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

Worksheet author(s)

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Clinical question.

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 (e.g. "placement of the rescuer's hands in the middle of the chest") (C), improve outcome (eg. ROSC, survival) (O)

Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention, hand placement for external chest compressions
State if this is a proposed new topic or revision of existing worksheet: previous similar worksheets W167A, W167B

Current recommendations

Adults:

AHA 2005 CPR and ECC part 4 BLS section IV-26: "The rescuer should compress the lower half of the victim's sternum in the center (middle) of the chest, between the nipples. The rescuer should place the heel of the hand on the sternum in the center (middle) of the chest between the nipples and then place the heel of the second hand on top of the first so that the hands are overlapped and parallel (LOE 6; Class IIa)."

Pediatrics

AHA CPR 2005 and ECC part 11 Pediatric BLS section IV-160: "To give chest compressions, compress the lower half of the sternum but do not compress over the xiphoid. In an *infant victim*, lay rescuers and lone rescuers should compress the sternum with 2 fingers placed just below the intermammary line (Class IIb; LOE 5, 6)."

The 2 thumb–encircling hands technique is recommended for healthcare providers when 2 rescuers are present. Encircle the infant's chest with both hands; spread your fingers around the thorax, and place your thumbs together over the lower half of the sternum. Forcefully compress the sternum with your thumbs as you squeeze the thorax with your fingers for counterpressure (Class IIa; LOE 5; 6. If you are alone or you cannot physically encircle the victim's chest, compress the chest with 2 fingers. The 2 thumb–encircling hands technique is preferred because it produces higher coronary artery perfusion pressure, more consistently results in appropriate depth or force of compression, and may generate higher systolic and diastolic pressures.

In a *child*, lay rescuers and healthcare providers should compress the lower half of the sternum with the heel of 1 hand or with 2 hands (as used for adult victims) but should not press on the xiphoid or the ribs. There is no outcome data that shows a 1-hand or 2-hand method to be superior; higher compression pressures can be obtained on a child manikin with 2 hands. Because children and rescuers come in all sizes, rescuers may use either 1 or 2 hands to compress the child's chest. It is most important that the chest be compressed about one third to one half the anterior-posterior depth of the chest."

Hypothesis: The use of a specific alternative hand placement for external chest compressions compared with standard care[in adult and pediatric patients the lower half of the victim's sternum in the center, middle of the chest, between the nipples and in infants the sternum just below the intermammary line] improves outcome in terms of ROSC, survival.

Conflict of interest specific to this question

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? **No conflict of interest**

Search strategy (including electronic databases searched).

Database search strategy:
PUBMED (NLM) (1966-September 29, 2009)
"CPR AND hand position"- 24 hits
"cardiopulmonary resuscitation AND hand position"-30 hits
"cardiac arrest AND hand position"-20 hits
"CPR quality AND hand position"-7 hits
"external chest compressions and hand position"-4 hits
"heart arrest and hand position"-15 hits

Cochrane- as of Sept 29, 2009
"cardiopulmonary resuscitation AND hand position"-8 hits

"cardiac arrest AND hand position"- 4 hits
"CPR quality AND hand position"- 9 hits
"external chest compressions and hand position"-2 hits
"heart arrest and hand position"- 1 hit

Embase- as of Sept 29, 2009
"CPR AND hand position"- 8 hits
"cardiopulmonary resuscitation AND hand position"-7 hits
"cardiac arrest AND hand position"-3 hits
"CPR quality AND hand position"-6 hits
"external chest compressions and hand position"-1 hit
"heart arrest and hand position"-2 hits

Including review of all references of previously selected articles

• State inclusion and exclusion criteria

Inclusion criteria: adult, pediatric, OHCA, IHCA, hand position, external chest compressions

Exclusion criteria: internal chest compressions, open chest compression cardiac massage, chest compressions delivered by mechanical devices, abdominal compressions and abstract only studies, studies not peer reviewed, and those that did not specifically answer the question

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

Of the 44 abstracts, 22 met criteria for review. After reading the articles 11 remained relevant to the question. Of these, 1 was LOE 2 and 10 were LOE 5.

Summary of evidence

Evidence Supporting Clinical Question

Good					
Fair		**Orlowski,** 1986 [E] Hand positioning: mid sternum vs. lower sternum			
Poor					
	1	**2**	**3**	**4**	**5**
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*

Evidence Neutral to Clinical question

Good					
Fair					**Aufderheide**, 2005[E] **Aufderheide**, 2006[E] Alternate finger-fulcrum, hand/heel positioning **Baubin,** 1997[E] Hypothenar eminence exerts the most force on chest compressions **Diószeghy,** 2005[E] ILCOR current standard hand position more favorable than Hungarian method **Handley**, 2002[E] Simplified hand position teaching **Kundra**, 2000[E] **Nikandish** 2008[E] Dominant hand in contact with the sternum maybe more advantageous for hand positioning **Perkins,** 2004[E] Over the head compressions yielded more consistently accurate hand position than standard at-the side-of the mannequin hand position **Shin**, 2007[E] CT images and inter-nipple line
Poor					
	1	**2**	**3**	**4**	**5**
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

Evidence Opposing Clinical Question

Good					
Fair					
Poor					**Clements,** 2000[E] Placing fingers one finger breadth below the intermammary line in infants may result in xiphisternum or abdominal compressions
	1	**2**	**3**	**4**	**5**
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

REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

This worksheet specifically addresses the question: 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 improve outcome(e.g. ROSC, survival)(O).

Based on this review, the hypothesis, "the use of a specific alternative hand placement for external chest compressions compared with standard care [in adult and pediatric patients the lower half of the victim's sternum in the center, middle of the chest, between the nipples and in infants the sternum just below the intermammary line] improves outcome in terms of ROSC, survival" was rejected. Specifically, there were no randomized controlled clinical human trials comparing a specific hand placement with the standard hand placement with a clinical outcome of ROSC or survival (LOE1) that would support changing the current guidelines.

Chest compressions and hand placement in pediatric and infant patients:

There were several studies of pediatric and infant patients which indirectly evaluated hand position and external chest compressions. One study (Orlowski et al. 1986, LOE 2, quality fair, neutral, other endpoint) of pediatric patients (ages 1month-3years) with a cardiac arrest and arterial monitoring in place compared chest compressions in the midsternum with chest compressions performed on the lower 1/3 of the sternum. In this study, participants performing CPR switched hand positioning during the resuscitation from one method to the other. The authors concluded that *arterial blood pressure measurements* were improved in pediatric patients who received chest compressions over the lower portion of the sternum but this was not correlated with outcome. Another study by Clements et al. 2000 (LOE 5, quality poor, other end point) demonstrated that the distance covered by adult fingers on template infant chests' (measured from a convenience sample of infants <1 year of age) one finger breadth below the inter-nipple line would likely result in xiphisternum or abdominal compressions. This conclusion was based on measurements and not actual simulation of chest compressions on "actual" infant chests'. The authors then suggest changing the directions for determining finger position to rather wordy complicated instructions: "run the fingers along the lower costal margin to locate the end of the bony sternum leaving the finger on that edge and place two fingers on that edge and place two fingers of the other hand up from it." These instructions were not the subsequently evaluated in mannequin or real CPR scenarios.

Chest compressions and hand placement in adult patients

Three adult studies compared a specific external chest compression hand/finger position to the current recommendations for hand/finger placement. In a mannequin study of physicians, Diószeghy et al. 2005 (LOE 5 quality fair, neutral, other endpoint) compared the traditional Hungarian approach to chest compressions ("the lower compressing hand is placed alongside the sternum and the other hand is placed on top of that hand") to the ILCOR 2000 recommendations ("placement of one hand on top of the other with the fingers interlocked or extended"). The two methods were compared by depth, rate, duty cycle, total surface area compressed, and appropriateness of surface area compressed. The authors concluded that the ILCOR 2000 recommended hand position was overall more likely to be effective than the Hungarian technique because the ILCOR approach allowed for more consistent hand placement in a smaller surface area of the chest. Two studies by Aufderheide et al. 2005 (LOE 5 quality fair, other endpoint) and 2006 (LOE 5 quality fair, other endpoint) evaluated chest wall recoil comparing the 2 finger fulcrum technique, 5-finger fulcrum technique, and hands-off technique with standard hand positioning for chest compressions. In both studies, the outcome measures were chest compression metrics (depth, rate, decompression duty cycle, chest recoil, fatigue/discomfort, hand positioning). None of the techniques (including the standard approach) consistently yielded proper chest compression depth. In addition, compared with the standard approach, the hands-off technique resulted in a shortened compression duty cycle but a higher rate of complete chest wall recoil.

Neither study evaluated hemodynamic functioning but it is unlikely that future studies will evaluate different hand/finger positions independently in a randomized patient trial with ROSC as an outcome.

Chest compressions and use of the dominant vs. the non-dominant hand

Although not specifically addressing the question of hand positioning in the middle of the chest, two simulation mannequin studies evaluated the use of the dominant versus non-dominant hand in external chest compressions. Kundra et al 2000 (LOE 5, quality fair, other end point) determined that placing the dominant hand in contact with the sternum in trained providers was advantageous (adequate chest compression depth, proper hand location placement) and lead to fewer errors in providing chest compressions while Nikandish et al 2008 (LOE 5, quality fair, other end point) demonstrated a trend but not significant difference in improved hand positioning in layperson providers when the dominant hand maintained contact with the sternum.

Correlation of hand placement and anatomy

To determine if placing hands at the inter-nipple line allowed for squeeze of the ventricles, Shin et al. 2007 (LOE 5, quality poor, other end point) used CT scans to evaluate the anatomy of non-arrest patients. They concluded that compressing the sternum at a location more caudal than the inter-nipple line may allow for more direct compression of the ventricles during arrest. Actual intra-arrest clinical application of these findings was not however performed. Baubin and colleagues (LOE 5, quality fair, other end point) demonstrated that the distribution of compression force in the hand was most prominent at the hypothenar rather than the thenar eminence. By extrapolation, compressions performed "too low" on the sternum with the increased force distribution from the hypothenar portion of the hand could theoretically place patients at increased risk for thoraco-abdominal injuries.

Teaching hand placement

Additionally, a study by Handley et al 2002 (LOE 5, quality fair, other endpoint) did not specifically address the clinical question of this worksheet but demonstrated that simple, concise instructions for hand position were associated with fewer pauses between ventilation and chest compression but did not impact overall CPR skill retention.

Abdominal compressions

Several studies exist which include standard chest compressions in the middle of the chest interposed with abdominal compressions but this was considered outside of the scope of this worksheet which focused on alternate hand positioning in delivery of "external chest compressions."

Hand position and location of the rescuer

Several studies evaluated efficacy of chest compressions and hand position when rescuers were located over the head rather than kneeling at the side of the patient. Perkins et al (LOE 5, quality fair, other end point) randomized participants to perform (1) over the head CPR with the "hands in the midline of the chest over the middle of the lower half of the sternum and the heel of the hand perpendicular to the sternum and (2) standard CPR at the side of the mannequin. In this study, hand positioning was more accurate (defined as compressions in the lower third of the sternum) in the over the head group compared with the standard at the side of the person group.

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Citation List

Aufderheide TP, Pirrallo RG, Yannopoulos D, Klein JP, von Briesen C, Sparks CW, Deja KA, Conrad CJ, Kitscha DJ, Provo TA, Lurie KG. (2005) "Incomplete chest wall decompression: a clinical evaluation of CPR performance by EMS personnel and assessment of alternative manual chest compression-decompression techniques."Resuscitation 64:353-62.

LOE: 5, mechanical model i.e. mannequin study
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Phase 1 was an observational study of CPR performance by emergency medical services (EMS) providers, and the authors reported that in almost half of the cases (6/13) full chest wall recoil did not occur during resuscitation efforts. This finding was important as animal studies suggest that incomplete chest wall decompression can potentially have negative effects on hemodynamic functioning. In phase 2 of the study, three alternate hand/finger positioning chest compression techniques were then tested to evaluate chest wall compression adequacy. Compared with the standard approach, the hands-off technique resulted in a shortened compression duty cycle but a higher rate of complete chest wall recoil without compromising proper hand placement, compression depth accuracy, or rescuer fatigue.

Aufderheide TP, Pirrallo RG, Yannopoulos D, Klein JP, von Briesen C, Sparks CW, Deja KA, Kitscha DJ, Provo TA, Lurie KG. (2006) Incomplete chest wall decompression: a clinical evaluation of CPR performance by trained laypersons and an assessment of alternative manual chest compression-decompression techniques. Resuscitation 71:341-51.

LOE: 5, mechanical model i.e. mannequin study
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Mannequin study of laypersons using three alternate chest compression techniques to assess chest wall recoil. Chest compression depth was inadequate across all groups, including the standard hand positioning. The hands-off technique notably yielded a decrease in duty cycle but was more likely to result in complete chest wall recoil when compared with the standard hand position technique.

Baubin M, Kollmitzer J, Pomaroli A, Kraincuk P, Kranzl A, Sumann G, Wiesinger GF, Gilly H. (1997) "Force distribution across the heel of the hand during simulated manual chest compression." Resuscitation 35:259-63.

LOE: 5, mechanical model i.e. simulation of chest compressions on a sensor mat
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Anesthetist performing simulated chest compressions on a sensor mat exerted maximal hand force at the hypothenar in contrast to the thenar emminence

Clements F, McGowan J. (2000) "Finger position for chest compressions in cardiac arrest in infants." Resuscitation 44:43-6.

LOE: 5
Quality: poor
Supportive/Neutral/Opposing: opposing

Brief summary statement(s): Based on infant chest measurements, adults in this study using the "one finger breadth below the inter-nipple line as a landmark for chest compressions would likely compress the xiphisternum or abdomen. Based on these findings, the authors suggest changing the directions for determining finger position to rather wordy complicated instructions: "run the fingers along the lower costal margin to locate the end of the bony sternum leaving the finger on that edge and place two fingers on that edge and place two fingers of the other hand up from it."

Diószeghy C, Kiss D, Fritúz G, Székely G, Elo G. (2005). "Comparison of effects of different hand positions during cardiopulmonary resuscitation." Resuscitation 66:297-301.

LOE: 5, mechanical model i.e. mannequin study
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Mannequin study of physicians trained in two alternate hand positions for performing chest compressions Hungary (the lower compressing hand was placed alongside the sternum and the other hand was placed on top of it) versus ILCOR (place one hand on top of the other with the fingers interlocked or extended). Hand positioning was considered more effective and safe (regarding likelihood of rib fracture or other injury) using the ILCOR approach instead of the traditional technique used in Hungary.

Handley AJ. (2002) "Teaching hand placement for chest compression--a simpler technique." Resuscitation 53:29-36.

LOE: 5, mechanical model i.e. mannequin study
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Simplifying the instructions for hand positioning in a layperson CPR course was associated with shorter pauses in delivery of chest compressions and ventilations but did not significantly impact overall CPR skill retention.

Kundra P, Dey S, Ravishankar M. (2000) "Role of dominant hand position during external cardiac compression." Br J Anaesth. 84:491-3.

LOE: 5, mechanical model i.e. mannequin study
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Trained health care providers performed external chest compressions in a mannequin simulation with the right hand in contact with the sternum one week and then subsequently with their left hand in contact with the sternum. Chest compression depth and proper hand placement was more accurate in those with the dominant hand in contact with the sternum compared with those with the non-dominant hand in contact with the sternum

Nikandish R, Shahbazi S, Golabi S, Beygi N. (2008) "Role of dominant versus non-dominant hand position during uninterrupted chest compression CPR by novice rescuers: a randomized double-blind crossover study." Resuscitation 76:256-60.

LOE: 5, mechanical model i.e. mannequin study
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Chest compression rate and depth were not significantly different in lay providers using their dominant or non-dominant hand in a CPR mannequin simulation.

Orlowski JP. (1986). "Optimum position for external cardiac compression in infants and young children."Annals of Emergency Medicine 15:667-73.]

LOE: 2, concurrent controls
Quality: fair
Supportive/Neutral/Opposing: supporting
Brief summary statement(s): During pediatric codes in patients with existing arterial monitoring in place, CPR performers used two hand position techniques when providing chest compressions: midsternum and the lower 1/3rd of the sternum. Lower sternal compressions yielded better systolic and mean arterial blood pressures.

Perkins GD, Stephenson BT, Smith CM, Gao F. (2004) "A comparison between over-the-head and standard cardiopulmonary resuscitation." Resuscitation 61:155-61.

LOE: 5, mechanical model i.e. mannequin study
Quality: fair
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): Mannequin study of volunteers performing OTH or standard CPR. Hand position was more accurate (i.e. chest compressions on the lower third of the sternum) in the OTH group compared with the standard kneeling- at- the- side of the mannequin standard group.

Shin J, Rhee JE, Kim K. (2007) "Is the inter-nipple line the correct hand position for effective chest compression in adult cardiopulmonary resuscitation?" Resuscitation 75:305-310.

LOE: 5
Quality: poor
Supportive/Neutral/Opposing: neutral
Brief summary statement(s): CT images were utilized to correlate interthoracic structures with external chest landmarks, sternum, inter-nipple line. The inter-nipple line was only directly over the left ventricle (LV) in 20% of cases suggesting that a more caudal hand placement may allow for more direct compression of the LV during CPR.