Aspects of Neonatal Resuscitation

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Houston, Texas
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Treatment of the newborn begins before birth

- Obstetric/Perinatologist assessments and interventions
- Regionalization of perinatal care
- Treatment of maternal conditions (diabetes, hypertension, etc)
- Prenatal steroids
- Prenatal antibiotics
Preterm birth interrupts normal lung development

- Lung is not anatomically or biochemically mature in ELBW or VLBW babies
- Anatomic phases on lung development: Embryonic-> pseudoglandular -> cannalicular (16->25 wks) -> saccular -> (25-36 wks) alveolar (mature)
- Type 2 cells begin to make and secrete Surfactant ( 25 wks – 38 wks)
- Surfactant synthesis is interrupted by preterm birth and lung damage
- Pre-natal steroids promote surfactant synthesis
- Steroids, mechanical ventilation, O2 toxicity delay alveolarization
Lung increases size and complexity during development

28 weeks ----->
Surfactant being synthesized and secreted into airways

Airways, saccules, alveoli are growing
Pulmonary blood vessels are growing around the alveoli
More complex airways and more Alveoli
Preterm birth is associated with an imbalance of regulatory amino acids

**Apnea** is common in premature babies due to:

- *Imbalance* of respiratory-inhibiting amino acids and respiratory-stimulating amino acids in VLBW babies

**Breathing**

- Inhibiting are up (GABA, taurine)
- Stimulating are down (glutamate, aspartate)
Hypoventilation, Apnea and Bradycardia at birth

- Failure of the lungs to expand completely
- Failure of expanded lungs to remain open
- Failure to maintain Functional Residual Capacity (the lung volume below tidal volume but above lung residual capacity)
- Sometimes due to physical block of the airway (secretions, meconium, congenital anomalies)
- Rarely due to cardiac arrhythmias

Underdeveloped anatomy, lack of surfactant secretion, tendency to inhibition of breathing can lean to:
An important concept

Functional Residual Capacity

Tidal Volume →

FRC →

←--- Total collapse
Maintaining Functional Residual Capacity

- Can be achieved by normal, mature lungs
- Can be achieved by Surfactant administration to premature lungs
- Can be achieved by PEEP
- Can be achieved by nasal CPAP
In the normal newborn: after birth the lungs assume the role of the placenta

- Placenta is no longer present to eliminate acid [H+] produced by metabolism
- Acid reacts with bicarbonate to produce carbonic acid, which in turn breaks down into water and carbon dioxide

Cell Metabolism $\rightarrow$ \[ H^+ + HCO_3^- \leftrightarrow H_2CO_3 \]
\[ H_2CO_3 \leftrightarrow H_2O + CO_2 \rightarrow \text{Lungs} \]
What happens when lungs fail?

Respiratory Acidosis

- Henderson-Hasselbach Equation (acid dissociation equation)

- \[ \text{pH} = 6.1 + \log \left( \frac{\text{bicarbonate}}{0.03 \times \text{PaCO2}} \right) \]

  where bicarbonate = 20

<table>
<thead>
<tr>
<th>PaCO2</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>7.27</td>
</tr>
<tr>
<td>65</td>
<td>7.11</td>
</tr>
<tr>
<td>85</td>
<td>6.99</td>
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</tbody>
</table>
Transitions expected immediately after birth

- Cord is clamped (more about this later)
- Lungs expand and air enters the lungs
- Increased pulmonary blood flow; decreased pulmonary resistance
- Increase in PaO2 up to about 70 torr dilates the pulmonary vasculature (beyond 70 minimal dilatation occurs and O2 toxicity is possible)
Fetal and Maternal O2-Hgb dissociation curves
% SaO2 after normal term birth

Minutes after birth

Upper STD
Mean
Lower STD
Some effects of oxygen toxicity on newborns

- Excess O2 can generate hydroxyl \( \cdot \text{OH} \) free radicals
- \( \cdot \text{OH} \) free radicals generate many other toxins
- \( \cdot \text{OH} \) damages DNA, proteins and cell membrane lipids
- Cell damage leads to CNS toxicity, ROP, and pulmonary toxicity
Mortality increases with decreased body temperature.

Providers (RT, RN, MDs) underestimate the heart rate and the SaO2 (compared to EKG or SaO2 monitors).

Large mechanical breaths can over-distend the lungs, resulting in lung damage; maintaining FRC is important.

Mortality is decreased in babies resuscitated in room air vs. 100% O2 (~30% less: Tan A et al, Cochrane DB Syst Rev 2005; CD 002273).
Some things (we think) we should do

- Warm the baby (turn on the warmer; place VLBW babies in plastic bags; use bed warmers; use temp probe)
- Use a SaO2 monitor
- Use an air-oxygen blender in the DR
- Use Neopuff for PIP and PEEP control
- Start with room air in term babies and 40 % FiO2 in preterm babies
Neopuff Infant Resuscitator (T-piece)  
Fisher & Paykel

Delivers PIP and Maintains PEEP
Self-inflating bag

PEEP valve
Flow-inflating bag
Neopuff Infant Resuscitator

Pressure monitor

PIP control

Max Pressure control

Gas inlet

Gas outlet

PEEP valve

Gas

Neopuff Infant Resuscitator

Thumb occluding PEEP valve

Dwell time of thumb on PEEP valve determines Ti
Comparing the 3 kinds of resuscitators
Neopuff vs SIB vs FIB

Bennett S et al. Resuscitation 2005; 67 (1): 113-8

<table>
<thead>
<tr>
<th>Target settings</th>
<th>Neopuff</th>
<th>Self-inflating bag</th>
<th>Flow-inflating bag</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIP = 20 cm</td>
<td>20.7 +/- 0.8</td>
<td>24.7 +/- 0.8</td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>PIP = 40 cm</td>
<td>39.7 +/- 2.1</td>
<td>44.0 +/- 3.3</td>
<td>45.3 +/- 4.7</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>PEEP = 5 cm</td>
<td>4.4</td>
<td>3.6</td>
<td>4.4</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Prolonged Inflation 5 sec (non-std breath)</td>
<td>4 sec</td>
<td>3.7 sec</td>
<td>2.2 sec</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>20/5 measured Tidal Volume</td>
<td>Tv = 3.6 +/- 0.8</td>
<td>Tv = 5.1 +/- 3.2</td>
<td></td>
<td>&lt;0.0005</td>
</tr>
<tr>
<td>Time to go from 20 to 40 cm PIP</td>
<td>5.7 sec</td>
<td>2.2 sec</td>
<td>1.8 sec</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
After resuscitation does Neopuff (vs SIB and FIB) prevent CLD or reduce pneumothorax, PIE?

- No studies on this question have been done
- No studies on value of PEEP in improving resuscitation
- BUT: “Each device was able to provide PIP and PEEP when used appropriately. When compared with other resuscitation devices, the T-piece provided the most accurate and consistent PIP and PEEP.” (Dawson JA. J Paed Child Health 2011; 47: 698-703) i.e Neopuff can resuscitate more accurately
Hazards of Neopuff

At 15 LPM flow the PIP and PEEP setting can be over-ridden.

If the PEEP valve blow off is occluded, PIP will be applied continuously (excessively long Ti).

If the PIP pop-off safety is set too low, insufficient PIP will be delivered.

If LPM is set too low, insufficient PIP and PEEP will be delivered.

Keep the flow ~ 8-10 LPM; check the PEEP and PIP before using.

Delayed Cord Clamping
Delayed Cord Clamping: Hemodynamic Effects
VLBW babies (30-120 sec delay)

Superior vena cava blood flow is increased
Right ventricular output is increased
Right ventricular stroke volume is increased
No difference in persistence of the patent ductus arteriosus

Delayed Cord Clamping: Clinical Effects

VLBW babies (30-120 sec delay)

- Increase in Hct by 4.5 %
- Increase in blood pressure
- Increase in blood volume
- Decreased need for blood transfusions
- Increase in bilirubin by 1.14 mg %

Rabe H et al. Cochrane database Rev 2012; 8: CD003248
Delayed Cord Clamping: Outcomes
VLBW babies 30-120 seconds

Rabe H et al. Cochrane database Rev 2012; 8: CD003248

<table>
<thead>
<tr>
<th>Negative Clinical Outcomes</th>
<th>Relative Risk</th>
<th>95% Confidence Interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfusion needed</td>
<td>0.61</td>
<td>0.46 to 0.81</td>
</tr>
<tr>
<td>IVH, any</td>
<td>0.59</td>
<td>0.41 to 0.85</td>
</tr>
<tr>
<td>NEC</td>
<td>0.62</td>
<td>0.43 to 0.90</td>
</tr>
<tr>
<td>Death</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>Severe IVH</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>PVL</td>
<td>n.s.</td>
<td></td>
</tr>
<tr>
<td>Bayley II scores at 7 months</td>
<td>n.s.</td>
<td></td>
</tr>
</tbody>
</table>
Putting it all together: VLBW or ELBW babies

- Turn on the warmer
- Place bed warmer on bed
- Have Neopuff, suction bulb, suction catheter and (bubble) CPAP ready and O2/air **blender** in DR
- Have surfactant, ET, laryngoscope ready
Putting it all together: VLBW or ELBW babies

- Delay cord clamping $> 30$ secs
- Place baby in warmed plastic bag on bed, head out; bulb suction mouth, nose
- Place SaO2 monitor on right hand
- Apply Neopuff mask to face + 5 cm, 40 % FiO2; check SaO2, HR (be careful of eyes)
Putting it all together: VLBW or ELBW babies

- Adjust FiO2, noting rise in SaO2, HR
- If baby is breathing, apply bubble nCPAP or nIPPV
- Readjust FiO2, noting SaO2, HR
Putting it all together: VLBW or ELBW babies

- If baby not breathing or having moderate-severe respiratory distress, bag with Neopuff 20/5, controlling Ti with thumb
- Readjust FiO2, noting SaO2 and HR and respiratory effort
- Insert OG tube to evacuate stomach of air
- When SaO2, HR satisfactory, intubate to deliver surfactant
- Bag in with Neopuff, adjusting PIP downward as compliance improves following surfactant administration; extubate
Putting it all together: VLBW or ELBW babies

- SaO2 monitor
- Temp probe
- Bubble CPAP
- OG tube
- Warmer and warm bed