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

**Worksheet author(s)**

<table>
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<tr>
<th>Masanori Tamura</th>
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**Date Submitted for review:** 26 Sep 2009

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**Clinical question.**

For non intubated bradycardic neonates (P) requiring positive pressure ventilation, is the CO2 monitoring device (I) more effective than chest rise, color (C) for assessing adequate ventilation (O)?

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**Is this question addressing an intervention/therapy, prognosis or diagnosis? Intervention**

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**State if this is a proposed new topic or revision of existing worksheet:** New topic

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**Conflict of interest specific to this question**

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

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

**Search strategy**

(((Monitoring, Physiologic OR Breath Tests) AND Carbon Dioxide) OR Capnography OR Colorimetry OR CO2...monitoring) AND (Infant, Newborn)

**MEDLINE (Search Date. 19 Sep 2009)**

# Searches Results

<table>
<thead>
<tr>
<th>ID</th>
<th>Search Hits</th>
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</thead>
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<td>#1</td>
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<tr>
<td>#2</td>
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<tr>
<td>#3</td>
<td>MeSH descriptor Breath Tests, this term only 987</td>
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<td>#4</td>
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<td>#5</td>
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<td>#6</td>
<td>(Carbon Dioxide):ti,ab,kw 3554</td>
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<td>#7</td>
<td>(co2):ti,ab,kw 1790</td>
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<td>MeSH descriptor Capnography, this term only 42</td>
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**Cochrane (Search Date. 19 Sep 2009)**

Current Search History

ID Search Hits

#1 MeSH descriptor Monitoring, Physiologic, this term only 1480
#2 (physiolog* monitoring):ti,ab,kw 2910
#3 MeSH descriptor Breath Tests, this term only 987
#4 (breath* test*):ti,ab,kw 3262
#5 MeSH descriptor Carbon Dioxide, this term only 2098
#6 (Carbon Dioxide):ti,ab,kw 3554
#7 (co2):ti,ab,kw 1790
#8 MeSH descriptor Capnography, this term only 42
#9 (capnogr*):ti,ab,kw 122
#10 MeSH descriptor Colorimetry, this term only 113  
#11 (colorimet*):ti,ab,kw 283  
#12 (carbon dioxide monit*):ti,ab,kw 326  
#13 (co2 monit*):ti,ab,kw 200  
#14 (#1 OR #2 OR #3 OR #4) 6135  
#15 (#5 OR #6 OR #7) 4402  
#16 (#14 AND #15) 464  
#17 (#16 OR #8 OR #9 OR #10 OR #11 OR #12 OR #13) 1148  
#18 MeSH descriptor Infant, Newborn explode all trees 10488  
#19 (newborn):ti,ab,kw 12738  
#20 (infant*):ti,ab,kw 27175  
#21 (baby):ti,ab,kw 2273  
#22 (babies):ti,ab,kw 2273  
#23 (premature):ti,ab,kw 6696  
#24 (birth weight):ti,ab,kw 4057  
#25 (#18 OR #19 OR #20 OR #21 OR #22 OR #23 OR #24) 31599  
#26 (#17 AND #25) 83  

**EMBASE** (Search Date. 19 Sep 2009)  
Session Results  
No. Query Results  
#1. 'monitoring'/exp AND [humans]/lim AND [newborn]/lim AND [embase]/lim 2,617  
#2. 'breath analysis'/exp AND [humans]/lim AND [newborn]/lim AND [embase]/lim 72  
#3. 'carbon dioxide'/exp AND [embase]/lim 27,932  
#4. ('carbon dioxide' OR co2) AND monitor* AND [humans]/lim AND [newborn]/lim AND [embase]/lim 173  
#5. 'Newborn monitoring'/exp AND [humans]/lim AND [embase]/lim 527  
#6. 'capnography'/exp AND [humans]/lim AND [newborn]/lim AND [embase]/lim 39  
#7. #1 OR #2 OR #5 2,840  
#8. #3 OR #4 28,053  
#9. #7 AND #8 89  
#10. #6 OR #9 104  
#11. #10 AND ([Cochrane review]/lim OR [controlled clinical trial]/lim OR [meta analysis]/lim OR [randomized controlled trial]/lim OR [systematic review]/lim) 6  
#12. #10 NOT #11 98  

.......................................................

**AHA Neonatal Library** (Search Date. 19 Sep 2009)  
monitoring^carbon dioxide  
breath^carbon dioxide  
monitoring^co2  
breath^co2  
capnography  
capnogram  
colorimetric  
colorimeter  
colorimetry  

34 references
### State inclusion and exclusion criteria

Any studies assessing effectiveness of CO2 monitoring devices for non-intubated neonates requiring resuscitation are included.

Any studies assessing effectiveness of CO2 monitoring devices for intubated patients are excluded. Abstract only studies and not peer reviewed studies are excluded. Consensus statement, theoretical model and reviews are excluded except systematic reviews and/or consensus statements by formal consensus methods.

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

Only 2 studies are included from identified studies (MEDLINE 445+Cochrane 83+EMBASE 104+AHA 34).  
LOE 1 0  
LOE 2 0  
LOE 3 0  
LOE 4 2 Finer 2009, Leone 2006  
LOE 5 0

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### Summary of evidence

#### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
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<tr>
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Leone 2006 E, Finer 2009 E

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#### Evidence Neutral to Clinical question

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<th>Good</th>
<th>Fair</th>
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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

<table>
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<th>Fair</th>
<th>Poor</th>
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</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

Italicics = Animal studies

REVIEWER’S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

Two case-series reported by the same group (LOE 4) (Leone, 2006, e202; Finer, 2009, 865) provide some supportive evidence of the usefulness of end-tidal CO\textsubscript{2} (ETCO\textsubscript{2}) detectors in this study population. These are summarized in table below as key studies on this topic.

The first case series (LOE 4) (Leone, 2006, e202) reviewed the video recording of the resuscitation of 24 infants whose median birth weight was 1295g (range 640g-4990g). It showed that colorimetric carbon dioxide detectors enabled to recognize the airway occlusion indicated by clear lack of cyclical color change on the colorimetric CO\textsubscript{2} detector, PediCap [Nellcor, Pleasanton, CA]. Some of the airway occlusion accompanying oxygen desaturation and it improved shortly after reestablishing cyclical color change on PediCap. The study showed CO\textsubscript{2} detector was useful as an indicator of a patent airway during mask ventilation. Another case-series(LOE 4) (Finer, 2009, 865) of the video recording of the resuscitation of 24 very low birth weight infants less than 32 weeks’ gestation showed that the airway obstruction occurs in 18 of 24 infants receiving face mask ventilation during resuscitation just after birth until the first airway opening event occur. The use of a calorimetric detector can facilitate its recognition and management such as repositioning of the head, checking the mask seal, and so on. No risks attributable to the use of ETCO\textsubscript{2} detectors were reported.

There was no controlled study that directly compares CO\textsubscript{2} monitoring devises with clinical parameters such as chest rise and color to assess adequate ventilation in non intubated neonates. Their use with other interfaces (e.g. nasal airways, laryngeal masks) during positive pressure ventilation in the delivery room has not been reported.

Acknowledgements:
Thanks to Dr. T. Isayama, Staff Neonatologist from Osaka Medical Center and Research Institute for Maternal & Child Health and Mr. T. Swa, Reference Librarian from Osaka University Life Sciences Library.
Citation List


Citation Abstracts


Comment
A retrospective review of the video recording of the resuscitation of 24 extremely low birth weight infants who were enrolled in the previous RCT comparing room air and 100% oxygen use for resuscitation. The airway obstruction was defined as no color change on the colorimetric CO2 detector and it was proved to occurs in the majority of the very low birth weight infants receiving face mask ventilation during resuscitation just after birth. The use of a calorimetric detector can facilitate its recognition and management (such as repositioning of the head, checking the mask seal, changing the operator or increasing the pressure). No comment about industry funding.

Level of Evidence 4
Quality Fair
Evidence Supportive


Comment
A retrospective review of infants who were enrolled in another randomized controlled trial of intubation premedication. It showed that colorimetric carbon dioxide detectors were helpful as an indicator of a patent airway during bag and masks ventilation or mask continuous positive airway pressure application. The study included 23 infants who had a median gestational age of 29 weeks (range: 25-42 weeks) and a median birth weight of 1295g (range: 640-4990). A total 21 occurrences of clear lack of cyclical color change in the CO2 detector (PediCap) were identified during stabilization before intubation in 6 infants and the median duration of each event was 15 seconds (range: 8-77). Six of the events were associated with an oxygen desaturation (oxygen saturation less than 85%) which improved shortly after the return of cyclical color change of the CO2 detector and the median time from establishing cyclical color change in the PediCap to improvement in the saturation were 9.5 seconds (range: 4-13 seconds). The most maneuvers used most frequently to achieve recovery of cyclical color change was an adjustment in the head/jaw position (n=20) and other maneuvers included changes in mask position (n=5), removal of other equipment from the face, such as nasal canula or nasogastric tube (n=3) and changing the operator (n=2). No comment about industry funding.

Level of Evidence 4
Quality Fair
Evidence Supportive
### Key Studies on this topic.

<table>
<thead>
<tr>
<th>Study</th>
<th>Objective</th>
<th>Study design</th>
<th>Setting</th>
<th>Patients</th>
<th>Intervention/ Measurement</th>
<th>Outcomes</th>
<th>Results</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leone TA, Lange A, Rich W, Finer NN. Disposable colorimetric carbon dioxide detector use as an indicator of a patent airway during noninvasive mask ventilation. Pediatrics. 2006 Jul; 118(1):e202-4.</td>
<td>To assess the usefulness of colorimetric carbon dioxide detectors as an indicator of a patent airway during bag and mask ventilation.</td>
<td>Retrospective case series. Reviewing video recordings.</td>
<td>The regional NICU of the University of California San Diego Medical Center.</td>
<td>24 infants with bag and mask ventilation or mask continuous positive pressure application before intubation. Median gestational age of 29 weeks (range: 25-42 weeks), Median birth weight of 1295g (range: 640-4990g). All of them were enrolled in the previous randomized controlled trial of premedication for intubation.</td>
<td>Colorimetric carbon dioxide detector(PediCap; Nellcor Puritan Bennett, Pleasanton, CA)</td>
<td>The occurrence of the lack of cyclical color change (CCC) in the PediCap during stabilization before intubation and the duration of the events.</td>
<td>A total of 21 occurrences of clear lack of CCC in the PediCap during stabilization before intubation in 6 infants. The median duration of the lack of CCC of 15 seconds (range: 8-77 seconds). Six of the episode associated with the oxygen desaturation. The median time from establishing CCC in the PediCap to improvement of saturation was 9.5 seconds (range: 4-13 seconds). The maneuver for recovery: an adjustment in the head/jaw position (n=20), a change of the mask position (n=5), a removal equipment from the face (n=3) and changing the operator (n=2).</td>
<td>Using a calorimetric carbon dioxide detector make the operator easily recognize the airway occlusion during bag and mask ventilation and it facilitates adjustments of ventilation and prevents long oxygen desaturation.</td>
</tr>
<tr>
<td>Finer NN, Rich W, Wang C, Leone T. Airway obstruction during mask ventilation of very low birth weight infants during neonatal resuscitation. Pediatrics. 2009 Mar; 123(3):865-9.</td>
<td>To determine the frequency of the occurrence of recognizable airway obstruction using colorimetric carbon dioxide detectors during resuscitation of very low birth weight (VLBW) infants.</td>
<td>Retrospective case series. Reviewing video recordings.</td>
<td>The regional NICU of the University of California San Diego Medical Center.</td>
<td>24 preterm VLBW infants less than 32 weeks’ gestation with bag and mask ventilation during resuscitation after birth. Median gestational age of 27 weeks (range: 24-31 weeks), Median birth weight of 955g (SD: 353g). All of them were enrolled in the previous randomized control trial and assigned to resuscitation with either room air or 100% oxygen.</td>
<td>Colorimetric carbon dioxide detector(PediCap; Nellcor Puritan Bennett, Pleasanton, CA)</td>
<td>The number of the obstructed breaths without a color change of the PediCap until the first opening event of airway occurs.</td>
<td>A median of 14 consecutive obstructed breaths (range: 4-37 breaths) in 18 of the 24 infants over a mean and median interval of 56.7 seconds and 45.0 seconds (range: 10-220). Intervention to overcome the obstruction occurred at a median of 4 breaths. The intervention for recovery: a repositioning of the head (n=10), checking the mask seal (n=5), a new operator (n=2), and increasing the pressure. Most of the obstructed breaths with the proper bag and mask ventilation reaching the target pressure, 30 cmH2O, for more than 0.2 seconds.</td>
<td>Airway obstruction occurs in the majority of the VLBW infants with face mask ventilation during resuscitation after delivery. The use of a calorimetric carbon dioxide detector can alert the resuscitation team to the situation and facilitate maneuvers that can re-establish a patent airway.</td>
</tr>
</tbody>
</table>

**Comment:**

These 2 studies were conducted at the same NICU and the study designs were resemble each other but the subjects were not overlapped. The subjects of Leone 2006 were preterm or term infants during stabilization before intubation and those of Finer 2009 were preterm infants less than 32 weeks’ gestation during resuscitation just after delivery until the first airway opening occurs.