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

**Worksheet author(s)**

| Myra H. Wyckoff, MD | Date Submitted for review: 1-15-10 |

**Clinical question.**

In neonates receiving chest compressions (P), do other ratios (5:1, 15:2) (I) versus 3:1 (C) improve outcomes (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: New topic for Neo group but has been examined by Peds Group

**Conflict of interest specific to this question**

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

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

PubMed: “Cardiopulmonary Resuscitation” or Cardiac Compressions” or “Chest Compressions” or “Heart Massage” as MeSH (heading) AND “Neonatal” OR “Newborn” or “Infant”

Cochrane Library, EMBASE, SCOPUS, AHA Endnote Database, hand review of references of articles of relevance

Last search 1-14-10

**State inclusion and exclusion criteria**

*Inclusion:* Human and animal, neonatal or neonatal model studies, pediatric or pediatric model studies, adult studies as long as truly examining compression to ventilation ratios of 3:1, 5:1 or 15:2, English Language

*Exclusion:* Abstract only

Did not include adult studies that examined compression only CPR or compression to ventilation strategies of >15:2 as the neonatal cause of cardiac arrest is asphyxia and ventilation will be critical for the neonate

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

Pub Med: 66 hits

Embase: 37 hits

AHA Library: 35 hits

Cochrane: 0 hits

All reviewed

11 met criteria to be placed on the grid. All are LOE5
## Summary of evidence
### Evidence Supporting Clinical Question

| Good | | | | | |
|------|---|---|---|---|
| Fair | | | | | |
| Poor | | | | | |

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
</table>

**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

<table>
<thead>
<tr>
<th>Good</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Babbs-2004 p173&lt;sup&gt;E&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Berg-1999 p189&lt;sup&gt;a,b,d&lt;/sup&gt;</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Berg-2000 p174&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Kinney-2000 p115&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Turner-2002 p55&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Greingor-2002p263&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Srikanton-2005 p293&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**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

<table>
<thead>
<tr>
<th>Good</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Berg-1999 p189&lt;sup&gt;a,b,d&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Berg-2000 p174&lt;sup&gt;a,b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Poor</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>Kinney-2000 p115&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Turner-2002 p55&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Greingor-2002p263&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Srikanton-2005 p293&lt;sup&gt;E&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

**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*
Unlike V-fib, during asphyxia, blood continues to flow to tissues, and arterial and venous oxygen saturation decrease while carbon dioxide and lactate continue to increase for many minutes. In addition, continued pulmonary blood flow before the cardiac arrest depletes the pulmonary oxygen reservoir. Therefore, asphyxia results in significant arterial hypoxemia and acidemia prior to resuscitation in contrast to V-fib. Not surprisingly, there is agreement from mathematical models as well as animal experiments that ventilations are critical for asphyxial arrest (the situation that is overwhelmingly present for infants requiring cardiac compressions in the delivery room and in all forms of prolonged arrest). In contrast to ventricular fibrillation models, piglet studies of CPR for asphyxia-precipitated cardiac arrests demonstrated that the addition of rescue breathing to compressions results in much better outcomes than compressions alone {Berg-1999A,B,D, Berg-2000A,B}. For piglets with asphyxia-precipitated asystole following endotracheal tube clamping rescue breathing plus chest compressions were necessary for successful resuscitation. This data would suggest that cardiac compressions alone would not be appropriate for neonatal resuscitation.

The compression to ventilation ratio for neonatal resuscitation that will optimize coronary and cerebral perfusion while providing adequate ventilation of an asphyxiated newborn remains unknown. The long-standing recommendation for 3 compressions to 1 ventilation during neonatal cardiac compressions is simply a consensus opinion, based on the physiologic plausibility that newborns who require cardiac compressions are asphyxiated and that newborns have higher respiratory rates than adults and older children even when not asphyxiated. However, there is no evidence that would demand a departure from the current 3:1 compression to ventilation ratio.

Acknowledgements: None

Citation List

**Babbs-2002 p147**

**Level of Evidence** 5-Theoretical analysis of C/V ratios using mathematical algorithms based on classical physiology of oxygen delivery and blood flow of adults

**Quality**: Fair

**Supportive/Neutral/Opposing**: Supports

**Industry Funding**: None

**Comments**: Findings: Suggest blood flow and oxygen delivery to the periphery would be improved with more compressions and fewer ventilations—thus one would theorize that 3:1 would be poorer than a longer compression to ventilation ratio.

**Babbs-2004 p173**

**Level of Evidence** 5-Theoretical analysis of C/V ratios using algorithms based on developmental anatomy and physiology.

**Quality**: Fair
Supportive/Neutral/Opposing: Neutral  
Industry Funding: None  
Comments: Adult ratios would under ventilate children. Suggest that $x^*$ is approximately $1.6 \sqrt{W}$ where $W$ is the patient’s body weight in kg for professional rescuers.

Berg-1999 p1893$^{A,B,D}$

Level of Evidence 5-Prospective, randomized pediatric swine model of asphyxia-induced cardiac arrest  
Quality: Good (although no power analysis)  
Supportive/Neutral/Opposing: Opposes (Does not directly address 3:1 ratio but demonstrates that ventilation is critical to recovery from asphyxial arrest)  
Industry Funding: None  
Comments:  
Participants: Pediatric swine asphyxiated until aortic pulse pressure < 2 mmHg  
Intervention/Comparator: control vs CC+V (15:2) vs CC only vs V only. Outcome: ROSC, 24 hour survival and 24 hour neurologic  
Findings: Outcomes are improved when cardiac compressions are combined with ventilations when the cause of arrest is asphyxia. Ventilations are critical.

Berg-2000 p1743$^{A,B}$

Level of Evidence 5-Prospective, randomized pediatric swine model of asphyxia-induced cardiac arrest  
Quality: Good (although no power analysis)  
Supportive/Neutral/Opposing: Opposes (Does not directly address 3:1 ratio but demonstrates that ventilation is critical to recovery from asphyxial arrest)  
Industry Funding: None  
Comments:  
Participants: Infant swine asphyxiated to point of systolic BP < 50 mmHg.  
Intervention/Comparator: control vs CC+V (15:2) vs CC only vs V only. Outcome: ROSC, 24 hour survival and 24 hour neurologic  
Findings: Outcomes are improved when cardiac compressions are combined with ventilations when the cause of arrest is asphyxia. Ventilations are critical.

Dorph-2002 p259$^{E}$

Level of Evidence 5-Prospective, randomized manikin study of different C:V ratios for BLS with ventilation provided via mouth-to-mouth  
Quality: Fair (no power analysis)  
Supportive/Neutral/Opposing: Supportive-Found benefit in longer compression to ventilation ratios because spend more time compressing rather than wasted time switching between compressions and giving rescue breaths  
Industry Funding: None  
Comments:  
Participants: BLS providers and pediatric manikin. Intervention/Comparator: 5:1 vs 15:2 compression to ventilation ratios. Outcome: Quality of chest compressions and minute ventilation. Findings: 15:2 provided more chest compressions with equivalent minute ventilation. How this would translate to 3:1 scenario is unknown as neonatal resuscitation would not be using mouth to mouth for ventilations
Greingor-2002 p263E

**Level of Evidence** 5-Prospective, randomized adult manikin study of different C:V ratios of 5:1 vs 15:2.

**Quality:** Fair (no power analysis)

**Supportive/Neutral/Opposing:** Opposing-Found benefit in shorter compression to ventilation ratio with better quality of compressions (correct hand placement and depth of compression).

**Industry Funding:** None

**Comments:** Participants: ACLS providers using an adult manikin. Intervention/Comparator: 5:1 vs 15:2 compression to ventilation ratios. **Outcome:** number and quality of chest compressions

**Findings:** Same number of chest compressions provided with both methods. Quality of compressions was improved with 5:1 (more often in correct location and appropriate compression depth). Seemed to be fatigue issues with the longer ratio. Ventilation effectiveness was not assessed.

Haque-2008 p82E

**Level of Evidence** 5-Prospective, randomized cross-over designed manikin study of different C:V ratios of 30:2 vs 15:2.

**Quality:** Fair (no power analysis)

**Supportive/Neutral/Opposing:** Supportive-Found longer compression to ventilation ratio allowed for delivery of more compressions per minute with no difference in quality of compressions. Rescuers preferred 15:2.

**Industry Funding:** None

**Comments:** Participants: BLS or PALS providers using an adolescent, child and infant manikins for single person CPR. Intervention/Comparator: 30:2 vs 15:2 compression to ventilation ratios. Outcome: number and quality of chest compressions

**Findings:** Found longer compression to ventilation ratio allowed for delivery of more compressions per minute with less ventilations with no difference in quality of compressions; however, rescuers preferred 15:2. It is unknown if more compressions but less ventilation would be beneficial in asphyxial arrest.

Kinney-2000 p115E

**Level of Evidence** 5-Prospective, randomized pediatric manikin study of different C:V ratios of 5:1 vs 10:2 vs 15:2.

**Quality:** Fair (no power analysis)

**Supportive/Neutral/Opposing:** Opposing-Found benefit in shorter compression to ventilation ratio (5:1) with increased number of effective compressions and increased minute ventilation

**Industry Funding:** None

**Comments:** Participants: Nurses with CPR training using a pediatric manikin for 2 person CPR. Intervention/Comparator: 5:1 vs 10:2 vs 15:2 compression to ventilation ratios. Outcome: number and quality of chest compressions and number of breaths/min and minute ventilation

**Findings:** The percentage of effective chest compressions was equal with all three methods but the number of effective chest compressions was greatest with a ratio of 5:1. Minute ventilation was improved as well in the 5:1 ratio arm.
Srikantan-2005 p293E

**Level of Evidence** 5-Prospective, randomized pediatric manikin study of different C:V ratios of 3:1 vs 5:1 vs 10:2 vs 15:2.

**Quality:** Fair (no power analysis)

**Supportive/Neutral/Opposing:** Opposing-Found benefit in shorter compression to ventilation ratio (3:1) with increased ventilations which may be key if asphyxia is cause of arrest.

**Industry Funding:** None

**Comments:** Participants: BLS trained rescuers using infant, pediatric and adult manikins for 1 person CPR. Intervention/Comparator: 3:1 vs 5:1 vs 10:2 vs 15:2 compression to ventilation ratios. For infant CPR 2-finger method was used. Outcome: number of effective chest compressions and ventilations per minute and subjective fatigue score and rescuer pulse rate. Findings: The 3:1 ratio provided more ventilations per minute than the other ratios and less compressions than the 15:2 ratio. Rescuers subjectively felt more fatigue with the 3:1 ratio but there was no difference in rescuer pulse rate. Important to note might not have felt so fatiguing if this was 2 rescuer 3:1. Also might have been able to get more compressions in if the single rescuer was not constantly having to switch between compressions and ventilation.

Turner-2002 p55E

**Level of Evidence** 5-Theoretical analysis of C/V ratios using mathematical algorithms based on classical physiology of oxygen delivery and blood flow of adults comparing 5:1 vs 15:2 vs 50:5.

**Quality:** Fair

**Supportive/Neutral/Opposing:** Opposes- study suggests longer rather than shorter compression to ventilation cycles provide better oxygen delivery to the tissues due to improved blood flow; however, after 3-4 minutes of hypoxia ventilations would become increasingly critical. Since neonates are typically already hypoxic at the start of their arrest from asphyxia, this would suggest that ventilations with oxygen may be important from the start for the neonate.

**Industry Funding:** None

**Comments:** Findings: Suggest blood flow and oxygen delivery to the periphery would be improved with more compressions and fewer ventilations-thus one would theorize that 3:1 would be poorer than a longer compression to ventilation ratio.

Wik-1996E

**Level of Evidence** 5

**Quality:** Fair (no power analysis)

**Supportive/Neutral/Opposing**

**Industry Funding:** None

**Comments:** Participants: Paramedic Students. Intervention/Comparator: 5:1 versus 15:2 compressions to ventilations. Outcome: quality of CPR, time to successful CPR. Findings: Quality of compressions NOT different. Took less time to perform successful CPR with 15:2 (had less missed ventilations).
Whyte-1999 p21E

Level of Evidence 5-Prospective observational infant manikin study of providers ability to successfully deliver 40 breaths during 3:1 compression to ventilation neonatal CPR-both single rescuer (mouth to nose) and 2-rescuer-BMV were studied.

Quality: Fair (no power analysis)
Supportive/Neutral/Opposing: Supports –Both single and 2-rescuer teams were unable to deliver the goal of 40 ventilations per minute during 3:1 CPR.

Industry Funding: None

Comments: Participants: Hospital- trained rescuers using an infant manikins for 1 and 2 person neonatal CPR. Intervention/Comparator: 3:1 compression to ventilation ratio was used by 1 and 2 person teams. Outcome: number of effective ventilations per minute Findings: Using the 3:1 ratio neither single or 2 person teams could deliver 40 ventilations per minute. Quality of cardiac compressions and number was not assessed. Note: Not sure this relates well to current recommendations in that now it is suggested to use 3:1 to achieve 90 compressions and 30 breaths per minute. Most could achieve 30 breaths per minute just not 40 breaths per minute in the study.

Articles reviewed but not included


Comments: Adult clinical and pig paper that demonstrates that in V-fib, excessive ventilation increases intrathoracic pressure, decreases coronary blood flow and decreases survival following CPR. This should raise concern, that although neonatal CPR will be more reliant on ventilation due to asphyxia arrest, that there may be a limit beyond which ventilation is detrimental to hemodynamics during CPR. Not really a study of specific C:V ratios though and data is all adult so will not include in table.

Comments: Excluded because review article of adult C:V ratio issues with no new data


Comments: Excluded because adult pig model study that compares 15:2 to 50:5 to 100:2 which would have very little relevance for neonatal CPR due to the need for ventilation due to the likely asphyxial cause of cardiac arrest.


Comments: Excluded because adult pig model study that compares 15:2 to 50:5 to 100:2 which would have very little relevance for neonatal CPR due to the need for ventilation due to the likely asphyxial cause of cardiac arrest.

Comments: Excluded because review article with no new data