High-Flow Nasal Cannula in Neonates

Current practice in neonatology is directed toward the preference of noninvasive ventilation and limitation of oxygen exposure. Early use of nasal CPAP either immediately or after surfactant administration (INSURE strategy: intubation, surfactant, extubation) has thus been strongly recommended through the last 2 decades.^{1,2}

High-flow nasal cannula (HFNC) was introduced through the last decade in adult, pediatric, and perinatal care as an alternative to other noninvasive ventilatory interfaces. Its goal is to optimize spontaneous breathing through the reduction of dead space and the creation of positive distending airway pressure.

In studies on adult subjects, including clinical trials, there was a clear increase in oxygen delivery achieved by increasing HFNC flow. This was explained by the limitation of oxygen dilution by ambient air and the action of the nasopharynx and oropharynx as an anatomic reservoir that increases the volume of inhaled oxygen for subsequent inhalation. HFNC use in adults with respiratory failure is now considered safe and effective.^{3,4} Being easy to use and well-tolerated, it can also be used in pediatric emergency departments and during patient transport.⁵

Whereas in adults and children, the role of HFNC is mainly optimization of oxygen delivery, the impact of high flow in neonates and infants is, more importantly, the created PEEP, like CPAP.⁶ The major indications for HFNC in neonates are thus the same as for nasal CPAP: respiratory distress syndrome, postextubation, and apnea of prematurity.⁷

Several clinical trials were conducted and meta-analyses done to evaluate the efficacy and safety of HFNC in neonates and infants in comparison with nasal CPAP, and almost all reports showed that it was as efficacious as nasal CPAP with even fewer adverse effects, especially trauma to the nasal septum.⁸⁻¹¹ Nevertheless, some researchers found HFNC less effective than nasal CPAP without the advantage of reduced nasal trauma.^{12,13}

A major concern about HFNC in neonates, particularly preterm infants, is the difficult prediction of the created continuous distending pressure.⁷ This pressure was found to vary on an inter-patient and even an intra-patient basis.¹⁴ However, HFNC proved not to be associated with

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increased air leak syndrome, and in some reports, air leak was even reduced with HFNC compared with nasal CPAP.¹⁵ In addition, a bench study using appropriately fitted nasal cannulae in a simulated infant model reported that flows of 2–6 L/min did not generate clinically important positive airway pressure.¹⁶ An appropriate balance between efficacy and safety of HFNC was suggested to be achieved by using a starting flow of 4–6 L/min in newly born preterm infants, with the babies <1 kg starting at the lower end of that range.¹⁷

Although standard HFNC therapy was reported by some researchers to be less invasive than nasal CPAP, it caused dryness of nasal mucosa, especially when gas flow exceeded 2 L/min.¹⁸ Humidified HFNC was then introduced into practice. Humidification improves HFNC efficacy further, because it preserves nasal mucosa, enhances mucociliary function, improves patient tolerance and comfort, reduces respiratory effort, and reduces the need for re-intubation.^{19,20}

In neonates, it particularly reduces total ventilator days, occurrence of bronchopulmonary dysplasia, re-intubation, intraventricular hemorrhage, necrotizing enterocolitis, and retinopathy of prematurity.²¹ Thus, humidified HFNC is, again, as efficacious as other modes of noninvasive support in preterm newborns with respiratory distress with significantly less nasal trauma.^{15,22,23}

In a Cochrane review,²⁴ some trials found HFNC to be associated with reduced rate of pneumothorax, reduced duration of hospitalization, and similar rates of re-intubation for humidified and non-humidified HFNC. In a previous bench study, Chikata et al²⁵ tested the effect of different heated humidified HFNC flows, tidal volumes, and breathing frequencies, by simulated spontaneous breathing, on absolute humidity of inspired gas. They found that absolute humidity increases with increasing gas flow and decreases with increasing tidal volume only when spontaneous breathing inspiratory flow exceeds the HFNC flow.

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They reported that optimal humidification was achieved when gas temperature was set around 37°C, and the same was reported several years ago.²⁶ The high flow permits constant oxygen delivery even with high inspiratory flows from intense respiration efforts, so it reduces oxygen dilution.⁵

In this issue of *RESPIRATORY CARE*, Chikata et al²⁷ tested the effect of ambient temperature, flow, tidal volume, and set F_{IO_2} on absolute humidity and actual delivered F_{IO_2} in a spontaneously breathing neonate/infant simulator. They found that increased temperature, increased HFNC gas flow, and breathing frequency each, independently, cause increased absolute humidity. As for the actual F_{IO_2} , it was close to set values at flow of ≤ 3 L/min. With higher flows, increments of tidal volume led to oxygen dilution, and actual F_{IO_2} decreased. Theoretically, actual F_{IO_2} is expected to decrease if inspiratory flow of the patient exceeds the cannula gas flow; due to contamination with ambient air. However, this was not seen in the study because they tested only one inspiratory flow waveform. These findings warrant further clinical trials using the high flows that were previously suggested without worrying about humidification efficacy. They also prompt measurement of the actually delivered oxygen concentrations at different set F_{IO_2} values in relation to gas flow.

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