Factors which may improve the respiratory effort at birth of preterm infants.

- The use of antenatal steroids
- Skilled personnel at deliveries
  - Each delivery should have at least 1 person whose primary role is the newborn baby
  - When a risk factor has been identified additional personnel need to attend the delivery
- Knowing the maternal history, antepartum and intrapartum risk factors
- Preparation of necessary equipment
- Surfactant Therapy
- Lung-protective strategy
Preparation for Resuscitation

- Resuscitation of newborn infants occurs in approximately 10% of the more than 100 million infants born annually worldwide.
- The techniques used during resuscitation, may revive many infants, but have the potential to harm their lungs.
- In recent years increasing attention has been applied to providing lung protection from the first breath.

Respir Care 2011;56(9):1360–1367

Preparation for Resuscitation

- From the first breaths, the preterm infant must be helped to clear the lung fluid, to recruit alveolar spaces, to form the functional residual capacity (FRC), to protect the lungs from large tidal volume and by shear stress forces giving an adequate positive end-expiratory pressure (PEEP), and to verify the real need for surfactant replacement.

Neonatology 2011;99:45–50
Risk Factors for VILI During Resuscitation

- Volutrauma, atelectrauma and oxidative stress have been identified by animal studies as the most important risk factors for VILI.
  - Volutrauma – overdistension of small airways and alveoli with assisted ventilation resulting in inflammation and physical damage to these lung areas.
  - Atelectrauma – using insufficient PEEP is the main mechanism for the repetitive opening and collapse of unstable lung units is insufficient PEEP. The air sacs are exposed to repeated shearing forces, with inflammation, membrane disruption, and surfactant dysfunction. The presence of atelectasis will result in a redistribution of the set (lungprotective) tidal volume to the open lung units, causing regional overdistension.
  - Biotrauma - premature neonates have inadequate concentrations of antioxidants, when exposed to fractions of inspired oxygen, thus high PO2 concentrations, this leads to free radicals overwhelming the antioxidant system and cause cell damage.

Respir Care 2011;56(9):1360 –1367, Neonatology 2011;99:338–341

Principles of Lung-Protective Ventilation

- Lung protection strategy should start from the moment the preterm or term infant is born until (assist ventilation is no longer required) or (the time discharged home.)
  - (1) to avoid use of high tidal volumes;
  - (2) to minimize the presence of atelectasis,
  - (3) to avoid high FiO2 leading to oxidative stress.

Neonatology 2011;99:338–341
Principles of Lung-Protective Ventilation: Volutrauma

- The initial peak inflating pressure used, in both premature and term infants, should be individualized since lung compliance and airway resistance varies from infant to infant.
- The initial few breaths to open the lungs typically require higher inflation pressures. The subsequent breaths probably require lower peak inflating pressure (clinicians beware).
  - Term infants: initial inflation pressure of approximately 30 cm H\(_2\)O.
  - Preterm infants: initial inflation pressure of approximately 20–25 cmH\(_2\)O.
- Assessing for adequate peak inflating pressure:
  - Increase in heart rate, SaO\(_2\), movement of the chest and bilateral breath sounds.

Respir Care 2011;56(9):1360–1367

Principles of Lung-Protective Ventilation: Atelectrauma

- The delivery room use of CPAP or PEEP of at least 4–5 cm H\(_2\)O has been advocated to assist in lung expansion, establish FRC, and improve oxygenation.
- Lungs of preterm infants at birth are surfactant deficient, so it may be difficult for them to achieve adequate functional residual capacity (FRC) and maintain open alveoli and distal airways.
- There is a scarcity of data supporting early use of CPAP in the delivery room as a result: The International Liaison Committee on Resuscitation report and the Neonatal Resuscitation Program guidelines suggest that the use of CPAP/PEEP should reflect local expertise and preferences.

http://oac.med.jhmi.edu/res_phys/Encyclopedi/Surfactant/Surfactant.HTML

Respir Care 2011;56(9):1360–1367
Principles of Lung-Protective Ventilation: Biotrauma - Minimize Oxidative Stress

- Supplemental oxygen should be administered using a blender, allowing adjustment of variable concentration, and should be titrated to maintain SpO2 within the interquartile range defined for uncomplicated term babies.
- NRP will advocate (but not mandate) starting resuscitation of a term baby with 21% oxygen and something greater than 21%, but less than 100%, oxygen for a preterm baby (which would encourage having the blender attached for all preterm deliveries).
- An oximeter is recommended whenever supplemental oxygen, positive ventilation, or CPAP is used.
- Every delivery area should have an oximeter readily available but not necessarily physically present at every delivery.

Surfactant Therapy

- Local expertise and clinicians' preferences
- Prophylactic Therapy
  - Assumed preterm infants are high risk for developing RDS
  - Intubate in the delivery room administered surfactant treatment
- Rescue (Therapeutic) Therapy
  - After the diagnosis of RDS administered surfactant treatment
Preparation for Resuscitation: Equipment

- Prepare necessary equipment
  - Turn on radiant warmer
  - Prewarm the linen
  - Suction equipment
    - Set at -100mmHg
  - Check resuscitation equipment
    - Oxygen, resuscitator bag, mask
    - T-piece resuscitator
    - Laryngoscope, miller blade, endotracheal tubes
    - Pulse oximeter
  - Prewarmed linen
  - Medications

Preparation for Resuscitation: Endotracheal Tube Selection

- Selection of endotracheal tube is based on weight and gestational age
- Select the appropriate size miller blade
  - Size 0 for premature newborns
  - Size 1 for term
- Stylet

<table>
<thead>
<tr>
<th>Tube Size (mm)</th>
<th>Gestational Age (weeks)</th>
<th>Weight (grams)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.5</td>
<td>below 28 weeks</td>
<td>Below 1,000</td>
</tr>
<tr>
<td>3.0</td>
<td>28 -34</td>
<td>1,000- 2,000</td>
</tr>
<tr>
<td>3.5</td>
<td>34 -38</td>
<td>2,000 – 3,000</td>
</tr>
<tr>
<td>3.5 – 4.0</td>
<td>Above 38 weeks</td>
<td>Above 3,000</td>
</tr>
</tbody>
</table>
Preparation for Resuscitation: Bag and Mask

- Select the correct size mask to achieve an adequate seal
- Select the resuscitation device
  - Self inflating, flow inflating or pressure limited T-piece resuscitator
- Assemble and connect to oxygen source – blender
- Check device and mask to ensure they are functioning properly

Preparation for Resuscitation

Options to Consider:

- Continuous positive airway pressure (CPAP) and PEEP
- Intubation, deliver surfactant, extubate
- Sustained inflations
- Intubation if required
- Airway management of meconium-stained amniotic fluid

Respir Care 2011;56(9):1360 –1367
The aim of using a sustained inflation in the preterm infant is not only to ‘resuscitate’ but also to facilitate uniform lung aeration and the formation of a functional residual capacity, thereby improving oxygenation and possibly avoiding intubation and lung injury from repeated collapse and expansion.

- Neonatology 2011;100:78–84

Sustained inflations for the first several breaths of manual ventilation are a popular method to assist the formation of FRC during resuscitation.
- Respir Care 2011;56(9):1360 –1367

- Neonatal resuscitation guidelines in some European countries advocate specifically using 3–5 initial inflations lasting 2–3 s using a peak inflating pressure (PIP) up to 30 cm H 2 O [4–6].
- Neonatology 2011;100:78–84

The baby is delivered.

What is next?
Initial Steps: No Meconium

- Provide warmth
- Position head and clear airway as necessary
- Suction the mouth then the nose with a bulb syringe
- Dry and stimulate the baby to breathe and remove the wet towels
- Reposition the head

Evaluation

- **Respirations**: good chest movement with adequate rate and depth of respirations
  - Assess for apnea, gasping, labored or unlabored breathing
- **Heart rate**: greater than or less than 100 bpm
  - Count beats in 6 seconds: ie: 8 beats then multiply by ten – heart rate 80 beats
  - Auscultation of the precordium preferred
  - Palpate the umbilical pulse
- **Color**: Pulse oximetry: – placement preductal- right hand or wrist. Better assessment for need of oxygen versus assessing color. Improvement of SpO₂

**You have 30 seconds to achieve a response from one step before deciding to go on to the next**
Term infants receiving resuscitation at birth:

- Begin positive-pressure ventilation with air rather than 100% oxygen
- If despite effective ventilation there is no increase in heart rate or if oxygenation guided by pulse oximetry remains unacceptable, use of a higher concentration of oxygen should be considered.

Preterm babies < 32 weeks receiving resuscitation at birth:

- Blended oxygen and air may be given guided by pulse oximetry
- If a blend of oxygen and air is not available, resuscitation should be begin with air guide adjustments by pulse oximetry

Initial Steps: Meconium Present

The initial steps of resuscitation, when meconium is present in the amniotic fluid, depends on if the newborn is or is not vigorous
Meconium Present: Newborn Vigorous

A vigorous newborn is defined as
- Strong respiratory effort
- Good muscle tone
- Heart rate >100 beats per minute (bpm)

Then
- Continue with initial steps of resuscitation
- Use bulb syringe or large-bore suction catheter to clear mouth and nose if needed

Meconium Present: Newborn Not Vigorous

- A newborn is not vigorous if
  - Depressed respirations or
  - Depressed muscle tone or
  - Heart rate < 100 beats per minute
- Direct laryngotracheal suctioning of the trachea is required
Meconium Present: Newborn Not Vigorous

- Place on radiant warmer
- Minimize tactile stimulation
  - Do not dry the baby this would result in tactile stimulation and increased risk of meconium aspiration
  - Do not use of positive pressure ventilation
- Administer oxygen, monitor heart rate
- Insert laryngoscope,
  - If unable to visualize the vocal cords, suction the mouth with a 12F or 14F suction catheter
- Insert endotracheal tube into trachea
- Attach meconium aspirator to endotracheal tube then to suction source
- Apply suction as tube is withdrawn
- Monitor the heart rate
- Repeat as necessary

Breathing

- If apneic or heart rate <100 bpm
  - Provide positive pressure ventilation
  - If breathing, heart rate is >100 bpm but baby is cyanotic, need to provide supplemental oxygen
  - If cyanosis persist need provide PPV
    - Endotracheal intubation maybe required
  - Ventilation of the lungs is the single most important and most effective step in cardiopulmonary resuscitation of the compromised infant
Frequency of Ventilation:

- 40 – 60 breaths per minute
  - “Breath”, “Two”, “Three”
  - Squeeze with breath and release while you say two, three
- Preterm initial pressure of 20 - 25 cmH₂O
- Term initial pressures of 30 – 40 cmH₂O

Signs of Effective Ventilation

- Signs of adequate ventilation
  - Assess for improvement in heart rate, color, pulse oximetry
- Assess for adequate chest excursion.
  - Monitor pressures
  - Excessive pressures could result in pneumothorax
After 30 seconds of positive pressure ventilation check for a heart rate

Count beats in 6 seconds:
  - 14 beats, heart rate equals 140 bpm
  - Proceed to assess color

Count beats in 6 seconds:
  - 5 beats, heart rate equals 50 bpm

Heart < 60 bpm despite adequate positive pressure ventilation with oxygen
  - Initiate chest compressions with positive pressure ventilation
  - If newborn not intubated need to prepare for intubation
  - Prepare for possible administration of epinephrine
### Chest Compressions

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Ventilation rate</td>
<td>30 breaths</td>
</tr>
<tr>
<td>Compress with</td>
<td>2 fingers or two thumbs encircling</td>
</tr>
<tr>
<td>Compression depth</td>
<td>1/3 of the anterior - posterior diameter of the chest</td>
</tr>
<tr>
<td>Compression rate</td>
<td>90/min</td>
</tr>
<tr>
<td>Compression to ventilation ratio</td>
<td>3:1</td>
</tr>
</tbody>
</table>

Chest compressions always must be accompanied by 100% positive pressure ventilation (5th edition of NRP)

“One and Two and Three and breath”

One cycle of 3 compressions and 1 breath takes 2 seconds

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### Transport the Newborn

Once stabilized transport the newborn for further evaluation
Goals of Neonatal Mechanical Ventilation

- Adequate pulmonary gas exchange
  - Provide adequate ventilation
  - Provide adequate oxygenation
- Promote patient/ventilator synchrony
  - Select appropriate ventilator mode
  - Provide adequate flow rate
  - Select appropriate inspiratory trigger
  - Terminate inspiration in conjunction with infant’s desire to exhale
  - Avoid air trapping

- Minimize lung injury (barotrauma)
  - Careful selection of appropriate respiratory rate, inspiratory and expiratory times and peak inspiratory pressures
- Patient comfort
- Recruit and maintain lung volume (volutrauma)
  - Peak inspiratory pressure to achieve tidal volume of 4 – 7 ml/kg
  - Use PEEP
  - Assess lung volume with chest x-ray
Sigh positive airway pressure (SiPAP)
CPAP, Bubble-CPAP
Nasal Intermittent Mandatory Ventilation

Types of Neonatal Ventilation

- Time Cycled Pressure Limited (TCPL)
- Nasal Neurally Adjusted Ventilatory Assist
- Volume Control Ventilation (VCV)
- Pressure Support Ventilation (PSV)
- Pressure Control Ventilation (PCV)
- High Frequency Ventilation
- High Frequency Jet Ventilation
### TCPL- SIMV/PSV Initial Settings

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td>PIP</td>
<td>15 - 20 cm H₂O</td>
</tr>
<tr>
<td>PEEP</td>
<td>3 - 6 cm H₂O</td>
</tr>
<tr>
<td>Resp Rate</td>
<td>30 - 60 bpm</td>
</tr>
<tr>
<td>Flowrate</td>
<td>4 - 10 lpm</td>
</tr>
<tr>
<td>T₁</td>
<td>0.2 - 0.6 seconds</td>
</tr>
<tr>
<td>Trigger level</td>
<td>0.2 lpm</td>
</tr>
<tr>
<td>Pressure support</td>
<td>8- 10 cm H₂O</td>
</tr>
<tr>
<td>FIO₂</td>
<td>adjust to maintain adequate PaO₂ &amp; SaO₂</td>
</tr>
</tbody>
</table>

### Peak Inspiratory Pressure (PIP)

Suggested range 15 - 20 cm H₂O

PIP level is determined by:

- Bilateral chest excursion
- Bilateral air entry
- Blood gases
- Lung pathology/severity of lung disease
- Lung mechanics
High Frequency Oscillatory Ventilation (HFOV)

- **Rescue** is a term used to describe the infant that has failed all CMV strategies, and gas exchange continues to deteriorate; or develops airleak and is then transitioned to the oscillator.

- **Pro-Active** – is a term applied to the infant on CMV that reaches specific thresholds and is then transferred to the 3100A prior to the onset of barotrauma or airleak.

- **Early Intervention** – is a term used to describe the application of HFOV to an infant within the first 4 hours of life, or one that has not been conventionally ventilated. Application is usually applied to infants with RDS.

*Viasys Healthcare, Inc.

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High Frequency Oscillation

- Mean airway pressure maintained throughout respiratory cycle
- Bidirectional movement of piston creates **active inspiration** and **active exhalation** at rates up to 900 breaths/min
- Unlike conventional ventilation, controls for oxygenation and ventilation are separate
High Frequency Jet Ventilation

- Delivers high pressure pulse of gas into the airway
  - distal to the proximal end of a triple lumen endotracheal tube (ETT) or
  - through an adapter connected to the ETT
- Used in tandem with a conventional ventilator
  - Delivers sigh breath
  - PEEP
  - Background rate
  - Continuous flow of gas

References

- Textbook of Neonatal Resuscitation 5th edition, NRP Slide Presentation Kit
- Special Report Neonatal Resuscitation: 2010 American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care
- Walsh, B., Czervinske, M., Dibiasi, R., Perinatal Pediatric Respiratory Care (3rd Edition), Saunders, 2010
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