Neonatal Resuscitation Algorithms Versus the Reality of the Delivery Room

Myra H. Wyckoff, MD
Associate Professor of Pediatrics
UT Southwestern Medical Center at Dallas
Achieving Consensus on Resuscitation Science

- Since 2000, a Neonatal Task Force participates with the International Liaison Committee on Resuscitation (ILCOR) for a complete review of newborn resuscitation science every 5 years.

- 32 new questions being reviewed for 2015 by the Neonatal Task Force
ILCOR Evaluation Process

- Identify and prioritize the questions that need scientific review and assign reviewers (2-3 per question)
- Minimum requirements for every search strategy are specified and done by professional librarians
  - Medline, Embase, and Cochrane Systematic Reviews
  - Hand searches
- Every reviewer rates the level and quality of evidence using a standardized evidence evaluation (GRADE system)
- Consensus for each question must be reached by entire Neonatal Task Force in Feb 2015
Hot Topics for ILCOR 2015

- Should cord clamping be delayed for neonates who are non-vigorous?
- How to best maintain euthermia of the neonate in the delivery room?
- Does intubation and suction benefit the non-vigorous meconium stained neonate?
- How should oxygen be used for premature neonates in the delivery room?
- How to deliver initial breaths to a premature neonate in the delivery room?
Guidelines for Neonatal Resuscitation

- Next guidelines available online October 19, 2015
- Printed Guidelines supplement will be published in *Circulation, Resuscitation* and likely *Pediatrics*
- Will be able to download at: www.heart.org/cpr
2010 ILCOR Guidelines for Neonatal Resuscitation
Neonatal Resuscitation Program Guidelines are set by the AAP NRP Steering Committee for the United States and based on the ILCOR Review.
Why have a resuscitation algorithm?

- Organize what can be a chaotic experience
- Provides an excellent teaching aid
- Focus medical providers on initial steps to promote initiation of spontaneous breathing
- Encourage rapid assessment as to a newborn’s success in taking effective breaths
- If needed, initiate effective positive pressure ventilation in a timely manner
- Balance desire for natural transition with need to prevent on-going asphyxia and injury
2005 Neonatal Resuscitation Algorithm

Birth

- Term gestation?
- Clear amniotic fluid?
- Breathing or crying?
- Good muscle tone?

Yes

- Provide warmth
- Position; clear airway (as necessary)
- Dry, stimulate, reposition

No

- Provide warmth
- Evaluate respirations, heart rate, and color

Breathing

- HR >100 & Pink
  - Observational Care

Cyanotic

- Give supplemental oxygen

Persistently cyanotic

- Provide positive-pressure ventilation

Apneic or HR <100

- HR <60
  - Provide positive-pressure ventilation
  - Administer chest compressions

- HR >60
  - Effective ventilation
  - HR >100 & Pink
    - Post-resuscitation Care

**Endotracheal intubation may be considered at several steps.**
Indications For Cardiac Compressions During Neonatal CPR: 2005

Chest Compressions are indicated when the heart rate remains below 60 bpm despite

- 30 sec of providing warmth, position, suction (if needed), dry and stimulate
- 30 sec of EFFECTIVE assisted ventilation

Note: Because chest compressions are likely to compete with effective ventilation, rescuers are encouraged to ensure that assisted ventilation is delivered optimally BEFORE initiation of chest compressions
Unintended Consequences of Time Intervals in the Algorithm

- Multiple reports compressions being initiated prior to effective positive pressure ventilation or advanced airway

- But if teams are trained to focus intently on inflating the lung and providing effective ventilation…
  - Only 1 in 1000 newborns need cardiac compressions

- The time pressure of 30 seconds for initial steps, 30 seconds for PPV and then start compressions for HR<60 bpm thought to contribute to these errors
2010 Neonatal Resuscitation Algorithm

Extra time for assuring optimization of ventilation
Techniques for Achieving Effective Ventilation (MR. SOPA)

<table>
<thead>
<tr>
<th></th>
<th>Actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>M</td>
<td>Adjust <strong>Mask</strong> to assure good seal on the face</td>
</tr>
<tr>
<td>R</td>
<td><strong>Reposition</strong> airway by adjusting head to “sniffing position”</td>
</tr>
<tr>
<td>S</td>
<td><strong>Suction</strong> mouth and nose of secretions, if present</td>
</tr>
<tr>
<td>O</td>
<td><strong>Open</strong> mouth slightly and move jaw forward</td>
</tr>
<tr>
<td>P</td>
<td>Increase <strong>Pressure</strong> to achieve chest rise</td>
</tr>
<tr>
<td>A</td>
<td>Consider <strong>Airway</strong> alternative (endotracheal intubation or laryngeal mask airway)</td>
</tr>
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</table>
Poor Mask Seal Often Inhibits Effective Ventilation

48% demonstrated significant mask leak
- Majority were corrected with repositioning of the mask
- Some required changing the way mask was held

Table 1  Infant demographics (n = 56)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Gestational age (weeks)*</td>
<td>26 (24–30)</td>
</tr>
<tr>
<td>Birth weight (g)†</td>
<td>839 (223)</td>
</tr>
<tr>
<td>1 min Apgar score‡</td>
<td>5 (3.6)</td>
</tr>
<tr>
<td>5 min Apgar score‡</td>
<td>7 (6.8)</td>
</tr>
<tr>
<td>Male§</td>
<td>24 (45%)</td>
</tr>
</tbody>
</table>

*Data are mean (range). †Mean (SD). ‡Median (IQR). §n (%).
Inappropriate Position Often Inhibits Effective Ventilation

- 25% demonstrated significant airway obstruction
  - Majority corrected with repositioning the infant in the open airway position

Schmolzer et al. ADC 2011
Techniques for Achieving Effective Ventilation (MR. SOPA)

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Indications For Cardiac Compressions During Neonatal CPR: 2010

Chest Compressions are indicated when the heart rate remains below 60 bpm despite

- Providing warmth, position, suction (if needed), dry and stimulate
- 30-60 s of EFFECTIVE assisted ventilation (focus on MRSOPA steps to achieve this first including an advanced airway)

Note: Because chest compressions are likely to compete with effective ventilation, rescuers are encouraged to ensure that assisted ventilation is delivered optimally BEFORE initiation of chest compressions
First 60 seconds of the Newborn Resuscitation Algorithm.

- **Birth**
  - Term gestation? Breathing or crying? Good tone?
    - **No**
      - Warm, open airway, dry, stimulate
    - **Yes**
      - Routine Care
        - Provide warmth
        - Assure open airway
        - Dry
        - Ongoing evaluation
  - **Yes, stay with mother**

- **30 sec**
  - HR below 100, gasping, or apnea?
    - **Yes**
      - PPV, consider SPO₂ monitoring
    - **No**
      - Labored breathing or persistent cyanosis?
        - **Yes**
          - Consider SPO₂ monitoring
          - Consider CPAP
        - **No**
          - No further intervention needed
Timing of Interventions in the Delivery Room: Does Reality Compare with Neonatal Resuscitation Guidelines?

Lisa K. McCarthy, MRCPI\textsuperscript{1,2,3}, Colin J. Morley, FRCP, FRCPCH, FRACP\textsuperscript{4}, Peter G. Davis, MD, FRACP\textsuperscript{4}, C. Omar F. Kamlin, MD\textsuperscript{4}, and Colm P. F. O’Donnell, MB, MRCPI, MRCPCH, FRACP, PhD\textsuperscript{1,2,3}

- N=189
- EGA 29 (IQR 27-34) wks
- BW 1220 (IQR 930-2197)g

<table>
<thead>
<tr>
<th>DR task</th>
<th>n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Placement in a polyethylene bag</td>
<td>109 (58)</td>
</tr>
<tr>
<td>Use of pulse oximetry</td>
<td>184 (97)</td>
</tr>
<tr>
<td>HR auscultation or cord palpation</td>
<td>153 (81)</td>
</tr>
<tr>
<td>HR available</td>
<td>181 (96)</td>
</tr>
<tr>
<td>Respiratory support</td>
<td>160 (85)</td>
</tr>
<tr>
<td>Free-flow O\textsubscript{2}</td>
<td>6 (3)</td>
</tr>
<tr>
<td>Continuous positive airway pressure</td>
<td>33 (17)</td>
</tr>
<tr>
<td>Intermittent PPV</td>
<td>67 (36)</td>
</tr>
<tr>
<td>Intubation</td>
<td>54 (29)</td>
</tr>
<tr>
<td>Use of surfactant</td>
<td>1 (1)</td>
</tr>
<tr>
<td>Chest compressions</td>
<td>3 (2)</td>
</tr>
<tr>
<td>Adrenaline administration</td>
<td>1 (1)</td>
</tr>
</tbody>
</table>
The median time taken to perform all tasks was greater than that recommended in the guidelines.

- The recommended initial 30- and 60-second intervals in the algorithm may be too short.
- The time pressure may encourage providers to skimp on the initial steps in order to initiate PPV.
- Or maybe there are tasks that are just taking too long.

Table III. Number (%) of infants with recommended tasks performed by 60 seconds

<table>
<thead>
<tr>
<th></th>
<th>On table (n = 189)</th>
<th>In bag (n = 109)</th>
<th>HR auscultated or palpated (n = 153)</th>
<th>HR first obtained by auscultation, palpation, or oximetry (n = 181)</th>
<th>Oximeter on (n = 184)</th>
<th>Oximeter reading (n = 184)</th>
<th>Respiratory support (n = 160)</th>
</tr>
</thead>
<tbody>
<tr>
<td>From birth</td>
<td>189 (100)</td>
<td>53 (49)</td>
<td>72 (47)</td>
<td>60 (33)</td>
<td>110 (60)</td>
<td>33 (18)</td>
<td>60 (38)</td>
</tr>
<tr>
<td>From arrival</td>
<td>NA</td>
<td>77 (71)</td>
<td>111 (73)</td>
<td>113 (62)</td>
<td>162 (88)</td>
<td>88 (48)</td>
<td>87 (54)</td>
</tr>
</tbody>
</table>

(J Pediatr 2013;163:1553-7)
So should we keep the 30 second intervals in the algorithm?

- There will always be the need to rationally balance careful initial steps and clinical assessment in the hopes of avoiding the need for positive pressure ventilation altogether.

- But this will have to be balanced with the risk of additional hypoxic/ischemic injury if ventilation is not assisted in a timely enough manner.
Perhaps we need to improve our methods of performing the initial steps/assessments.
Heart Rate Remains The Most Important Vital Sign

- Cardiac Output = Stroke Volume X Heart Rate
- Stroke Volume Does not Change Significantly in the Newborn
- Therefore, Heart rate determines the output to the lungs
Determination of heart rate in the baby at birth

Catherine Jane Owen, Jonathan Peter Wyllie*

- Healthy Term Deliveries (n=61)
- All had HR assessed with auscultation as well as palpation of the pulse at either
  - Cord base
  - Femoral
  - Brachial
- All auscultated heart rates were > 100 bpm
Umbilical cord palpation was more reliable but still only 55% identified as >100 bpm, 25% <100 bpm and 20% undetectable.

Fig. 1. A comparison of the heart rate as determined by femoral, brachial and cord pulse palpation.
61 nurses, midwives, doctors

Simulation manikin with audible heart beat

Assessed heart rate at
- Birth
- During initial positive pressure ventilation
- During cardiac compressions
Providers Are Frequently Inaccurate When Auscultating Heart Rate in Manikins

Fig. 2. Accuracy related to heart rate.
Providers are Frequently Slow in Determining the Heart Rate and Inaccurate Enough to Frequently Make Decision Errors

### Time and accuracy of heart rate assessment.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Mean time to assess (SD) (s)</th>
<th>Accurate (set rate ±5 bpm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>17 (11.5)</td>
<td>29 (48%)</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>9.8 (5.6)</td>
<td>44 (72%)</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>7.8 (5.5)</td>
<td>45 (74%)</td>
</tr>
<tr>
<td>Overall</td>
<td>N.A.</td>
<td>118 (64%)</td>
</tr>
</tbody>
</table>

### Time and accuracy of heart rate assessment.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Inaccurate sufficient to alter management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario 1</td>
<td>19 (31%)</td>
</tr>
<tr>
<td>Scenario 2</td>
<td>17 (28%)</td>
</tr>
<tr>
<td>Scenario 3</td>
<td>16 (26%)</td>
</tr>
<tr>
<td>Overall</td>
<td>52 (28%)</td>
</tr>
</tbody>
</table>

*Resuscitation 81 (2010) 1000–1003*
ECG and Pulse Oximetry during resuscitation

- Time from arrival at radiant warmer until ECG electrodes vs Pulse Ox sensor placed
  - VLBW infants (n=30): 26 vs 38 sec (p=0.04)
  - >1500g infants (n=16): 20 vs 26 sec (p=0.74)

- Time to achieve audible heart tones from ECG vs Pulse Ox
  - VLBW infants: 2 vs 24 sec (p<0.001)
  - >1500g infants: 4 vs 32 sec (p=0.001)

ECG provides continuous audible heart rate and may improve timeliness of critical interventions
Electrocardiogram shows reliable heart rates much earlier than pulse oximetry during neonatal resuscitation

Hiroshi Mizumoto, Seiichi Tomotaki, Hirofumi Shibata, Kazutoshi Ueda, Ryoko Akashi, Hiroko Uchio and Daisuke Hata
Department of Pediatrics, Kitano Hospital, Tazuke Kofukai Medical Research Institute, Osaka, Japan
Pulse Oximetry Measures a Lower Heart Rate at Birth Compared with Electrocardiography

Jeroen J. van Vonderen, BSc¹, Stuart B. Hooper, PhD², Jacco K. Kroese, BSc¹, Arno A. W. Roest, MD, PhD³, Ilona C. Narayen, MD¹, Erik W. van Zwet, PhD⁴, and Arjan B. te Pas, MD, PhD¹

- N=53 babies, 755 data pairs
  - Median (IQR) gestational age was 37 (31-39) wks
  - Delayed cord clamping

- Simultaneous heart rate determinations by pulse oximetry and ECG
  - Time to signal
    Pulse Ox 99 ± 33 vs ECG 82 ± 26 sec after birth (P = .001)
Pulse Oximetry Measures a Lower Heart Rate at Birth Compared with Electrocardiography

Blue = pulse ox
Green = ECG

Heart Rate (BPM) vs. Time after birth (s)
Heart Rate by Pulse Ox is significantly lower compared with ECG with clinically important differences in the first minutes of life.

Table II. Frequency of occurrence of HR <100 bpm and HR <60 bpm (%)

<table>
<thead>
<tr>
<th>Time</th>
<th>HR PO below 100 bpm</th>
<th>HR ECG below 100 bpm</th>
<th>P value</th>
<th>HR PO below 60 bpm</th>
<th>HR ECG below 60 bpm</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 s</td>
<td>64</td>
<td>27</td>
<td>.05</td>
<td>9</td>
<td>0</td>
<td>.05</td>
</tr>
<tr>
<td>90 s</td>
<td>56</td>
<td>26</td>
<td>.04</td>
<td>27</td>
<td>4</td>
<td>.03</td>
</tr>
<tr>
<td>120 s</td>
<td>53</td>
<td>21</td>
<td>.01</td>
<td>11</td>
<td>8</td>
<td>.05</td>
</tr>
<tr>
<td>150 s</td>
<td>27</td>
<td>13</td>
<td>.04</td>
<td>11</td>
<td>2</td>
<td>.05</td>
</tr>
<tr>
<td>180 s</td>
<td>32</td>
<td>9</td>
<td>.01</td>
<td>13</td>
<td>2</td>
<td>.05</td>
</tr>
</tbody>
</table>

- **Unnecessary** Interventions may be initiated if relying solely on Pulse Oximetry for Heart Rate in the delivery room.
Conclusions

- The resuscitation algorithm becomes more science based with each iteration.
- The algorithm is a guideline with some suggested time intervals to balance our desire for a natural transition at birth with the need to prevent on-going asphyxial injury when transition is not going well.
- With our current practice, we often Do NOT meet the suggested time lines.
Heart Rate is the most important determinant of need for interventions in the algorithm.

Palpation of Heart Rate is often inaccurate.

Auscultation of Heart Rate is often inaccurate and can take time away from other important resuscitation activities.

ECG is much faster and more accurate in determining HR in the DR compared to pulse oximetry.
Speculation

- Use of ECG may have increasing prominence in the Neonatal Resuscitation Algorithm for Heart Rate Determination in the Future
  - For those babies needing resuscitation!

- New technologies for rapid acquisition of ECG signal are on the horizon

- There will of course be new difficulties
  - Cost
  - How to apply quickly to wet baby
  - Pulseless Electrical Activity