Original Article

Efficacy of High-Flow Nasal Cannula Therapy Compared with Conventional Oxygen Therapy in Children with Bronchiolitis

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Abstract

Background: Bronchiolitis is an acute respiratory condition in the pediatric population, which sometimes requires hospital admission and supplemental oxygen therapy. Conventional oxygen therapy has been in use; however, High-flow nasal cannula (HFNC) is now increasingly being used because of potential clinical advantages. The current study aimed to compare the clinical effectiveness of HFNC with conventional oxygen therapy in children with acute respiratory distress. **Material and Methods:** This prospective observational study was done in the Department of Pediatrics of a Tertiary care teaching hospital. A total of n=200 children diagnosed with bronchiolitis were included in the study. They were allotted into two equal groups: conventional oxygen (n=100) and HFNC group (n=100). Baseline demographics were recorded. Clinical variables compared were respiratory rate, heart rate, oxygen saturation, and work of breathing at admission and defined intervals. Appropriate statistical analysis was performed. **Results:** Baseline characteristics of the cohort were found to be comparable, indicating adequate distribution for comparison. The analysis of values at 2 hours of therapy showed the HFNC group demonstrated a significantly greater reduction in respiratory rate (55.04 ± 5.26 vs 65.48 ± 7.12 breaths/min) with significant p-values. This lasted at 4-hour intervals and 6-hour intervals. Heart rate reduction was also significantly greater in HFNC groups at 2 hours and 6 hours (156.0 ± 4.85 vs 168.12 ± 4.67 bpm) and (129.76 ± 8.90 vs 152.56 ± 13.86 bpm). Oxygen saturation in the HFNC group improved more rapidly with HFNC at 2 hours (97.14 ± 1.36% vs 94.92 ± 3.72%). Logistic regression analysis results found that HFNC therapy significantly reduced the odds of treatment failure (OR 0.457; 95% CI 0.176–0.984; p<0.01). **Conclusion:** Our study found that HFNC therapy cases showed superior clinical outcomes as compared to conventional oxygen therapy in pediatric cases with acute respiratory distress. Therefore, it may be preferred as one of the effective methods of a non-invasive respiratory support strategy in the pediatric population.

Keywords: Acute respiratory distress, Bronchiolitis, Conventional oxygen therapy, High-nasal cannula (HFNC) therapy.

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Introduction

The most commonly occurring lower respiratory tract infection in the pediatric age group is bronchiolitis, especially in infants under the age of two years. It is the common cause of hospital admission among the pediatric age group across the globe.[1] Pathogenesis of bronchiolitis involves acute airway inflammation, swelling, and necrosis of the small airways, with increased mucus secretion, which results in blockage of the airflow or causes disruption of gas exchange.[2] The most frequent etiological agent is the respiratory syncytial virus (RSV), but other viruses such as rhinovirus, parainfluenza, adenovirus, and human metapneumovirus have shown to play a significant role.[3,4] The clinical presentation may vary from a mild upper respiratory symptom to severe respiratory arrest and the need for intensive care. Treatment for Bronchiolitis is mostly supportive because pharmacological therapies, including bronchodilators, corticosteroids, and antibiotics, have proven to be of little or no use in routine cases.[4] Oxygen therapy has been the mainstay of the treatment of children with hypoxemia, where the low-flow nasal cannula or face masks have been traditionally used.[5] Nevertheless, the traditional approaches might be insufficient in moderate to acute disease due to restrictive oxygen delivery and insignificant decrease in work of breathing and ventilation.[6] The use of High Flow Nasal Cannula (HFNC) therapy as a significant non-invasive respiratory support has gained prominence in the pediatric practice in the last decade. HFNC supplies both heated and humidified air-oxygen mixtures in the flow rates that are equivalent to or beyond the inspiratory demand of the patient, hence ensuring a reliable oxygen delivery.[7] In infants and young children, HFNC usually provides flow rates of 1-2 L/kg/min,

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which produces low positive airway pressure, which serves to maintain airway patency and improve functional residual capacity.[8] Other physiological advantages involve washout of dead space of the nasopharynx, decreased inspiratory resistance, increased mucociliary clearance, and patient comfort as a result of humidification.[9] Few clinical trials have shown that HFNC therapy is able to decrease respiratory distress, decrease respiratory rates, and enhance oxygen saturation among children with bronchiolitis.[10] The HFNC has been linked with a lower rate of escalation to more invasive respiratory support, including continuous positive airway pressure (CPAP) or mechanical ventilation, compared to conventional low-flow oxygen therapy.[11] These advantages are especially applicable in resource-constrained conditions, where pre-emptive HFNC can lead to a decrease in the number of children admitted to the pediatric intensive care unit.[12] Although there is an increasing use of HFNC, there is still variability in clinical practice regarding indications, optimal flow rates, when it should be started, and when it should be escalated or weaned.[13] There have also been concerns over the possible risks, such as air leak syndromes, delayed recognition of failed treatment, and high health care expenses.[14] Thus, evaluate evidence-based practice, the effectiveness and safety of HFNC in children with bronchiolitis was required. The current study aimed to determine the effectiveness of the High Flow Nasal Cannula treatment in children with bronchiolitis, based on its effects on changing clinical outcomes in terms of alleviation of respiratory distress, oxygen demand, escalation of respiratory support requirement, and length of stay.

Materials and Methods

This prospective observational study was done in the Department of Pediatrics, Kakatiya Medical College and MGM Hospital, Warangal, Telangana. Institutional Ethical approval was obtained for the study. The duration of the study was 18 months. Written informed consent was obtained from all the parents of the child involved in the study after explaining the nature of the study and possible outcomes in the vernacular language.

Inclusion criteria

1. Children with a clinical diagnosis of bronchiolitis
2. Children aged 1 month to 24 months
3. Existing respiratory distress requiring oxygen supplementation
4. Written informed consent from parents or guardians

Exclusion criteria

1. Congenital heart disease with hemodynamic impact
2. History of wheeze or diagnosed with bronchial asthma
3. Neuromuscular diseases affecting respiration
4. Upper airway anomalies
5. Children requiring immediate intubation on presentation
6. Chronic lung diseases

The study population consisted of infants and children admitted with bronchiolitis. The sample collection was done by a convenience sampling method, with successive pediatric patients diagnosed with bronchiolitis included in the study based on the inclusion and exclusion criteria. The study included n=200 subjects. They were separated into two groups, namely, HFNC (High-Flow Nasal Cannula) (n=100) and Conventional O_2 therapy (n=100).

Data Collection: A validated questionnaire was to be used to capture detailed demographic data, such as age, sex, weight, and gestational age at birth, during the time of admission. Bronchiolitis was clinically defined as the first instance of acute lower respiratory infection, which was an episode of cough, tachypnea, wheeze, and/or crackles, occurring in children aged between 1 month and 24 months. Baseline clinical assessment was conducted regarding respiratory rate, heart rate, oxygen saturation (SPO_2), chest retractions, nasal flaring, and feeding difficulty. A usual clinical severity score was used to grade the severity of bronchiolitis. The respiratory rate, pulse rate, oxygen saturation, and work of breathing data were measured on presentation and intervention (after 2, 4, and 6 hours).

High Flow Nasal Cannula (HFNC) was used as respiratory support for all enrolled children in the study group. The HFNC was provided through a heated and humidified system with nasal prongs, which were age-specific. The initial flow rates were adjusted to 1-2 L/kg/min, and the fraction of inspired oxygen (FiO_2) was adjusted to ensure that SpO_2 is not less than 92%. The progress of vital parameters was closely monitored during treatment.

Clinical reassessment was done after 2 hours, 4 hours, 6 hours, and 24 hours of the commencement of HFNC. The parameters that were measured were respiratory rate, heart rate, SpO_2, work of breathing, and FiO_2 demands. Failure of HFNC therapy was predetermined by the deterioration of respiratory distress, hypoxemia that persisted despite FiO_2>0.6, the increase of carbon dioxide level (where measured), repeated apnea or hemodynamic instability, and the need to increase to CPAP or invasive mechanical ventilation. Supportive treatment, such as intravenous fluids or nasogastric feeding, antipyretics, and minimum handling, was done according to unit protocol. No bronchodilators, corticosteroids, or antibiotics were used unless clinically required.

Outcome measures: The main outcome was clinical improvement after the HFNC therapy, which was measured by the decrease in respiratory distress and stabilization of the oxygen saturation. The secondary outcomes analysis included the need to increase respiratory support, duration of HFNC therapy, hospital stay, and adverse events like nasal trauma or air leak syndrome.

Statistical analysis: All the available data were uploaded to an MS Excel spreadsheet and analyzed by SPSS version 26 in Windows format. Continuous variables were represented as mean, standard deviation, frequency, and percentage. The categorical variables were calculated by the chi-square test for determining significance between two groups. The values of p (<0.05) were considered statistically significant.

Results

Demographic, baseline, and clinical characteristics of the cohort are depicted in [Table 1]. A critical analysis of the table showed that out of 200 cases, distributed equally among two groups of n=100 each. The age comparison of the two groups showed that overall, 36% cases were aged 6–12 months and 64% cases were

older than 12 months. No statistically significant difference between the two groups based on age. Similarly, the sex distribution of the two groups was exactly the same, showing perfect comparability. The baseline vital parameters, including heart rate, respiratory rate, and oxygen saturation, appeared similar between the two groups with no significant p-values. This showed that the two groups were well matched for comparison of results, and confounding factors that could affect the results do not exist in this cohort.

Table 1: Baseline Demographic and Clinical Characteristics

Characteristic Age, n (%)	Overall (N=200)	HFNC Group (n=100)	Conventional O_2 Group (n=100)	p-value
6-12 months	72 (36.0)	35 (35.0)	37 (37.0)	0.821
>12 months	128 (64.0)	65 (65.0)	63 (63.0)	0.884
Sex, n (%)				
Male	98 (49.0%)	49 (49.0)	49 (49.0)	1.000
Female	102 (51.0%)	51 (51.0)	51 (51.0)	1.000
Baseline Vital Signs, Mean ± SD				
Respiratory Rate (bpm)	-	76.86 ± 5.1	77.28 ± 4.81	0.673
Heart Rate (bpm)	-	174.90 ± 1.89	175.28 ± 1.78	0.303
Oxygen Saturation (%)	-	89.84 ± 2.01	89.94 ± 1.91	0.303
Work of Breathing, n (%)				
Increased	200 (100.0)	100 (100.0)	100 (100.0)	1.000

[Table 2] shows the comparative changes in respiratory rate at different intervals. The baseline values of respiratory rates between the HFNC and conventional oxygen groups were comparable. After starting therapy, the mean respiratory rate at 2 hours in the HFNC group decreased to 55.04 ± 5.26 bpm; at the same time, in the conventional oxygen group, the decrease was modest to 65.48 ± 7.12 bpm. The differences were statistically significant. Similarly, at the intervals of 4 hours and 6 hours, it was found that the HFNC group showed a substantial decrease in respiratory rates to 49.36 ± 5.99 bpm and 38.16 ± 7.45 bpm, respectively, compared to a decrease to 64.72 ± 7.98 bpm and 56.96 ± 10.32 bpm at the same intervals. Therefore, this table showed that HFNC therapy resulted in more rapid and sustained improvement in respiratory distress as evidenced by faster reduction in respiratory rates in this group.

Table 2: Comparative Changes in Respiratory Rate Over Time

Time Point	HFNC Group (bpm) Mean ± SD	Conventional O_2 Group (bpm) Mean ± SD	p-value
Baseline (At presentation)	76.86 ± 5.10	77.28 ± 4.81	0.673
2 hours	55.04 ± 5.26	65.48 ± 7.12	<0.001*
4 hours	49.36 ± 5.99	64.72 ± 7.98	<0.001*
6 hours	38.16 ± 7.45	56.96 ± 10.32	<0.001*
* Significant			

The description of comparative changes in heart rate and oxygen saturation in two groups of cases is given in [Table 3]. The analysis of the table showed that baseline heart rate and oxygen saturation were similar between the two groups. Over time intervals, it was found that the HFNC group showed a marked reduction in heart rate at 2- and 6-hour intervals. The comparison of 6-hour heart rate between the HFNC group and the conventional oxygen group was 129.76 ± 8.90 bpm versus 152.56 ± 13.86 bpm, with significant p-values. Similarly, the oxygen saturation improvement was seen in two groups following the oxygen therapy; however, the improvement was significantly better in the HFNC group at all follow-up intervals. The differences were found to be significant at 4- and 6-hour intervals.

Table 3: Prevalence of Microalbuminuria in the Study Population

Vital Sign	HFNC Group Mean ± SD	Conventional O_2 Group Mean ± SD	p-value
Heart Rate (bpm)			
Baseline	174.9 ± 1.89	175.28 ± 1.78	0.303
2 hours	156 ± 4.85	168.12 ± 4.67	<0.001*
6 hours	129.76 ± 8.9	152.56 ± 13.86	<0.001*
Oxygen Saturation (%)			
Baseline	89.84 ± 2.01	89.94 ± 1.91	0.303
2 hours	97.14 ± 1.36	94.92 ± 3.72	<0.001*
4 hours	98.84 ± 1.13	96.32 ± 4.16	<0.001*
6 hours	98.84±1.13	96.40 ± 4.06	<0.001*
*Significant			

Progress of Work of Breathing (WOB) after intervention in comparison to baseline between the two groups is given in Table 4. Analysis of the table showed that at a 2-hour interval following intervention, the HFNC group showed a higher proportion of children with decreased work of breathing (98%) compared to the conventional oxygen group (70%); the differences were found to be statistically significant. The same pattern continued at intervals of 4 hours and 6 hours, with greater improvement in the HFNC group. By 6 hours, 94% of children in the HFNC group had decreased work of

breathing, compared to 60% in the conventional oxygen group, while persistent increased work of breathing was more common in the conventional oxygen group (30%).

Table 4: Progress of Work of Breathing (WOB) After Intervention

Time Point	WOB Category	HFNC Group n (%)	Conventional O_2 Group n (%)	p-value
Baseline	Increased	100 (100.0)	100 (100.0)	1.000
2 hours	Decreased	98 (98.0)	70 (70.0)	<0.001*
	Increased	2 (2.0)	30 (30.0)	
4 hours	Decreased	94 (94.0)	66 (66.0)	
	Increased	2 (2.0)	30 (30.0)	<0.001*
	Normal	4 (4.0)	4 (4.0)	
6 hours	Decreased	94 (94.0)	60 (60.0)	<0.001*
	Increased	2 (2.0)	30 (30.0)	
	Normal	4 (4.0)	10 (10.0)	

*Significant

[Table 5] Logistic Regression Analysis for Treatment Failure in the cohort of the study is given in Table 5. Analysis showed that the type of oxygen therapy was a significant predictor of treatment failure. Compared to conventional oxygen therapy for reference, HFNC therapy significantly reduced the odds of treatment failure with an odds ratio of 0.457 (95% CI: 0.176–0.984; p<0.01). HFNC therapy was associated with a statistically significant reduction in the risk of treatment failure, highlighting its clinical advantage over conventional oxygen therapy.

Table 5: Logistic Regression Analysis for Predictors of Treatment Failure

Variable	Odds Ratio (OR)	95% Confidence Interval		p-value
		Lower	Upper	
Conventional O_2 Therapy	1.0 (Reference)	-	-	-
HFNC Therapy	0.457	0.176	0.984	<0.01*

*Significant

Discussion

The current study was carried out on pediatric patients with a clinical diagnosis of bronchiolitis and respiratory distress. The aim was to evaluate the clinical utility of high-flow nasal cannula (HFNC) therapy compared with conventional oxygen therapy. The cases were allotted to two groups. The comparison of baseline parameters in both groups, as shown in [Table 1], reveals that both groups were comparable with respect to age, age distribution, sex, vital signs, and work of breathing, ensuring internal validity and minimizing these confounding factors. It also indicated good sample distribution. This allows the observed differences in outcomes to be attributed to the method of intervention rather than the disease severity. Such baseline comparison is important for interventional respiratory studies involving the pediatric population.[15] An important observation of the study was a rapid and early reduction in respiratory rate in the HFNC group within two hours of initiation of therapy. The improvement was continued progressively as the time following the intervention progressed compared to the cohort of the conventional oxygen therapy cases. It has been shown that HFNC delivers heated and humidified gas at high flow rates, reducing nasopharyngeal dead space, decreasing inspiratory resistance, and lowering the work of breathing.[16,17] Prior studies with HNFC treatment have also shown similar early reduction of respiratory rate and improved respiratory mechanics and increase patient comfort these observations are similar to those found in the current study.[18] We observed a greater decline in heart rate in HNFC groups because of improved physiological stability and decreased respiratory distress. Tachycardia in children with respiratory disease is a marker of increased work of breathing and hypoxia-related stress. The faster normalization of heart rate in the HFNC group shows better overall respiratory support provided, as well as decreased sympathetic discharge; similar findings have been reported by Milesi et al,[19] Wing et al,[20] in their studies.

In this study, both groups showed improvement in oxygenation, although the HFNC group had higher oxygen saturation levels at all time points. This is attributed to the fact that HFNC was able to provide a constant and correctly titrated proportion of inspired oxygen with minimal entrainment of room air.[21] Oxygenation improvement without the use of invasive ventilation is especially applicable in resource-limited health care hospitals, as HFNC can be used to decrease intensive care hospitalization. The decreased work of breathing also proves the superiority of the HFNC therapy in our study. The reduced work of breathing was significantly higher in the HFNC group of children as compared to conventional oxygen therapy. This showed that the conventional oxygen group did not provide adequate respiratory support, although a minor improvement in cases was found. Similar observations have been reported by other studies assessing the use of HFNC in bronchiolitis and pneumonia conditions, in which HFNC was linked to better clinical scores and reduced escalation of care.[22,23] Notably, the analysis with logistic regression showed that HFNC therapy would decrease the odds of failure of the treatment in comparison with conventional oxygen therapy. The results of this finding highlight the protective effect of HFNC and justify its application as a respiratory support mode in the early stages. A decrease in treatment failure will result in a reduction of escalation to non-invasive or invasive ventilation, healthcare expenses, and patient outcomes.[24] In the end, the findings of this study support the

increasing amount of evidence on the use of HFNC as a safe and effective approach to treating pediatric respiratory distress. The rapidity with which it enhances clinical parameters, decreases the work of breathing, and minimizes rates of treatment failure are what make HFNC an excellent addition to the respiratory care of the pediatric population, especially of tertiary care and high-burden settings.

Conclusion

Within the limitations of this study, HFNC therapy demonstrated superior clinical outcomes compared with conventional oxygen therapy in children with bronchiolitis and acute respiratory distress. HFNC was associated with faster improvement in respiratory rate, heart rate, oxygen saturation, and work of breathing, along with a lower risk of treatment failure. Given its favorable safety profile, ease of application, and clinical effectiveness, HFNC may be preferred an effective non-invasive respiratory support strategy in pediatric patients with bronchiolitis.

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Conflicts of interest

There are no conflicts of interest.

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