Neonatal Respiratory Care

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Agenda

- Continuum of care
- Case presentation
- Respiratory care
  - Non invasive support
  - Modes of ventilation
- Volume guarantee
Continuum of Care

Evidence favors the use of non invasive support as the first line of treatment.

Progress to volume guarantee ventilation.

Then high frequency ventilation.

Early Hum Dev. 2012 Dec 88(12) 925-929  Keszler
Continuum of Care
Full term infant who scheduled by emergency C-section noticed to have meconium at the time of delivery.

Baby after full resuscitation, noticed to be tachypneic, retractions, desaturation to 80’s
Differential diagnosis ??
## Non Invasive Support

<table>
<thead>
<tr>
<th>HFNC</th>
<th>nCPAP</th>
<th>NIPPV</th>
</tr>
</thead>
<tbody>
<tr>
<td>- HFNC system assembled from blender, heater/humidifier, heated circuit, and cannula</td>
<td>- T-piece</td>
<td>- T-piece</td>
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<tr>
<td></td>
<td>- Bubble</td>
<td>- Infant Vent</td>
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<tr>
<td></td>
<td>- Infant Vent</td>
<td>- SiPAP</td>
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<td></td>
<td>- Infant Flow</td>
<td>- HFOV</td>
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</table>

Others:
HHFNC “Humidified Heated High flow NC”

1- High Flow system

2- Heated and Humidification system
   - Gas flow must be warm to 37°C and humidified to 100% of delivered gas prevent dryness of the respiratory mucosa.

3- Oxygen blender

4- “Open” system: a standard rule is to size the nasal cannula's prongs to occupy no more than 50% of the cross-sectional area of each nostril.
Advantages:
- **Minimal tissue injury** due to heat and humidity
- Improved comfort
- Improved patient tolerance
- Nursing care, feeding and handling easier compared to CPAP

Disadvantage:
- Unmeasured CPAP effect
HHHFNC vs. nCPAP as Non Invasive Respiratory support in neonate

<table>
<thead>
<tr>
<th>Reference</th>
<th>Patients</th>
<th>HHHFNC flow rate (L/min)</th>
<th>NCPAP level (cmH₂O)</th>
<th>Monitor</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sreenan et al 2001*</td>
<td>40 preterm infants, mean PMA 30.3 wk, mean CW 1260 g</td>
<td>6</td>
<td>6</td>
<td>The pressure transducer was placed in the distal esophagus</td>
<td>No difference between the EP during at 6 cmH₂O and with HHHFNC 6 L/min (4.65 vs. 4.53 cmH₂O)</td>
</tr>
<tr>
<td>Saslow et al 2006*</td>
<td>18 preterm infants, mean GA 28 wk, mean BBW 1118 g</td>
<td>3–5</td>
<td>6</td>
<td>The esophageal balloon catheter was advanced into the esophagus to the lower third of the tracheal length.</td>
<td>No significant increase in EDP in both NCPAP and HHHFNC (&lt; 2 cmH₂O)</td>
</tr>
<tr>
<td>Al-Alaiyan et al 2014*</td>
<td>12 premature infants, mean GA 28 wk, mean BBW 1040 g</td>
<td>4, 6, and 8</td>
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<td>The pressure transducer was placed in the distal esophagus</td>
<td>HHHFNC almost have equally EP to NCPAP (4.5 vs. 3.6 at 4; 5.5 vs. 4.8 at 6; 6.7 vs. at 6.3 cmH₂O)</td>
</tr>
</tbody>
</table>

BBW = birthweight; CW = current weight; EDP = end-distending pressure; EP = esophageal pressure; GA = gestational age; HHHFNC = heated, humidified high-flow nasal cannula; NCPAP = nasal continuous positive airway pressure; PMA = postmenstrual age.
Figure 1  Nasopharyngeal pressure of infants during heated humidified high-flow nasal cannula.
Comparison HHHFNC and NCPAP

- Observation of comfort and pain comparing NAPCP and HHHFNC is still controversial and subjective.

- Noise exposure in the NICU is a potential risk factor for hearing loss.

- The American Academy of Pediatrics recommended that environmental noise levels > 45 **decibels level** should be avoided, and it warned that prolonged exposure to sound levels > 90 dB led to hearing loss.

- The study indicated that although both devices produced noise levels > 45 dBA, there was no difference in average noise levels (BCPAP 50.6 dBA vs. HHHFNC 49.1 dBA).
Interface use for HFNC

Optiflow Fisher & Paykel (F&P)

Hudson RCI
RAM Nasal Cannula

Nasal oxygen cannula used to provide respiratory support
CPAP Devices

Delivery Methods
- Ventilators (constant flow)
- Bubble (Constant flow)
- Variable flow devices
  ~ Infant flow/SIPAP

Interfaces
- Endotracheal tubes
- Mask
- Prongs
- Ram Cannula
CPAP
Nasal CPAP

- Recruits alveoli, prevents atelectasis
- Stabilizes chest wall and upper airway
- Maintains lung volume
- Reduces WOB
- Promotes surfactant release

C. Dani et al, Pediatrics, 2004
Bubble CPAP

**Advantage:**
- unexpansive
- Multiple interface devices available

**Disadvantage:**
1. No built-in monitors
2. Potential for ↑ WOB
3. Excessive flow rates a greater than intended peep has been measured at patient. (M. Wald ET AL., 2010)

Note: Pressure oscillations are present at both the airway opening and pharynx.
Bubble CPAP vs. CPAP with Mech. Ventilator

Bubble CPAP pressure is flow dependent

Mean Pressure (±sd) vs. Bubble Bias Flow (L/min)

- Bubble CPAP
- Ventilator

Set CPAP
No Leak

Kahn, Habib, Courtney, Pediatrics 2008
Conventional vent CPAP

Advantages

- Used for past 35+ years = Literature
- High comfort level with caregivers
VF–NCPAP

- Variable flow NCPAP or Fluidic flip CPAP

Comprised of:
- An Infant flow generator
- An infant flow driver
VF–NCPAP

The Generator: Directs flow toward the patient during inhalation. Then diverts flow away from the patient during exhalation. (The Flip)
The Generator: Directs flow toward the patient during inhalation. Then diverts flow away from the patient during exhalation. (The Flip)

During exhalation the gas flow is directed away from the patient

Set pressure is maintained during expiratory phase
VF-NCPAP

Advantages
- Free standing system
- Internal monitors
- Safety dump valve
- Better delivery of pressure (prescribed)
- Better synchrony

Disadvantages
- Up front cost
Limitations of Nasal CPAP

- Difficult to maintain proper position of prongs/mask/cap
  - Less effective if dislodged
- Physically irritating
  - Pressure necrosis
  - Bleeding/swelling
  - Trauma to nasal septum
  - Nasal deformities
- Gastric distension ("CPAP-belly") from swallowing excessive air
NIPPV

- There are a number of overlapping NIPPV terms used in the literature such as Bi-level CPAP, N-BiPAP, Si-PAP

- This strategy may be beneficial in preterm infants with increased work of breathing and or inconsistent respiratory drive.

- NIPPV may be synchronized with the patient spontaneous inspiration (SNIPPV), by using a pneumatic and abdominal capsule, a flow sensor or by using a special ventilator responding to the patient’s diaphragm activity. This latter synchronization technique is called neutrally adjusted ventilator assist (NAVA) and is used for or invasive and non-invasive ventilation.
it remains unknown if NIPPV is better than NCPAP or if SNIPPV is better than non-synchronized forms of NIPPV

Cochrane meta-analysis comparing the use of various NIPPV modes versus NCPAP

- NIPPV reduced the incidence of extubation failure
- no effect on chronic lung disease or mortality
Invasive mechanical ventilation
Conventional Ventilation

Assist Control vs SIMV

**Volume**
- **Constant Volume**
- **Variable PIP**

Advantage:
- Deliver target volume
- Volume limit
- Auto adjustment of PIP

**Pressure**
- **Constant Pressure**
- **Variable Tidal Volume**

Advantage:
- Limit delivered pressure
Advances in Ventilation

- Flow transducer
- Synchronized ventilation
- Volume ventilation
New Generation Ventilators

Draeger VN500

Maquet Servo-i
Assist Control

- Pressure or Volume mode

- Full Support of volume or pressure per breath
  - Synchronized
  - Optimal lung recruitment

- Weaning a challenge during spontaneous breathing

<table>
<thead>
<tr>
<th>Draeger</th>
<th>Servo</th>
</tr>
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<tbody>
<tr>
<td>PC/AC/VG</td>
<td>PRVC</td>
</tr>
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<td>PC/AC</td>
<td>PC</td>
</tr>
</tbody>
</table>
SIMV with Pressure Support

- Pressure or Volume mode

- Synchronized
  - No breath stacking
  - Improved comfort
  - Less sedation need

- Pressure Support allows tolerance of SIMV modes by VLBW
Assist Control **Pressure** Mode

Set Pressure = 20
Ventilation of Preterm Infants

Volume or Pressure?
Volume Targeted Ventilation

Meta Analysis of 12 randomized controlled trials:

- Reduction in combined outcome of death or BPD
- Decreased incidence of:
  - Pneumothorax
  - Hypocarbia
  - Duration of ventilation
  - Neurologic injury (PVL, Grade 3–4 IVH)

Resp Care Med 2011, Donn Vol 20 Issue 3
Cochrane Collaborative
Volume Guarantee Ventilation

- Volume guarantee (VG) is a mode of ventilation that automatically adjust PIP to achieve a set tidal volume (ml/kg)

- Inspiration ends when the tidal volume has been delivered

- In the tiny baby, may have to increase tidal volume to overcome dead space of the wye transducer

- Standard of care for ventilating preterm infants

Why Volume Guarantee Ventilation?

- Minimize inadvertent hyperinflation
- Limit damaging tidal volumes as a result of rapid improvement in lung compliance

Primary Limitation of VG

Significant leaks around the endotracheal tube

Keszler. J Perinatol. 2009 Apr;29(4):262-75
Evidence supports **CPAP** as an alternative to routine intubation and surfactant administration in preterm infants

- **Prophylaxis Surfactant**
  - If intubated at delivery and gestational age is less than 27 wks

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Early CPAP versus Surfactant in Extremely Preterm Infants
SUPPORT Study Group of the Eunice Kennedy Shriver NICHD Neonatal Research Network* 2010
Prevention of CLD in the Delivery Room

- Room air –vs– oxygen
  - Pulse oximetry
- Nasal CPAP
- Controlled PPV
  - End tidal CO2
- Prophylactic/therapeutic surfactant
- Early extubation
Recent multicenter randomized controlled trials indicate that early use of CPAP with selective surfactant administration in extremely preterm infants results in lower rates of BPD/death when compared with treatment with prophylactic or early surfactant therapy.

Continuous positive airway pressure started at or soon after birth with subsequent selective surfactant administration may be considered as an alternative to routine intubation with prophylactic or early surfactant administration in preterm infants.

Pediatrics 2014;133:171–174
Delivery Room
(CPAP versus Surfactant)

- CPAP group:
  - Lower rate intubation
  - Reduced post natal steroid use
  - Shorter duration of mechanical ventilation

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