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

Worksheet author(s)
Michael Sayre, MD

Date Submitted for review: November 5, 2009

Clinical question
In adult and pediatric patients in cardiac arrest (prehospital [OHCA], in-hospital [IHCA]) (P), does the use of another specific C:V ratio (I) compared with standard care (30:2) (C), improve outcome (eg. ROSC, survival) (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: Revision of W154 Gabrielli Fenici

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
Conducted: November 5, 2009

<table>
<thead>
<tr>
<th>Search</th>
<th>Most Recent Queries</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>#3</td>
<td>Search #1 AND #2</td>
<td>458</td>
</tr>
<tr>
<td>#2</td>
<td>Search ratio[tiab]</td>
<td>438713</td>
</tr>
</tbody>
</table>

458 Titles scanned.
56 abstracts selected for review.

Reviewed 2005 worksheet on same topic by Fenici & Gabrielli (W154). No additional relevant citations were identified.

Cochrane Library (Issue 1 – 2008)
Query: “compression AND ventilation AND ratio” – 19 hits. No value added.

Cochrane Register of Controlled Clinical Trials (Issue 1 – 2008)

ECC Master Library (March 24, 2008)
Query: “compression AND ventilation AND ratio” – 133 hits. One additional article found that was not yet indexed in MEDLINE.

Citations Search
Scanned citations of selected articles. One additional article found.

• State inclusion and exclusion criteria

Include studies comparing different C:V ratios with V > 0 in both groups.
Include animal and human studies.

Exclude studies only comparing one C:V ratio with V = 0 (compression-only CPR).
Exclude review articles without new data.

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

31 studies met criteria for further review.
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Good</th>
<th>Evidence Supporting Clinical Question</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bjorshol, 2008, 95-100 E [50:2]</td>
</tr>
<tr>
<td></td>
<td>Dunkley, 1998, 7-12 E [15:2]</td>
</tr>
<tr>
<td></td>
<td>Sanders, 2002, 553-62 B,D [100:2]</td>
</tr>
<tr>
<td></td>
<td>Srikantan, 2005, 293-7 E [pediatric 10:2]</td>
</tr>
<tr>
<td></td>
<td>Yannopoulos, 2005, 628-35 E [15:1]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fair</th>
<th>Evidence Supporting Clinical Question</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Babbs, 2002, 147-57 (computer model) [30:2]</td>
</tr>
<tr>
<td></td>
<td>Babbs, 2004, 173-81 (computer model) [pediatric 5+age in years:1]</td>
</tr>
<tr>
<td></td>
<td>Dorph, 2002, 259-64 E [15:2]</td>
</tr>
<tr>
<td></td>
<td>Greingor, 2002, 263-7 E [5:1]</td>
</tr>
<tr>
<td></td>
<td>Hostler, 2005, 325-8 E [60:2]</td>
</tr>
<tr>
<td></td>
<td>Turner, 2004, 209-17 (Computer model) [20:1]</td>
</tr>
<tr>
<td></td>
<td>Walker, 2001, 179-83 E [15:2]</td>
</tr>
<tr>
<td></td>
<td>Wik, 1996, 113-9 E [15:2]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Poor</th>
<th>Evidence Supporting Clinical Question</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Kinney, 2000, 115-20 E [pediatric 5:1]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></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 Neutral to Clinical question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Evidence Opposing Clinical Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td></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>Level of Evidence</th>
<th>Evidence Opposing Clinical Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td></td>
</tr>
<tr>
<td>Good</td>
<td></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*
DISCUSSION: In essence, this clinical question comes down to the following: is there enough evidence to warrant changing the current recommendation for a universal 30:2 compression:ventilation ratio to some other ratio. Several studies report outcomes for adult humans in cardiac arrest using different C:V ratios. However, no study is “pure”, that is more than one change was implemented at the same time, making it impossible to determine the contribution of changing the compression:ventilation ratio compared to other changes such as altering the post-defibrillation pause.

Two studies support keeping the current 30:2 C:V ratio. The ROC investigators (Christenson, 2009, 1241-7) identified a prospectively collected cohort of patients with witnessed ventricular fibrillation cardiac arrest and measured the no flow fraction prior to the first shock. As the no flow fraction fell, survival to hospital discharge increased. However, with no flow fractions below 0.4, survival seemed to plateau. Investigators in Columbus, OH (Sayre, 2009, 469-77) followed patients suffering out-of-hospital cardiac arrest before and after implementation of the 2005 American Heart Association CPR and ECC guidelines. The no-flow fraction decreased from 0.46 before the guideline change to 0.34 after. Among all patients, survival to hospital discharge increased from 6.1% to 9.4%.

Two studies are neutral. Investigators in Norway (Olasveengen, 2009, 407-11) followed patients suffering out-of-hospital cardiac arrest before and after implementation of the 2005 European Resuscitation Council CPR and ECC guidelines. In both groups, there was excellent CPR quality with a no-flow fraction of 0.23 prior to the guideline change and 0.14 after. While measures of CPR quality improved after the guidelines were implemented, no significant change in survival to hospital discharge was noted.

Hostler (Hostler, 2007, 446-52) trained firefighters in Pittsburgh to use 30:2 CPR and a one shock sequence rather than 15:2 CPR and a three shock sequence. AED electronic recordings were accessed to identify whether the firefighters were following the protocol. After the protocol change, the number of chest compressions delivered increased from 55 per minute to about 78 per minute and the no-flow fraction decreased from about 35 to about 29. However, rates of ROSC were similar.

Supporting a hypothesis that a C:V ratio with even more chest compressions than 30:2, Garza and colleagues in Kansas City, MO (Garza, 2009, 2597-605) implemented a somewhat different version of CPR guidelines for care of victims of out-of-hospital cardiac arrest. They compared outcomes with a 50:2 C:V ratio after April 2006 with 5:1 CPR given prior to April 2006. After the protocol change, survival to hospital discharge increased to 14% from 8% at baseline.

A variety of manikin studies attempt to address fatigue as well as feasibility of different C:V ratios and could be used as a partial basis for additional animal and possibly human studies on the optimal C:V ratio for adults and children in cardiac arrest. None of the studies is compelling and they come to a variety of different conclusions as to the optimal ratio ranging from 5:1 to 100:2.

Acknowledgements:
Citation List


LOE: 5 - computer simulation study  
Quality: Fair  
Direction: Supportive  
Brief Summary: The model predicts that oxygen delivery is optimized for lay rescuers at a 60:2 and for professional rescuers at a 30:2 CV ratio.  
Support: None noted.


LOE: 5 - computer simulation study  
Quality: Fair  
Direction: Supportive  
Brief Summary: The model predicts that, in children, optimal C:V ratio is dependent on size. For professional rescuers, the optimal C:V ratio is approximately 1.6 * SQRT(Weight in Kg). For lay rescuers a good rule of thumb may be 5 + age in years.  
Support: None noted.


LOE: 5 - manikin  
Quality: Fair  
Direction: Opposed  
Brief Summary: In a cohort of healthcare providers, increasing the CPR ratio from 15:2 to 30:2 did not change physical or perceived exertion during a 5-min bout of CPR when continuous, real-time feedback is provided. The 30:2 compression to ventilation ratio resulted in more chest compressions per minute without decreasing CPR quality.  
Support: None noted.


LOE: 5 - manikin study using one professional rescuer  
Quality: Good  
Direction: Supportive  
Brief Summary: Single paramedics randomly assigned to 15:2, 30:2, and 50:2 for 10 mins. The paramedics were highly motivated and performed compressions above 100/min the entire time without change in depth between ratios but less depth after 2 minutes. The no-flow fraction dropped from .5 at 15:2 to .33 at 30:2 to .23 at 50:2.  
Support: Laerdal Foundation


LOE: 5 - Animal model
Quality: Fair
Direction: Neutral
Brief Summary: Compared 15:2, 30:2, and compression only. 4/8, 2/8, and 0/8 animals in the 15:2, 30:2, and CC groups, respectively, had ROSC at the end of the study period (p=ns).
Support: None noted.


LOE: 4 - human cohort study
Quality: Good
Direction: Opposed
Brief Summary: Measured actual chest compression fraction for 506 VF/VT patients with at least 1 minute of CPR prior to the first shock. Found that survival to hospital discharge was best among patients receiving compressions for >60% of the time prior to the first shock.
Support: NIH.


LOE: 5 - manikin study using one professional rescuer
Quality: Fair
Direction: Opposing
Brief Summary: While the rescuers perceived 5 mins of 30:2 CPR to be more tiring than 15:2 CPR, the quality of compressions remained unchanged. 50% more compressions were delivered with 30:2.
Support: None reported


LOE: 5 - manikin study using single trained lay rescuers
Quality: Fair
Direction: Supportive
Brief Summary: Because of the time required to move from the chest to the airway and back to the chest, a ratio of 15:2 delivered more compressions with the same minute volume as a 5:1 ratio with a single lay rescuer.
Support: Laerdal Foundation


LOE: 5 - pig study using mechanical thumper compressions and ventilation of ET tube with 17% O2 and 4% CO2 with compression pause to give the 2 breaths of about 5-6 seconds.
Quality: Good
Direction: Neutral
Brief Summary: Pigs randomized to 15:2, 50:2, and 50:5 CPR. Short pause for breathing simulating excellent professional rescuers. Oxygen delivery to the brain was 21.5% of baseline with 15:2, 18.7% with 50:2 and 14.7% with 50:5. However, coronary perfusion pressure was 16 mmHg with 15:2, 20 with 50:2, and 22 with 50:5. ETCO2 was highest with 50:2. Actual compressions delivered were 64 with 15:2, 86 with 50:2, and 66 with 50:5. These mixed results
suggest 50:5 is not useful, but since defibrillation was not attempted there is no information on the relative importance of higher coronary perfusion vs lower brain oxygen delivery. Support: Laerdal Foundation, Jahre Foundation, and the Norwegian Air Ambulance.


LOE: 5 - manikin study for compressions and human volunteers in OR for airway using two professional rescuers  
Quality: Good  
Direction: Supportive  
Brief Summary: Two professional rescuers performed CPR with bag-mask ventilation for 4 minutes comparing 5:1 with 15:2 in which the rescuer performing compressions also squeezed the bag and the rescuer on the airway used both hands to make a face seal with the mask. Because the face seal was better with the modified airway technique in the 15:2 CPR, minute volume was similar despite a ventilation rate of 6/min. Compression rate was higher as well at 82/min with 15:2 compared to 65/min with 5:1.  
Support: Laerdal Foundation


LOE: 5 - manikin study using professional rescuers  
Quality: Fair  
Direction: Neutral  
Brief Summary: A professional rescuer performed CPR with mouth-to-mouth ventilation for 7 minutes using 5:1 (infant), 15:2, 30:2, 30:5, 50:5, and 100:10. The purpose was to measure changes in O2 concentration in the gas exhaled from the rescuer into the manikin. The oxygen concentration varied between 15.9% and 17.0% in adult manikins and 17.9% in the infant manikin because of the higher concentration of O2 in the dead space of the rescuer with only 30 mL breaths. None of the differences were clinically significant.  
Support: No manufacturer involvement.


LOE: 3 - Human with historical controls  
Quality: Fair  
Direction: Supportive  
Brief Summary: Changed EMS protocol from 15:2 to 50:2. Survival from witnessed VF improved from 22% to 44%.  
Support: None noted.


LOE: 5 - manikin study using two professional rescuers  
Quality: Fair  
Direction: Supportive  
Brief Summary: Two professional rescuers performed CPR with bag-mask ventilation for 5 minutes. After the first minute, the count of correctly applied compressions was lower with 15:2 compared with 5:1.  
Support: No comment on industry funding.

LOE: 5 - manikin
Quality: Fair
Direction: Opposed
Brief Summary: During single rescuer pediatric BLS, more compression cycles were achieved with 30:2 C:V ratio compared with 15:2 without effect on compression depth, pressure and rate. Increased HR with 30:2 C:V ratio was noted during larger manikin CPR without subjective difference of reported fatigue. Most rescuers did not achieve recommended compression depth regardless of C:V ratio.
Support: None noted.


LOE: 5 - manikin study using two professional rescuers with BVM
Quality:
Direction:
Brief Summary: Teams gave 2 mins of CPR using 15:2, 30:2, 40:2, 50:2, or 60:2 and then switched positions with a one min rest period before resuming CPR. With increasing C:V ratios, more compressions and fewer breaths were performed without change in compression depth, rate or hand position.
Support: None reported

Hostler D, Rittenberger JC, Roth R, Callaway CW. Increased chest compression to ventilation ratio improves delivery of CPR. Resuscitation. 2007 Sep;74(3):446-52.

LOE: 3 - human study in out-of-hospital cardiac arrest patients comparing 30:2 with historical controls using 15:2
Quality: Fair
Direction: Neutral
Brief Summary: Looked at the first 3 mins of CPR recorded by AEDs. More chest compressions were delivered with 30:2 CPR but the rate of ROSC remained unchanged. This only looked at the firefighter based AEDs and not at how the second tier paramedics cared for the patients.
Support: Laerdal Foundation


LOE: 5 - dog study using two professional rescuers with a metronome giving 2 manual breaths in 7 seconds and one breath in 3 secs
Quality: Fair
Direction: Neutral
Brief Summary: Compared 15:1 with 15:2 and 30:2. Coronary perfusion pressure was only about 7 mm Hg in the 24 dogs. Rates of ROSC were about the same as were various hemodynamic measures.
Support: Ministry of Health of South Korea

LOE: 5 - manikin study using two professional rescuers
Quality: Fair
Direction: Neutral
Brief Summary: Cross-over design in manikins comparing 15:2 vs 50:5 CPR. The paramedics liked the 50:5 better because they felt less stress, but the number of compressions and breaths were about the same.
Support: None reported


LOE: 5 - manikin study using two professional rescuers simulating pediatric arrest
Quality: Poor - underpowered
Direction: Supportive
Brief Summary: Compared 5:1 with 10:2 and 15:2 CPR when performed by student nurses. The number of delivered compressions remained constant despite the change in C:V ratio while the number of ventilations dropped.
Support: None reported


LOE: 5 - manikin study using single lay rescuers in the Oslo airport
Quality: Good
Direction: Opposing
Brief Summary: Compared 15:2, 30:2 and hands-only CPR. 3/4ths of the subjects had previous CPR training but it was 8-12 years previously. Compression depth with hands-only was less than 15:2 and 30:2 and dropped over 5 minutes. The count of compressions per minute was about 40 in both the 15:2 and 30:2 groups and the count of effective breaths was 3 per min in the 15:2 group and 2 in the 30:2 group. It took 13 secs to give 2 breaths. The study subjects seemed quite representative of real bystanders.
Support: Laerdal Foundation and the Research Council of Norway


LOE: 3 - human with historical control
Quality: Good
Direction: Neutral
Brief Summary: Quality of CPR improved after implementation of the modified 2005 Guidelines with only a weak trend towards improved survival to hospital discharge.
Support: None noted


LOE: 5 - Pig study using two professional rescuer CPR with 17% O2 and 4% CO2
Quality: Good
Direction: Supportive
Brief Summary: Compared pigs receiving 15:2 with CC-only, 50:5, and 100:2. 24 hour survival similar between the groups. However the 24-hour neuro outcome was best with 100:2 CPR.
Support: American Heart Association


LOE: 3 - human with historical control
Quality: Fair
Direction: Opposed
Brief Summary: Overall survival improved with implementation of 2005 CPR guidelines.
Support: None noted.


LOE: 5 - manikin study using one professional rescuer
Quality: Good
Direction: Supportive
Brief Summary: Pediatric manikin study comparing 5 mins of one professional rescuer, metronome guided CPR at C:V ratios of 3:1, 5:1, 10:2, & 15:2 on infant, pediatric, and adult manikins. Pulse rate changes in rescuers were similar regardless of the ratio. In infant manikins, compressions per min (as judged by an "expert" observer) increased from 57 at a 3:1 ratio to 70 at a 15:2 ratio while ventilations decreased from 19 to 9. In a pediatric manikin, compressions per min increased from 47 at 3:1 to 62 at 15:2 while ventilations decreased from 16 to 8. In an adult manikin, compressions per min increased from 31 at 3:1 to 56 at 15:2 and ventilations decreased from 12 to 8. Authors suggest a 10:2 ratio for all victims with one rescuer.
Support: None noted


LOE: 5 - computer simulation study
Quality: Fair
Direction: Neutral
Brief Summary: The model predicts that continuous chest compression, with no ventilations, produces a cardiac output of 1.39 l/min, which was significantly greater than that from a 5:1 ratio (0.73 l/min), a 15:2 ratio (0.86 l/min) or a 50:5 ratio (0.94 l/min). The range of cardiac outputs (15–29% of the normal output) are consistent with those reported in the literature. The model predicts that PO2 will be about 25 mm Hg after 6 mins of compression only CPR and near normal with 15:2 CPR. The best oxygen delivery occured with 15:2 and 50:5 CPR at 5-6 mins of CPR, but compression only was best in the first 1-2 minutes.
Support: None noted.


LOE: 5 - computer simulation study
Quality: Fair
Direction: Supportive
Brief Summary: The model compared 10:1, 15:1, 20:1 and 40:1 C:V ratios. It found that after 6 mins of CPR simulation with 17% inspired oxygen, O2 delivery increased at the ratio increased from 10:1 to 30:1 and then began to fall. If 50% supplemental oxygen was given, then the O2 delivery continuously increased from 10:1 to 50:1.
Support: None noted.


LOE: 5 - manikin study using professional rescuers in one or two-person teams  
Quality: Fair  
Direction: Supportive  
Brief Summary: Medical students performed CPR for 15 mins. Over the 15 mins, PCO2 fell to low levels in the rescuers providing mouth to mouth using a 5:1 C:V ratio leading to lightheadedness. With 15:2, one person CPR, PCO2 and PO2 remained fairly constant.  
Support: None noted.


LOE: 5 - manikin study with two professional rescuers  
Quality: Fair  
Direction: Supportive  
Brief Summary: When there are only two rescuers treating a patient with asystole, performing CPR using a 15:2 ratio by one rescuer allows the second rescuer to focus on tasks such as establishing an IV and giving epinephrine. Those tasks happen much more slowly with a 5:1 C:V ratio.  
Support: None noted.


LOE: 5 - animal study with pigs  
Quality: Fair  
Direction: Supportive  
Brief Summary: The study was underpowered for ROSC, but showed improved hemodynamics with 10:1 compared to 5:1 CPR.  
Support: Dr. Lurie, one of the co-authors, invented the ITD.


LOE: 5 - animal study with pigs  
Quality: Good  
Direction: Supportive  
Brief Summary: The pigs were randomly treated with either 15:1 or 15:2 CPR. When 15:1 was used, the coronary and cerebral perfusion pressures were higher.  

Quality: Good
Direction: Opposing
Brief Summary: Part 1. 1 of nine pigs had ROSC with 15:2 and 6 of 9 with 30:2. Part 2. The human phase used a metronome to guide compressions. The ventilation pause was set at about 6 seconds, and the single rescuers did not actually give rescuer breaths during the 5 min test of compressions. The 30:2 subjects gave about 12 more compressions/min than the 15:2 subjects with similar quality of compressions except worse chest wall recoil in the 30:2 group. Fatigue was similar between the groups.
Support: Supported in part by an American Heart Association Postdoctoral Fellowship (grant 0425714Z) and a research gift from the Dwight Opperman Foundation. Dr. Lurie is the inventor of the Inspiratory Impedance Threshold Device.