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

## Clinical question.

In neonates receiving positive pressure ventilation (P) does the use of gas volume monitoring (I) versus clinical assessment with or without pressure monitoring (C) improve clinical outcome (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

## 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).

**OVID  Medline 1950-present**

- **Mechanical Ventilation & Volume & Birth to 23 months inclusion**
  - 10 papers 3 merit further review
- **Resuscitation, Limit to birth to 23 months & mechanical ventilation**
  - 1 paper
- **Ventilation or Intermittent Positive pressure ventilation (IPPV)(limit Birth-23 months) & volume**
  - 24 papers 16 merit further review
- **Gas Volume monitoring & Positive pressure ventilation: not useful**
- **Resuscitation & Tidal Volume or gas volume**
  - 117 papers  Limit to “Newborn” 11 papers 10 merit further review
- **Newborn & Ventilation or IPPV & volume & Respiration, Artificial or volume limited ventilation**
  - 7 papers none unique
- **Respiration, Artificial or volume limited ventilation & Resuscitation, Limit to “birth to 23 months”**
  - 411 papers 5 merit further review
- **Volume guarantee (limit to birth to 23 months)**
  - 34 papers 19 merit further review, 11 unique
- **Device or equipment & Resuscitation (limit to birth to 23 months)**
  - 76 papers 12 merit further review 10 unique
- **Ventilation or IPPV & Volume (limit to birth to 23 months)**
  - 24 papers 12 merit further review 4 unique
- **Resuscitation, & Respiration artificial or volume limited (limit to birth to 23 months)**
  - 13 papers merit further review 2 unique
- **Resuscitation newborn & Volume monitoring**
  - 503 papers 7 merit further review

**Pub Med**

- **Neonates & positive pressure ventilation & gas volume monitoring**
  - 21 papers 3 unique that merit further review
- **Treatment outcome & Respiration, newborn**
  - 0 papers
- **Infant & blood gas analysis & Neonate ventilation**
  - None useful
- **Positive pressure ventilation & neonate & gas volume monitoring**
  - 8 papers 5 merit further reviews
- **Positive pressure ventilation & neonate & Clinical Assessment**
  - 21 papers 4 merit further review

**EMBASE Volume, Newborn, Resuscitation 126 references**

- **Add Ventilation 54 references**
- **Volume, Monitoring, Resuscitation**
  - 23 references

**ECC ENDO NOTE Library**

- **Volume, Resuscitation, Newborn**
  - 26 references 16 unique
- **Tidal Volume, Resuscitation, Newborn**
  - 7 references 2 unique

**Cochrane Review**

- **Manual Ventilation Devices**
  - No references on volume monitored devices

Preprint paper on Lung compliance in manual ventilation of a lung model, Comparing volume to pressure monitoring

Searches current 9/09

## State inclusion and exclusion criteria

- **No exclusion criteria**
- **Most searches done (as noted) with inclusion criteria limited to Newborns or “birth to 23 months”**
- **Non-English studies not excluded**
- **Except when used as search term, not limited to newborns only**
- **Animal Studies not excluded**

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

- 72 merit further review of which 59 appear most directly relevant. Only 15-16 papers appear to directly relate to the question raised (on initial brief review)
- Upon further review and additional database searches 54 references met criteria for further review and assessment
## Summary of evidence

### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of Evidence</th>
<th>Good Evidence</th>
<th>Fair Evidence</th>
<th>Poor Evidence</th>
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<tr>
<td>Good</td>
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<td>Resende 2006E</td>
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<td>Probyn 2005E</td>
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<td>Kattwinkel 2009</td>
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<td>Hillman 2007E</td>
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<td>Cheema 2001E</td>
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<td>Field 1986E</td>
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<td>Hassan 2001E</td>
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<td>Hoskyns 1987E</td>
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<td>Kissoon 1990E</td>
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<td>O’Donnell 2005E</td>
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<td>O’Donnell, Kamlin 2005E</td>
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### 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

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<td>Boon 1979E</td>
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**Italics = Animal studies**

### Evidence Opposing Clinical Question

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<td>Fair</td>
<td>Nafday 2005E</td>
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<td>Osterwalder 1998E</td>
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<td>Poor</td>
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<td>Jaecklin 2007E</td>
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**Italics = Animal studies**
Current practice during resuscitation includes visual inspection and pressure limited ventilation by bag and mask, bag and endotracheal tube or T-piece resuscitator to ensure adequacy of chest rise. The key variable in ensuring adequate ventilation without lung overdistention is lung volume, not pressure, {Jobe and Ikegami 1998 review} Very early studies {Boon et al 1979a, 1979b LOE %, Boon 1981a LOE 4 } determined that babies initially produce a large positive intraesophageal pressure as they take a first breath, but the establishment of stable FRC depended on repeated breaths of adequate volume {Hoskyns et al, 1987 LOE 5}. Babies who are depressed do need a critical opening pressure for the first breath, apparently mimicking normal spontaneous first breaths {Vyas et al 1981 LOE4}. The Hering-Breuer reflex, in which spontaneous breathing is triggered by lung distention, has been shown to be volume, not pressure dependent {Hassan et al 2001 LOE5}. Clinical assessment of chest rise is a volume measurement; it just cannot be accurately quantified.

Several studies of volume-guarantee ventilation that have demonstrated the feasibility of the method across the gestational age range for initial stabilization and ongoing mechanical ventilation. {Cheema et al 2001, LOE 5, Cheema 2007, LOE 5} although the reproducibility of volume delivery has been questioned in manikins {Jaecklin et al 2007, LOE 5}. The use of volume rather than pressure results in better ventilation, and lower peak and mean pressures, in almost all studies {Nafday et al 2005 LOE 4}. Without volume monitoring, there is a risk of lung overdistention and subsequent negative effects. Manual ventilation with even a few big breaths has been shown to compromise surfactant effectiveness in lambs {Bjorklund et al 1997 LOE 5}, and ventilation without volume regulation is harmful to human lungs {Hillman et al 2007 LOE 5}.

In mechanically ventilated babies, clinical assessment alone of chest rise may result in significant hypocarbia in premature infants transported from delivery to NICU {Tracy et al 2004 LOE 4}. Tidal volume measurement increases the effectiveness of ventilation of manikins, while the use of a visible manometer does not {O'Donnell et al 2005a, 2005b 2005c LOE 5}. Resuscitation of human babies with manual resuscitators is volume dependent and improved by the use of volume controlled resuscitators {Field, et al 1986 LOE 5, Kissoon et al 1990, LOE 5}. A prototype volume controlled neonatal resuscitator has been effectively used in animals {Pasquet et al 1988 LOE 5} and the use of the correct lung volume reduces injury. {Polglase et al 2008 LOE5, Probyn et al 2005 LOE 5}. The use of small tidal volume ventilation allows lung recruitment on atelectatic lungs, and allows the use of lower PEEP, minimizing lung injury {Rimensberger et al 1999a 1999b LOE 5}. This may be because pressure limited ventilation results in wide variations in lung volumes and peak pressures, especially when used by inexperienced physicians, {Resende et al 2006, LOE 5}. Volume controlled ventilation may provide a benefit over either clinical assessment or pressure limitation, but no studies have been done in depressed, apneic full term babies requiring ventilatory support, and manikin studies only mimic real life. A recent study {Kattwinkel et al 2009, LOE 5} has shown, using a lung model designed for teaching positive pressure ventilation, that simulated compliance changes are responded to much better when lung volume, instead of peak pressure, is displayed to the users. There is no available volume limited device for mechanical ventilation in the delivery room, so a change in practice cannot be recommended. The available evidence at least strongly suggests that this would be a superior method for assessment, when compared with clinical assessment or pressure limited resuscitation procedures, and a comparative study should be done. to the appropriate volumes to use in different size and gestational age patients, as well as in different lung disorders, are unknown at this time.

Acknowledgements:

Citation List


2. Comment: Lamb study shows that resuscitation with just a few large breaths impairs the effect of surfactant in premature animals. Monitoring of the volume of lung expansion and the use of stepped breaths would prevent this injury. LOE 5 Fair support

Comment: A hallmark study in which ventilatory exchange and lung inflations were measured in "asphyxiated" babies. The pattern of lung expansion in these babies was one of gradual increase in volume and compliance over the first several breaths. LOE 5 Neutral


Comment: Study of 20 babies demonstrating the need for large initial pressures in the absence of spontaneous breathing LOE 5 Neutral


Comment: Step wise increase in lung volume over first few breaths. Volume is key variable in lung expansion.


Comment: Not directly relevant


Comment: Not relevant to question


Comment: Study of volume guarantee ventilation in the NICU in both acute and convalescing phase of RDS which demonstrated the utility of this mode of ventilation, and the ability to achieve good gas exchange at lower pressures. LOE 5 Supportive Poor


Comment: Similar to the above study but in smaller premature infants, ELBW infants, Confirmed VG as feasible in these infants. LOE 5 Supportive Poor

Comment: No data, editorial comment


Comment: Animal study in pigs on the impact of age related changes in chest geometry on effectiveness of chest compressions. Not directly relevant


Comment: Study of manual resuscitators which is relevant in demonstrating wide variation in delivered volume depending on device. LOE 5 Weakly supportive evidence


Comment: This is an interesting study that demonstrates that there is a minimum volume needed for activation of the Hering-Breuer reflex. It is relevant to the question because with volume monitoring, resuscitation could be tailored to stimulate this reflex adequately to help promote the onset of breathing without overdistension. LOE 5 Supportive Weak


Comment: Sheep study demonstrating that even brief periods of overdistension can initiate lung injury. LOE 5 Good Support


Comment: A study of infants 25-36 week gestation compared with term infants resuscitated with endotracheal intubation. Preterm infants had much less lung expansion and required more breaths to achieve adequate lung volumes than did the term babies. Pressure limited ventilation may not achieve adequate lung volumes easily, suggesting that volume monitoring might be more efficacious. LOE 5 Poor Support

**Comment:** Not relevant


**Comment:** Mannikin study that found inaccuracies in delivered volumes by volume guarantee ventilators. Relevant in pointing out technical reasons for inaccurate delivery of a set volume

**LOE 5** Negative Poor


**Comment:** Review


**Comment:** No new data


**LOE 5** Supportive Good Quality

**Comment:** Manikin study which demonstrates that without volume display, professionals are better able to assess compliance changes in the lung and maintain constant volume than when pressure alone is displayed


**Comment:** No new data


**LOE 5** Supportive Poor quality

**Comment:** Study of 25 infants ventilated using a prototype volume controlled resuscitator. Demonstrate less hyperventilation even with this early technology.

Comment: not directly relevant


Comment: Review


Comment: Review, discussion of sustained inflation


Comment: Review discussing sustained inflation to achieve slow increase to stable lung volume


Comment: Small study that showed facemask ventilation to be inefficient in achieving adequate tidal volumes, compared to endotracheal intubation. Weakly relevant in that it underscores the need to achieve adequate volume, which enhanced monitoring might facilitate.


Comment: Editorial


Comment: Study of PS-VG as initial mode of ventilation in intubated, surfactant treated infants. No advantage seen in terms of overall ventilator support LOE 1 Negative


LOE 5 Neutral Fair Quality
Comment: Mannikin study comparing different T-piece resuscitators which found that during mask ventilation there are often large leaks, making pressure monitoring inaccurate for ensuring adequate inflation volumes


LOE 5 Neutral Fair Quality
Comment: Mannikin study demonstrating that the use of a manometer does not help resuscitators better deliver adequate pressures or volumes, nor does it change the amount of air leak around the mask.


Comment: Review NOT ON GRID


Comment: Review NOT ON GRID


NOT ON GRID
Comment: Describes an experimental system to assess effectiveness of face mask ventilation. NOT ON GRID


Comment: Not relevant NOT ON GRID

Comment: Not relevant NOT ON GRID


LOE 5 Negative Fair
Comment: Mannikin study that demonstrates the effectiveness on a resuscitation device set in a pressure limited mode, in ensuring adequate volumes compared with a bag and mask. This suggests that it is the manner of breaths that improves effectiveness, and that volume monitoring per se is not needed


Comment: Study of volume controlled device in cats that resulted in better ventilation and oxygenation at lower pressures. LOE 5 Fair support


Comment: Study in preterm lambs that examined the effect of different inflation volumes on lung injury, supporting the concept that volume controlled resuscitation could reduce potential lung injury. LOE 5 Fair support


Comment: Study in lambs showing that a volume controlled device is effective, an that the use of different tidal volumes in resuscitation impacted pCO2 levels. The inference is that lung injury could be reduced in these animal subjects by using volume controlled resuscitation  LOE 5 Good support


Comment: Study of resuscitators using a bag mask system to resuscitate lambs. Using just this system without monitoring, the delivered volumes varied widely. LOE 5 Supportive Good

Comment: Study in isolated rat lungs showing that a lung recruitment strategy of using small tidal volumes is effective in reducing lung injury. LOE 5 Supportive Fair


Comment: Companion study to the one above that further supports the use of controlled volumes in a specific sequence of resuscitation maneuvers to allow lung inflation and ventilation while reducing the potential for lung injury. LOE 5 Fair Support


Comment: Review


Comment: Not relevant


Comment: Not relevant to question


Comment: Study of ventilation monitoring to which resuscitators were masked while they provided usual mechanical ventilation of infants after birth. During transport from the delivery area to the NICU, the monitoring revealed that it is difficult to determine correct settings and overventilation occurs commonly, as well as hyperoxia. Supportive of using monitored volumes for this care. LOE 4 Supportive Fair


Comment: Not relevant

**Comment:** Small study of short sustained inflation pressures in resuscitation. No direct relevance LOE 4 Neutral


**Comment:** Not relevant


**Comment:** Guideline statement