**Clinical question.**

"In adult 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 (eg. 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 of existing worksheet

**Conflict of interest specific to this question:** NONE

**Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet?** NONE

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


All EBM Reviews (included Cochrane, DARE, ACP Journal Club)= ("padS" OR “transthoracic” OR "transsthoracic impedance" OR "transsthoracic resistance" OR “impedance”) AND (“cardiopulmonary resuscitation” OR “heart arrest” OR “electric countershock”))=138 titles and abstracts (2 full text articles)

Web of Knowledge=(Topic=("Heart Arrest") OR Topic=("cardiopulmonary resuscitation") OR Topic=("electric countershock") AND Topic=(pad) OR Topic=(paddle) OR Topic=("transthoracic impedance") OR Topic=("transsthoracic resistance") OR Topic=("transthoracic impedance")=854 titles and abstracts (32 full text articles)

EMBASE=(("pad$" OR 'transthoracic impedance' OR 'transthoracic resistance' OR 'impedance'/exp) AND ('cardiopulmonary resuscitation'/exp OR 'heart arrest'/exp OR 'electric countershock'/exp)) AND [embase]/lim=240 titles and abstracts (1 full text article)

AHA Endnote Library=5 full text articles

Hand Search of Bibliographies=2 full text articles

*92 Full text articles pulled*

Updated search 7/20/09- PubMed, EMBASE, Web of Knowledge and all EBM Reviews- will include one article from PubMed-Stanaitiene 2008, Based upon combined search with Dr. Baubin- two more articles to include- Marrouche 2001 and Kratseya 2006

**total of 95 Full Text Articles Pulled**

**State inclusion and exclusion criteria**

Inclusion: 1) cardiac arrest either in-hospital or out-of-hospital 2) who receive defibrillation/cardioversion shock 4) all human and animal studies

Exclusion: 1) Studies of atrial arrhythmias , epicardial or transvenous electrodes.

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

95 full text articles reviewed- 36 met inclusion criteria

Excluded studies: 24 reviews/commentaries/practice guidelines, 17 defibrillation techniques (i.e. shock delivery, escalating shocks), 4 pads vs. paddle, 5 electrode-chest wall coupling agents, 5 paddle force, 4 duplicate studies (published in separate journals)
# Summary of evidence

## Evidence Supporting Clinical Question

<table>
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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 (Transthoracic Impedance, Defibrillation/ Cardioversion)  

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

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### Level of evidence

A = Return of spontaneous circulation  
C = Survival to hospital discharge  
E = Other endpoint (Transthoracic ImpedanceΓ, Defibrillation/ Cardioversion≈)  
B = Survival of event  
D = Intact neurological survival  
Italics = Animal studies

## Evidence Opposing Clinical Question

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### Level of evidence

A = Return of spontaneous circulation  
C = Survival to hospital discharge  
E = Other endpoint (Transthoracic ImpedanceΓ, Defibrillation/ Cardioversion≈)  
B = Survival of event  
D = Intact neurological survival  
Italics = Animal studies
There are no published RCT's on this topic. However, based upon the available evidence, we have based our final recommendations.

**Pad/Paddle Size** - 12 cm size appears to lower transthoracic impedance and decrease chance of myocardial necrosis (LOE 5 Camacho1995, 572; LOE 5 Connell 1973, 313; LOE 5, Dahl 1994, 956; LOE 5 Hoyt 1981, 818; LOE 3 Kerber 1981, 676; LOE 5 Thomas 1977, 463) in animal studies. There is one human study (LOE 3 Kerber 1981, 676 that found larger paddles (13cm compared to 8.5 cm) were more effective in reducing transthoracic impedance, however it was never linked to defibrillation success in these patients. The second study LOE 3, Dalzell 1989, 741 does poorly define defibrillation success, but finds that large pads do observe higher rates of defibrillation success with larger (12cm vs. 8cm) paddles. The literature shows that myocardial damage is greater with smaller electrodes (i.e. 4cm or 8cm), and rates of defibrillation success increase with large electrode sizes. However, there is a point of maximal benefit, after which the rates of defibrillation success decrease and transthoracic current increases (shunting current across the thorax rather than intracardiac). Four studies concluded that any person over 10kg, or who can accommodate adult size electrode pads on chest with at least 3cm separating the pads, should have adult pads placed (not pediatric sized pads).(LOE 5 Atkins 1994, 90; LOE 5 Atkins 1988, 914; LOE 5 Killingsworth 2992, 177; LOE 5 Samson 1995, 544) This is based upon lower rates of measured transthoracic impedance with the usage of “adult” size pads vs. “pediatric” size pads. The studies did not correlate this to defibrillation success. Based upon the animal studies on myocardial necrosis, decreased TTI in humans, and one human study on defibrillation success, the 12 cm pads do appear to be best when using monophasic defibrillators.

Position of Paddle - Appears that there is no position that is superior for ventricular arrhythmia defibrillation success. The studies are also mixed on the best position for atrial arrhythmia cardioversion. Anterior-apex was slightly superior to anterior-posterior for defibrillation in two study examining the interelectrode impedance in humans (no actual defibrillation/cardioversion delivered), (LOE 5 Caterine 1997, 588; LOE 5 Dalzell 1990, 903) and for atrial fibrillation cardioversion in humans. One study showed anterior-posterior position better for reducing TTI. (LOE 5 Krasteya 2006, 1009) However the majority of studies found all 4 (anterior-apex, anterior-posterior, anterior-left infrascapular, anterior right-infrascapular) positions are equally effective in ventricular defibrillation or elective atrial arrhythmia cardioversion success in humans, (LOE 2 Kerber 1985, 57; LOE 5 Stanaitiene 2008, 665) decreasing transthoracic impedance in computer simulation (LOE 5 Camacho1995, 572), decreasing electrode skin impedance in humans (LOE 5 Lateef 2000, 381) and increasing myocardial current delivery in humans.(LOE 4 Lateef 2000, 381) These are all factors that increase effectiveness of shock delivery.

In the setting of atrial fibrillation,six studies (LOE 5 Boodhoo 2007, 16; LOE 5 Brazdzioyte 2006, 994; LOE 5 Chen 2003, 921; LOE 5 Dodd 2004, 283; LOE 5 Kerber 1981, 658; LOE 5 Mathew 1999, 576) showed that no one position was superior for cardioversion. In two studies, the anterior-posterior position was superior to anterior-apex for defibrillation success in pigs (LOE 5 Karlsson 2001, 77) and computer modeling simulation,(LOE 5 Panescu 1995, 185) Two studies for atrial fibrillation cardioversion in humans ( LOE 5 Botto 1999, 726; LOE 5 Kirchhof 2002, 1275) showed better results with an anterior-posterior position.

Other- Pad should be placed below the female breast.(LOE 5 Pagan-Carlo 1996, 449) Hirsute males should be shaved prior to application of pad.(LOE 5 Bissing 2000, 587; LOE 5 Sado 2004, 98) Polarity of pads was important in two studies,(LOE 5 Schuder 1987, 262; LOE 5 Taren 1997, 183) but not significant in one study.(LOE 5 Karlsson 2001, 77) Ensure that electrode gel is not smeared between pads (LOE 5 Caterine 1997, 588) as this shunts electrical energy away from the myocardium and results in more energy delivered transthoracically. One study compared the longitudinal vs. horizontal application of the apex paddle in the anterior-apex orientation. One study measured TTI in men using paddles and pads (LOE 5 Deakin 1998, 43) The longitudinal application of the paddle over the lateral aspect of heart increased contact with the skin surface and decreased overall TTI, which may result in better delivery of myocardial current. (LOE 5 Deakin 2003, 15)

The studies included in this systematic review of the literature were conducted with defibrillators using monophasic waveforms, except for three studies. (LOE 5 Brazdzioyte 2006, 994; LOE 5 Karlsson 2001, 77; LOE 5 Killingsworth 2992, 177) and one in addition which compared the effect of monophasic vs biphasic waveform (LOE 5 Stanaitiene 2008, 665). Because biphasic waveforms may be different in overcoming TTI, the role of increased pad size in decreasing TTI as a surrogate marker of improved defibrillation success is not clear in humans. Subsequently, further
research is needed on the role of pad size, placement, and orientation in the setting of biphasic waveforms, as the role of biphasic waveforms is not proven to be the same as monophasic in context to TTI.

Acknowledgements:
Alice Beckman, B.S. for her assistance with article retrieval.

Citation List


LOE 5. Good. Neutral
Randomized controlled trial with single-blinding looking at paddle position for cardioversion of atrial fibrillation/atrial flutter. Suggest that anterior-lateral (AL) position is better than anterior-posterior (AP).


LOE 5. Fair. Supporting
Study determines TTI for pediatric patients newborn to 8 years. There was no control group. Confounders not taken into account (i.e. weight, chest size). Patients were actually defibrillated, but defibrillation success not reported in results, only TTI. Recommendation is that "adult" sized patches can be used at body weights greater than 10kg.


LOE 5. Good. Supporting
Study determines TTI for patients age 6 weeks to 15 years old. However, 10 out of the 47 patients could not have "adult" sized pads placed because their thorax was too small. Confounders are controlled for, outcomes are well-measured but not blinded. Study suggests that pediatric patients >10 kg can utilize "adult" sized pads.

We determined transthoracic impedance (TTI) before and after shaving in 9 hirsute and 11 nonhirsute subjects. TTI in hirsute subjects was mean +/- SE 162 +/- 11 versus 103 +/- 6 ohms in nonhirsute subjects (p <0.01); TTI decreased to 105 +/- 3 ohms after shaving the hirsute chests (p <0.01).

LOE 5. Fair. Supporting
This study has a small sample size (n=20). Confounders are not controlled for. Outcomes are not blinded and there is no randomization. Study recommends that hirsute males be shaved to decrease TTI.

not fitting the question, but ok

LOE 5. Good. Neutral
Randomized controlled trial comparing different shocks and AP vs. AL vs. PA pad placement for the cardioversion of atrial fibrillation. Initial shock energy was significant, but pad position was not significant in the overall success rates of cardioversion.
Cardioversion, comparison of protocols but not directly positions -


LOE 5. Good. Neutral
Randomized controlled trial that determines success of atrial fibrillation/flutter cardioversion. Unknown randomization technique. AP is superior to AL position for cardioversion, however this success is linked to duration of atrial arrhythmia prior to cardioversion. As a result, unsure of the application of this study cases of acute onset of arrhythmia (i.e. ventricular fibrillation) in the setting of defibrillation.


LOE 5. Good. Neutral
This is a non-blinded randomized controlled trial for cardioversion of atrial fibrillation with AP vs. AL paddle positions using biphasic waveform. AP and AL positions had no clinically significant differences in cardioversion success.


LOE 5. Fair. Supporting
3-D computer model of human thorax that simulated 8 cm vs. 12 cm paddles to measure myocardial current density and uniformity. Compared to 8cm paddles, 12 cm paddles have better shock delivery. All 4 paddle positions (precordial vs. anterior-posterior vs. lateral-lateral and parasternal-infrascapular) resulted in uniform delivery of shock.


LOE 5. Fair. Supporting
This study measures interelectrode impedance and transcardiac current while comparing to apex-anterior placement to parasternal-anterior placement with and without smearing of gel and post-exercise (sweat and vasodilatation). Improper application of electrodes and gel but not sweating and vasodilation substantially degrades
transcardiac current; There is a small sample size (n=10), outcomes were not blinded, and confounders not controlled for. It does suggest that the anterior-apex approach with no smearing of gel between pads results in the best delivery of shock.


LOE 5. Good. Neutral
This a randomized-controlled trial examining the cardioversion of atrial fibrillation in the AP vs. AL position. Although success rates for cardioversion were similar for both positions, the TTI was lower for the AP position. The TTI also was the greatest predictor of success of cardioversion. As a result, there is no specific recommendation for pad position for cardioversion.


LOE 5. Fair. Supporting
This is a dog study (n=16) comparing the TTI of different paddle sizes. The outcomes are not blinded, and no confounders are controlled for. The 12 cm paddles with electrode paste did appear to have the lowest TTI.


LOE 5. Good. Supporting
This is a dog study measuring myocardial necrosis and TTI with different paddle size (4.5 cm, 8.0, 12.8 cm) and different time intervals between delivery of shocks (15 second vs. 1 minute vs. 3 minute). The study recommends using the largest paddles (12.8 cm) with 3 minutes between shocks.


LOE 3. Fair. Supporting
This study compares 8cm/8cm pads vs. 8cm/12cm and 12cm/12cm paddles by measuring TTI and defibrillation "success." However, defibrillation success is poorly defined as any conversion from ventricular fibrillation to any other rhythm or asystole. It does not measure return of spontaneous circulation or any other clinical outcome. There are only retrospective controls with no clinical characteristics. The study does recommend that the 12cm/12cm combination is best.


LOE 5. Fair. Neutral
Transthoracic impedance was significantly greater in the AA than the AP position.

LOE 5 (Good) Supporting Transthoracic impedance differ between different paddles and pads


LOE 5. Good. Supporting
This is a pseudo-randomized study, with a small sample size (n=20). Outcome measure is TTI using paddles. Study concludes that the longitudinal orientation of a rectangular defibrillation apical paddle provides a lower TTI than orientation horizontally. Transthoracic impedance decreases as paddle force increases if paddle force equals 12 kg, both orientations work equally well. Application to pads was not discussed.


LOE 5. Fair. Supporting
This study compares pads vs. paddles in the AP vs. AL position for cardioversion of atrial fibrillation. The study has a small sample size (n=20), outcomes were not blinded and confounders were not clearly stated or controlled. AP and AL position yielded similar cardioversion success, with paddles having lower TTI than pads.


LOE 5. Good. Neutral
This study does not have a control group, but it does adjust for age, BMI and other confounders. TTI was similar for all three orientations- anterior-apex, apex-posterior, anterior-posterior and was more dependent upon body surface area.


LOE 5. Good. Neutral
This is a dog study measuring the amount of intracardiac current delivered by varying paddle sizes. The confounders were well controlled and the outcome well measured. The sample size was small and its applicability to humans was questioned in the study. The study did show that optimal paddle size varied by body weight and chest circumference, but generally the 12 cm diameter was best for a 20 kg dog. No specific paddle size recommendation was given.

LOE 5. Fair. Opposing
Very small pig study (5 animals completed full protocol) that measures defibrillation "success" due to paddle position. Defibrillation success is not clearly defined. Anterior-apex position had a lower defibrillation rate than anterior-posterior. The polarity of nodes did not make a significant difference.


LOE 3. Fair. Supporting
This is non-randomized study with non-blinded outcomes comparing 13 cm with 8.5 cm paddles. 13 cm paddles were better at reducing TTR, but authors did not tie into clinical defibrillation success. There is also a secondary study in 4 dogs that is described measuring the effect of paddle force. Firm contact pressure (50 newtons) decreases TTR by 31% as compared to light pressure (10N). Larger paddles also decrease TTR.


LOE 5. Good. Neutral
This study uses 8.5 vs. 13 cm paddles in AP vs. AL orientation for the cardioversion of a fibrillation. The patients were not-randomized and the outcomes were not blinded. Both paddle positions had no difference in cardioversion success. The TTI was less in the larger paddle size, but the same amount of energy was needed to cardiovert.


LOE 5. Fair. Neutral
This is a patient (n=80) and dog study (n=11) measuring defibrillation or cardioversion using pads. Defibrillation success is not clearly defined, patients are not randomized to treatments, and confounders are not accounted for. There was no difference in success rates for apex-posterior and apex-anterior pad placement in defibrillation success.


LOE 5. Good. Supporting
This is a pig study examining defibrillation success with 2-20kg pigs (simulating newborn to <8 years old), comparing adult vs. child sized electrode pads. The outcomes were not blinded. Confounders were controlled. Recommendation is to use adult sized pads as long as there are 3cm between pads on the thorax.


LOE 5. Good. Supporting
This is a randomized controlled trial with cross-over comparing AP to AL position for the cardioversion of atrial fibrillation. The outcomes were not blinded. The AP position was superior to AL in cardioversion.


LOE 5. Fair. Supporting
Antero-posterior position of the electrodes is favourable for defibrillation. Women have significantly higher TTI.


LOE 5. Fair. Neutral
This study compared the difference in electrode skin impedance between anterior-apex position vs. a mirror-image orientation. The outcomes were not blinded, confounders not controlled. The study was attempting to correlate ESI to electrocardiogram ventricular fibrillation amplitude. There was no difference in ESI in the anterior apex left vs. right orientation of pads.


LOE 5. Good. Supporting
Quadruple pads external cardioversion is highly effective in converting chronic AF.


LOE 5. Good. Neutral
Randomized controlled trial comparing AP vs. AL pad placement for the cardioversion of atrial fibrillation. Randomization was not clearly defined. AP and AL electrode pad position is not a determinant of cardioversion success rate or energy requirement in the overall success rates of cardioversion. Duration of atrial fibrillation was the only independent predictor of success.

LOE 5. Good. Opposing
This is a dog study measuring intracardiac current. The dogs did have thoracotomies to place an intracmyocardial electrode so the properties of TTI may have been altered. This study finds intracardiac current to be highest in the intermediate size (5.8 or 8cm) as compared to 4 and 10 cm pads.


LOE 5. Good. Supporting
This study measures TTI in both men and women with different breast sizes. Although there is a small sample size (n=27), it does attempt to control for confounders. Outcomes are not blinded and there is no randomization. Study does recommend placing the electrode under the breast tissue.


LOE 5. Fair. Supporting
This is a computer model simulation for transcutaneous pacing. Does not account for confounders and their effect on TTI. It does recommend anterior-posterior orientation and electrode size of 90cm2 as optimal for defibrillation.


LOE 5. Fair. Supporting
This study examines TTI in hirsute males. The outcomes are not blinded and confounders were not controlled for. There was also no clear definition on what constitutes a hirsute vs. non-hirsute male. This study found that shaving decreased TTI in all participants, possibly due to the abrasions on the skin caused by shaving.


LOE 5. Good. Supporting
This study measures TTI in children ages 3 weeks to 12 years. 4, 4.5, and 5.8 cm pads were tested on 24,23, and 25 children respectively. 7, 7.5, 8, and 10 cm pads were tested on 19,15,10, and 9 children. TTI was measured using a test pulse technique. Mean TTI values were 148 +/- 23 ohms for the smallest pads and 49 +/- 9 ohms for the largest pad. There was a random order of pad application on the children. Confounders were adequately controlled for. Study recommends 5.8 cm pad for <1 year old and 7cm pads for >1 year old.

LOE 5. Fair. Supporting This is a dog/calf study measuring defibrillation success as it relates to polarity. The outcomes are not blinded and confounders are not controlled. Study concludes that there may be a difference with polarity of leads, but more research is needed.

Stanaitiene, G. and Babarskiene, R. M., [Impact of electrical shock waveform and paddle positions on efficacy of direct current cardioversion for atrial fibrillation], Medicina (Kaunas), 2008, 44(9):665-672.

LOE 5. Fair. Neutral
No influence of paddle positions on efficacy of cardioversion.


LOE 5. Fair. Supporting
This is a dog study examining the difference in TTI based upon electrode polarity. Confounders are not controlled for and there is a small sample size (n=9). There were small differences in TTI based on electrode polarity.


LOE 5. Good. Supporting
This is a dog study looking at defibrillation success comparing 8.0 vs. 12.8 cm paddles. The outcomes were not blinded and randomization did not occur. The study did find that 12.8 cm paddles were more effective than 8cm paddles.