sizes. Patient population was adults and paddles were standard or extra large adult paddles. Controlled randomized.


LOE 5  Neutral Good Not directly pertinent to question, but does demonstrate the equivalence of hand-held paddles to self-adhesive paddles. Paddle position did not affect success. Since study was performed in cardiac EP lab, high shock success is expected and this cannot be used to predict outcomes for long duration cardiac arrest.


LOE 5  Supportive Good Study demonstrates that the electrode pads should be at least 3 cm apart for adequate transmission of the electric current into the chest. It supports the current recommendation that adult sized pads be used as soon as the chest can accommodate the pads and be 3 cm apart. The study did not evaluate specific positions of the pads.

LOE Background study to explain relationship between transthoracic current and transmyocardial current. Only 4-10% of transthoracic current passes through the myocardium for a given shock. Various clinical situations will alter this percentage. Not used in review.


LOE 5 Supportive Fair One situation where pad placement directly affects TTI. All diagrams of pad placement are of male models. This suggests that diagrams of placement on females may be beneficial.


LOE 5 Neutral Good Animal study measuring intracardiac voltage gradient as a measure of intracardiac current with varying paddle sizes. Unable to demonstrate a specific relationship between paddle size and voltage gradient. Current was highest at intermediate paddle sizes. Larger pads may relative to size of chest may actually decrease intracardiac current.


LOE 5 Neutral Fair No difference demonstrated in time to first shock between using pads or paddles in a manikin study. Persons tested were nurses and physicians who had previously been trained in ALS.


LOE 5 Neutral Good Randomized cross-over design. No difference demonstrated in time to first shock between using pads or paddles in a manikin study. Primary outcome of study was time to defibrillation comparing 2005 ERC and AHA recommended sequences for CPR, paddle/pad application and shock delivery. Secondary outcome was time to defibrillation comparing pads and paddles within each sequence.


LOE 4 (Good) Study demonstrating that TTI increases with declining surface area of self-adhesive pads.

Schuder JC, Stoeckle H, McDaniel WC, Dbeis M. Is the effectiveness of cardiac ventricular defibrillation dependent upon polarity? Medical Instrumentation. 21(5):262-5, 1987

LOE 5 Neutral Fair Another study which looked at defibrillation success. However animals were quite large 100 kg.


LOE 4, Supportive Fair Quality. Only study to evaluate only ROSC based on pads vs paddles and position. Data collected contemporaneously (not a completely retrospective study) but no controls and operators allowed to chose energy dosages. No difference in ROSC was observed between paddle/pad position or type. Primary emphasis of paper was on defibrillation dosing.

LOE 5 Supportive Fair. Large case series of out-of-hospital cardiac arrest. Although actual position was not varied, this study demonstrates that polarity does not affect defibrillation success.