**Clinical question.**

In infants and children in cardiac arrest (out-of-hospital and in-hospital) (P), does any specific compression depth (I) as opposed to standard care (i.e. depth specified in treatment algorithm) (C), improve outcome (O) (e.g. Blood Pressure, ROSC, survival)?

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

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

**Conflict of interest specific to this question**

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

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

PubMed: Cardiac Arrest [39523];Heart massage [MESH] 2231;Heart Massage [MESH] All Children 372;Heart Massage[MESH] all infants birth-23mths 192; Heart Massage[MESH] infant 1-23 mths 114; Heart Massage[MESH] Preschool Child 2-5yrs 89; Heart Massage[MESH] Child 6-12yrs 174; Heart Massage[MESH] Adolescent 13-18yrs 139; Heart Massage[MESH] Clin Trial, CRCT 31; Heart Massage[MESH] Clin Trial, CRCT All Children 0-18 7; Heart Massage[MESH] Clin Trial, CRCT All Infant 0; Heart Massage[MESH] Clin Trial, CRCT infant 1-23mths 0; Heart Massage[MESH] Clin Trial, CRCT Preschool 2-5yr 0; Heart Massage[MESH] Clin Trial, CRCT Child 6-12yr 2;Heart Massage[MESH] and Depth 29;Heart Massage[MESH] and Depth All children 2; Heart Massage[MESH] and Quality 51; Heart Massage[MESH] and Quality All Children 5.

Embase: Resuscitation 5283; Heart Massage 61; Combined 27; + human 22; Limit to child (unspecified age) 1; Limit to adolescent 13-17 1. Limit to infant 0; limit to preschool child 0; limit to school child 0.

Cochrane: MESH Cardiopulmonary Resuscitation 320; MESH Heart Arrest 777; MESH Heart Massage 26; (#1 OR #2) AND #3 24.

Google Scholar: Hand search for Chest Compression Depth & Children/Paediatric/Infant - no additional sources

Endnote library: Chest compression depth 4; Chest compression quality 2; Chest compression infant, child, paediatric, pediatric 0

• **State inclusion and exclusion criteria**

I have not included papers more that 10 years old.

• **Number of articles/sources meeting criteria for further review: 11**

4 new papers have been sourced over recent weeks. Three have been published; one is still in its final pre-publication phase.
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Evidence Supporting Clinical Question</th>
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<tr>
<td><strong>Good</strong></td>
<td><strong>Braga et.al. 2009</strong>(E)**</td>
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<td></td>
<td>[CT measurements of infant and child chests demonstrate that CCs targeted to 1/2 AP chest depth is not feasible (results in residual internal depth &lt;10mm in 94%; suggests 1/3 minimal depth or 38mm as possible alternative)]</td>
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<td><strong>Kao et.al. 2009</strong>(E)**</td>
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<td>[CT measurements of infant and child chests demonstrate that CCs targeted to 1/3 to 1/2 AP chest depth will be deeper than adult recommendations (~ 4-6cm)]</td>
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<td><strong>Pickard et.al. 2006</strong>(E)**</td>
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<td>[CT measurements of adult chests demonstrate that CCs targeted 4-5cm result in CCs of approximately 1/5 AP chest depth]</td>
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<td><strong>Sutton et.al. 2009</strong>(E) (b)**</td>
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|                   | [External thoracic measurements of children ages 6m to 8yrs suggests that adult depth of 38mm would not meet minimal depth of 1/3 AP depth frequently: compress children deeper?]
| **Fair**          | **Maher et.al. 2009**(E)**              |
|                   | [CCs targeted to ½ AP chest depth resulted in higher systolic and mean intra-arterial BPs] |
| **Poor**          |                                         |

### 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 | | | | | |
|------|------|------|------|------|
| Maguire et al. 2006(E) | [systematic review: rib fractures in children who underwent CPR are rare] |
| Sutton et al. 2009(E) (a) | [shallow CCs (<38mm) common during adolescent arrest] |
| Sutton et al. 2009(E) (c) | [variability in post-pause CCs] |
| Edelson et al. 2006(A) | [higher mean CC depth prior to defibrillation improves shock success (adjusted odds ratio 1.99 for every 5mm increase)] |
| Kramer Johansen et al. 2006(A) | [increased CC depth was associated with increased rate of survival to hospital admission in a logistic regression model] |
| Abella et al. 2005(E) | [shallow CCs common during in-hospital adult resuscitation] |
| Wik et al. 2005(E) | [shallow CCs common during out-of-hospital adult resuscitation] |

### Evidence Opposing Clinical Question

| Good | | | | |
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<td>Level of evidence</td>
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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*
**REVIEWER’S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:**

**Adult studies**

One adult good study (LOE 5)[**Edelson, 2006, 137**] showed that good quality CPR prior to defibrillation improves outcome, whilst a second good adult study (LOE 5)[**Kramer-Johansen, 2006, 283**] concluded that increased depth of compression improved short-term survival. There is one further good study in adults (LOE 5) [**Picard, 2006, 387**] that recommends a compression depth of 4-5cms (1/5 of the A/P diameter) based on CT scan evidence.

This is a very specific question about the depth of chest compression in infants and children. Previous guidelines have made recommendations without published scientific evidence. There has been little if any direct evidence published to support a specific depth of chest compression in infants and children until recently.

**Paediatric studies**

One poor paediatric case series (LOE 4) [**Maher, 2009, 662**] showed that increasing compression depth from 1/3 to 1/2 of the chest diameter did improve systolic blood pressure by 62%; this was a small study of chest compressions performed on six post cardiac surgery children but the compression depth was estimated and not definitively measured (ie: there was no qualitative standard for chest compression depth).

Two good (LOE 5) paediatric radiological studies [**Kao, 2009, 49**][**Braga, 2009, e69**] directly measured the chest parameters of infants and children
- Kao - infant group (25 boys, 11 girls), mean age 3.6 months; child-age group (21 boys, 17 girls), mean age 4.0 years.
- Braga – 280 children between 0 and 8 years.

and one good paediatric paper (LOE 5)[**Sutton, 2009(b), 1259-63**] provides additional supportive evidence derived from anthropometric measurements (150 children, aged 6 months to 8years). All three papers do provide useful evidence for the depth of chest compression that should be recommended but one paper (LOE 5)[**Braga 2009, e69**] does include internal thoracic measurements to show that compressions to 1/2 the chest diameter would not be possible without potential severe damage to intrathoracic organs. All three papers support a recommendation of chest compressions to 1/3 the anterior/posterior chest diameter (approximately 38mm) and that this would be achievable in a significant proportion of infants and children.

Previous recommendations have always demonstrated caution in terms of potential harm when performing chest compressions. A good study (LOE 5)[**Wik, 2005, 299**] showed that there was a tendency to underperform chest compressions, especially in children, for the same reason. A further good study (LOE 5)[**Sutton 2009 (a), 1259-1263**] measured the variability in chest compression depth following pauses in the resuscitation sequence. A good retrospective literature search of children who had received cardiopulmonary resuscitation (LOE 4)[**Maguire, 2006, 739**] concluded that rib fractures were rare (3 in 923 children). Considering the importance of providing adequate and effective chest compressions, three good papers (LOE 5)[**Abella 2005, 305**, (LOE 5)[**Sutton 2009 (a), 494-9**] and (LOE 5)[**Sutton 2009 (a), 494-9**] support the development of feedback devices for paediatric resuscitation to improve the quality of chest compressions.

**Acknowledgements:**

Professor Vinay Nadkarni
Citation List

Quality of cardiopulmonary resuscitation during in-hospital cardiac arrest.
JAMA 2005 Jan 19;293(3):305-310

Level of Evidence  5
Quality   Good
Direction   Neutral

Comment: A small (n=67) prospective observational study in ADULTS (LOE 5) showing that rescuers did not perform CPR to guideline standards. Shallow compressions, slow rate, hyperventilation and pauses were the main issues. Rescuer feedback an important part of high quality CPR.

(2) Braga MS, Dominguez TE, Pollock AN, Niles D, Meyer A, Myklebust H, et al.
Estimation of optimal CPR chest compression depth in children by using computer tomography.
Pediatrics 2009 Jul;124(1):e69-74

Level of Evidence  5
Quality   Good
Direction   Supporting

Comment: A good quality Paediatric study (LOE 4) where the diameter of childrens' chests (age 0-8; n=280) were measured from CT scans. Compression depths of 1/3 or 1/2 depths were then calculated and it was shown that 1/2 depth of compression could result in a residual depth of less than 10mm in 94% of cases. Recommends 1/3 depth.

Effects of compression depth and pre-shock pauses predict defibrillation failure during cardiac arrest.
Resuscitation 2006 Nov;71(2):137-145

Level of Evidence  5
Quality   Good
Direction   Neutral

Comment: A small(n=60) prospective multicentre ADULT study (LOE 5) showing that the quality of CPR prior to defibrillation affected outcome.

Level of Evidence  5  
Quality  Good  
Direction  Supporting  

Comment: Observational study of chest measurements from 36 infants (<1) and 38 children (1-8 years) (LOE 4) from CT. The results show that current guidelines recommend a greater compression depth in children than would be performed in adults. Useful study in that it provides more chest measurement data.


Quality of out-of-hospital cardiopulmonary resuscitation with real time automated feedback: a prospective interventional study.

Resuscitation 2006 Dec;71(3):283-292

Level of Evidence  5  
Quality  Good  
Direction  Neutral  

Comment: A prospective non-randomised ADULT study (LOE 5) comparing resuscitation with (n=108) or without feedback (n=176). Compression depth was better with feedback and resulted in improved short term outcome.


Does cardiopulmonary resuscitation cause rib fractures in children? A systematic review.

Child Abuse Negl. 2006 Jul;30(7):739-751

Level of Evidence  4  
Quality  Good  
Direction  Neutral  

Comment: A systematic review of 55 years of papers reporting (n=427) rib fractures from CPR. Incidence was extremely low (3 cases)

(7) Maher KO, Berg RA, Lindsey CW, Simsic J, Mahle WT.

Depth of sternal compression and intra-arterial blood pressure during CPR in infants following cardiac surgery.
Resuscitation 2009 Jun;80(6):662-664

Level of Evidence 4
Quality Poor
Direction Supporting

Comment: A very small (n=6) case review in post cardiac surgery infants who required CPR showing that increased depth of compression improved systolic blood pressure. The depth of compression was qualitative estimates and NOT measured. Neutral as it is poor evidence that may support current depths.

(8) Pickard A, Darby M, Soar J.
Radiological assessment of the adult chest: implications for chest compressions.
Resuscitation 2006 Dec;71(3):387-390

Level of Evidence 5
Quality Good
Direction Supporting

Comment: An ADULT (LOE 5) observational study reporting adult chest dimensions from CT scans (n=100). Concludes that 4-5cm would equate to 1/5 depth of compression.

Quantitative Analysis of CPR Quality During In-Hospital Resuscitation of Older Children and Adolescents.

Level of Evidence 5
Quality Good
Direction Neutral

Comment: Prospective observational Paediatric study in children ≥ 8 yrs old (n=20) showing that shallow chest compressions and residual leaning were common during in-hospital CPR. Retraining and feedback did not necessarily improve quality of CPR.


Pediatric CPR Quality Monitoring: Analysis of Thoracic Anthropometric Data.
Comment: A paediatric (LOE 4) observational study (n=150) providing anthropometric measurements on children aged 6 months to 8 years. 1/3 AP depth 37mm and 1/2 AP depth 55.4mm. Feedback mechanisms set at 38mm would meet guideline standards in 55%.

(10) Sutton RM (c), Maltesec MR, Nilesb D, Frenchd B, Nishisakia A, Arbogastc KB, Donoghuea A, Berg RA, Helfaera MA, Nadkarni V

Quantitative analysis of chest compression interruptions during in-hospital resuscitation of older children and adolescents

Resuscitation 2009; 80: 1259-1263

Comment: A qualitative study (n = 20) of the effect of pauses to CPR showing a great variation in the depth of chest compressions performed on children (Age>8 yrs)


Quality of cardiopulmonary resuscitation during out-of-hospital cardiac arrest.

JAMA 2005 Jan 19;293(3):299-304

Comment: An adult case series (LOE 5) of out-of-hospital CPR (n=176) showing that chest compressions were too shallow and not delivered for 48% of arrest time.