High-flow nasal $O_2$ therapy used as an alternative to CPAP and NIMV to improve comfort and relieve distress

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A premature infant on relatively high levels of CPAP following extubation in the NICU tolerated a heated high-flow nasal cannula (HFNC) better, resulting in reduced anxiety, lower respiratory distress, and improved gas exchange.

At birth, Baby Boy (BB) was a 25-week, 560-gram premature infant born at a community hospital following a complicated C-section delivery for intrauterine distress. He was transferred to a Level IV NICU for further care on day of life 20. Upon arrival, BB was intubated and placed on the Dräger Babylog VN500 ventilator in Assist Control with Volume Guarantee mode.

Over the next several days, BB was weaned from mechanical ventilation and extubated to non-invasive ventilation using PC-CMV with the Dräger VN500. Within 24 hours, BB was reintubated for severe respiratory distress. Subsequent attempts to wean and extubate him from invasive ventilation over the next several weeks were unsuccessful due to increased WOB, severe agitation, hypercarbia, and increasing FiO2 requirements.

On day of life 40, BB remained on the ventilator with severe BPD, mild pulmonary hypertension, small grade III/IV IVH, and mild tracheomalacia. He also had a surgical closure of a patent ductus arteriosus. Following a course of Dexamethasone, the PIP was 10-12 cmH2O on the PC-SIMV with VG mode with Vt 7 ml/kg and PEEP 6, FiO2 0.35.

There was a small audible endotracheal tube leak, minimal work of breathing, and a chest X-ray showed good bilateral inflation. The following day, BB was extubated to non-invasive PC-CMV 20/5, Ti: 0.4s, FiO2: 0.40. Initially, there was mild upper airway obstruction, stridor, grunting, nasal flaring, intercostal and substernal retractions, and occasional apneic episodes responding to intermittent tactile stimulation. There was some improvement in relieving the obstruction following administration of an 11.25 mg/0.5 mL racemic epinephrine nebulizer and by increasing PEEP to 6 cmH2O on non-invasive PC-CMV.

Adjustments to PIP and breath rate were made to make BB comfortable over the next day. Initial Capillary Blood Gas (CBG) on non-invasive PC-CMV 24/6, FiO2: 0.50 was: pH: 7.33, PCO2: 56, HCO3-: 32 and PO2: 50. A transcutaneous monitor was placed for continuous trending and non-invasive monitoring of gas exchange. The transcutaneous CO2 (TcCO2) correlated well with the PCO2.
BB was weaned from non-invasive ventilation the next day and was placed on bubble nasal CPAP (BCPAP). An OG tube was placed and a weighted naso-duodenal tube remained in place. The CBG results on CPAP +8 cmH\textsubscript{2}O and Fi\textsubscript{O\textsubscript{2}} 0.30-0.35 was: pH: 7.36, PCO\textsubscript{2}: 60, HCO\textsubscript{3}-:32 and PO\textsubscript{2}: 40. Shown (Figure 1) is BB chest x-ray.

BB remained stable over the next day with minimal work of breathing and stable gas exchange. The next day, BB was placed on binasal short prongs secured with a head bonnet, alternating with a nasal mask every 4-6 hours following nasal inspection and suctioning. Upon being placed on the prongs with bonnet, BB became agitated and diaphoretic. PRN boluses of Morphine Sulfate and Ativan were administered to help reduce pain and anxiety.

The next morning, BB developed more pronounced respiratory distress with an increased respiratory rate (65-80 breaths/min), abdominal distension, diaphoresis, agitation, and crying. Based on increasing Fi\textsubscript{O\textsubscript{2}} requirements and TcCO\textsubscript{2}, a CBG and chest X-ray were ordered.

Following transition to CPAP and bi-nasal short prongs with a bonnet fixation, CPAP 8 cmH\textsubscript{2}O, and Fi\textsubscript{O\textsubscript{2}}: 0.50, the CBG results showed pH: 7.26, PCO\textsubscript{2}: 80, HCO\textsubscript{3}-: 36 and PO\textsubscript{2}: 34 and chest X-ray shown in Figure 2.
Based on the progressive changes in respiratory distress and presence of increased gastric insufflation of gases, the OG tube was readjusted. There was no improvement in underlying work of breathing or gas exchange. BB appeared increasingly more agitated and diaphoretic.

Following rounds, the medical team discussed reintubating BB and options to have a tracheostomy tube placed for chronic ventilation for BPD. A respiratory therapist suggested a brief trial of heated high-flow oxygen therapy.

BB was removed from bubble CPAP and placed on HFNC with the Dräger Babylog VN500 ventilator at 8 L/min and FIO₂ 0.55. Within 5 minutes of removing the bonnet and CPAP prongs and placing BB on HFNC, he appeared less diaphoretic and the respiratory rate decreased from 75 to low 50 breaths/min. There was nearly a 25 torr reduction in the TcCO₂ levels following transition to HFNC. Also, there was reduced work of breathing and BB appeared more comfortable and was able to fall asleep. The FIO₂ was able to be weaned over the next hour to 0.30 and the HFNC flow setting was able to be reduced to 6 L/min. There was less evidence of gastric insufflation and the OG tube was removed later that evening.

The next morning, a CBG and chest X-ray (Figure 3) were obtained. Overall, the medical team agreed that BB tolerated transitioning to HFNC very well. pH: 7.26, PCO₂: 80, HCO₃⁻: 36 and PO₂: 34

Over the next week, BB was slowly weaned from HFNC and discharged to the medical ward on room air.
**Conclusion**

This represents a case where an infant on relatively high levels of CPAP tolerated HFNC better, with reduced anxiety and respiratory distress and improved gas exchange. Many clinicians remain skeptical about using HFNC and maintain that this strategy provides less support than CPAP due to nasal leaks and variable pressure delivery. As such, this therapy is typically reserved for weaning patients from CPAP. However, some centers have found that HFNC may be better tolerated and as effective as CPAP prior to intubation and following extubation in the NICU.

A growing body of evidence supports that HFNC can be used safely and effectively as an alternative to non-invasive therapies in NICU for term and pre-term infants following extubation.¹ Unlike CPAP, the HFNC prongs are intended to occlude only 50% of the nasal airway opening. By increasing flows, HFNC provides increased FiO₂ and pressure. Studies in vitro² and in vivo³,⁴ have shown that increasing flow will provide end-expiratory pressure in the lungs that is similar to pressure provided by CPAP in infants.

The primary feature that sets HFNC apart from CPAP is that HFNC eliminates re-breathing of exhaled carbon dioxide from the anatomic deadspace.²,⁵ This effect may be more pronounced in infants – who have proportionally higher deadspace than adults, due to the relatively larger upper airway volumes and small tidal volumes.⁶ By flushing deadspace from the nasopharynx, HFNC may reduce the inhaled carbon dioxide levels and improve effective alveolar minute ventilation, thus requiring infants to breathe at lower frequencies.²,⁶,⁷,⁸ Also, HFNC has been shown to reduce rates of nasal trauma and reduce newborn infant pain scores, stress and pneumothorax when compared to CPAP and NIV.¹ HFNC could be considered as an alternative to CPAP and NIMV to improve comfort and distress.
References


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