Clinical question.
In infants and children with cardiac arrest and an advanced airway (P), does the use of a higher ventilation rate (I) compared with the current recommendation of 8 – 10 breaths/min (C) improve outcome (ROSC, survival to discharge, survival with favorable neurologic status) (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

Search strategy (including electronic databases searched).
PubMed “heart arrest”, “cardiac arrest” or “cardiopulmonary resuscitation” as MESH (headings) AND “Ventilation” and “Minute ventilation” as textwords in abstract.
EMBASE search using text words (all fields) ventilation AND (cardiac arrest OR resuscitation)
AHA EndNote Master library, Cochrane database for systematic reviews, Central Register of Controlled Trials, Review of references from articles.

• State inclusion and exclusion criteria
The following studies were excluded: neonatal human studies, resuscitation with cardiopulmonary bypass instead of CPR, editorials, abstracts, letters to the editor.

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

Summary of evidence

Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>1</th>
<th>2</th>
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A = Return of spontaneous circulation  C = Survival to hospital discharge  E = Other endpoint
B = Survival of event  D = Intact neurological survival  Italics = Animal studies

* = overlapping patients
### Evidence Neutral to Clinical question

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Good</th>
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1 2 3 4 5  

**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint  

*Italicics = Animal studies*

### Evidence Opposing Clinical Question

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<th>Level of evidence</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
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| **Good**          | Idris (2004/CCM)[D]  
Yannopoulos (2010/CCM) [A, B, D] | | |
| **Fair**          | Aufderheide (2004/CCM)[A]  
Aufderheide (2004/Circulation)[A]  
Berg (1999/CCM) [A] | | |
| **Poor**          | | | |

1 2 3 4 5  

**Level of evidence**

A = Return of spontaneous circulation  
B = Survival of event  
C = Survival to hospital discharge  
D = Intact neurological survival  
E = Other endpoint  

*Italicics = Animal studies*
In 2005, the ILCOR Consensus on Science and Treatment Recommendations (CoSTR)\(^1\) stated that “there is insufficient data to identify an optimal compression-ventilation ratio for CPR in children.” Furthermore, “even in asphyxial arrest, few ventilations are needed to maintain an adequate ventilation-perfusion ratio in the presence of the low cardiac output (and, consequently, low pulmonary blood flow) produced by chest compressions.” The specific treatment recommendations included the following: “When an advanced airway is established (eg, a tracheal tube, esophageal-tracheal combitube [Combitube], or laryngeal mask airway [LMA]), ventilations are given without interrupting chest compressions.” While the CoSTR document does not specifically recommend a rate of ventilations following establishment of an advanced airway, the AHA Pediatric Advanced Life Support Guidelines recommend 8 – 10 breaths/min during continuous chest compressions: “If an advanced airway is in place during CPR (eg, endotracheal tube, Combitube, LMA), ventilate at a rate of 8 to 10 times per minute without pausing chest compressions.”\(^2\) In contrast, the European Resuscitation Council guidelines recommendations state, “once the airway is protected by tracheal intubation, continue positive pressure ventilation at 12—20 breaths min\(^{-1}\) without interrupting chest compressions.”\(^3\) The rationale for the AHA’s use of 8 – 10 breaths/min was consistency with the adult guidelines and the absence of data to support a different rate of ventilations, while the ERC adult guidelines suggest a ventilation rate of 10 breaths/min after the airway is secured.

These recommendations are based on the following scientific evidence from animal models: (1) Ventilation vs. no ventilation appears to improve outcome from cardiac arrest, including asphyxial cardiac arrest (Idris 1994 [827-834], Berg 1999 [1893] LOE 5) and fibrillatory arrest (Yannopoulos 2010 [254] LOE 5); (2) Hyperventilation is deleterious to hemodynamics during CPR, by raising intrathoracic pressure and reducing coronary perfusion pressure (Aufderheide 2004, LOE 5 [S345-351]); (3) During low-flow states, mixed venous oxygen saturation and oxygen delivery are primarily related to cardiac output, and are minimally affected by changes in minute ventilation [Idris (1994 ), LOE 5], and that during cardiac arrest decreasing minute ventilation by up to 50% produces acceptable blood gas parameters (Winkler 1998, LOE 5 [201-6]).

Two animal studies, including one from 2007, demonstrated that the use of either oxygen insufflation or continuous positive airway pressure (CPAP) can provide adequate gas exchange during CPR (Hayes 2007 [357-365] LOE 5 and Hevesi 1999 [1077-1083] LOE 5). A randomized trial using adult humans with out-of-hospital cardiac arrest showed no differences in ROSC, hospital admission, or survival to discharge between patients who received mechanical ventilation compared with constant oxygen insufflation (Bertrand 2006 LOE 1). Collectively, these data suggest that decreasing minute ventilation from baseline in proportion to the decrease in cardiac output during CPR may provide sufficient gas exchange without the negative effects of hyperventilation. Furthermore, the possibility that adequate oxygenation may be provided without use of positive pressure ventilations is an intriguing concept that requires further investigation.

Citation List


Comment: LOE 5 (adults/animals); Fair quality with regard to adult case series; good quality with regards to animal study.


Comment: LOE 5 (adults/animals); Fair quality with regard to adult case series; good quality with regards to animal study.


Comments: LOE 5 (animal); Fair quality based on simulation of out-of-hospital arrest conditions.


Comments: LOE 5 (adult); Good quality (prospective, randomized).


Comments: LOE 5 (animal); Fair quality


Comments: LOE 5 (animal); Fair quality.


Comments: LOE 5 (animal); Good quality


Comments: LOE 5 (animal); Fair quality


Comments: LOE 5 (animal); Good quality


Comments: LOE 5 (animal); Good quality.