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

<table>
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<tr>
<th>Worksheet author(s)</th>
<th>Date Submitted for review:</th>
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<tr>
<td>John Kattwinkel</td>
<td>January 6, 2010 (3rd revision)</td>
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Clinical question.

For newborns requiring resuscitation (P), does the use of specific adjunct measures to direct resuscitation (e.g., CO2 detection, pulse oximetry) add useful information to the usual clinical findings (e.g., heart rate, chest movement) and lead to improved outcome (O)?

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

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).

| Strategy 1: Ovid Medline 1950 to present - Heartrate resuscitation/ or exp cardiopulmonary resuscitation/ or heart massage/ or respiration, artificial/ OR resuscitat:.ti. AND exp Infant, Newborn/ OR neonat:.tw. AND exp Heart Rate/ OR *Heart Rate/ Limits for strategy 1: Humans AND English language Yield = 44 |
| Strategy 2: Ovid Medline 1950 to present – Physiologic monitoring resuscitation/ or exp cardiopulmonary resuscitation/ or heart massage/ or respiration, artificial/ OR resuscitat:.ti. AND exp Monitoring, Physiologic/ OR exp Monitoring, Physiologic/is, mt [Instrumentation, Methods] AND exp Infant, Newborn/ OR neonat:.tw. Limits for strategy 2: Humans AND English language Yield = 110 |
| Strategy 3: Ovid Medline 1950 to present – Oxygen monitoring/Oximetry resuscitation/ or exp cardiopulmonary resuscitation/ or heart massage/ or respiration, artificial/ OR resuscitat:.ti. AND *Oxygen/an, bl, du [Analysis, Blood, Diagnostic Use] OR exp Oximetry/ OR oximet:.tw. AND exp Infant, Newborn/ OR neonat:.tw. Limits for strategy 3: Humans AND English language Yield = 156 |
| Strategy 4: Ovid Medline 1950 to present – CO2 detection resuscitation/ or exp cardiopulmonary resuscitation/ or heart massage/ or respiration, artificial/ OR resuscitat:.ti. AND carbon dioxide.mp. or exp Carbon Dioxide/ OR co2 detect:.tw. AND exp Infant, Newborn/ OR neonat:.tw. Limits for strategy 4: Humans AND English language Yield = 166 |
| Strategy 5: References from key papers Review abstracts and appropriate papers of references from 4 recently-published key papers Yield = 136 |
| Strategy 6: The Cochrane Library (including DARE) Oximet* in the title AND Neonat* in the text Yield: 1 |
| Strategy 7: The Cochrane Library (including DARE) Carbon dioxide in the title AND neonat* in the text Yield: 10 |

State inclusion and exclusion criteria

See above for inclusion criteria. Non-newborns or non-infants were excluded.

Number of articles/sources meeting criteria for further review:

(see above)
### Summary of evidence

#### Evidence Supporting Clinical Question

<table>
<thead>
<tr>
<th>Level of evidence</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
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<tr>
<td>3</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

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

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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

*Italics = Animal studies*

### Evidence Opposing Clinical Question

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*Italics = Animal studies*
REVIEWER'S FINAL COMMENTS AND ASSESSMENT OF BENEFIT / RISK:

The longstanding recommendation of using a prompt increase in heartrate as the earliest and most sensitive indicator of a response to neonatal resuscitation was made after the animal studies of Dawes et al (Dawes, 1968, 149) over 40 years ago and there are no studies since then refuting these observations. There are no recent studies to refute the recommendation that auscultation of the chest and/or palpation of the base of the umbilical cord are the most sensitive clinical methods for determining heartrate and there are several studies confirming that palpation of femoral, brachial, or carotid pulses are not as sensitive. Numerous studies have reported that apparently reliable heartrate readings may be obtained by pulse oximetry within 2 minutes or less following birth, although many of these studies were conducted on healthy neonates, with only a few subjects from two studies involving ELBW babies requiring major resuscitation measures. Oximeters with newer technology will produce more accurate results than earlier models. Probes should be connected to the subject before connecting them to the leads. CO2 detectors have been shown to be very specific and reasonably sensitive to indicate successful intubation of the trachea, but this is not the primary issue raised in this worksheet. No recent publications were found to refute the previous recommendation that CO2 detectors be used to confirm successful endotracheal intubation. No recent studies were found to test the value of chest movement as an indicator of successful ventilation.

Acknowledgements:
Thanks to Ms. Elaine Attridge from the University of Virginia Health Sciences Library for assistance with literature search.

Citation List

Please see NRP014 for additional references on pulse oximetry.


Level of Evidence: Not used in worksheet
Quality of Evidence: Not used in worksheet
Reviewer's Comments: 45 newborns who required endotracheal intubation at birth had ET tube placement confirmed by CO2 detector and clinical confirmation. CO2 detection was faster, had 100% specificity, but only 91% sensitive (3 false negatives). This study supports the use of CO2 detectors for intubation confirmation, but does not contribute helpful data for this worksheet’s question.


Level of Evidence: 5
Quality of Evidence: Poor
Reviewer's Comments: Adult volunteers were asked to determine a carotid pulse in healthy adults. 95% took up to 35 sec to detect it. Age range, health of subject, and current recommendation not using carotid pulse render this article minimally contributory to hypothesis.


Level of Evidence: Not used in worksheet
Quality of Evidence: Not used in worksheet
Reviewer's Comments: 40 non-neonatal children had ET intubation confirmed by CO2 detector. This study supports the use of CO2 detectors for intubation confirmation, but does not contribute helpful data for this worksheet's question.


Level of Evidence: Not used in worksheet
Quality of Evidence: Not used in worksheet
Reviewer's Comments: 25 parents asked palpate brachial and apical pulse in 3-12 month old healthy infants. Brachial pulse was more reliable. Age and health of infant and location of palpation (brachial or precordial, vs. umbilical) render this article non-contributory to the hypothesis.


Level of Evidence: 5
Quality of Evidence: Good
Reviewer's Comments: Fetal monkeys (also rabbits) delivered near term, cord tied, and permitted to breathe only normal saline initially developed primary apnea within 30 seconds. Associated with a prompt bradycardia, followed by loss of muscle tone and pallor. After about 1 minute there are gasping efforts that continue for several minutes, followed by a "last gasp". Resuscitation efforts at any point up to after last gasp, if successful, are associated with a prompt increase in heart rate as the first sign of recovery. This supports heart rate as an appropriate initial sign of resuscitation response.


Level of Evidence: 4
Quality of Evidence: Poor
Reviewer's Comments: Paper describes a vacuum stethoscope that attaches to a cassette tape recorder which records the heartrate and respirations of a neonate. 6 of 37 neonates had more accurate Apgar score when data was used over person in attendance. Still supports heartrate as appropriate first sign.


Level of Evidence: 4
Quality of Study: Fair
Reviewer's Comments: 26 neonates on supplemental O2 and/or mechanical ventilation in the NICU had oximetry determined with 2 different oximeters. The Massimo more reliably identified bradycardias than did the Nellcor, Phillips, or Novametrix. The patient population (stable NICU subjects, not during resuscitation) and outdated technology render this study non-contributory to the hypothesis.


Level of Evidence: 5
Quality of Study: Fair
Reviewer's Comments: This is a very early study using oximetry. Probably because of the technology, the SPO2 results are not entirely consistent with more recent studies. However, even with this earlier technology, the clinicians were able to achieve a reliable reading early in the majority of subjects within 2 minutes of birth.

**Level of Evidence:** 4  
**Quality of Study:** Good  
**Reviewer's Comments:** 205 infants >=31 weeks gestation who did not require supplemental oxygen or resuscitation were evaluated by Massimo pulse oximetry as soon as possible after birth. The purpose was to evaluate the normal state of O2 saturation following birth. 53% had reliable data by 60 sec. Probe was connected to baby before the cable, which may facilitate signal acquisition (see O'Donnell, 2005).


**Level of Evidence:** 4  
**Quality of Study:** Fair  
**Reviewer's Comments:** 110 healthy term newborns were evaluated by Massimo pulse oximetry as soon as possible after birth. The purpose was to evaluate the normal pre-post ductal O2 saturation following birth. Interquartile range to obtain a reliable signal was 2.4-4.1 minutes. However, there was inconsistent first application of the probe to the cable vs to the patient, which likely delayed the time to signal acquisition (see O'Donnell, 2005).


**Level of Evidence:** 5  
**Quality of Study:** Fair  
**Reviewer's Comments:** 27 clinicians assessed videos of 20 infants (mean gestation 31 weeks) and scored them for color ("pink" or "not pink") and timing of when turned pink. Oximetry data were available at a mean of 66 seconds after birth. 17/22 had supplemental oxygen, 11/20 had CPAP and 4 were intubated. 81% of the observers judged 19/20 babies to never become pink, although sats achieved >90% in 17/19. There was considerable variation in the judgement of "pink" among observers. It is quite possible that technological limitations influenced the outcome of this study (i.e., there was no comparison of actual visualization to visualization of the video, or of actual assessment of color by viewing the baby as compared to saturation measurements). Nevertheless, the study suggests that assessment of color is an unreliable sign.


**Level of Evidence:** 5  
**Quality of Evidence:** Good  
**Reviewer's Comments:** The investigators studied the difference in time to acquire a reliable signal if the probe is (1) to the cable first, (2) to the cable then the investigator then the subject, or (3) to the subject first. 40 babies were evaluated in the NICU (i.e., not immediately following birth). Method 3 was quicker by an average of 10 seconds.


**Level of Evidence:** 2  
**Quality of Study:** Good  
**Reviewer's Comments:** These investigators studied the relative efficacies of listening to the precordium with a stethoscope, feeling for pulsations at the base of the umbilical cord, or feeling the brachial or femoral pulses to follow the 2000 ILCOR neonatal resuscitation guidelines. Sixty babies born at term were
randomized for the midwife or resident to assess the heartrate for 30 seconds by feeling the femoral, brachial, or umbilical cord pulse while the investigator listened to the precordium, following which they would be give 15 seconds to state a heartrate. Babies requiring resuscitation were excluded. All heart rates were >100 when assessed by the investigator. However, when subjects felt the femoral pulse heartrate was correctly determined to be >100 in only 20% and was erroneously assessed as < 100 in 40%. Brachial pulse detection was similarly poor. Umbilical palpation was better, with 55% correctly judged to be >100 and erroneously assessed in another 45%; 75% correctly identified the pulse as >60 bpm. This study supports the current practice of using umbilical pulse confirmed by precordial stethoscope, although palpation of the pulse was the only other sign evaluated. The authors suggest perhaps using precordial stethoscope or Doppler device may deserve study.


**Level of Evidence:** 4  
**Quality of Evidence:** Good  
**Reviewer's Comments:** The rate of CO2 production (VCO2), heartrate, and O2 sats were recorded during resuscitation of 30 neonates (5 term, 8 late preterm, 17 VLBW). VCO2 was determined by sampling facemask gas, heartrate was recorded with chest electrodes, O2 sats were by an oximeter probe on the right hand (although post-ductal "when not feasible"), and spontaneous respirations determined by an esophageal pressure catheter. All were successfully resuscitated and 28 survived to discharge. Increase in heartrate correlated with increased CO2 production and there was no difference in CO2 production in term babies after 5 minutes of resuscitation when compared to spontaneously breathing infants. The investigators had inadequate VCO2 norms to draw such conclusions about preterm babies. Post ductal sats were lower than preductal and both showed a correlation with VCO2. This study confirms the sensitivity of heart rate as an indicator of successful resuscitation (i.e., the heartrate only rose to > 130 bpm when the VCO2 was > 2 mL/kg/min). VCO2 was satisfactory only when pre-ductal O2 sat was > 70%.


**Level of Evidence:** 5  
**Quality of Evidence:** Good  
**Reviewer's Comments:** 115 newborns >= 35 weeks gestation who did not require supplemental oxygen were evaluated by Masimo pulse oximetry as soon as possible after birth. The purpose was to evaluate the normal state of O2 saturation following birth. Median time to data acquisition was 82 seconds from birth, with an interquartile range of 30-140 secs. Only 6% had reliable data within 1 minute. Probe was connected to the cable before the patient, which may delay signal acquisition (see O'Donnell, 2005)


**Level of Evidence:** 2  
**Quality of Evidence:** Good  
**Reviewer's Comments:** 95 infants > 1000 gms requiring resuscitation were compared to 30 control newborns using pulse oximetry, but with older technology (Novametrix 515A). 10.5% of resuscitated and 6.7% of controls were unable to acquire a signal and 6.3, 36.5, 63.1, and 80% of the resuscitated babies had a signal acquired by 1,3,5, and 10 minutes of age respectively. >90% saturation was achieved at a median time of 300 and 170 seconds, respectively in resuscitated infants and controls, respectively. Supplemental oxygen use was not specifically defined.

**Level of Evidence:** Not used in worksheet

**Quality of Evidence:** Not used in worksheet

**Reviewer's Comments:** 15 healthy term babies were evaluated by 2 brands of oximeters during circumcisions. The Massimo reflected EKG heart rate more accurately and had less motion artifact than the Nelcor. The patient population (stable NICU subjects, not during resuscitation) and outdated technology render this study non-contributory to the hypothesis.


**Level of Evidence:** 2

**Quality of Study:** Poor

**Reviewer's Comments:** Data from 591 infants treated in the oxygen-air controlled trials were reviewed in a study to determine the most predictive variables for outcome. Heart rate was noted to increase rapidly in all infants resuscitated, but there was no detailed description of the protocol for how the heart rate was determined and specifically at what intervals. Nevertheless, the observation supports animal studies demonstrating that heart rate is a sensitive sign of response to resuscitation.


**Level of Evidence:** 5

**Quality of Evidence:** Fair

**Reviewer's Comments:** This study was performed in stable babies in the NICU, not following birth in the delivery room. The purpose was to authenticate the accuracy of oximetry in determining heart rate, and in the somewhat related population it was very accurate.

Stola, A., Schulman, J., and Perlman, J. Initiating delivery room stabilization/resuscitation in very low birth weight (VLBW) infants with an FiO(2) less than 100% is feasible. *J Perinatol.* 2009;29(8):548-552

**Level of Evidence:** Not used in worksheet

**Quality of Evidence:** Not used in worksheet

**Reviewer's Comments:** 53 infants were studied prospectively and compared to 47 historical controls to evaluate the feasibility of using blended oxygen and oximetry during delivery room resuscitation. The study demonstrated an improved outcome in terms of target oxygenation following resuscitation when oximeters were used, but did not address the the primary question of the worksheet.


**Level of Evidence:** 5

**Quality of Evidence:** Fair

**Reviewer's Comments:** 200 parents were asked to determine the heart rate of their 3-day to 9-month old healthy infants using 4 methods (palpating brachial, apical, carotid pulse, listening over precordium directly with their ears) and compared with a nurse listening to the precordium with a stethoscope. Direct auscultation was most accurate. The age and stability of subject and lack of a gold standard for the criterion reference (stethoscope), render this study not very germane to the hypothesis. However, it does support the use of precordial auscultation over palpation of peripheral pulses.


**Level of Evidence:** 5

**Quality of Evidence:** Fair
Reviewer's Comments: The authors studied the ability of resuscitators to determine the heartrate from a metronome during simulation. A device that gave an alarm at the start and end of a 6-second period permitted the subjects to estimate a heart rate significantly more accurately than did other methods. The audible heartrate was the only sign of “life” evaluated. The study does not address the worksheet question as to what vital sign is most predictive of resuscitation success but does suggest that tools to evaluate heartrate can improve accuracy.


Level of Evidence: 4
Quality of Evidence: Fair
Reviewer's Comments: 50 healthy newborns were assessed for oxygen saturations following birth. Values were obtained in all by 2 minutes. The purpose was to evaluate saturations, but heartrates were also determined. The health and gestation was not typical of newborns requiring resuscitation, but it does support the practicality of obtaining pulse oximeter readings quickly. The instruments used in this study have been improved since the study.