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

Worksheet author(s)

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<th>Nigel McBeth Turner</th>
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Clinical question.

The clinical question for this worksheet, which addresses a new interventional topic, was: "In adult and pediatric patients with cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of any specific placement of hands for external chest compressions (I) compared with standard care (eg. "placement of the rescuer’s hands in the middle of the chest") (C), improve outcome (eg. ROSC, survival) (O)". In order to make this question relevant to patients of all ages, the comparator in adults was taken as written in the example stated, in children older than one year and up to puberty the comparator was taken to be "placement of one or both of the rescuer’s hands on the lower third of the sternum" and in children under one year of age (including the newly born) the comparator was taken to be "placement of digits on the lower third of the sternum".

Conflict of interest specific to this question

The author is not aware of a possible conflict of interest relevant to this worksheet.

Search strategy (including electronic databases searched).

PubMed, EMBASE, the AHA EndNote Master library and the Cochrane database for systematic reviews were search using the following basic search strategy: ("Heart Arrest"[Mesh] OR "Cardiopulmonary Resuscitation"[Mesh] OR "Resuscitation"[Mesh] OR "Heart Massage"[Mesh] OR "basic life support") AND ("hand position" OR "hand placement"). The abstracts of all articles found using this strategy were considered for inclusion according to the criteria below. Subsequently a manual search of the references from all relevant articles was performed as was a forward search of all relevant articles using the “cited by” function of both Scopus and Google scholar.

• Inclusion and exclusion criteria

Articles involving patients of all ages and animal studies were included regardless of the study’s end-point. Primary exclusion criteria were articles in languages other than English, Dutch, German or French; articles with an abstract in a language other than English; abstract only studies; articles from non-peer reviewed sources. After reviewing the abstracts articles not relevant to the worksheet question were secondarily excluded.

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

A search of the Cochrane library revealed no existing Cochrane review, other reviews of effect nor referenced clinical trails in this area. The search of Pubmed and Embase revealed 32 and 37 possibly relevant articles respectively. Combining these searches left a total of 33 possibly relevant articles, 24 of which were excluded after perusing the abstract. Forward- and backward-searching of the citations of these articles revealed a further 26 possibly relevant articles. From the AHA Endnote library 26 articles were identified. Combining all of these searches left a list of 45 references which were reviewed. These articles dealt with the following topics: Anatomy 3 (infant 2); child 1; complications 2; decompression phase 2; depth of compression 1; use of the dominant hand 2; hand position (adult) 2; finger/thumb position infant 13 (animal study 1); over the head resuscitation 6; leg-heel 1; over the head 6; physics of chest compressions 1; quality of compression 1; rescuer position 2; retention 1; other topics 4. At review 27 articles were found to be of little relevance to the clinical question and the specific reasons for exclusion are summarized for each article at the end of the results section. All of the remaining 18 articles were in English, one was LOE 4 (case series) the others being LOE 5.
# Summary of evidence

Black text = adults, Red text = infants, Blue text = children

## Evidence Supporting Clinical Question

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## Evidence Neutral to Clinical question

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## Evidence Opposing Clinical Question

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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
There is no clinical evidence which provides insight into the question posed for patients of any age, and the non-clinical studies which were found are of limited relevance to the question. As the standard technique of thorax compression varies with age, the following discussion is divided into the age-groups adult, child and infant. All studies cited are LOE 5.

**ADULTS**

In adults there has been research into the use of the dominant or non-dominant hand; hand-placement parallel or perpendicular to the sternum; hand-placement intended to improve decompression and force distribution and the ease of retention of different hand-positions.

Two studies, Kundra et al (2000) and Nikandish et al (2008) looked at the effect of placing the dominant or non-dominant hand underneath the other hand for thorax compressions in mannequin studies. Both used pre-C2005 guidelines. In professional rescuers the use of the dominant hand underneath was associated with an improvement in thorax compressions overall and a reduction in the number of compressions with an inadequate depth. However, in novice lay-rescuers there was generally no significant differences between the use of the dominant and non-dominant hand in the underneath position and the number of correct compressions was in both cases very low. Neither of these studies looked at the effect of letting the rescuer decide which hand to use – i.e. placing the preferred hand underneath. One might cautiously conclude from these studies that there might be a small benefit for professionals in placing the dominant hand on the sternum with the non-dominant hand above, but further research is needed to compare this with the use of the preferred hand.

The equal effectiveness of placing the lower hand either parallel or perpendicular to the sternum has been demonstrated in the overhead thorax compressions by Bollig et al (2007) in a mannequin study. Diószeghy et al (2005) also used a perpendicular hand placement in respect of the sternum which is the technique traditionally advocated in Hungary. They concluded that this results in a smaller area of direct compression which the authors supposed might lead to fewer complications, although they present no evidence for this conclusion.

Decompression during thorax compressions might be facilitated by specific hand positions. Aufderheide et al (2005) and Aufderheide et al (2006) investigated this in a mannequin studies of both professional responders and lay-persons. All three techniques studied – the two finger fulcrum, five-finger fulcrum and hands-off technique – improved decompression and in the case of the hands-off technique, the improvement was large for professionals. In both groups, however, the overall performance of thorax compressions was poor, raising the possibility that the in particular the professional group did not represent the norm. Baubin et al (1999) found that the force applied to the sternum was greater in the hypothenar than the thenar area of the applied hand. They postulate that applying the hands such that the greatest sternal force is exerted caudally might reduce the risk of sternal fractures, but this suggestion is based on little evidence.

Handley (2002) found that the now standard hand placement facilitated change-over from compressions to ventilation and was as easily retained as hand placement in relation to the xiphisternum.

In conclusion, it appears form adult mannequin studies that hand placement parallel or perpendicular to the sternum might be equally effective, that in particular the hands-off technique improves decompression, at least in professionals, and that the currently recommended hand-placement improves the change-over form compressions to ventilations compared to the previously recommended technique. The evidence for benefit from placing the dominant hand below or above the non-dominant hand is equivocal. However, it must be emphasized that none of the studies identified used a clinically significant end-point.

**INFANTS**

In infants there is level 5 evidence from animal, clinical and experimental studies that use of the two-thumb method produces higher arterial pressures than the two-finger method. Houri, P.K., et al (1997) showed this in a randomised cross-over study in piglets using a hypoxic cardiac arrest model. However the pressures achieved with both techniques and would have resulted in minimal coronary perfusion pressures. Menegazzi et al (1993) found similar results with a similar study design, but achieved higher perfusion pressures with both techniques than Houri et al. Neither study compared the outcome of using each technique and it is not entirely clear which compression:ventilation ratio was used. The extrapolation of these studies to humans needs to be cautious as the anatomy of young swine may differ from that of the human infant such that the benefit of the two-thumb technique is more evident in piglets.

However, there is also clinical evidence from case reports to support the use of the two-thumb technique over that of the two-finger technique. Todres and Rodgers (1975) and David (1988) demonstrated the superiority of the two-thumb technique in case reports of circulatory arrest in infants with an indwelling arterial catheter in whom the mean arterial pressure was higher with the two-thumb than with the two-finger technique.

Experimental models also suggest that the two-thumb technique is superior to the two-finger technique. Dorfsman, M.L. et al (2000) demonstrated this in a crude experimental model involving a bag of saline attached to the chest of an infant mannequin. Whitelaw et al (2000) found that the two-thumb technique was marginally better than the two-finger technique in terms of the number of compressions of adequate depth. This study is of marginal significance to the clinical question as skills meter settings may not be representative of the clinical setting.
correspond to the optimal compression depth in real patients.

There is evidence from a case series of Orlowski (1986) that compression over the lower third of the sternum results in higher systolic, diastolic and mean pressures in infants than compression over the mid-third. No organ damage attributable to thorax compressions was seen at autopsy in non-survivors or clinically in survivors. It is however no certain which compression technique was used.

Clements and McGowan (2000) found that application of fingers for the two-finger technique often resulted in pressure over the xiphisternum when the finger position was determined in relation to the internipple line. They felt this might be a risk factor for organ (in particular liver) rupture during thorax compressions, although the association has not been proved. The two cases of liver-lacerations following thorax compression cited in the article were at locations one would not suspect if the compressions had been the cause of the injury, and Ryan (1999) found no visceral injuries at autopsy in a series of 153 children who had undergone a resuscitation attempt. Clements and McGowan recommend identifying the finger position by working up from the xiphisternum, although this might result in the sternum being compressed above its lower third, thus generating lower arterial pressures as demonstrated by Orlowski (1986).

In infants it appears that the two-thumb technique of thorax compressions generates higher arterial pressures than the two-finger method. Compression over the lower third, rather than the mid-third, of the sternum produces higher arterial pressures. The incidence of complications of thorax compressions appears to below, and it is not clear whether compression over the xiphisternum is a risk factor for such complications.

CHILDREN

Only two studies of hand technique in children, as opposed to infants, were identified, both being mannequin studies. Both suggested a preference for the use of two-hands as opposed to one-hand. Stevenson (2005) demonstrated that professionals generate more pressure using two-hands than one hand for paediatric thorax compressions and that they found this easier to perform than one-handed compressions. As often with mannequin studies, this research was performed on a modified mannequin of standard size, and these findings may not apply to other patient sizes. Peska (2006) also found a preference for two-handed in professional but inexperienced rescuers on a standard paediatric mannequin. Thorax compression frequency was higher than the recommended rate (in the region of 130 /min) and declined more rapidly with the use of one hand than two, which suggests earlier fatigue with the one-handed technique.

In paediatric resuscitation it appears that, at least for children conforming in size to the standard mannequin, the use of two hands for thorax compressions generates a higher intrathoracic pressure, is easier to perform and may be less fatiguing than the use of one-hand.

Acknowledgements:

Library services of the Academisch Medisch Centrum Amsterdam, University of Utrecht and Dundee University.
Citation List

Articles included in the summary of evidence


Aufderheide et al (2005) compared the effects of three different ECC techniques designed to improve the decompression phase of ECC with standard ECC in a mannequin study of professional responders. All three – the two finger fulcrum, five-finger fulcrum and hands-off technique – improved decompression (in the case of hands-off the improvement had an OR of 129.0; (CI: 43.4–382.0). The study appears to be methodologically good, but is non-clinical. Its relevance to clinical outcomes is at best presumptive. A similar study in trained lay-persons (Aufderheide et al (2006) (3) yielded similar results. In both studies, the overall performance of ECC was poor which compromises the validity of the conclusions.

LOE 5 fair quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Aufderheide et al (2005) (2) compared the effects of three different ECC techniques designed to improve the decompression phase of ECC with standard ECC in a mannequin study of professional responders. All three – the two finger fulcrum, five-finger fulcrum and hands-off technique – improved decompression (in the case of hands-off the improvement had an OR of 129.0; (CI: 43.4–382.0). The study appears to be methodologically good, but is non-clinical. Its relevance to clinical outcomes is at best presumptive. A similar study in trained lay-persons (Aufderheide et al (2006) (3) yielded similar results. In both studies, the overall performance of ECC was poor.

LOE 5 fair quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Baubin et al (1997) (1) looked at the force distribution across the hand when simulating ECC on a measurement plate. He force was greater in the hypothenar than the thenar area. The authors felt that the greatest sternal force should be applied caudally to reduce the risk of sternal fractures. However this assumption was based on one presumably non-peer-reviewed reference (book). They recommend using the right hand when positioned to the victim’s right and the left hand when on the victim’s left. This study is of marginal relevance to the clinical question as it is several dubious assumptions removed from clinical practice.

LOE 5 fair quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Bollig et al (2007) compared over the head (OTH) external chest compressions (ECC) with standard ECC (rescuer at the victim’s side, using hand-placement in the centre of the chest between the nipples for both, which can be taken to be the standard position referred to in the PICO. In the case of standard ECC the heel of the hand was parallel to the sternum and for OTH ECC the heel of the hand was perpendicular. There was no difference in performance on a mannequin, which was the end-point. The study is marginally relevant to the clinical question as it in no way relates to a clinical outcome.

LOE 5, fair quality, neutral to the clinical question.


Clements and McGowan (2000) found that application of fingers for the TF technique often resulted in pressure over the xiphisternum if the finger position was determined in relation to the internipple line. They felt this might be a risk factor for organ (in particular liver) rupture during ECC. This conclusion seems to be based on supposition as this association
has not been proved. The two cases of liver-lacerations following ECC cited in the article were at locations one would not suspect if ECC had been the cause of the injury, and Ryan (1999) found no visceral injuries at autopsy in a series of 153 children who had undergone a resuscitation attempt. Clements and McGowan recommend identifying the finger position by working up from the xiphisternum, although this might mean that both the lower and middle third of the sternum are compressed.

LOE 5 poor quality opposing the clinical question – i.e. suggesting that NO change to the current guidelines should be considered.


David (1988) presented a case report of two cases of circulatory arrest in infants with an indwelling arterial catheter using both TT and TF in both patients. The mean BP was higher with the TT than with the TF method in both cases. The diastolic pressure or coronary perfusion pressure is not reported. Resuscitations conformed to the guidelines then pertaining, including an compression:ventilation ratio of 5:1.

LOE 5 poor quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Diószeghy et al (2005) (16) compared placing the lower hand perpendicular to the sternum with the recommended technique of placing the lower hand parallel to the sternum. The latter resulted in a smaller area of direct compression which the authors supposed might lead to fewer complications. This study is marginally relevant as it does not address the clinical outcome. Furthermore its clinical relevance seems to be based purely on supposition.

LOE 5 fair quality opposing the clinical question – i.e. suggesting that NO change to the current guidelines should be considered.


Dorfsman, M.L. et al (2000) used a crude experimental model in a randomised crossover trial to compare the effect of TT and TF on pressures generated in a bag of samine attached to the chest of an infant mannequin. All BPs were higher in the TT group (p < 0.001), 21 rescuers performed ECC for 10 minutes for each technique. They were blinded to the generated pressure and seem to have been predominantly familiar only with TF-technique. The validity of this study is limited by non-physiological model.

LOE 5 poor quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Handley (2002) (15) compare the now standard direction (hands in the centre of the chest) with the then standard (in relation to the xiphisternum) and found no difference in learning or retention. There was however a decrease in time to change from ventilation to ECC with the new standard technique. Therefore this paper suggests that an alternative technique is less good than the standard one. Again this study is marginally relevant as it does not address the clinical outcome of the PICO.

LOE 5 fair quality opposing the clinical question – i.e. suggesting that NO change to the current guidelines should be considered.


Houri, P.K., et al (1997) (6) performed a similar randomised cross-over study in piglets using a hypoxic cardiac arrest model and measurement of the force of compression. The compression force was higher in the TT-group and the target force was only achieved in TT group, however all compression forces were higher when given feedback about the force. The systolic BHP was higher in the TT-group with and without feedback. Diastolic blood pressures were not significantly different. They conclude that TT is the better technique because the systolic pressure was higher and it was easier to achieve the target force. However they don’t say how they decided on the target pressure used. BP was much lower than in Menegazzi’s study for both techniques and would have resulted in minimal coronary perfusion pressures, possibly related to hypoxic versus chemical arrest. Neither study looked at outcome. It is not entirely clear which compression:ventilation ratio was used.
LOE 5 fair quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Kundra et al (2000) (4) looked at the effect of placing the dominant or non-dominant hand under the other hand for ECC in a mannequin study in professional rescuers (anaesthesiologists) using the 1998 guidelines. Use of the dominant hand was associated with an improvement of ECC overall and a reduction of the number of compressions with inadequate depth. The authors did not consider the issue of the "preferred hand" rather than the dominant hand. Again this study is of marginal relevance as it is non-clinical and does not use the currently recommended hand position.

LOE 5 fair quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Menegazzi et al (1993) compared two-thumb (TT) and two-finger (TF) ECC in 7 piglets in a randomised crossover trial. Diastolic, systolic and mean BP and coronary perfusion pressure were higher with the two-thumb technique. The anatomy of young swine may differ from that of infant and the study was non-clinical and double blind. It is not entirely clear which compression:ventilation ratio was used.

LOE 5 fair quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Nikandish et al (2008) investigated the use of the dominant (DH) or non-dominant (NH) hand in the underneath position on the quality of ECC given by novice lay-rescuers. They presumably used the 2005 guidelines. There were generally no significant differences between the use of the DH or NH, however there were significantly more correct compressions given in the DH group in the 5th and last minute of testing, but by then the number of correct compressions was very low (DH 30/min, NH 16/min). The authors did not consider the issue of the "preferred hand" rather than the dominant hand. This study is also marginally relevant to the clinical question as it does not relate to a clinical outcome.

LOE 5 good quality, neutral to the clinical question.


Orlowski (1986) presents a series of ten cases of circulatory arrest in infants with an arterial catheter. Higher systolic, diastolic and mean arterial BP was achieved by ECC by trained rescuers over the lower third of the sternum than over the mid third. No organ damage attributable to ECC was seen at autopsy or clinically in survivors. Rescuers were not blinded to BP registration and were allowed to modify technique, which presumably means that the BP achieved was the best obtainable BP. Only limited statistics are presented which makes it difficult to quantify the magnitude of the effect and no outcome data for the comparison of the digit position. It is not clear which ECC method (TT or TF or another) was used.

LOE 2 fair quality opposing the clinical question – i.e. suggesting that NO change to the current guidelines should be considered.


Peska (2006) also found a preference for two-handed ECC in professional but inexperienced rescuers on a standard pediatric mannequin. ECC frequency was higher than the recommended rate (in the region of 130 /min) and declined more rapidly with the use of one hand than two. This may indicate earlier fatigue with the one-handed technique.

LOE 5, poor quality, neutral to the clinical question.

Stevenson (2005) demonstrated in a mannequin study that professionals generate more pressure using two-hands than one hand for paediatric ECC and found this easier. The study was performed on a modified mannequin of standard size, and these findings may not apply to other patient sizes.

LOE 5, poor quality, neutral to the clinical question.


Todres and Rodgers (1975) also demonstrate the superiority of the TT-method in a case report.

LOE 5 poor quality supporting the clinical question – i.e. suggesting that a change in the current guidelines should be considered.


Whitelaw et al (2000) compared TT and TF in 209 professionals with varying levels of training and experience using a mannequin and skills meter in a randomised crossover trial. ECC was generally poor and there was no significant difference in the number giving adequate ECC (according to the skills-meter) with either method. However, the two-finger method was found to be more likely to be too shallow. This study is of marginal significance to the clinical question as skills meter settings may not correspond to the optimal compression depth in real patients.

LOE 5, fair quality, neutral to the clinical question.

The following articles were found to be less relevant to the clinical question and could not be included in the summary of evidence but are reported here for completeness’s sake. The reason for not considering the article further are given in each case.

**ADULT**


Bilfield (1978) study the use of the foot instead of the hands and falls therefore outside the reference limits of the clinical question.


Bonfante et al (2003) describes a case report of splenic rupture during ECC which may or may not be related to hand-position.


Chi et al (2008) and Jones and Lee (2008) studied the position of the rescuer and did not describe the hand-position used.


Gruben et al (1993) is a study in dogs which did not use survival as an outcome nor compression position as a variable. Furthermore the relationship between the optimal hand position in different species is unclear.


Handley and Handley (2004), Hupfel (2004) and Perkins et al (2004 paper) studied the over-the-head technique for ECC and used the same hand position for all groups which was not the current standard in any of the papers. They did not therefore make comparisons with the standard hand position referred to in the clinical question.

Handley and Handley (2004), Hupfel (2004) and Perkins et al (2004 paper) studied the over-the-head technique for ECC and used the same hand position for all groups which was not the current standard in any of the papers. They did not therefore make comparisons with the standard hand position referred to in the clinical question.


Mirza, M., et al., Instructions to "push as hard as you can" improve average chest compression depth in dispatcher-assisted cardiopulmonary resuscitation. Resuscitation, 2008.

Mirza et al (2007) primarily looked at compression depth in a mixed group of rescuers using two instruction protocols and mannequin measurement. Although they mention using different advice for the hand-position in the two protocols, these are not described in such a way as to allow useful conclusions on the effect this might have had.


Handley and Handley (2004), Hupfel (2004) and Perkins et al (2004 paper) studied the over-the-head technique for ECC and used the same hand position for all groups which was not the current standard in any of the papers. They did not therefore make comparisons with the standard hand position referred to in the clinical question.

Perkins (2004 letter) is a response to the Hupfel paper, which is itself not relevant to this clinical question.

Rachapalli V. et al., Adult resuscitation: are we up to date? A study of staff resuscitation skills in the radiology department of a tertiary referral centre. Br J Radiol, 2009 82(980): p. 645-8. This is a questionnaire study of knowledge among potential providers of CPR which does not address the issue of hand-position.


INFANT


*Finholt et al (1986) and Phillips and Zideman (1986)* using standard chest X-rays, Orlowski (1986) using chest X-rays, chest tomograms and observations at autopsy and during open heart operations all identified the heart as lying under the lower third of the sternum.


*Manole (2008) does not address the issue of digit position for infant cardiac arrest.*


*Martin and Butler (2004) is a best evidence topic report which included no references not reviewed in this worksheet.*


*McNamara (2008) refers to an article comparing periodic acceleration CPR with a mechanical thumper device which is itself not relevant to this clinical question.*


*Moya et al (1962) is a case report which describes the feasibility of TF-method but does not compare this with the standard recommended technique. A ONE-thumb technique seemed to be less successful than the TF.*


*Finholt et al (1986) and Phillips and Zideman (1986) using standard chest X-rays, Orlowski (1986) using chest X-rays, chest tomograms and observations at autopsy and during open heart operations all identified the heart as lying under the lower third of the sternum.*


*Thaler (1963) is a historic paper but contains little actual data on which to base conclusions of the TT-method described.*


*Worn (1996) discusses the factors which might induce rib fractures in infants during ECC. They conclude that TF method is unlikely to cause rib fractures but are uncertain about the TT-method. They suggest ideas for future research which does not seem to have been performed (one on 1 reference in the “cited by” function of Scopus).*


*Wyckoff (2008) is a review article discussing the papers already included in this worksheet.*