Clinical question.

"In adult cardiac arrest (out-of-hospital and in-hospital) with either a protected and unprotected airway (P), does the monitoring and control of ventilatory parameters (eg. minute ventilation and/or peak pressures) (I) as opposed to standard care (without ventilatory monitoring) (C), improve outcome (O) (eg. ROSC, survival)?"

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

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).

(heart arrest OR cardiopulmonary resuscitation) AND ventilat*: 2238 hits

660 titles reviewed after exclusion criteria applied

17 studies given further consideration as below

Included


No abstract / study available


Not relevant to question


(heart arrest OR cardiopulmonary resuscitation) AND (hyperventilation OR hypoventilation OR minute volume): 283 hits

Exclusion criteria as above

113 titles reviewed after exclusion criteria applied

9 titles given further consideration

Included


Not relevant


(heart arrest OR cardiopulmonary resuscitation) AND (peak pressure OR airway pressure): 463 hits

Exclusion criteria as above

204 titles reviewed after exclusion criteria applied

12 titles given further consideration
Included


Not relevant


Databases searched: Medline, EMBASE, CINAHL (last searched 26 January 2010).

Search of the AHA Master EndNote Library (24 March 2008) using the terms (abstract) ventilation AND monitor NOT cerebral NOT children produced 61 hits – 3 of these were reviewed but subsequently found not to be relevant.

In addition the reference lists from the papers selected for further review were hand searched.

State inclusion and exclusion criteria

Excluded: Neonates / paediatrics
Quality of cardiopulmonary resuscitation
Compression only CPR
Haemorrhagic shock
BATLS / BLS / ALS / Acute Care Undergraduate Teaching Initiative / First responders
Cardiopulmonary bypass
Transoesophageal cardiac pacing
Cor pulmonale / lung transplantation
Cerebral oxygenation
Metabolic derangement
Hypothermia / cooling
Vasopressors / inotropes
End tidal carbon dioxide / capnography
Reviews

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

6 papers.
### Summary of evidence

#### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Rating</th>
<th></th>
<th>Abella 2007 (E)</th>
<th>Aufderheide 2004 (E)</th>
<th>Aufderheide 2004 (A)</th>
<th>Kleinsasser 2002 (A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = Return of spontaneous circulation</td>
</tr>
<tr>
<td>B = Survival of event</td>
</tr>
<tr>
<td>C = Survival to hospital discharge</td>
</tr>
<tr>
<td>D = Intact neurological survival</td>
</tr>
<tr>
<td>E = Other endpoint</td>
</tr>
</tbody>
</table>

*Italics = Animal studies*
### Evidence Neutral to Clinical question

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fair</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Poor</strong></td>
<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 Opposing Clinical Question

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Good</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Fair</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Poor</strong></td>
<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*
O’Neill & Deakin 2006 demonstrated that hyperventilation is common when resuscitating patients. This is due to excessive respiratory rates rather than excessive tidal volumes. During resuscitation attempts 11/12 (91.7%) patients had airway pressures that remained positive for more than 90% of the time.

Losert 2006 concluded that an impedance measurement system sensor of a defibrillator is likely to provide adequate monitoring of the presence or absence of ventilations, which would also allow quantification of ventilation rates and inspiration times.

Aufderheide 2004 found that rescuers persistently hyperventilate patients during CPR. Rapid-rate, short-duration ventilations and slow-rate, long-duration ventilations contributed to a high percentage of time that pressure in the chest was increased. Animal studies demonstrated that excessive ventilation rates during CPR resulted in increased positive intrathoracic pressures, decreased coronary perfusion, and decreased survival rates. VF was induced in pigs. The animals were resuscitated with standard CPR (5:1 compression:ventilation rate) for the first 2 minutes then randomized to receive 3 different ventilation rates (12, 30 breaths per minute with 100% O2, or 30 breaths per minute with 5% CO2, 95% O2) with each phase lasting for 2 minutes. 6 of 7 (86%) of pigs ventilated at a rate of 12 per minute survived, compared with a survival rate of 1 of 7 (17%) at a rate of 30 breaths per minute (100% O2), and 1/7 (17%) at a ventilation rate of 30 breaths per minute (5% CO2/95% O2).

Voelckel 2001 induced ventricular fibrillation in anaesthetized ventilated pigs and administered active compression – decompression CPR with an inspiratory threshold valve. After 4 minutes of cardiac arrest the pigs underwent CPR. During the first 8 minutes of CPR, all pigs received pressure controlled pure oxygen ventilation at constant flow rate, with a 5:1 compression:ventilation ratio. After 8 minutes animals were randomly assigned to receive either further IPPV alone or increasing levels of PEEP at 2.5, 5.0, 7.5, and 10 cm H2O for 4 consecutive minutes. The study demonstrated that PEEP significantly improved coronary perfusion pressure when compared to the IPPV alone group. Tidal volume decreased after the application of 7.5 and 10 cm H2O of PEEP. If 10 cm H2O of PEEP was applied, aortic and left ventricular pressures were significantly higher at maximal compression during CPR. Defibrillation was successful in 7 of 8 animals in PEEP + IPPV group after 28 minutes of cardiac arrest, compared to 5 of 8 animals in the IPPV alone group.

Kleinsasser induced VF arrest in 24 pigs who subsequently received CPR with either CPAP with pressure support ventilation, CPAP, or IPPV. Haemodynamics, blood gases, and inert gas measurements were performed before VF arrest was induced and at 10 and 20 minutes after induction. CPAP PSV resulted in the highest blood flow to lung units with a normal V′A/Q′ ratio during CPR. Animals treated with CPAP, highest blood flow was to lung units with a low V′A/Q′ ratio, and in animals treated with IPPV, the highest blood flow to lung units with a high V′ A/Q′ ratio was recorded. PaO2 was significantly higher in animals treated with CPAP PSV than in animals treated with CPAP (P<0.01) or IPPV (P<0.05). End-tidal carbon dioxide was higher in animals of the CPAP PSV group than in animals treated with CPAP or IPPV.

8 of 8 animals ventilated with CPAP PSV could be resuscitated, compared with 6 of 8 animals treated with CPAP and 3 of 8 treated in the IPPV group. The difference between CPAP PSV and IPPV was significant (P<0.025).

Abella 2007 evaluated quality of CPR using a defibrillator capable of monitoring chest compression rate and depth, and ventilation rate and volume, for patients in cardiac arrest receiving CPR. Two groups of patients are described in the study, the baseline group (no real-time feedback) and the (real-time) feedback group. The defibrillator was capable of providing real-time audiovisual feedback. Improvements were seen in the mean values of all four variables, though these improvements were not statistically significant. The study recorded a statistically significant reduction in distribution of chest compression depth and rate, and ventilation rate; demonstrated by a decrease in standard deviation. In addition, the fraction of time during which no compressions were administered was reduced in the feedback group. There was a small, statistically insignificant increase in the rate of ROSC between the baseline and feedback groups but no difference in survival to hospital discharge between the two groups.
**Citation List**


Level 3 evidence which supports the clinical question. The study demonstrated that real-time feedback to personnel performing CPR resulted in closer correlation to current resuscitation guidelines.


Level 5 evidence which supports clinical question. Animal study which demonstrated that excessive ventilation rates during CPR resulted decreased survival rates.

Kleinsasser A, Lindner K et al (2002). Decompression-triggered positive-pressure ventilation during cardiopulmonary resuscitation improves pulmonary gas exchange and oxygen uptake. Circulation;106(3):373-8

Level 5 evidence which supports the clinical question. Study demonstrated a higher rate of return of spontaneous circulation in animals resuscitated with CPAP pressure support ventilation compared to those resuscitated with either CPAP or IPPV alone.


Level 5 evidence, did not directly address clinical question (neutral). The study concluded that an impedance measurement system sensor of a defibrillator is likely to provide adequate monitoring of the presence or absence of ventilations


Level 4 evidence, did not directly address clinical question (neutral). Demonstrated that hyperventilation is common in CPR.


Level 5 evidence, neutral to clinical question. Study demonstrated that PEEP may improve oxygenation in CPR if used with a device designed to improve venous return.

(Voelckel 2001; Kleinsasser 2002)
(Aufderheide 2004; Losert 2006; O'Neill 2007; Abella 2007)