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A Prospective Observational Study On Clinical Profile And Immediate Outcome Of Children Requiring HFNC Oxygen Therapy In A Tertiary Care Hospital

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ABSTRACT

Objective: To evaluate the clinical profile and immediate outcomes of pediatric patients receiving high-flow nasal cannula (HFNC) oxygen therapy for respiratory distress.

Design: Prospective observational study.

Methods: Eighty children (0 months to 18 years) admitted to the PICU/NICU of a tertiary care hospital with acute respiratory distress and hypoxia were included. Patients whose parents did not provide consent or those with facial deformities preventing HFNC application were excluded. Improvements in respiratory distress, oxygenation, the need for escalation to other ventilation methods (CPAP/mechanical ventilation), duration of HFNC therapy, and the length of hospital stay were measured.

Results: The study included 80 patients: 21.25% neonates, 27.5% infants, 30% children aged 1-5 years, and 21.25% children >5 years; 66.25% were male. Common respiratory distress signs included chest retractions (83.75%), nasal flaring (73.75%), and head bobbing (38.75%). The mean SpO2 was 92.62% (range: 72-99), the mean heart rate was 128.51 bpm (range: 77-207), and the mean respiratory rate was 50.42 breaths/min (range: 20-82). The most common indications for HFNC were respiratory distress of varied etiology (41.25%) and pneumonia (37.5%). Mean initial HFNC settings were FiO2 42% and flow 18.58 L/min, while weaning FiO2 27.43% and flow 9.64 L/min. The mean HFNC duration was 43.5 hours, and the mean hospital stay was 10 days. 83.75% of patients recovered with HFNC, 10% required invasive ventilation, and 6.25% required non-invasive ventilation. No interface-related issues were observed.

Conclusions: HFNC therapy is an effective intervention for managing pediatric respiratory distress, significantly improving oxygenation and reducing the need for invasive ventilation.

Keywords: *High-flow nasal cannula, respiratory distress, respiratory support.*

1. INTRODUCTION

The evolution of pediatric oxygen therapy has been a significant journey in medical history, reflecting the constant exploration to provide effective and life-saving support to children experiencing respiratory distress.

High-Flow Nasal Cannula (HFNC) therapy has emerged in recent years as a sophisticated alternative to traditional oxygen delivery methods. HFNC provides warmed and humidified oxygen at high flow rates, optimizing oxygenation and ventilation while minimizing discomfort [1]. This non-invasive approach has been shown to be effective for various pediatric respiratory conditions, reducing the need for invasive interventions like intubation [2]. HFNC therapy has been effective in infants with respiratory distress syndrome and bronchiolitis, reducing respiratory distress and intubation rates, enhancing patient comfort, and shortening pediatric ICU stays compared to face masks or traditional cannulas. [3-4]

Despite the growing use of HFNC therapy, there remains a lack of comprehensive data regarding its clinical profile and immediate outcomes in pediatric patients. Understanding the characteristics of children who benefit most from HFNC therapy and evaluating its effectiveness in real-world settings is crucial for optimizing patient care and refining treatment protocols. This study aims to fill this gap by studying the clinical profile and immediate outcomes of pediatric patients requiring HFNC oxygen therapy for respiratory distress. The duration of HFNC therapy required and the length of hospital stay for various indications is also measured.

2. METHODS

This was a Prospective observational study based on real time data collected concurrently during treatment of patient and their responses to HFNC therapy in a clinical setting to investigate the clinical profile and immediate outcomes of children requiring High Flow Nasal Cannula (HFNC) oxygen therapy. The study was conducted in the Pediatric Intensive Care Unit (PICU) and Neonatal Intensive Care Unit (NICU) of a tertiary care hospital located in Greater Noida, India from June 2022 to May 2024 during which patients were enrolled as they presented with respiratory distress to hospital. Respiratory distress was defined as persistence of hypoxemia (SpO2 < 94%) and respiratory distress symptoms despite standard-flow oxygen therapy. Standard-flow oxygen therapy was administered to all patients using a conventional nasal cannula at 1–5 L/min, a simple mask at 6–10 L/min, or an oxygen hood with 35–50% oxygen before switching to high flow (5-6). Respiratory distress manifested as elevated heart and breathing rates, colour changes, grunting, nasal flaring, retractions, wheezing, and sweating. The eligibility criteria for this study were: (1) children aged from 0 months to 18 years who were admitted to the PICU or NICU and required HFNC oxygen therapy due to acute respiratory distress and hypoxia. We excluded those (1) children whose parents did not provide consent for participation and (2) those with facial deformities that prevented the application of the HFNC interface. This study was approved by Institutional ethics committee (Ref. No. SU/SMS&R/76-A/2022/170).

An institutional protocol for the use of HFNCs was initiated according to standard clinical protocol and guidelines (Figure 1). HFNC oxygen therapy was delivered by Fischer and Paykel, AIRVO2 which contain adult and junior modes. Mode was selected based on age and requirement of flow rate. Guidelines for the indications, settings, monitoring, and results (success or failure) of HFNC treatment were included in the protocol. Flow rates were adjusted based on patient's body weight; <12 kg: 2 L/kg/minute; > 12 kg:2 L/kg/minute for the first 12 kg + 0.5 L/kg/min for each kg above (maximum flow 60 L/min) , Fraction of inspired oxygen (FiO2) was set to target a desired peripheral oxygen saturation between 92 -97% and dew point temperature close to body temperature at 370 to optimize humidification effect. Respiratory parameters such as respiratory rate (RR), SpO2 and heart rate (HR) were continually monitored in patients along with signs of respiratory distress. To evaluate oxygenation and ventilation status, blood gas analysis was carried out as clinically indicated, and oxygen saturation (SpO2) was measured using pulse oximetry. If there was improvement in respiratory rate (RR), heart rate (HR), signs of respiratory distress, and FiO2 requirements, the flow rate was gradually reduced to 0.5 L/kg/min, and HFNC therapy was deemed successful and the outcome recorded as recovered. Conversely, if parameters worsened, the patient was upgraded to alternative ventilation methods such as CPAP or mechanical support and the reason documented. The decision to escalate treatment was made by the intensive care physician, typically if FiO2 exceeded 0.6 or if the clinical condition deteriorated.

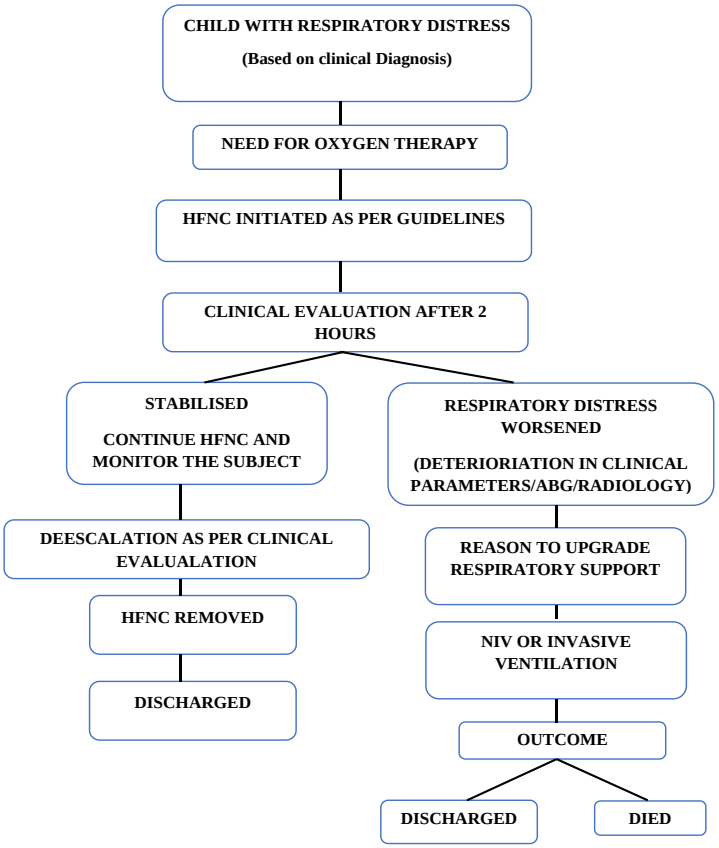

Figure 1: Protocol followed for high-flow nasal cannula therapy in the study

The following data was collected through structured case record form by healthcare personnel who were not involved in treatment decisions for all patients: (1) demographic information (age and gender) and medical history; (2) Indication (3) clinical parameters of disease severity, such as heart rate, respiratory rate, and SpO2 at initiation of HFNC therapy; (4) variables of HFNC respiratory support, including the initial and maximum HFNC settings (FiO2 and flow); (5) underlying diagnoses; (6) comorbidities and (7) outcomes. Outcomes included improvements in respiratory distress, oxygenation levels (measured by SpO2), need for escalation to non-invasive or invasive ventilation and duration of HFNC therapy and hospital stay. Additionally, the observational design allowed for real-time monitoring of patient outcomes, reducing recall bias. The patients' characteristics including demographic and HFNC utilization data are presented as percentage (%) or mean ± standard deviation (SD).

3. RESULTS

Out of 118 eligible patients as per inclusion and eligibility criteria, statistical analysis was done for 80 patients and results were analyzed. The remaining 38 patients were excluded as they either left against medical advice or were referred to a higher center for further treatment **(Figure 2)**.

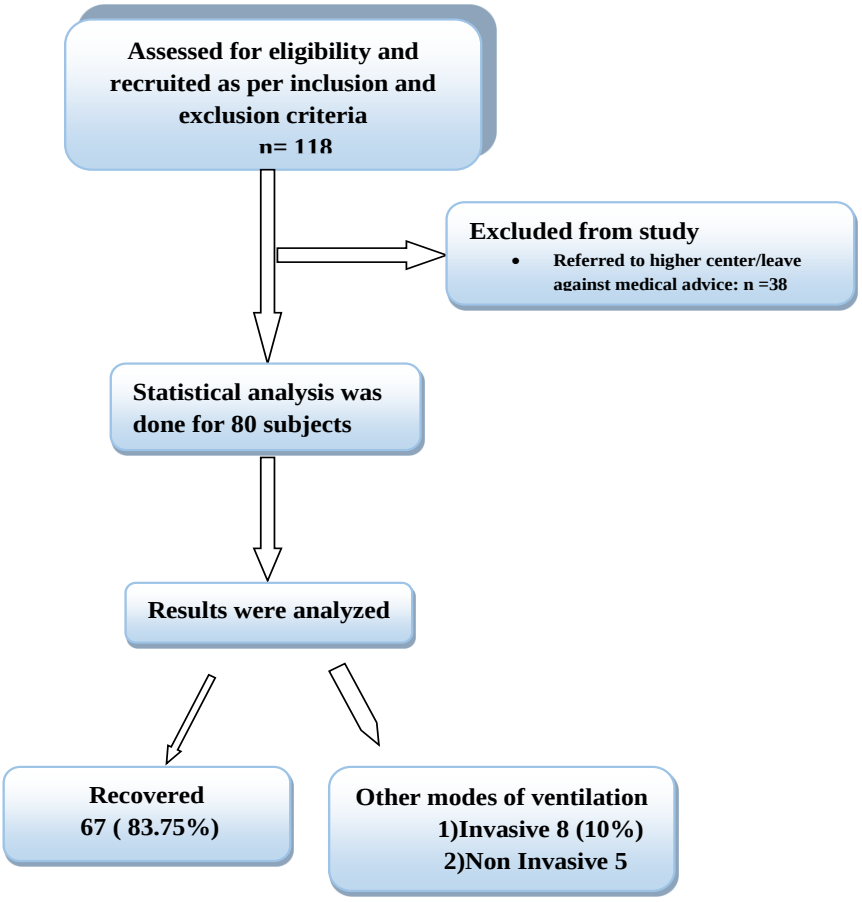

Figure 2. Flowchart of the included patients.

Based on age groups, distribution of participants includes **Neonate (< 28 days):** 17 participants (21.25%); **Infant (28 days to 1 year):** 22 participants (27.5%); **1 year - 5 years:** 24 participants (30%); **More than 5 years:** 17 participants (21.25%). The gender distribution of study subjects includes 27 (33.75%) were female and 53 (66.25%) were male **(Table 1).** Among the 80 participants, the signs of respiratory distress were observed as follows: **Head Bobbing** in 31 participants (38.57%); **Nasal Flaring** 59 participants (73.75%); **Chest Retractions:** 67 participants (83.75%) **(Table 2-A).** The mean and range for various vital signs among the participants includes : **SpO2 (%):** Mean 92.62 (Range: 72.00 - 99.00);**Temperature (°F):** Mean 99.47 (Range: 96.00 - 103.00);**Heart Rate (bpm):** Ranged from 77 to 207;**Respiratory Rate (breaths/min):** Ranged from 20 to 82;**Systolic BP (mmHg):** Ranged from 62 to 124;**Diastolic BP (mmHg):** Ranged from 38 to 91**(Table 2-B).**

The indications for HFNC therapy included were **Respiratory Distress:** 33 subjects (41.25%);**Post Extubation:** 12 subjects (15%);**Pneumonia:** 30 subjects (37.5%);**Acute Exacerbation of Bronchial Asthma:** 5 subjects (6%) **(Table 3)**.The diagnoses among the study subjects were :**Pneumonia:** 25 subjects (31.25%);**Dengue:** 8 subjects (10%);**Bronchiolitis:** 18 subjects (22.5%);**Bronchial Asthma:** 5 subjects (6.25%);**Meningoencephalitis:** 1 subject (1.25%);**Empyema Thoracis:** 5 subjects (6.25%);**Transient Tachypnea of Newborn (TTN):** 2 subjects (2.5%);**Meconium Aspiration Syndrome (MAS):** 6 subjects (7.5%);**Acute Respiratory Distress Syndrome (ARDS):** 3 subjects (3.75%);**Postextubation in Cases of Hyaline Membrane Disease (HMD):** 7 subjects (8.75%) **(Table 4)**.

The mean HFNC settings at initiation were: **FiO2 (%):** 42.00 with Flow **(L/min):** 18.58 and at weaning off, the settings were: **FiO2 (%):** 27.43 with **Flow (L/min):** 9.64 **(Table 5-A).**

The duration of HFNC therapy was: **<1 Day:** 14 (17.5%);**1-2 Days:** 31 (38.75%);**2-5 Days:** 25 (31.25%); > **5 Days:** 10 (12.5%).**(Table 5-B) .**The mean duration of HFNC use was 43.5 hours.

Among the study subjects, comorbidities were present in 16 (20%) of the subjects: **Cerebral Palsy:** 2 (2.5%); **Acyanotic Congenital Heart Disease (ACHD):** 2 (2.5%); **Preterm:** 12 (15%) **(Table 6).**

The length of hospital stay for recovery was categorized as:**1 Day to 5 Days:** 22 (22.5%) and > **5 Days:** 58 (72.5%) **(Table 7 -A)**. The mean duration of hospital stay was 10 days. Among the 80 study subjects, the outcomes were: **Recovered** in 67 (83.75%); **Invasive Ventilation** in 8 (10%) and **Non-Invasive Ventilation** in 5 (6.25%) **(Table 7-B)**.

Notably, none of the subjects experienced interface-related issues with HFNC, such as pressure injuries, which are common with nCPAP interfaces. Additionally, HFNC did not require frequent readjustments, indicating its effectiveness and comfort in the study population.

Table 1: Demographics of study participants

Variable	Category	N	Percentage (%)
Age Group	**Neonate (<28 days)**	17	21.25
	Infant (28 days–1 year)	22	27.5
	1 year–5 years	24	30.0
	>5 years (up to 13 years)	17	21.25
Sex	**Female**	27	33.75
	Male	53	66.25

Table 2-A: Clinical profile of study participants (Respiratory Distress Signs)

Respiratory Distress Signs	N	Percentage (%)
Head Bobbing	31	38.75
Nasal Flaring	59	73.75
Chest Retractions	67	83.75

Table 2-B: Clinical profile of study participants (Vitals)

Vitals	Range	Mean
Heart Rate (bpm)	77–207	128.51
Respiratory Rate (breaths/min)	20–82	50.42
Systolic BP (mmHg)	62–124	91.30
Diastolic BP (mmHg)	38–91	61.70
SpO2 (%)	72–99	92.62
Temperature (°F)	96.0–103.0	99.47

Table 3: Indications for HFNC Therapy

Indication	N	Percentage
Respiratory Distress	33	41.25%
Post Extubation	12	15%
Pneumonia	30	37.5%
Acute Exacerbation of Bronchial Asthma	5	6%

Table 4: Diagnosis among study subjects

Diagnosis	N	Percentage
Pneumonia/ Empyema Thoracis	30	37.5%
Dengue	8	10%

Bronchiolitis	18	22.5%
Bronchial asthma	5	6.25%
Meningoencephalitis	1	1.25%
Transient Tachypnea of Newborn (TTN)	2	2.5%
Meconium Aspiration Syndrome (MAS)	6	7.5%
Acute Respiratory Distress Syndrome (ARDS)	3	3.75%
Postextubation in cases of Hyaline membrane disease (HMD)	7	8.75%

Table 5-A: HFNC Settings used

HFNC Settings	At Initiation (Mean ± SD)	At Wean Off (Mean ± SD)	P-value
FiO2 (%)	42.00 ± 6.589	27.43 ± 9.306	p≤0.001 (Sig)
Flow (L/min)	18.58 ± 11.269	9.64 ± 8.523	p≤0.001 (Sig)

Table 5-B: Duration of HFNC provided

Duration of HFNC Therapy	N	Percentage
<1 Day	14	17.5%
1-2 Days	31	38.75%
2-5 Days	25	31.25%
More than 5 Days	10	12.5%

Table 6: Comorbidities among Study Subjects

Comorbidity	N	Percentage
Cerebral Palsy	2	2.5%
Acyanotic Congenital Heart Disease (ACHD)	2	2.5%
Preterm	12	15%
Total	16	20%

Table 7-A: Length of Hospital Stay

Length of Hospital Stay	N	Percentage
1 Day to 5 Days	22	22.5%
More than 5 Days	58	72.5%

Table 7-B: Outcomes of HFNC Therapy

Outcome	N	Percentage
Recovered	67	83.75%
Invasive Ventilation	8	10%
Non-Invasive Ventilation	5	6.25%

4. DISCUSSION

The results of this study indicate that HFNC therapy is an effective intervention for managing respiratory distress in pediatric patients. A significant proportion of patients (83.75%) recovered with HFNC alone, which aligns with the primary objective of the study to investigate the clinical profile and immediate outcomes of children requiring HFNC therapy.

The present study encompassed 80 pediatric patients aged from neonates to 18 years. Neonates and children >5 years each constituted 21.25%, while infants (27.5%) and children aged 1–5 years (30%) formed the majority. Comparable studies, such as Milani et al.,7 and Ergul et al.,8, focused on younger age groups (<2 years), whereas BÜYÜKŞEN et al.,9, and Hoffman et al.,10, included broader pediatric populations. These comparisons demonstrate HFNC's efficacy across diverse age groups and highlight the need for age-specific therapeutic strategies.

Gender analysis revealed a male predominance (66.2%) in this study, consistent with BÜYÜKŞEN et al.,9 (65.3%), and Ergul et al.,8 (63.3%). Such trends could stem from sociocultural factors influencing healthcare-seeking behaviours. Recognizing these disparities is vital for designing equitable healthcare interventions.

5. CLINICAL PARAMETERS AND HFNC EFFICACY

Vital signs at HFNC initiation showed a mean heart rate of 128.5 bpm and respiratory rate of 50.4/min, consistent with Ergul et al.,8, and Yaman,11, suggesting similar illness severity. The study found a moderate prevalence of pneumonia (31.25%), lower than Yaman.,11 (40.3%), and Hoffman et al.,10 (63.6%). This suggests differences in patient populations or selection criteria. Bronchiolitis had a moderate prevalence (22.5%), higher than Yaman.,11 (14.9%), and comparable to Hoffman et al.,10 (25.8%)

FiO2 settings were initiated at 42% and weaned to 27.43%, lower than Ergul et al.,8 (60%) and Hoffman et al.,10 (75.8%). This indicates less severe hypoxemia in our cohort. Median HFNC duration (43.5 hours) aligned with Hoffman et al.,10 (46.3 hours) but was shorter than Milani et al.,7 (4 days), reflecting faster recovery rates.

6. OUTCOMES AND HOSPITAL STAY

The need for invasive or alternative ventilatory modes (16.25%) was lower than Sekar et al.,12 (26%) and Hoffman et al.,10 (24.2%), implying effective HFNC application in this study. Mean hospital stay (10 days) exceeded Ergul et al.,8 (4 days) but paralleled BÜYÜKŞEN et al.,9 (7 days). These findings underscore HFNC's role in reducing respiratory distress while emphasizing differences in patient severity and institutional practices. Among the 17 neonates which included conditions like transient tachypnea of newborn, meconium aspiration syndrome and postextubation, most of the neonates required alternative mode of ventilation and only 2 recovered with HFNC. No similar studies were noted for comparison.

The findings suggest that HFNC therapy can significantly improve oxygenation and reduce the work of breathing in children experiencing acute respiratory distress. Additionally, the study highlighted that the most common indications for HFNC therapy were respiratory distress due to pneumonia and bronchiolitis, which are prevalent conditions in pediatric populations.

7. LIMITATIONS

The study's single-center design and relatively small sample size limit the generalizability of its findings. The absence of a standardized scoring system to assess the initial severity of respiratory distress in patients prior to the initiation of HFNC therapy could impact the interpretation of outcomes, as the severity of illness at baseline is a critical factor in determining treatment success Additionally, the absence of a control group receiving conventional oxygen therapy prevents direct comparisons of efficacy. Future multi-center, randomized controlled trials are needed to establish standardized guidelines for HFNC use in pediatric respiratory care.

8. CONCLUSION

HFNC therapy is a valuable intervention for managing pediatric respiratory distress, offering significant clinical benefits and reducing the need for invasive support. Its role in improving outcomes, minimizing complications, and enhancing patient comfort positions HFNC as a cornerstone of modern pediatric respiratory care. Future research should focus on refining HFNC parameters, such as optimal flow rates and FiO2 levels, for specific pediatric subgroups and to optimize its use and

expand its applicability across diverse clinical settings. Additionally, investigating long-term outcomes and potential benefits in chronic respiratory conditions could broaden HFNC's therapeutic scope.

9. KEY MESSAGES

1. What is Already Known: HFNC is a non-invasive oxygen delivery method beneficial in pediatric respiratory distress.

What This Study Adds: HFNC effectively reduces the need for invasive ventilation and improves clinical outcomes in children.

Data Availability Statement:

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Funding : No funding.

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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