Non-Invasive Respiratory Support…NCPAP
Are we there yet?

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Neonatal Respiratory Care Practitioner

Every Little Thing
Case Scenario 1

Level 2 NICU

• Preterm 30wk GA is born
• Requires minimal resuscitation
• Apgars 7¹, 8⁵
• Develops mild/moderate indrawing
• Requires FiO₂ = 0.30 using blow by from a flow inflating bag and mask device to maintain oxygen saturations ~ 92%
• Placed on low flow cannula @100cc/min on arrival to the special care nursery
Assessment
Why might the neonate present in this way
Interventions and therapy decisions…
So many options available along the way

- **NCPAP**
- **HHFNC**
- **NIPPV**
- **NIHFOV**

Commonly used Level 2 treatment strategies

Additional Level 3 strategies
The immediate respiratory therapy for this newborn should be:

a) “eyes on, hands off” (clinical observation only)
b) prophylactic intubation and surfactant administration

c) application of nasal Continuous Positive Airway Pressure (nCPAP)

d) application of Non-Invasive Positive Pressure Ventilation (NIPPV)
e) application of Biphasic nCPAP
Case Scenario – Baby Boy Charles

37 week 2.8 kg male born by urgent C-section
Serologies protective; GBS negative
APGAR 7 (1 min) & 9 (5 min)

Initially was well and placed skin to skin with mom.
20 minutes later, the nurse noted the baby to have blue tinged lips and increased WOB
The baby was placed on low flow nasal cannula 0.5L of O2 and transfer to the NICU
NICU assessment

• Vitals → Temp 36.8°, HR 155, RR 70+, BP 65/42,
• SpO2 95% on nasal cannula
• ↑ WOB noted, subcostal retractions, nasal flaring, grunting
• No murmur. Cap refill < 3 secs.
• No pre/post saturation difference.

Now what?
Why did Charles’s respiratory status change?

What therapy should be considered?

a. Skin-to-skin holding with mom to calm the baby down
b. Intubation for surfactant
c. Start NCPAP 5-8 cmH2O
d. Start Heated High Flow Nasal Cannula

Why?
Non-Invasive Respiratory Support

Benefits of nCPAP:

- Establishing and maintaining lung volume
- Stabilizing/stenting the upper airway and chest wall
- When applied early and effectively it can reduce the need for intubation and surfactant administration in preterm infants

Why might you avoid intubation?
Ventilator Induced Lung Injury (V.I.L.I) Mechanisms

- **Volutrauma**
  - Excessive tidal volumes
  - Epithelial injury/shear stress
  - Protein leak & surfactant inhibition
  - Increased microvascular permeability/pulmonary edema
  - Air leak syndrome

- **Atelectrauma**
  - "PEEP-a-phobia"
  - Low lung volume injury is just as harmful as excessive lung volume

- **Oxytrauma**
  - Exposure to high FiO2 is toxic!

- **Hypocarbia**
  - Is very harmful to the neonatal brain and steps should be taken to avoid CO2 swings. Increased IVH risk

- **Excessive Exhalation**
  - Has been linked to auditory impairment and neurodevelopmental delay
  - Increased incidence of PVL

- **Endotrauma**
  - Injury induced by placement of ETT, tracheomalacia, etc.
How about invasive mechanical ventilation?

“Perhaps the only consensus about mechanical ventilation of infants is that, all else being equal, avoidance of mechanical ventilation is the best way to avoid lung injury.”

### Early nCPAP versus Intubation

**Schmölzer et al.** *Non-invasive versus invasive respiratory support in preterm infants at birth: systematic review and meta-analysis.*

*BMJ* 2013;347:f5980 doi: 10.1136/bmj.f5980 (Published 17 October 2013)

#### No of events/total

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Nasal CPAP</th>
<th>Intubation</th>
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<tbody>
<tr>
<td>Death or BPD</td>
<td></td>
<td></td>
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<tr>
<td>Dunn 2011</td>
<td>68/223</td>
<td>138/425</td>
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<tr>
<td>Morley 2008</td>
<td>108/307</td>
<td>118/303</td>
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<tr>
<td>Sandri 10</td>
<td>33/103</td>
<td>32/105</td>
</tr>
<tr>
<td>SUPPORT 8</td>
<td>323/663</td>
<td>353/653</td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>532/1296</td>
<td>641/1486</td>
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</table>

Test for heterogeneity: $\chi^2=0.00$, $\chi^2=0.60$, df=3, $P=0.90$, $I^2=0\%$

Test for overall effect: $z=2.10$, $P=0.04$
## Is early intubation and surfactant prophylaxis required for all preterm infants?

<table>
<thead>
<tr>
<th></th>
<th>CPAP (n=663)</th>
<th>Surfactant (n=653)</th>
<th>P</th>
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<tbody>
<tr>
<td>BW, g</td>
<td>835 ±188</td>
<td>826 ± 198</td>
<td>NS</td>
</tr>
<tr>
<td>GA, wks</td>
<td>26.2 ± 1</td>
<td>26.2 ± 1</td>
<td>NS</td>
</tr>
<tr>
<td>GA 24 or 25/26-27 wks</td>
<td>43%/57%</td>
<td>43%/57%</td>
<td>NS</td>
</tr>
<tr>
<td>Antenatal Steroids, Any</td>
<td>97%</td>
<td>96%</td>
<td>NS</td>
</tr>
<tr>
<td>Antenatal Steroids, Complete</td>
<td>74%</td>
<td>70%</td>
<td>NS</td>
</tr>
<tr>
<td>Male</td>
<td>52%</td>
<td>57%</td>
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<tr>
<td>Intubated in the delivery room or NICU for Surf Rx</td>
<td>67%</td>
<td>99%</td>
<td>&lt;0.001</td>
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<td>BPD or death by 36 weeks</td>
<td>48%</td>
<td>51%</td>
<td>0.3</td>
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NCPAP vs Surfactant: SUPPORT TRIAL: 24+0-27+6 weeks GA (n=1316)
SUPPORT: Surfactant, Positive Pressure and Pulse Oximetry Randomized Trial Finer et al NEJM. 2010; 362; 1970-9
nCPAP: The Evidence/Consensus Simplified

• the use of optimal nCPAP is appropriate as an initial supportive strategy (versus NIPPV or prophylactic intubation)

• nCPAP is indicated immediately after birth with subsequent selective surfactant administration if criteria are met

• considered an alternative to routine intubation
Studies have demonstrated feasibility to initiate NCPAP in the delivery room.

When on NCPAP: ↓ corticosteroids & ↓ days on mechanical ventilation.

↓ days of mechanical ventilation, quicker to RA, and discharge without O2.

American Association of Pediatric and Canadian Pediatric Society recommendation of using CPAP for the management of RDS as an alternative to routine intubation and surfactant therapy.
Conditions thought to be responsive to NCPAP:

- Tachypnea with ↑ WOB
- Increased oxygen requirements
- Poorly aerated lung fields
- Low threshold to initiate for infants <1000 grams or 30 weeks gestation
Conditions thought to be responsive to NCPAP:

- Diseases with low FRC e.g. RDS, TTN, pulmonary edema, & pneumonia
- Apnea and bradycardia of prematurity
- Previous failure to extubate
- Paralysis of hemi diaphragm
- Tracheomalacia or other similar airway abnormality that may require stinting
- Neuromuscular weakness with adequate respiratory efforts
Contraindications

Remember…
If the Infant is not breathing spontaneously you can not use NCPAP!

Also avoid CPAP with:
Ventilatory failure → inability to maintain adequate blood gases
Severe cardiovascular instability and impending arrest
Upper airway abnormalities that make NCPAP ineffective or potentially dangerous
e.g. choanal atresia, cleft palate, tracheoesophageal fistula
Untreated diaphragmatic hernia
Gregory Headbox
Commonly used CPAP devices

Can you use it?
Can you deliver the desired nCPAP level?
Nasal **Continuous Positive Airway Pressure** (NCPAP)

1. NCPAP is one level of continuous positive pressure maintained throughout inspiration and expiration
2. The patient must be breathing spontaneously for NCPAP to be effective
During inspiration, a patient in distress can easily access the flow that is used to generate CPAP leading to decreased work of breathing (WOB)
Mechanism of action

During the **expiratory phase**, the patient will breathe against a positive pressure level that works as a pneumatic splint to hold the airways open, like the effects of **Positive End Expiratory Pressure (PEEP)**

Having the airways stinted open during exhalation will make inspiration on the next breath less difficult
Risk associated with NCPAP – nasal breakdown

Prevent nasal breakdown

- routine checks and massage (q4-6 hrs)
- Do not apply too tight
- Proper size mask and prongs
- Alternating PRONG to MASK q4-6hrs
- Alternative therapy: Ram Cannula (if available) or HFNC (with similar oxygen needs)
- Use approved barrier strategies
- comfort measures
NASAL PROTECTIVE STRATEGIES

NEOBOND

NEOSEAL (aka nasal bumper pads)

Short prongs one should do
Long prongs 2-3 stacked
Risk associated with NCPAP – Air leaks

CAUSES OF PNEUMOTHORAX

Spontaneous: some air leaks are unavoidable

Patient “fighting” the NCPAP…no matter the pressure level

Gas trapping from inadequate pressure (ball valve effect): airways not being stinted open

Delayed weaning of pressure level once lungs have been expanded
Preventing Air Leaks

Appropriate level and early use of NCPAP based on FiO2 and WOB

PLUS:

Use of *comfort measures* such as prone positioning, use of a pacifier, decreasing light and noise stimulation, and use of positioning aids may help to settle a very active distressed infant.

Consider sucrose

Minimize handling and cluster care

Involving parents in care (kangaroo care, holding pacifier, comfort touch.)
Key Points for Effective use of NCPAP

Start NCPAP early and at an appropriate level according to patient history, WOB and FiO2 level

- Recommendation of 5-8cmH2O
- Start at 8cmH2O for higher FiO2 needs and wean down once stable

Suctioned both nares and oral pharyngeal thorough prior to and as needed during NCPAP to prevent obstruction from secretions

Appropriate interface, seal and fit are very important

- Prongs may create a better seal, but they can become obstructed at the back of the nose if the prongs are too long for the nares
- A larger leak can occur when the mask is used requiring due diligence
- Nasal gastric tube may cause nasal mask to leak
- Ensure correct size hat and interface

Use comfort measures to prevent nasal excoriation, leaks, and pneumothorax
Therapy Assessment: If baby is NOT improving, consider…

re-assess the need for current respiratory intervention
re-assess the efficacy of the current respiratory intervention

- troubleshooting the nCPAP delivery
- assessment of nasopharyngeal patency
- positioning of the interface
- patient comfort – need comfort measures
- continuous delivery (versus “cycling”)
Patient Assessment: Is your patient improving?

- Decreasing FiO₂ requirements
- Diminished work of breathing (versus respiratory rate)
- Improving blood gas
- Normalizing transcutaneous CO₂ values (45-60 mmHg)
Continued Monitoring and Assessment

- Remove Obstruction
- Skin checks
- Prongs/mask Positioning
- NG to OG?
- Minimize handling
- Provide comfort care
- Consider PRONE position
**Biphasic vs. NIPPV**

**BiPhasic** on the SiPAP device

- *is not* NIPPV
- It is cycling the infant to 2 levels of nCPAP (hi and lo)
- Often only 2-3 cmH₂O difference i.e. 8 on 6
- Use it wisely, longer TI 1-3 seconds and rates 10-20
- Pay attention to your MAP (maybe matching this to nCPAP level will suffice)

✓ may be useful as a stimulus as you intermittently push the patient to a higher level of CPAP blowing a higher flow up the nose

**NIPPV**

- Much higher delta pressures at least 10-15 above PEEP, rates of 30-40, Insp period 0.6-1.0 sec
- It is best utilized in a tertiary setting
- This is not a rescue therapy and may delay required treatment

✓ Evidence supports its application as a means of avoiding extubation failure after prolonged intubation or previous extubation failures
Case Scenario 2

• Level II NICU
• 36 wk GA, 3.2kg, NRFHR – C/S, no labor
• grunting post delivery
Respiratory Assessment

- grunting and nasal flaring
- increasing FiO₂ requirement (>0.50)
- moderate intercostal retractions
- persistent tachypnea

This is not a “HAPPY GRUNTER”
What is the indicated respiratory therapy for this newborn?

a) suction the nasopharynx
b) intubate (with RSI) and ventilate

c) apply nCPAP then consider obtaining an arterial blood gas

d) position the infant prone
e) provide low flow oxygen
f) BiPhasic with SiPAP device
nCPAP: The Strategy

Optimization of nCPAP:
- assessment of nasopharyngeal patency (NP suctioning)
- positioning of the interface
- patient comfort – consider sucrose during application

Assessment of nCPAP Delivery:
- is it being delivered effectively?
- given the patient’s history: start at 8 cmH₂O
- consider other options if the patient is fighting therapy excessively
- beware of sudden deterioration (pneumothorax)
Question

Which of the following are reasons to trial off nCPAP?

a) improved lung compliance as retained fluid moves out of the lung
b) decreasing oxygen needs and improved C0₂ levels
c) diminished severity of retractions
d) increased patient irritability associated with the nCPAP interface
e) all the above
Despite the infant improving, the decision was to continue nCPAP for 6 more hours. The RN notes the infant is not handling as well as before and is requiring significant increases in FiO$_2$. She suctions the nasopharynx (NP) and it is clear…

The infant deteriorates suddenly with a significant desaturation and bradycardia without apnea. The next step should be:

a) evaluate the system and increase the nCPAP level
b) assess for a possible air leak and be prepared to treat ASAP
c) suction the infant to rule out airway obstruction
d) provide the infant with PPV and stimulation
e) place the infant in an oxyhood or cannula to maintain SpO$_2$
f) remove nCPAP immediately so it does not make the pneumothorax worse
High Flow Nasal Cannula

Definition of Nasal High Flow

DEFINITION: Delivery of heated and humidified blended oxygen at optimal flow rates directly into the nares via a non-sealing nasal cannula.

FiO2 is set!
Mechanism of Action

Humidification

Accurate FiO2 delivery

Deadspace washout

Dynamic Pressure

Flow + Pressure/Resistance

- set
- varies
- size of cannula and upper airway
**Patient Interface**

Designed for high flow oxygen delivery

The larger diameter cannula and prongs can withstand higher flows than the standard oxygen therapy nasal cannula

**Prongs should occupy 1/2-2/3 diameter of nares**

various prong sizes with maximum flow rates

Images retrieved from Fisher Paykel website
SickKids NICU RRT High flow initiation guideline:

- Start at 2 lpm/kg ((Minimum of 3lpm total flow) and titrate up to effect up to 4 lpm/kg
- Consult with medical team if higher flows are required and may consider an alternate therapy
- Weaning down to 1lpm/kg
Advantages

Compared to nCPAP

• Less invasive and traumatic to the nasal septum
  • Improved patient comfort

Compared to low flow

• Improved humidification of inspired gases
  • Consistent $\text{FiO}_2$
• Increase secretion clearance due to the increased relative humidity
  • Can help with decreasing WOB

For bronchiolitis it is reported to

• Associated with decrease in respiratory rate
  • Appears to reduce work of breathing
  • Improved comfort
Indications

• Primary mode of support for infants with bronchiolitis (high humidity)
• Infants with mild respiratory distress where the CXR does not show poor lung inflation/FRC (Functional Residual Capacity)
• Alternate therapy for ex-preterm infants ≥30 weeks GA not tolerating or unable to wean off NCPAP
• Post-extubation therapy for preterm infants ≥28 weeks GA (not a current practice at SickKids)
Contraindications

- Ventilatory failure
- Marked retractions and evidence of low lung volumes
- Upper airway abnormalities
- Severe cardiovascular instability
- Frequent apneas despite caffeine therapy in preterm infants
- Tension Pneumothorax
Set Up

Set up by Registered Respiratory Therapist (RRT)

- Prongs selected must be no more than 2/3 the diameter of the nares
- Apply protective dressings on the infant’s cheeks
- Flows should be **started at 2 Lpm/kg** and at **minimum 3Lpm (TOTAL)**
- **Max flow at 4 Lpm/kg** and/or the prong specifications
- Adjustments to FiO$_2$ should be made to keep the SpO$_2$ within the prescribed oxygen saturation range
- A respiratory assessment is required prior to increasing flows.

HHFNC INDICATED

- **Start 2LPM/kg**
- **Titrate up/down**
- Min. **3LPM total**
Weaning

• FiO₂ may be weaned by RN or RRT

• RT should assess readiness to wean flow every 4 hours and attempt to wean at least once per day unless medical team decision to hold the wean

• Flow should be weaned once FiO₂ < .30

• Consider transition to low flow if patient has minor O₂ requirement, or consider transition off support if patient is in room air and there is no work of breathing

• Discontinue high flow therapy once patient reaches 3 Lpm total and can tolerate low flow or room air

Weaning is Winning!
Types of patients it may serve...

- FiO\textsubscript{2} requirements
- High humidity requirements (bronchiolitis)
- Not tolerating NCPAP or NIV due to agitation
- Nasal or facial pressure injury
- Mild-moderate respiratory distress
- Patients with CXR that does not show low lung volumes
Flow Strategies in Neonates

1. **Fixed Flow**
   - All infants in the NHF arm of the study received initial flows of 8 L/min.*
   - *Once weaning of therapy commenced, flows could be reduced to a minimum of 4 L/min.

2. **Weight Based**
   - Infants receiving flows ≥2 L/kg/min demonstrated rapid unloading of respiratory muscles.*
   - *As of February 2016 there are currently no RCTs that have evaluated a L/kg/min approach in the neonatal population.

3. **At the Clinician’s Discretion**
   - Infants in the NHF arm received either 5 or 6 L/min then flows were titrated at the clinician’s discretion.*
   - *Flows could be titrated to a minimum of 2 L/min and a maximum of 6, 7 or 8 L/min based on max flow of the cannula used.

4. **Combine 2 and 3**
   - The study recommended that infants in the NHF arm receive starting flows based on weight:
     - 1kg – 1.9kg = 3 L/min
     - 2kg - 2.9kg = 4 L/min
     - ≥3kg = 5 L/min
   - Flows were then titrated based on observation and defined clinical criteria.
   - *Flows could be increased to a max of 3 L/min above the starting flow rate.
Heated, Humidified High-Flow Nasal Cannula Versus Nasal CPAP for Respiratory Support in Neonates
Bradley A. Yoder, Ronald A. Stoddard, Ma Li, Jerald King, Daniel R. Dirnberger and Soraya Abbasi
Pediatrics 2013;131:e1482; originally published online April 22, 2013;
DOI: 10.1542/peds.2012-2742

<table>
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<tr>
<th>Patient Group</th>
<th>432 infants 28 to 42 weeks GA</th>
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<tr>
<td>Intervention</td>
<td>HHHFNC vs. NCPAP (post-extubation or primary therapy)</td>
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<tr>
<td>Outcome</td>
<td>No difference in intubation rates, BPD or time to hospital discharge</td>
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**Failure:** if they needed intubation before 72 hrs.
They used 3-8 Lpm High Flow OR CPAP of 5-8 cmH\textsubscript{2}O

**Result:** No significant difference in failure rate, BPD, or LOS. **Secondary outcome:** significant difference in length of treatment (Babies on CPAP had shorter treatment than those on HHHFNC)
HHFNC - Key Messages

• Primary mode of support for infants with bronchiolitis
• Alternative therapy for ex-preterm infants not tolerating or unable to wean off nCPAP
• Use patient weight and clinical status to guide flow administration
• Flows are limited by prong size capacity

**Initial flow:**
- 2 Lpm/kg
- Minimum 3Lpm total flow

**Maximum flow:**
- 4 Lpm/kg. Consult MD/NP if patient needs >4Lpm/kg
- Maximum flow as indicated by cannula specifications

• NOT a primary mode of treatment for RDS
THANK YOU

QUESTIONS?

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