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

### Worksheet author(s)

<table>
<thead>
<tr>
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<th>Date Submitted for review:</th>
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<tbody>
<tr>
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<tr>
<td></td>
<td>revision 2 February 2010</td>
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### Clinical question.

In infants and children (not including newborns) with cardiac arrest (out-of-hospital and in-hospital) (P), does the use of compression-only CPR (I) as opposed to standard CPR (ventilations and compressions) (C), improve outcome (O) (eg, ROSC, survival)?

### Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention/therapy—different wording, but an update

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

### Conflict of interest specific to this question

Do any of the authors listed above have conflict of interest disclosures relevant to this worksheet? RB has a potential intellectual COI because of many grants, studies, and publications on various aspects of these issues

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

**Medline, AHA Endnote Library and Cochrane data bases**

<table>
<thead>
<tr>
<th>Search String</th>
<th>Hits</th>
</tr>
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<tbody>
<tr>
<td>Cardiac arrest and child</td>
<td>2075</td>
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<tr>
<td>Chest compressions and child</td>
<td>60</td>
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<tr>
<td>Chest compressions and cardiopulmonary resuscitation</td>
<td>248</td>
</tr>
<tr>
<td>Chest compressions and cardiac arrest</td>
<td>367</td>
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<tr>
<td>No ventilation and cardiopulmonary arrest</td>
<td>907</td>
</tr>
<tr>
<td>No ventilation and cardiac arrest</td>
<td>1249</td>
</tr>
<tr>
<td>Rescue breathing and cardiopulmonary resuscitation</td>
<td>37</td>
</tr>
<tr>
<td>Chest compression only and cardiopulmonary resuscitation</td>
<td>145</td>
</tr>
<tr>
<td>Chest compression only and cardiac arrest</td>
<td>119</td>
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</tbody>
</table>

**Cochrane Library** in Cochrane Central Register of Controlled Trials

Mesh term ‘resuscitation’, ‘cardiopulmonary’ ‘heart massage’ ‘respiration, artificial’ ‘heart group’

**PubMed** Mesh term

- "Cardiopulmonary Resuscitation"[Mesh] NOT "Respiration, Artificial"[Mesh]
  - 6386 hits
- ("Child"[Mesh] AND "Cardiopulmonary Resuscitation"[Mesh]) AND "Respiration, Artificial"[Mesh]
  - 39 hits
- "Child"[Mesh] AND "Cardiopulmonary Resuscitation"[Mesh] and respiratory and method 4 hits

**PubMed search**

- ‘Children and resuscitation’ 7247 hits
- Cardiac arrest and children: 2870 hits
- ‘children and chest compressions’ 69 hits
- ‘Chest compression only’ 424
- ‘asphyxial cardiac arrest’ 111 hits

Revision 31/1/2010:

- Cardiac arrest and child: 3887
- Chest compressions and child: 85
- Chest compressions and cardiopulmonary resuscitation: 628
- Chest compressions and cardiac arrest: 487
- No ventilation and cardiopulmonary arrest: 2286
- Rescue breathing and cardiopulmonary resuscitation: 57
- Chest compression only and cardiopulmonary resuscitation: 201
- Chest compression only and cardiac arrest: 156
<table>
<thead>
<tr>
<th>Chest compression only: 557 hits</th>
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<tbody>
<tr>
<td>No ventilation and chest compression: 646 hits</td>
</tr>
</tbody>
</table>

- **State inclusion and exclusion criteria**

Peer-reviewed manuscripts only with any information about chest compression only CPR with special focus on outcomes or hemodynamic changes

No reviews included.

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

Pediatric patients: 1; Adult patients (for extrapolations): 9; Animal asphyxial models: 2; Animal VF models: 12; mathematical models: 1
## Summary of evidence

### Evidence Supporting Clinical Question #1

<table>
<thead>
<tr>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
<th>Level of evidence</th>
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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

### Evidence Neutral to Clinical question #1

<table>
<thead>
<tr>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
</thead>
</table>
| Hallstrom 2000-1546 BC  
| Iwami 2007-2900 BCD  
| Berg 1993-1907 BD  
| Bohm 2007-2908 BCD  
| Bossaertvan Hoeweyghen 1989/1993-47 BC  
| Waalewijn 2001-273 BC  
| Berg 1995-342 ABD  
| Chandra 1994-3070 E  
| Engoren 1997-607 E  
| No 1995-861 BD  
| Berg 1997-4364 BD  
| Berg 1997-1635 ABD  
| Kern 1998-179 BD  
| Berg 2001-2465 E  
| Sanders 2002-553 BD  
| Dorph 2004-3 09 A  
| Ong 2008-119 C |
| | Kouwenhoven 1960-1064 BCD | |
Berg 1999-1893 ABD  
Berg Circ 2000-1743 BD  
Idris Circ 1994-143AE  
Dorph 2004-309 E  
Babbs 2004-173E  
Kill 2009-1060 AE  
Yannopoulos 2010-254 DE

Evidence Opposing Clinical Question #1

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

For G2000 and G2005 we addressed a related but somewhat different issue: was cc-only or rescue breathing-only better than no bystander CPR. Based on many of the studies noted above and some limited information from observational studies of pediatric out-of-hospital arrests, there was (and is) evidence suggesting that both hands-only (ie, cc-only) and rescue breathing-only by bystanders can result in successful resuscitations. The rescue breathing was presumably successful for children with respiratory arrests and some circulation (e.g., pulses were present or child was in “pseudo-EMD”—pulsatile flow without palpable pulses).

This question for G2010 is a bit different with a specific focus on the comparative effectiveness of hands-only CPR versus standard CPR, and inclusion of both out-of-hospital and in-hospital pediatric arrests. Consideration of out-of-hospital versus in-hospital CPR is also important because bystanders for out-of-hospital arrests are much more likely to have to perform single-rescuer CPR for a substantial amount of time. Adult manikin models indicate that a single rescuer typically interrupts chest compressions for 14-16 seconds to move from the chest to the head, re-position the head and neck and mouth, create a mouth-to-mouth seal, provide 2 breaths, and return to the chest to provide chest compressions (Assar, Resus 2000; Heidenreich, Resus 2004). The duration of interruptions is less in pediatric manikin models because children are smaller than adults (Whyte, Resus 1999). In animal models of VF arrests, hands-only CPR generally results in outcomes as good as standard CPR (CC+Rescue Breathing), if 2 breaths can be provided within 4 seconds (Berg 1993-1907, Berg 1995-342, Engoren 1997-607, Noc 1995-861, Berg 1997-1635, Berg1997-4364, Kern 1998-179, Dorph 2004-309), [with rare exceptions (Idris 1994)]. However, when 2 breaths interrupt chest compressions for 14-16 seconds,
hands-only CPR results in better outcomes than standard CPR in these animal models of single-rescuer CPR (Kern 2002-645; Ewy 2007-2525). Adult clinical observational studies also indicate that outcomes are generally at least as good with hands-only bystander CPR as standard bystander CPR (Hallstrom 2000-1546, Iwami 2007-2900; Bohm 2007-2908, Bossaert/van Hoeweyghen 1989/1993-47, Waalwijn 2001273, SOS-Kanto Lancet 2007-920; Ong 2008-119), but most of the good outcomes are in adults who had VF/VT. In addition, hands-only bystander CPR was associated with better outcomes among patients with witnessed VF/VT in one study (SOS-Kanto Lancet 2007-920). **Hands-only bystander CPR may be the best approach when a child has a witnessed sudden collapse cardiac arrest, presumably due to VF/VT (e.g., commotio cordis or a sudden collapse while playing basketball or football).**

However, most children with out-of-hospital arrests do not have VF/VT, and most do not receive any bystander CPR (Donoghue AEM 2005, Young AEM 1999). Two swine experiments have established that rescue breathing is critically important for successful resuscitation from an asphyxial cardiac arrest (Berg 1999-1893, Berg 2000-1743). In addition, mathematical models suggest that chest compression plus assisted ventilation would provide better oxygen delivery than chest compressions alone (Babbs 2004-173). Some animal studies have also demonstrated that blood gas exchanges deteriorated and chances of ROSC decreased during CC only resuscitation (Kill 2009-1060; Yannopoulos, 2010-254; Idris 1994-143) if resuscitation last more than 4-6 min and gasps are not frequent (Noc 1994-861) or airway is not open (Dorph 2004-309). Although animal studies, mathematical models, and clinical experience support the importance of rescue breathing for resuscitation from asphyxial arrests, there is very limited published pediatric or adult cardiac arrest/CPR literature to support the importance of rescue breathing for resuscitation from asphyxial arrests. In addition, there is some pediatric clinical data indicating that hands-only CPR can be effective for pediatric cardiac arrests (even non-VF arrests). In the original description of closed-chest cardiac massage (Kouwenhoven 1960-1064), 17 of the 20 patients did not have VF, 7/20 did not receive any rescue breathing, and at least 3 were children (the data reported are somewhat sketchy). All 20 attained ROSC, 14 were discharged alive “without neurological damage.” At least one well-described child survived with good outcome after CC-only CPR for an asphyxia-precipitated cardiac arrest. Although outcomes are dismal when the child is still in cardiac arrest by the time EMS providers arrive, excellent outcomes are typical when the child is successfully resuscitated prior to EMS provider arrival (Mogayzel ‘95, Sirbaugh ‘99, Hickey ‘95, Nichter ‘89, Friesen ‘82, Biggart ’90, Christensen ’97, Fiser ’87, Quan ’90, Kemp ’91, Kyriacou ’94, Schindler ’96, Kuisma ’95, Young ’99). Anecdotal successful bystander resuscitation techniques in these studies have included mouth-to-mouth rescue breathing alone, chest compressions alone, and chest compressions plus mouth-to-mouth rescue breathing; however, authors have retrospectively questioned whether these patients needed resuscitation (ie, were they truly in cardiac arrest). **Despite inadequate data, it is prudent to continue to recommend: 1) standard CPR as the treatment of choice for most pediatric out-of-hospital cardiac arrest, and 2) a single rescuer should provide “something” (e.g., either standard CPR or hands-only CPR) rather than “nothing” until someone joins them in the resuscitative efforts.**

In-hospital pediatric cardiac arrests are generally precipitated by asphyxia and/or circulatory shock (Nadkarni, JAMA 2006). Only 10% have VF/VT as the first documented rhythm. Moreover, single rescuers rarely are left to provide CPR alone for substantial periods of time in hospitals. Although the optimal order and ratio of chest compressions and rescue breaths for in-hospital pulseless pediatric cardiac arrests is not well established, it is **prudent to continue to recommend standard CPR with chest compressions and rescue breathing for in-hospital pediatric cardiac arrests.**

**Acknowledgements:**
Citation List


      LOE 5 good Opposing the clinical question (mathematical model)
Compression:ventilation ratio should be smaller for children than for adults, children requiring more ventilation than adults to optimise oxygen delivery and blood flow.


      LOE 5 neutral (Animal model)
Swine with 30 sec VF received standard CPR, CC only or no CPR. ROSC, 24-hour intact survival were equivalent in the 2 resuscitated groups and were better than in the no-CPR group


      LOE 5 neutral (Animal model)
Swine treated by 10 min standard CPR or CC only after 2 min VF. No difference in ROSC, 48-hour survival and neurological outcome.


      LOE 5 neutral (Animal model)
In a swine model of 5 min VF, ROSC, 24-hour survival and neurological outcome were similar with standard CPR and CC only and better than when no CPR was provided


      LOE 5 neutral (Animal model)
In a swine model of myocardial infarction with 2 min VF, standard CPR and CC only resulted in similar survival and were better than no CPR


      LOE 5 Opposing clinical question 1 (animal model)
In a pediatric asphyxial cardiac arrest swine standard CPR improves blood gases, early ROSC, 24-h survival and neurological outcome compared to CC only


      LOE 5 Opposing clinical question (animal model)
In this swine model of asphyxial cardiac arrest, 24 h survival was superior in the 3 groups with some CPR than in the group with no CPR

LOE 5 (Animal model) neutral
IN a swine model of 3 min VF, standard CPR delivered less compression than CC only (62+/−1 versus 92+/−1 compressions, P<0.001), a lower coronary perfusion pressure and lower left ventricular blood flow.


LOE 5 good neutral
Adult series; 8209 patients in OOH cardiac arrest received bystander CPR and 1145 patients received chest compression only. No difference in one-month survival


LOE 5 Neutral (animal model)
In a canine model of VF, arterial saturation remained above 90% during the first 4 minutes of CC only.


LOE 5 good Animal model neutral for ROSC (but opposing clinical question for arterial blood gases and time to ROSC)
In a swine model of 3 min VF with obstructed airway (not allowing gasping), standard CPR with ventilation at a ratio of 30:2 for 10 min improves arterial blood gases and time to ROSC but not ROSC compared to CC only.


LOE5 Good Neutral (animal model)
In a model of VF mimicking bystander resuscitation in Swine, CC only with airway open to room air or mouth-to-mouth plus CC resulted in similar gas exchanges


LOE 5 Good supporting the question (Animal study)
Adult swine in VF 3,4,5,6 min before CC or CPR 30:2 up to 12 min before defibrillation
Better 24 h intact survival with CC than 30:2 with interruption of 16 seconds for administration of RB (70% vs 42%) OR 3.7 CI 95% 1.2-11.3
OR for ROSC and 14h survival no difference
Perfusing rhythm after defibrillation for chest compression 64% and for standard CPR 29% (p0.006) no difference in ABG after 12 min


LOE 5 Neutral


LOE 5 Neutral (animal model)
Swine with 30 sec of VF, Airway occluded
Standard CPR was performed with the 2 rescue breathing administered in 4 seconds CC only was performed with an occluded airway allowing no spontaneous air entry during chest compressions. No difference in 24-hour survival between the two methods for a cardiac arrest duration of 6.5 min

recorded, three were VF. 14/20 patients survived without neurological damage. Two children are reported and had sudden collapse during a procedure without record of the arrest rhythm. One child was ventilated at the time of the arrest (two episodes), the other one received seemingly 1 min chest compression only and both children recovered without damage.


LOE5 Neutral (Animal model)
Rats with 5 min VF: During chest compression the non ventilated animals who developed more gasps were more susceptible to be successfully defibrillated than the animals whose gasps frequency was below 6/min.


LOE 5 good adult study
Cohort of OOH cardiac arrests among them 287 received standard CPR and 154 CC only. And were more susceptible to survive than patients who receive no CPR. No difference in survival at discharge between standard CPR and CC only.


LOE 5 Good neutral (animal model)
Swine with 3 min VF
This model showed similar ROSC but better neurological outcome when some rescue breathing were given, however not with a pediatric ratio of 15:2


LOE 5 Good Supporting clinical question (adult study)
Multicenter prospective series of 4068 witnessed OOH cardiac arrests in adults
No additional benefit of rescue breathing over CC-only
Favorable outcome of any type of resuscitation compared to no CPR


LOE 5 good neutral
Adult series of 922 OOH cardiac arrests with 437 patients receiving CPR, 41 CC only and 15 rescue breaths only. No difference in hospital admission alive p=0.570 and discharge alive p=0.713 between CPR and partial CPR.


LOE 5 neutral (adult series)
885 Adult cardiac arrests received bystander CPR that was performed as correct or incorrect standard CPR, CC only or rescue breath only. Long term survival was comparable in correct standard CPR(16%) or CC or RB only (10%) and both were better) with no CPR (7%) or incorrected CPR (4%) 

LOE 5 good opposed to question
24 h survival with good neurological outcome is better after standard CPR than after CC only with more severe hypoxia and respiratory acidosis in a model of swine cardiac arrest with 8 min resuscitation