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Original Research Article

Comparison of high flow oxygen therapy in children with respiratory distress due to bronchiolitis and pneumonia

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ABSTRACT

Background: Respiratory support through high flow nasal cannula (HFNC) therapy has emerged as a new method to provide respiratory support with bronchiolitis. Aim was to study outcome of HFNC therapy in children with bronchiolitis and pneumonia.
Methods: The study was a prospective observational study involving children admitted to pediatric intensive care unit with respiratory distress (RD) in the age group of 1 month to 6 years over a period of 3 months (February 2017 till April 2017). Severity was assessed by clinical respiratory score (CRS). Children with RD were initiated with high flow nasal cannula. During treatment various parameters including CRS were documented at baseline and at 15 min and then hourly in a carefully designed performa. The primary outcome was failure of HFNC and need for ventilation.
Results: Sixty children were included in the study of which 22 (37%) were in the bronchiolitis group and 38 (63%) were in the pneumonia group. 38 children presented with severe RD and 19 children with moderate RD. There was significant decrease in heart rate (HR) (20%), respiratory rate (RR) (20%) and in CRS within 1 hour of HFNC with a clinical stabilization within 24 hours in 16 cases (27%), 24-48 hours in 35 cases (58%) and >48 hours in 5 (8%) cases. Therapy was successful in 55 (92%), and failed in 5 (8%).
Conclusions: HFNC has better outcome in children with RD due to acute bronchiolitis when compared to pneumonia. HFNC can be safely commenced in RD in critically ill child with monitoring.

Keywords: Bronchiolitis, High flow nasal cannula oxygen therapy, Pneumonia, Respiratory distress

INTRODUCTION

Heated humidified high flow nasal cannula (HHHFNC) is now increasingly being used in the management of acute respiratory failure in older infants, children and adults with respiratory distress. Over the last decade high flow nasal cannula (HFNC) therapy has emerged as a new method to provide respiratory support for bronchiolitis.[1]

High-flow oxygen therapy through a nasal cannula is a technique whereby heated and humidified oxygen which prevents drying of nasal passages, mucosal injury and impaired secretion clearance in patients with acute respiratory failure of various origins. Also high-flow oxygen has been shown to result to decrease the work of breathing, provide better comfort and oxygenation than standard oxygen therapy delivered through a face mask and nasal cannulae which are limited by poor tolerance of flows.[2-4] Studies have suggested that initiation of HFNC therapy decreases the need for intubation in bronchiolitis.[4] Data regarding the use of HFNC in older infants and children are even more limited than in neonates. The aim of was to study the outcome of HFNC therapy in children

with bronchiolitis and pneumonia presenting as respiratory distress (RD).

METHODS

The study was conducted in Indira Gandhi Institute of Child Health (IGICH), Bangalore, a tertiary care centre with 35 bed pediatric intensive care unit with 20 ventilators and 5 HFNCs. It was a prospective study conducted over a period of three months from February 2017 through April 2017 involving patients admitted to the pediatric intensive care unit (PICU) with respiratory distress to determine whether high-flow oxygen therapy could improve outcomes.

All children between the age group of 1 month to 6 years admitted to pediatric intensive unit with respiratory distress were included in the study group. Children less than 1 month, patients with hemodynamic instability, use of vasopressors, Glasgow coma scale (GCS) score of 12 points or less, urgent need for endotracheal intubation at admission/a do-not-intubate order, upper airway obstruction, craniofacial malformations and decision not to participate were excluded from the study.

Informed consent was taken from the parents of children before enrolling the study. All children between the age group of 1 month to 6 years, who were admitted to PICU with respiratory distress, were evaluated. Severity of respiratory distress was assessed by using clinical respiratory score (CRS). Child with respiratory distress in the inclusion group was started on high flow nasal cannula. The children with bronchiolitis and pneumonia were diagnosed by standard criteria. No statistical software was used as it was an observational comparison study. Sample size was based on the 3 month study period. All children admitted to PICU was taken as sample and then allocated into the study as per inclusion criteria.

Once the inclusion criteria were satisfied, during treatment with HFNC oxygen therapy, we documented the following parameters (heart rate, respiratory rate, oxygen saturation, temperature, fraction of inhaled oxygen that was administered, flow rate and CRS), at the initiation of HFNC oxygen therapy that is baseline and at 15 min and then hourly. HFNC oxygen therapy was delivered using the Fisher and Paykel Airvo 2. Therapy was initiated at a rate of 1 l/kg/min that was increased progressively to a maximum of 2 l/kg/min until clinical improvement was achieved. In infants, flow rates (greater than 2 l/min) were usually adjusted to body weight i.e. 2 l/kg/min up to maximum of 25 l/min. In children flow rates were kept greater than 6 l/min and up to 20 to 30 l/min (closer to 1 l/kg/min).[5-6] We followed the protocol of 2 l/kg for first 10 kg body weight and additional 0.5 l/kg for each kg above 10 kg. Improvement in CRS score was assessed after 1 hour of therapy and then allocated as failure if no improvement following which therapy was escalated. If there is improvement in CRS, then HFNC therapy was continued and weaned off (Figure 1).

The initial FiO_2 was set at the pressure required to achieve a SpO_2 of more than 92% and was adjusted based on how the patient responded to a maximum FiO_2 of 40% (Figure 2).

The primary outcome of the study was failure in of the HFNC therapy; which was determined if two of following three criteria were satisfied: heart rate remains unchanged or increased, respiratory rate remains unchanged or increased, oxygen requirement arm exceeds $FiO_2 \geq 40\%$ to maintain $SpO_2 \geq 92\%$. The success of the HFNC therapy was when there was significant decrease in heart rate (20%), respiratory rate (20%) and improvement in the CRS within 1 hour of HFNC with a clinical stabilization of the child within 24 hours.

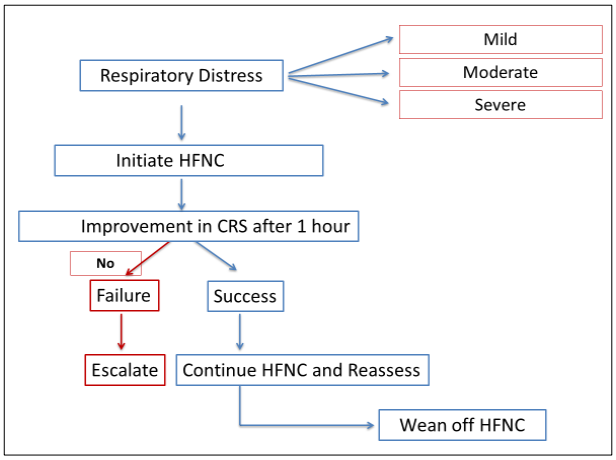

Figure 1: Initiation of HFNC and allocation as failure or success.

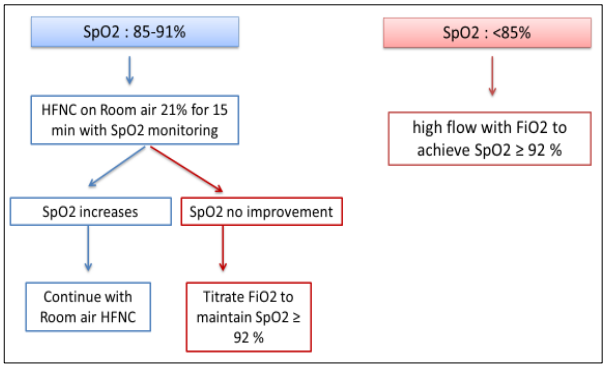

Figure 2: FiO_2 titration.

The secondary outcome of the study included duration of oxygen therapy, adverse effects, intubation rates and mortality.

If the patient became clinically stable with the indication for using HFNC had resolved and a CRS score of 3 or lower, the flow rate was gradually reduced to 1 l/kg/min and the FiO_2 to 21%, and HFNC oxygen therapy was discontinued. All data was collected in a systematically

designed proforma and analysed. The study was conducted after the approval institutional ethics committee.

RESULTS

A total of 520 children with acute were admitted to the PICU of which 102 patients with respiratory distress were eligible for the study, during the three month study period. A total of 60 children, out of which 26 were male and 34 were female were assigned to high-flow oxygen therapy and 42 were excluded from the study (Table 1). 28 patients were intubated at the time of admission, 4 were hemodynamically unstable, 6 had upper airway obstruction and 4 had decided not to participate.

Table 1: Total number of cases.

Sex	Cases (%)
Male	26 (43)
Female	34 (57)
Total	60

Our study enrolled a total of 60 cases of which 22 (37%) were in the bronchiolitis group and 38 (63%) were in the pneumonia group of which 26 cases had pneumonia and 12 cases had severe pneumonia (Table 2). Cases were further assessed as per CRS in to severe (38 cases), moderate (19 cases) and mild (3 cases) respiratory distress (Table 3).

Table 2: Table showing allocation of cases.

Diagnosis	Cases (%)
Bronchiolitis	22 (37)
Pneumonia	38 (63)

Table 3: Table showing distribution of number of cases as per grading with clinical respiratory scoring in bronchiolitis and pneumonia study groups and mean duration of HFNC.

CRS-respiratory distress	Bronchi-olitis	Pneum-onia	Mean duration of HFNC (hours)
Mild	3	0	58/3=19.33
Moderate	11	8	551/19=29
Severe	8	30	1290/33=39.09
Total	22	38	

Mean duration of HFNC therapy was 27.95 hours in bronchiolitis group and 39.54 hours in pneumonia group (Table 4).

Table 4: Table showing mean duration of HFNC.

HFNC	Mean duration (hours)
Bronchiolitis	615/22=27.95
Pneumonia	1226/39=39.54

There was significant decrease in heart rate (20%), respiratory rate (20%) and in the CRS within 1 hour of HFNC (Figure 3) with a clinical stabilization within 24 hours in 15 cases (27%), 24-48hrs in 35 cases (58%) and >48 hours in 10 cases (8%) (Figure 4). Majority (34) of the children required HFNC for a duration of 24-48 hours with mean duration of 27.95 hours in bronchiolitis group and 39.54 hours in the pneumonia group.

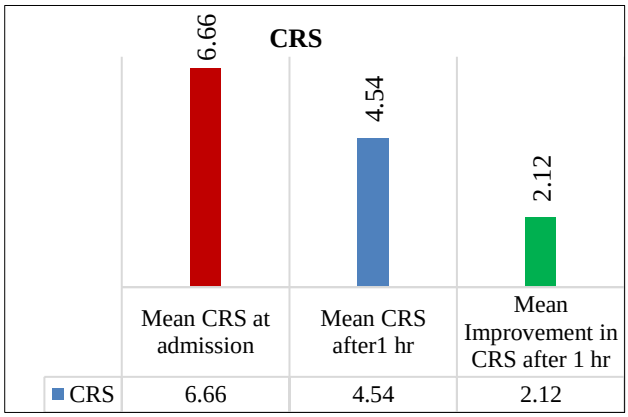

Figure 3: Mean CRS score at admission and after 1 hour of HFNC.

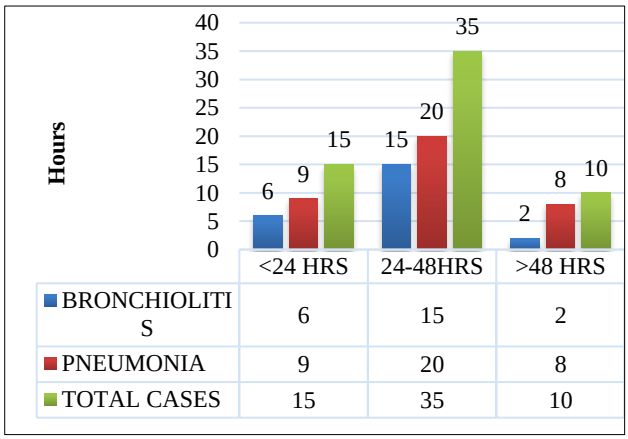

Figure 4: Duration of HFNC in bronchiolitis and pneumonia group.

The cases that didn't show any significant decrease within 1 hour of initiation were classified as failures. Therapy was successful in 55 (92%) and failed in 5 (8%).

All the 5 failures were in the severe respiratory distress in pneumonia group with comorbidities (congenital heart disease with pulmonary hypertension, severe combined immunodeficiency, acute respiratory distress syndrome, congenital tuberculosis) that eventually required invasive mechanical ventilation. None of the cases in the bronchiolitis group required mechanical ventilation.

We did not observe any adverse effects in children while on HFNC therapy. The primary outcome of the study showed that success rates were 100% in the bronchiolitis

group and the secondary outcomes were all the failures required sequential treatment with invasive mechanical ventilation. No mortality in the present study.

DISCUSSION

Sixty children were provided HFNC therapy when presented with respiratory distress due to pneumonia and bronchiolitis, where 92% patients successfully tolerated the therapy and overcame their respiratory distress with only HFNC therapy as respiratory support.

Wing et al in his retrospective study of all patients admitted from the PED to the PICU with ARI concluded that high-flow nasal cannula used early in the development of pediatric ARI is associated with a decreased the need for intubation and mechanical ventilation which was well compared to bronchiolitis cases in which did not require mechanical ventilation.[7] Need for invasive ventilation was 20% compared to 8% in our study.[8]

Mayfield et al reported that heart rate fell from 158 bpm to 144 bpm in the HFNC responders whereas it rose from 159 bpm to 162 bpm in HFNC non-responders (p=0.02). Likewise, RR was reduced to 38/min at 30 minutes and 35/min at 12 hours from 41/min at baseline. Mean dyspnea score was also reduced from 8 at baseline to 7 at 30 minutes and 4 at 12 hours.[9] In our study mean decrease in heart rate and respiratory rate was found to be around 20%.

Schibler et al studied 167 infants with bronchiolitis supported with HFNC and showed that 5% of infants required intubation. This study established that infants who had a 20% decrease in RR and HR did not require escalation of support while on HFNC. Therefore, if improvement is not seen after 90 min of HFNC, it is imperative to assess the need for escalation of respiratory support.[10] The HFNC therapy led to significant reduction in HR, RR and significant increase in SpO_2 with success rate in 80% study by Schibler et al when compared to success rate of 92% in our study.

Two clinical studies by Keenam et al and Schibler et al using HFNC therapy in a non-randomized design have shown a reduction in intubation rates in critically ill infants in the intensive care setting.[10,11] The main finding of our study was a significant decrease in the use of invasive mechanical ventilation after the introduction of HFNC oxygen therapy. Previous studies have demonstrated that HFNC oxygen therapy reduces the need for intubation from 23% to 9% in patients with bronchiolitis admitted to the PICU. Significant decrease in HR, RR and Wood-Downes score. Significant reduction in HR, RR and significant increase in SpO_2 with success rate in 80% versus 92% in our study. Need for invasive ventilation was 20% compared to 8% in our study.[8]

Limitations of our study were that the study was conducted in a single tertiary care center with small study population and proper randomization of age and sex was not done with bronchiolitis and pneumonia group.

Current evidence suggests that HFNC is a well-tolerated and feasible respiratory support across different age groups and indications in the pediatric ICU and emergency room. Available evidence suggests that it is not inferior to the alternate modes of non-invasive positive pressure ventilation and may have the advantage of more patient comfort and need for less pharmacological sedation. The initiation, escalation and weaning practices vary across different institutions and needs to be standardized.

CONCLUSION

We conclude that HFNC has better outcome in acute bronchiolitis when compared to pneumonia which has to be outweighed against comorbidities. HFNC can be safely commenced in respiratory distress in critically ill child when adequate equipment and monitoring tools exist.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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