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Original Article

Comparative Evaluation of High-Flow Nasal Cannula Therapy Versus Conventional Oxygen Therapy in Children with Acute Lower Respiratory Tract Infections

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ABSTRACT

Background: Acute lower respiratory tract infections (ALRTIs) are a major cause of morbidity and hospitalization among children under five years of age. High-Flow Nasal Cannula (HFNC) therapy has emerged as an effective non-invasive respiratory support modality that may provide better oxygenation and clinical outcomes than Conventional Oxygen Therapy (COT). This study compared the efficacy and outcomes of HFNC with COT in children with ALRTIs presenting with hypoxemic respiratory distress.

Methods: This prospective comparative observational study was conducted in the Department of Pediatrics, ESIC Medical College and Hospital, Kalaburagi, Karnataka, from April 2025 to April 2026. A total of 94 children aged 1 month to 5 years with ALRTIs requiring supplemental oxygen were enrolled and divided into two groups: HFNC (n=47) and Conventional Oxygen Therapy (n=47). Baseline demographic and clinical characteristics were recorded. Clinical parameters including respiratory rate, heart rate, oxygen saturation (SpO_2), treatment success, need for escalation of respiratory support, mechanical ventilation, PICU admission, duration of oxygen therapy, length of hospital stay, and mortality were compared between the two groups. Statistical analysis was performed using SPSS version 26.0, with a p-value <0.05 considered statistically significant.

Results: Baseline demographic characteristics and disease severity were comparable between the two groups. After 24 hours of therapy, children receiving HFNC showed significantly lower respiratory rate (42.1 ± 5.3 vs. 47.9 ± 6.4 breaths/min; p<0.001), lower heart rate (128.5 ± 10.8 vs. 136.7 ± 12.1 beats/min; p=0.001), and higher oxygen saturation (97.1 ± 1.3% vs. 95.2 ± 1.8%; p<0.001) compared with the COT group. Treatment success was significantly higher with HFNC (91.5% vs. 74.5%; p=0.028), while treatment failure requiring escalation of respiratory support was significantly lower (8.5% vs. 25.5%; p=0.028). The duration of oxygen therapy (2.8 ± 0.9 vs. 4.1 ± 1.3 days; p<0.001) and length of hospital stay (4.6 ± 1.5 vs. 6.2 ± 1.9 days; p<0.001) were significantly shorter in the HFNC group. Although mechanical ventilation (4.3% vs. 14.9%) and PICU admission (10.6% vs. 23.4%) were less frequent with HFNC, these differences were not statistically significant. Mortality was low, with one death occurring in the COT group.

Conclusion: HFNC therapy was more effective than Conventional Oxygen Therapy in improving oxygenation, reducing respiratory distress, increasing treatment success, and shortening oxygen requirement and hospital stay in children with acute lower respiratory tract infections. HFNC represents a safe and effective first-line non-invasive respiratory support strategy for pediatric patients with hypoxemic ALRTIs and may reduce the need for escalation of respiratory support.

Keywords*: Acute lower respiratory tract infections, High-flow nasal cannula, Conventional oxygen therapy, Bronchiolitis, Pneumonia, Hypoxemia, Children, Pediatric respiratory support.*

INTRODUCTION

Acute lower respiratory tract infections (ALRTIs) remain one of the leading causes of morbidity and mortality among children under five years of age worldwide, accounting for a substantial proportion of pediatric hospital admissions, particularly in low- and middle-income countries. Despite advances in vaccination, antimicrobial therapy, and supportive care, ALRTIs continue to impose a significant healthcare burden due to high rates of hospitalization, respiratory failure, and mortality. The World Health Organization (WHO) estimates that pneumonia alone is responsible for approximately 14% of all deaths among children younger than five years, highlighting the continued need for effective respiratory support strategies in this vulnerable population.[1]

ALRTIs comprise a spectrum of respiratory illnesses including bronchiolitis, bronchopneumonia, and community-acquired pneumonia, all of which are characterized by inflammation of the lower airways, impaired gas exchange, and varying degrees of hypoxemia and respiratory distress.[2] Viral pathogens such as respiratory syncytial virus (RSV), influenza virus, parainfluenza virus, and human metapneumovirus are common etiological agents in infants, whereas bacterial pathogens including *Streptococcus pneumoniae* and *Haemophilus influenzae* contribute significantly in older children.[3] Regardless of etiology, hypoxemia remains one of the strongest predictors of disease severity and mortality, making timely oxygen supplementation the cornerstone of management.[4]

Conventional oxygen therapy (COT), delivered through nasal prongs, face masks, or oxygen hoods, has traditionally been the first-line method for correcting hypoxemia in pediatric patients. Although effective in improving arterial oxygenation, conventional oxygen systems have several limitations. They provide relatively low and variable inspired oxygen concentrations, offer little humidification, may be poorly tolerated in young children, and do not significantly reduce the work of breathing or improve airway mechanics in patients with moderate to severe respiratory distress.[5]

High-flow nasal cannula (HFNC) therapy has emerged over the past decade as an increasingly popular non-invasive respiratory support modality in pediatric critical care. HFNC delivers heated and humidified oxygen-air mixtures at high flow rates that can meet or exceed the patient's inspiratory flow demand, thereby providing more stable oxygen concentrations. Physiologically, HFNC improves mucociliary clearance, decreases anatomical dead space through nasopharyngeal washout, generates a low level of positive airway pressure, enhances alveolar recruitment, and reduces the work of breathing.[6,7] These mechanisms contribute to improved oxygenation and patient comfort compared with conventional oxygen therapy.

Several randomized controlled trials and observational studies have demonstrated that HFNC therapy is associated with lower treatment failure rates, reduced need for escalation of respiratory support, shorter duration of oxygen therapy, and decreased intensive care admissions in infants with bronchiolitis and other respiratory illnesses.[8,9] The multicenter randomized trial by Franklin et al. showed that HFNC significantly reduced escalation of care compared with standard oxygen therapy in infants with bronchiolitis, supporting its growing use in pediatric emergency and inpatient settings.[10] Similarly, systematic reviews and meta-analyses have reported improved clinical outcomes with HFNC, although evidence regarding its effect on mechanical ventilation and mortality remains inconsistent.[11,12]

Despite increasing adoption of HFNC in tertiary pediatric centers, data from Indian healthcare settings remain relatively limited. Differences in patient demographics, disease spectrum, healthcare resources, and clinical practice patterns necessitate locally generated evidence to determine the effectiveness of HFNC in routine pediatric practice. Comparative studies evaluating HFNC against conventional oxygen therapy in children with various acute lower respiratory tract infections are particularly scarce in the Indian population.

Therefore, the present prospective comparative observational study was undertaken to evaluate the clinical efficacy of High-Flow Nasal Cannula therapy compared with Conventional Oxygen Therapy in children aged one month to five years admitted with acute lower respiratory tract infections requiring oxygen supplementation. The study aimed to compare treatment success, improvement in physiological parameters, duration of oxygen therapy, length of hospital stay, need for escalation of respiratory support, intensive care admission, mechanical ventilation, and overall clinical outcomes.

MATERIALS AND METHODS

Study Design and Setting

This prospective comparative observational study was conducted in the Department of Pediatrics, **ESIC Medical College and Hospital, Kalaburagi, Karnataka, India**, over a period of one year from **April 2025 to April 2026**. The study was designed to compare the clinical efficacy and outcomes of **High-Flow Nasal Cannula (HFNC) therapy** with

Conventional Oxygen Therapy (COT) in children admitted with acute lower respiratory tract infections (ALRTIs) presenting with hypoxemic respiratory distress. HFNC has increasingly been used as a non-invasive respiratory support modality in pediatric respiratory illnesses, with evidence suggesting improved oxygenation and reduced treatment failure compared to conventional oxygen therapy.

Study Population
A total of **94 children** diagnosed with acute lower respiratory tract infections requiring supplemental oxygen therapy were enrolled consecutively during the study period.

Patients were managed according to the treating pediatrician's clinical judgment and received either HFNC therapy or conventional oxygen therapy. The study compared outcomes between these two treatment groups.

Inclusion Criteria
Children fulfilling all of the following criteria were included:

- Age between **1 month and 5 years**
- Clinical diagnosis of acute lower respiratory tract infection (bronchiolitis, bronchopneumonia, or pneumonia)
- Hypoxemia requiring oxygen supplementation (SpO_2 <92% on room air)
- Presence of respiratory distress characterized by tachypnea, chest retractions, nasal flaring, or grunting
- Parents or legal guardians providing written informed consent

Exclusion Criteria
Children were excluded if they had:

- Congenital heart disease with significant hemodynamic instability
- Chronic lung disease requiring long-term oxygen therapy
- Neuromuscular disorders affecting respiration
- Upper airway obstruction
- Immediate need for invasive mechanical ventilation at presentation
- Hemodynamic shock requiring vasopressor support
- Do-not-resuscitate status
- Refusal of consent by parents or guardians

Sample Size
The study included **94 eligible children**, divided into:

- **HFNC Therapy Group:** 47 patients
- **Conventional Oxygen Therapy Group:** 47 patients

Clinical Assessment
At admission, all enrolled children underwent detailed clinical evaluation, including:

- Demographic profile (age, sex)
- Duration of illness
- Presenting symptoms (fever, cough, breathing difficulty, poor feeding)
- Vital signs:
    - Respiratory rate
    - Heart rate
    - Temperature
    - Oxygen saturation (SpO_2)
- Assessment of respiratory distress:
    - Chest retractions
    - Nasal flaring
    - Grunting
    - Accessory muscle use
- Auscultatory findings
- Requirement for PICU admission

Baseline severity was assessed before initiation of oxygen therapy.

Intervention
High-Flow Nasal Cannula Therapy
Children in the HFNC group received heated and humidified oxygen through a high-flow nasal cannula system using appropriately sized nasal prongs. Initial flow rates were adjusted according to body weight (approximately **1.5–2 L/kg/min**, up to institutional maximum limits), with FiO_2 titrated to maintain oxygen saturation ≥94%. Flow and FiO_2

were adjusted according to clinical response and oxygenation. HFNC provides heated, humidified gas at high flow rates, improving oxygen delivery and reducing work of breathing.

Conventional Oxygen Therapy
Children in the conventional oxygen therapy group received oxygen through standard nasal prongs, simple face masks, or oxygen hood according to age and clinical condition. Oxygen flow rates were adjusted to maintain peripheral oxygen saturation ≥94%.

Monitoring
Patients in both groups were monitored at baseline and at regular intervals after initiation of therapy.
The following parameters were recorded:

- Respiratory rate
- Heart rate
- Oxygen saturation (SpO_2)
- Degree of respiratory distress
- Requirement for escalation of respiratory support
- Need for non-invasive ventilation
- Requirement for invasive mechanical ventilation
- Duration of oxygen therapy
- Length of hospital stay
- Treatment complications
- Clinical outcome at discharge

Outcome Measures
Primary Outcome

- Treatment failure requiring escalation of respiratory support

Secondary Outcomes

- Improvement in oxygen saturation
- Reduction in respiratory rate
- Reduction in heart rate
- Improvement in respiratory distress
- Need for PICU admission
- Need for mechanical ventilation
- Duration of oxygen therapy
- Length of hospital stay
- Mortality

Data Collection
Clinical data were recorded prospectively using a structured case record form designed for the study. Patient confidentiality was maintained throughout the study.

Statistical Analysis
Data were entered into **Microsoft Excel** and analyzed using **Statistical Package for the Social Sciences (SPSS) version 26.0** (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as **mean ± standard deviation (SD)**, whereas categorical variables were presented as **frequency and percentage**. Comparisons between the HFNC and conventional oxygen therapy groups were performed using:

- Independent Student's *t*-test for continuous variables
- Chi-square test or Fisher's exact test for categorical variables

A **p-value <0.05** was considered statistically significant.

Ethical Considerations
The study protocol was approved by the **Institutional Ethics Committee of ESIC Medical College and Hospital, Kalaburagi, Karnataka, India**, before commencement of the study. Written informed consent was obtained from the parents or legal guardians of all enrolled children. The study was conducted in accordance with the ethical principles of the **Declaration of Helsinki**.

RESULTS AND OBSERVATION

Table 1. Baseline Demographic Characteristics of Study Participants

Characteristics	HFNC (n=47)	Conventional Oxygen Therapy (n=47)	P value
Age (months)			
Mean ± SD	18.9 ± 11.6	19.7 ± 12.3	0.74
1–12 months	20 (42.6)	19 (40.4)	
13–24 months	14 (29.8)	15 (31.9)	
25–60 months	13 (27.7)	13 (27.7)	0.83
Gender			
Male	28 (59.6)	27 (57.4)	
Female	19 (40.4)	20 (42.6)	0.83

Table 2. Distribution of Clinical Diagnosis

Diagnosis	HFNC (n=47)	Conventional Oxygen Therapy (n=47)	Total (n=94)
Bronchiolitis	22 (46.8)	21 (44.7)	43 (45.7)
Bronchopneumonia	15 (31.9)	16 (34.0)	31 (33.0)
Pneumonia	10 (21.3)	10 (21.3)	20 (21.3)

Table 3. Baseline Clinical Parameters

Variable	HFNC (Mean ± SD)	Conventional Oxygen Therapy (Mean ± SD)	P value
Respiratory rate (breaths/min)	60.8 ± 6.4	61.2 ± 6.7	0.77
Heart rate (beats/min)	152.6 ± 15.1	151.8 ± 14.8	0.81
Oxygen saturation (%)	88.3 ± 2.5	88.6 ± 2.7	0.56

Table 4. Clinical Parameters After 24 Hours of Oxygen Therapy

Variable	HFNC (Mean ± SD)	Conventional Oxygen Therapy (Mean ± SD)	P value
Respiratory rate (breaths/min)	42.1 ± 5.3	47.9 ± 6.4	<0.001
Heart rate (beats/min)	128.5 ± 10.8	136.7 ± 12.1	0.001
Oxygen saturation (%)	97.1 ± 1.3	95.2 ± 1.8	<0.001

Table 5. Comparison of Treatment Outcomes

Outcome	HFNC (n=47)	Conventional Oxygen Therapy (n=47)	P value
Treatment success	43 (91.5)	35 (74.5)	0.028
Treatment failure	4 (8.5)	12 (25.5)	
Escalation of respiratory support	4 (8.5)	12 (25.5)	0.028
Mechanical ventilation	2 (4.3)	7 (14.9)	0.081
PICU admission	5 (10.6)	11 (23.4)	0.096

Table 6. Hospital Outcomes

Variable	HFNC (Mean ± SD / n)	Conventional Oxygen Therapy (Mean ± SD / n)	P value
Duration of oxygen therapy (days)	2.8 ± 0.9	4.1 ± 1.3	<0.001
Length of hospital stay (days)	4.6 ± 1.5	6.2 ± 1.9	<0.001
Mortality	0	1 (2.1)	0.31

DISCUSSION

The present prospective comparative observational study compared the effectiveness of High-Flow Nasal Cannula (HFNC) therapy with Conventional Oxygen Therapy (COT) in 94 children admitted with acute lower respiratory tract infections (ALRTIs) associated with hypoxemic respiratory distress. The findings demonstrate that HFNC therapy resulted in significantly faster clinical improvement, lower treatment failure, shorter duration of oxygen therapy, and reduced hospital stay compared with conventional oxygen therapy.

Baseline demographic characteristics were comparable between the two groups. Mean age was approximately 19 months in both groups, with nearly 43% of patients being infants younger than one year. Male predominance was observed in both treatment groups. Bronchiolitis constituted the commonest diagnosis (45.7%), followed by bronchopneumonia (33.0%) and pneumonia (21.3%). Baseline respiratory rate, heart rate, and oxygen saturation were similar, indicating comparable disease severity before initiation of therapy. These findings are consistent with previous pediatric studies where bronchiolitis represented the predominant indication for HFNC therapy and baseline characteristics were well matched between treatment groups.[8,10]

One of the most important findings of the present study was the significantly greater improvement in respiratory parameters after 24 hours among children receiving HFNC. Respiratory rate declined more rapidly in the HFNC group (42.1 ± 5.3 breaths/min) than in the conventional oxygen group (47.9 ± 6.4 breaths/min; $p<0.001$). Similarly, heart rate decreased significantly, reflecting reduced work of breathing and improved cardiorespiratory stability. Oxygen saturation also improved significantly with HFNC (97.1% vs 95.2%; $p<0.001$). These physiological improvements can be explained by the mechanisms of HFNC, including delivery of heated humidified oxygen, reduction of nasopharyngeal dead space, improved airway humidification, decreased inspiratory resistance, and generation of low levels of positive airway pressure that improve alveolar recruitment.[6,7]

Treatment success was achieved in 91.5% of children receiving HFNC compared with 74.5% receiving conventional oxygen therapy, while treatment failure requiring escalation of respiratory support was significantly lower in the HFNC group (8.5% vs 25.5%; $p=0.028$). These findings closely resemble those reported by Franklin et al., who demonstrated significantly lower rates of treatment escalation among infants treated with HFNC in emergency departments.[10] Similar reductions in treatment failure have also been demonstrated in systematic reviews by Lin et al. and Luo et al., supporting the superiority of HFNC over conventional oxygen therapy in pediatric respiratory illnesses.[11,12]

Although the need for mechanical ventilation was numerically lower in the HFNC group (4.3%) compared with conventional oxygen therapy (14.9%), the difference did not achieve statistical significance. Likewise, PICU admission occurred less frequently with HFNC (10.6% vs 23.4%) but without statistical significance. These findings likely reflect the relatively modest sample size, which may have limited statistical power for these secondary outcomes. Nevertheless, the observed trend is clinically meaningful and consistent with previous reports suggesting that early HFNC may reduce progression to more invasive respiratory support.[9,10]

Another clinically significant observation was the shorter duration of oxygen therapy and hospitalization among children treated with HFNC. Patients receiving HFNC required oxygen therapy for an average of only 2.8 days compared with 4.1 days in the conventional oxygen group. Similarly, hospital stay was significantly reduced (4.6 vs 6.2 days; $p<0.001$). Shorter hospitalization not only reflects faster clinical recovery but may also reduce healthcare costs, improve bed availability, and decrease caregiver burden. Similar reductions in hospital stay have been reported in several observational studies evaluating HFNC in bronchiolitis and pediatric pneumonia.[8,9]

Mortality was extremely low in both groups, with only one death occurring in the conventional oxygen therapy group. The absence of a statistically significant mortality difference is expected because pediatric ALRTIs generally have favorable outcomes when appropriate respiratory support is instituted promptly, and mortality is relatively uncommon in tertiary care settings. Most previous HFNC studies have similarly reported no significant mortality benefit because of the low event rate.[11,12]

The overall findings of this study support the growing body of evidence that HFNC provides more effective respiratory support than conventional oxygen therapy in children with moderate hypoxemic respiratory distress due to acute lower respiratory tract infections. HFNC improves oxygenation, decreases work of breathing, reduces treatment failure, and shortens hospitalization while maintaining an excellent safety profile. These advantages are particularly important in resource-limited settings where avoiding invasive ventilation and reducing PICU utilization can substantially improve healthcare efficiency.

The study has certain limitations. It was conducted at a single tertiary care center with a relatively small sample size, limiting generalizability. Allocation to treatment groups was observational rather than randomized, introducing the possibility of selection bias. Long-term follow-up after discharge was not performed, and disease-specific subgroup analyses could not be undertaken because of limited sample numbers. Larger multicenter randomized controlled trials in Indian children are needed to further validate these findings and evaluate cost-effectiveness.

In conclusion, the present study demonstrates that High-Flow Nasal Cannula therapy is superior to conventional oxygen therapy in improving short-term clinical outcomes among children with acute lower respiratory tract infections. HFNC significantly improved physiological parameters, reduced treatment failure, shortened oxygen requirement, and decreased hospital stay, supporting its wider use as an effective first-line non-invasive respiratory support modality in appropriately selected pediatric patients.

CONCLUSION

High-Flow Nasal Cannula (HFNC) therapy demonstrated superior clinical efficacy compared with Conventional Oxygen Therapy (COT) in children with acute lower respiratory tract infections presenting with hypoxemic respiratory distress. HFNC was associated with significantly greater improvement in oxygen saturation, respiratory rate, and heart rate within the first 24 hours, along with a higher treatment success rate and a lower requirement for escalation of respiratory support. Additionally, children receiving HFNC had a significantly shorter duration of oxygen therapy and hospital stay,

indicating faster clinical recovery. Although the reductions in PICU admission and mechanical ventilation were not statistically significant, favorable trends were observed. These findings support the use of HFNC as an effective and safe first-line non-invasive respiratory support modality in appropriately selected pediatric patients with moderate to severe ALRTIs. Further large-scale multicenter randomized studies are warranted to confirm these results and establish standardized treatment protocols.

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