



Review Article

High Flow Nasal Cannula Oxygen Therapy in Children; a Review

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ABSTRACT

High flow nasal cannula (HFNC) oxygen therapy is a non-invasive respiratory support consisting in the administration of heated, humidified and blended air/oxygen delivered via nasal cannula. The inspired oxygen concentration can be varied from 21% to 100%, therefore giving a greater ability to titrate the concentration of oxygen delivered. Its potential benefits include; increase fraction of oxygen and carbon dioxide in the alveoli, a decrease in damage to upper airway mucosa, reduction of upper-airway resistance, reduction of the metabolic cost of gas conditions, and ventilation improvement by providing a continuous positive airway pressure. However, this technique has contraindications, including severe hypoxia, hemodynamic instability, pneumothorax, upper airway abnormalities and facial bone or skull base trauma. In addition, it should not be used in patients with hypercapnia. There has been an increase in the use of HFNC in pediatrics in recent years, despite the fact that there is little evidence of its effectiveness and safety in children. Its main indication is acute bronchiolitis. Nevertheless, other respiratory diseases including asthma, pneumonia and post-extubation respiratory support have been studied. The aim of this article is to review the available evidence on the use of HFNC in most frequent respiratory diseases in pediatric age, including bronchiolitis, asthma and pneumonia.

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INTRODUCTION

High flow nasal cannula (HFNC) oxygen therapy is a non-invasive respiratory support consisting in the administration of heated (34-38°C), humidified and blended air/oxygen delivered via nasal cannula at variable flow rates over 2 L/min. It provides both concentrations of oxygen and potentially continuous

distending pressure [1]. HFNC delivers this oxygen-air mixture above the patient's peak inspiratory flow [2]. The inspired oxygen concentration can be varied from 21% to 100% [3], therefore giving a greater ability to titrate the concentration of oxygen delivered [4].

There has been an increase in the use of HFNC in pediatrics in recent years, despite the fact that there is

little evidence of its effectiveness and safety in children [1,5].

The aim of this article is to review the available evidence on the use of HFNC in most frequent respiratory diseases in pediatric age.

Action Mechanism

Several mechanisms have been described by which HFNC may be better than conventional oxygen therapy (COT) for the treatment of various respiratory diseases:

- Increase fraction of oxygen and carbon dioxide in the alveoli through the washout of nasopharyngeal dead space [4,6].
- Decrease in damage to upper airway mucosa and by using heated and humidified air. Furthermore, this mechanism prevents inflammatory reactions and bronchoconstriction induced by cold dry air [7,8].
- Reduction of upper-airway resistance also contributes to reduce inspiratory resistance and work of breathing, by providing adequate flow [4,8,9].
- Reduction of the metabolic cost of gas conditions by providing air with 100% relative humidity [4].
- Ventilation improvement by providing a continuous positive airway pressure. This pressure may not be measured or regulated, and its level depends on the flow delivered and on the anatomical leak that is always present in these systems [10-13]. This positive airway pressure leads alveolar recruitment of collapsed areas and the elevation of functional residual capacity [14].

Indications and Contraindications

Acute bronchiolitis is the main indication for HFNC in children. However, other indications have been

studied, such as asthma, pneumonia and post-extubation respiratory support [14-16].

In addition, it is important to take into account the contraindications of HFNC, which include severe hypoxia, hemodynamic instability, pneumothorax, upper airway abnormalities and facial bone or skull base trauma. HFNC should not be used in patients with hypercapnia either, since it could nullify the respiratory stimulus generated by hypoxia. It could be applied carefully in patients with a decreased level of consciousness or chronic respiratory failure [15,16].

Bronchiolitis

One of the most common causes of hospitalization in infants younger than 1 year old is acute bronchiolitis. Until recent years, the supplementary oxygen required by these patients was provided with non-invasive ventilation (NIV), providing good results. However, this treatment is poorly tolerated by infants [17].

One of the most common use of HFNC in pediatric observed in the literature is related with bronchiolitis management. One of the first studies reported in Spain observed that heart rate, respiratory rate, and scale of severity significantly improved in patients affected by bronchiolitis in a pediatric ward. The beneficial effects of HFNC also generated a positive impact decreasing the length of stay as well as a decreased in Pediatric Intensive Care Unit (PICU). In addition, few adverse effects were observed [18]. These results are agreed with the study performed by Monteverde et al., where an improvement in respiratory rate was observed [19]. However, a recent study in a large population did not observe these results in a general pediatric ward [20].

Various studies in the literature has been also studied the potential beneficial effects of HFNC therapy compared to COT. Franklin et al. observed that infants affected by bronchiolitis and treated with

HFNC showed significantly lower rates of escalation of care due to treatment failure [21]. In addition, this treatment was also observed to be effective as a rescue therapy in infants who suffered treatment failure with COT. However, these results with the beneficial effects did not affect in a significant manner in the duration of hospitalization or supplementary oxygen requirements [21]. The reported results are agreed with previous studies [22].

The potential benefits of HFNC have been also observed in critical pediatric population. A randomized controlled study in the PICU conducted by Ergul et al. observed a decrease in supplementary oxygen requirements and treatment failure using HFNC, suggesting that this treatment should be the first choice for treating patients admitted to the PICU with severe bronchiolitis [23]. These results are agreed with recent studies which observed that HFNC results are similar to continuous positive airway pressure (CPAP), considering HFNC as a potential treatment due to its comfortable characteristics [24,25].

Asthma

There are few data supporting the use of HFNC in indications other than bronchiolitis. However, its ease of use and comfort for the patient has been extended its application to other respiratory diseases, including asthma [14].

The benefits of HFNC in asthmatic exacerbations (AE) in pediatric population are still unclear, with few studies conducted in this regard. According to the pilot clinical trial carried out by Ballesteros et al, HFNC appears to be superior to COT for reducing respiratory distress within the first 2 hours of treatment in children with moderate to severe asthma exacerbation refractory to first line treatment in emergency department [26]. However, another clinical trial conducted in the emergency department in which patients with asthmatic attacks were randomized into two treatment groups (HFNC and

COT) concluded that the incorporation of HFNC did not show clinical benefits nor did it diminish the stay time [27].

Baudin's group conducted a retrospective observational study in asthmatic children admitted to the PICU and treated with HFNC, observing that clinical parameters and blood gases improved significantly in the first 24 hours of treatment [28]. In another observational cohort study carried out by Pilar et al, showed that, compared to NIV, HFNC did not increase the length of stay in PICU, but 40% of patients initially treated with HFNC required an escalation to NIV, increasing the length of stay in this subgroup [29]. For that reason, authors conclude that, in some subjects with AE, HFNC may delay NIV and potentially cause longer respiratory support and longer PICU length of stay.

Although the benefits of HFNC compared to NIV are controversial, it is suggested that this treatment could be better than COT in severe asthma [28]. Gonzalez-Martínez's and his group carried out a retrospective study in which 536 children admitted to the pediatric ward for AE were included, comparing patients treated with HFNC and those treated with COT [30]. Heart rate, respiratory rate and pulmonary score significantly decreases 6 hours after starting HFNC. They also found that patients with a higher pulmonary score and a higher number of previous admissions required HFNC more frequently. So, they conclude that HFNC seems to be useful for AE in pediatric wards.

As previously mentioned, there is great controversy regarding the use of HFNC in asthma. More studies are needed to evaluate the efficacy and safety of the application of HFNC in the pediatric population with AE.

Pneumonia

Pneumonia is the leading cause of death in children between one month and six years old [31].

Nevertheless, despite being such a frequent pathology, the available evidence on the use of HFNC is very scarce, both in adults and in the pediatric population.

Only one study has been found on the use of HFNC in the treatment of pneumonia in pediatric population. Chisti's group carried out a randomized and controlled clinical trial in Bangladesh [32]. They randomized patients younger than 5 years with severe pneumonia and hypoxemia into three treatment groups: bubble CPAP, COT, or HFNC. The study could not be concluded and had to be stopped by the evidence, in preliminary data, of the superiority of CPAP over the other two treatment options.

Obviously, with the data presented in this study, the use of HFNC in severe cases of pneumonia with hypoxemia cannot be recommended. Though, more studies should be carried out in this regard. It is possible that including children with milder forms of pneumonia HFNC may play a role in treatment, as CPAP has been shown to be significantly more effective in severe forms.

CONCLUSIONS

HFNC use is increasing in pediatric wards, PICUs and emergency departments, despite the lack of clear evidence compared to other treatments. The simplicity of the system, comfort for the patient, and its excellent tolerance, make it a very attractive alternative, especially in patients with bronchiolitis. The most frequent indication and on which there are more studies available is acute bronchiolitis, however, its use is gradually spreading to other respiratory diseases, such as asthma. There are still few studies on its use in pathologies other than bronchiolitis, and the results of these are controversial, so it is a treatment that should be used with caution.

CONFLICT OF INTEREST STATEMENT

There are no competing financial interests.

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