DOI: 103126/JNPS.V4113

Original Article

High flow nasal cannula therapy in Children with Acute Respiratory Distress – A Prospective Observational study

Divya Ajith[1], Aparna Namboodiripad[2]

[1] Paediatric Resident, Jubilee Mission Medical College and Research Institute, Fathima Nagar, Mahatma Nagar, Nellikunnu, Thrissur – 680005 Kerala, India.

[2] Associate Professor, Department of Paediatrics, Jubilee Mission Medical College and Research Institute, Fathima Nagar, Mahatma Nagar, Nellikunnu, Thrissur - 680005 Kerala, India.

Article History

Received on - 2025 Mar 11
Accepted on - 2025 May 08

Keywords:

Pneumonia; Reactive airway disease; Comfort score; ROX index; S/F ratio

Online Access

DOI:https://doi.org/10.60086/jnps1297

Correspondence

Aparna Namboodiripad,
Associate Professor,
Department of Paediatrics,
Jubilee Mission Medical College and Research Institute,
Fathima Nagar,
Mahatma Nagar,
Nellikunnu,
Thrissur - 680005
Kerala,
India.
Email – apnarel@gmail.com

Abstract

Introduction: Acute respiratory distress (ARD) is one of the most common causes for PICU admission among children. Though invasive mechanical ventilation is an effective respiratory support, it has many adverse effects. Hence newer modes of less invasive methods have been studied. High Flow Nasal Cannula therapy (HFNC) is a new mode of respiratory support which can efficiently deliver heated and humidified gas at very high flow rates. The studies on HFNC therapy in paediatric population is limited, but it is being used in many PICUs effectively for various indications. The aim of this study is to elucidate the clinical profile and outcome of HFNC therapy as a primary modality of treatment in children with ARD.

Methods: Children aged one month to 14 years with ARD requiring HFNC respiratory support during PICU admission were recruited for the study. Demographics, clinical parameters, HFNC setting and outcome of HFNC therapy was documented in a proforma.

Results: 144 children with ARD were assessed, of which 130 (90.3%) responded successfully to HFNC therapy, and 14 (9.7%) required more invasive support. Indications that required HFNC support included pneumonia (43.1%), bronchiolitis (31.2%), reactive airway disease (25%) and tracheal web (0.69%). Most HFNC failures happened in children with pneumonia (16.1% of all pneumonia cases).

Conclusions: For children experiencing respiratory distress, HFNC is a primary respiratory support method that is both safe and effective. Children who respond well to HFNC exhibit a positive clinical response in the first few hours.

Introduction

Respiratory illnesses are the most common reason for paediatric hospital admissions; pneumonia and asthma are the two most common diagnoses across all age groups.[1] Although mechanical ventilation and endotracheal intubation are well-established treatments for respiratory failure, they come with risks such as infection, lung and airway damage, prolonged hospital stays, and complications related to sedation.[2]

To minimize these risks, non-invasive respiratory support techniques such as High Flow

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0)

Nasal Cannula (HFNC), continuous positive airway pressure (CPAP), and non-invasive ventilation (NIV) have emerged as viable alternatives.[2-4] HFNC therapy, in particular, has shown to reduce the need for intubation.[5-8] With this delivery system, 2 L / kg / min of heated, humidified air and oxygen are produced. It is believed that HFNC reduces respiratory distress by lowering the breathing effort, lowering their heat-related work expenditure, improving lung compliance, reducing the amount of dead space, and clearing more mucous secretions from the lungs. A positive airway pressure may also be administered via HFNC, even though the precise pressure may vary.[9]

HFNC has demonstrated effectiveness in improving oxygenation and reducing respiratory distress and intubation rates in children with asthma, bronchiolitis, pneumonia, congenital cardiac lesions, cardiomyopathy, post extubation, neonatal respiratory distress syndrome, apnea of prematurity, and obstructive sleep apnea.[10] However, data on its safety in children beyond bronchiolitis cases remain limited to retrospective studies.[11] Only a few prospective studies have been conducted in the Indian sub-continent on the efficacy and safety of HFNC in paediatric intensive care units (PICUs) for respiratory failure that is not brought on by bronchiolitis.[12-14] This study aims to fill that gap by evaluating the clinical profile and outcomes of HFNC therapy as a primary modality of treatment in children with acute respiratory distress (ARD) admitted to the PICU of a tertiary care centre.

Methods

This prospective observational study was conducted over 18 months (January 2023 – June 2024) in the PICU of a tertiary care centre in Thrissur, Kerala, India. The sample size was calculated based on prevalence data from a prior study, HFNC therapy in children with ARD with hypoxia in a PICU – A single centre experience. Using a cross-sectional study design, a 95% confidence interval and 15% relative allowable error, the minimum required sample size was 144 children. Children aged one month to 14 years with ARD requiring HFNC respiratory support during PICU admission were included after obtaining informed consent from parents and assent from children, where applicable. ARD was defined as hypoxia (SpO_2 < 94% in room air), tachypnea as per age and increased work of breathing (Retractions / use of accessory muscles / nasal flaring / grunting). Children where HFNC was not the initial treatment provided, as in those requiring post-extubation respiratory support or HFNC after weaning from CPAP or bilevel positive airway pressure (BiPAP) were excluded. Participants were recruited using a successive sampling approach until the required sample size was achieved.

Data collection included: (1) Demographics (Age and sex) (2) Primary indication for HFNC therapy (3) Clinical parameters of severity of illness, including heart rate, breathing rate, SpO_2, retractions, chest findings and the respiratory clinical score (RCS), SpO_2 / FiO_2 (S / F ratio) and ROX index was calculated (4) Variables after HFNC respiratory support (5) COMFORT scale and (6) Outcomes (Failure / success). The parents and the children provided written informed consent and assent respectively. Each research subject and their parent received a participant information leaflet in their mother tongue. This study was conducted after obtaining institutional ethical committee approval (Ref.no:58/22/IEC/JMMC&RI). The HFNC system from Fisher and Paykel Healthcare was used, with nasal prongs selected based on the child's weight, age, and required flow rate. HFNC was initiated at 1 – 2 L / kg / min for infants and 1.5 L / kg / min for paediatric patients, with adjustments based on patient response and tolerance, up to a maximum of 2 L / kg / min. FiO_2 was adjusted to maintain an SpO_2> 94%. HFNC failure was defined as the need for escalation to non-invasive ventilation (NIV) or invasive mechanical ventilation due to clinical deterioration. The primary indication for HFNC therapy was determined based on clinical records. Additional parameters recorded included the respiratory clinical score at initiation, 60 - 90 mins, 12 - 24 hrs, calculated using age-specific respiratory rate (scores 0 to 3), retractions (0 to 3), dyspnoea (0 to 3), and wheeze (0 to 3) with a total score ranging from 0 (normal) to 12 (severe distress).[17] Other recorded parameters included the S / F ratio (at initiation, 60 - 90 mins, 12 - 24 hrs), ROX index score (at initiation, 60 - 90 mins, 12 - 24 hrs) and Modified COMFORT score (at initiation, 60 - 90 mins, 12 - 24 hrs), with the score ranging from 1 (low) to 5 (high), assessing eight different indicators, including muscle tone, facial tension, respiratory response, physical movement, mean arterial pressure, and alertness.[18] Additionally, data on initial and maximum HFNC settings, duration of HFNC usage, duration of ICU stay, and final outcome (success or failure) were collected. Patient characteristics and HFNC utilization data were summarized using percentages (%) or mean ± standard deviation (SD). Patients were categorized into HFNC success and HFNC failure groups, and between-group differences were analysed using appropriate statistical tests. Chi-square test or Fisher's exact test was applied for categorical variables, while Student's t-test was used for normally distributed continuous variables. For non-normally distributed data, the Mann-Whitney test was employed. Additionally, univariate analysis was conducted to determine associations between HFNC outcomes (Success vs. failure).

Results

A total of 144 children [80 (56.6%) males] aged one month to 14 years, requiring HFNC support during PICU admission were enrolled. The demographic characteristics of the study population has been shown in Table 1. The outcome of children with HFNC support is demonstrated in Figure 1. Among total 144 children studied, most [130 (90.3%)] successfully

continued on HFNC therapy without requiring additional ventilatory support. The rest [14 (9.7%)] experienced treatment failure, necessitating either NIV or intubation with mechanical ventilation.

Table 1: The age distribution of enrolled children

Age (Years)	Frequency (%)
< 1	40 (27.8 %)
1 - 5	64 (44.4%)
6 - 10	32 (22.2%)
11 - 13	8 (5.6%)



Figure 1: Outcome of HFNC of study population

The primary indications for HFNC therapy are summarized in Table 2. The most common diagnoses included pneumonia (43.05%), bronchiolitis (31.25%), and reactive airway disease (25%). The Respiratory Clinical Score (RCS), S/F ratio, ROX index, and Modified COMFORT Score were evaluated at initiation, 60 – 90 minutes, and 12 – 24 hours of HFNC therapy (Table 3). Comparison of clinical parameters, HFNC settings, and ICU duration between HFNC success and failure groups is presented in Table 4. Significant associations were observed in key parameters, with p-values < 0.05.

Table 2: Indications for HFNC use

Diagnosis	Total (%)
Pneumonia	62 (43.05%)
Bronchiolitis	45 (31.25%)
Reactive airway disease	36 (25%)
Tracheal web	1 (0.69%)
Total	144

Table 3: Clinical parameters and comfort score over time

Parameters	Initial	60 - 90 mins	12-24 hrs
RCS	9.77 ± 1.06	6.89 ± 1.62	3.92 ±1.86
S / F	211 ± 38.6	218 ± 32.7	236 ± 33.2
ROX index	4.06 ± 0.78	5.20 ± 1.09	6.57 ± 1.35
Comfort score	28.3 ± 2.35	26.6 ± 2.42	25.6 ± 2.55

Table 4: Associations with outcome (Success vs. failure)

		Failures	Success	P-Value
Indication	Bronchiolitis	1	44	0.007
	Pneumonia	10	52	
	RAD	2	34	
	Tracheal Web	1	0	
RCS	Initial	11.86 ± 0.36	9.546 ± 0.85	0.000
	60 - 90 Minutes	10.00 ± 0.96	6.554 ± 1.29	
	12 - 24 Hours	8.571 ± 1.02	3.415 ± 1.06	
S / F	Initial	153.3 ± 2.30	217.6 ± 35.26	0.000
	60 - 90 Minutes	155.6 ± 1.65	225.3 ± 26.65	0.000
	12 - 24 Hours	155.4 ± 2.03	244.9 ± 20.97	0.000
ROX Index	Initial	2.909 ± 0.46	4.185 ± 0.70	0.000
	60 - 90 Minutes	3.330 ± 0.49	5.404 ± 0.93	0.000
	12 - 24 Hours	3.654 ± 0.54	6.880 ± 0.99	0.000
Comfort Score	Initial	31.43 ± 0.51	28.02 ± 2.22	0.000
	60 - 90 Minutes	31.86 ± 0.66	26.05 ± 1.77	0.000
	12 - 24 Hours	31.64 ± 0.75	24.93 ± 1.65	0.000
HFNC Settings	Initial (Flow – L / Kg)	1.821 ± 0.25	1.619 ± 0.28	0.011
	Initial (FiO_2%)	60.00 ± 0.00	43.00 ± 7.12	0.000
	Maximum (Flow – L / Kg)	2.000	1.677 ± 0.26	0.000
	Maximum (FiO_2%)	60.00	46.69 ± 9.84	0.000
	Hours	18.36 ± 2.71	72.72 ± 19.65	0.000
Duration of ICU stay		8.214 ±1.93	4.138 ± 1.01	0.000

Discussion

In order to evaluate the clinical profile and efficacy of HFNC therapy in children with ARD, we examined 144 children admitted to a tertiary PICU over a period of one and half years. Our findings indicate a low failure rate, highlighting the effectiveness of HFNC in preventing the need for intubation in many cases.

The average age of children in our study was 3.89 ± 3.46 years, with ages ranging from two months to 13 years. The highest HFNC utilization was observed in the 1 – 5 year age group (44.4%, N = 64). Similar trends were reported by Shah et al, where most HFNC cases were in children aged six months to one year.[11] In contrast, Tracey et al reported a mean age of 3.5 months, while Chang et al found a mean age of 7.00 ± 6.79 years.[12,13] The study by Coletti et al noted an even distribution across all age groups.[10] Regarding gender distribution, 55.6% of the children were males, a finding consistent with other studies: Shah (65% males), Chang (55%), and Asseri (52%). However, Tracey et al. reported a higher proportion of females (59%).[11–14]

Among the 144 children enrolled, only 14 (9.7%) did not respond to HFNC therapy and required escalation to higher respiratory support. This aligns with findings from other studies: Coletti et al reported a 10.1% failure rate (63 out of 620 children), Chang et al reported 15%, and Tracey et al observed a 22% failure rate. Shah et al, in an Indian cohort, found an 8.3% failure rate.[10–13] The failure rate is found to be low in most of the studies, which shows high efficacy of HFNC support in various study settings.

In our study, the most common indications for HFNC were pneumonia (43.1%), bronchiolitis (31.3%), and reactive airway disease (25%). HFNC failure was highest in children with tracheal web (100%) and pneumonia (16.1%), whereas those with bronchiolitis (2.2%) and reactive airway disease (5.6%) showed better outcomes. Other studies reported similar trends. Coletti et al found pneumonia as the leading cause of HFNC failure.[10] Chang et al also identified pneumonia as the primary reason for HFNC escalation.[12] Shah et al noted that pneumonia accounted for 33% of HFNC cases, with a 21% failure rate.[11] Tracey et al reported bronchiolitis as the most common diagnosis (61%), but pneumonia had the highest failure rate (40%).[13] Asseri et al found that 40% of HFNC cases were due to bronchopneumonia.

The respiratory clinical scoring (RCS) was high at the initiation of HFNC but significantly reduced at 60 - 90 minutes. RCS was significantly higher in failure cases, indicating a higher chance of failure in more severe diseases. Children who succeeded on HFNC therapy showed significant improvement in RCS by 60 - 90 minutes, while those who required ventilation showed no significant improvement. Hence, early improvement in clinical condition can predict HFNC therapy success. Though not many studies have used clinical scoring to assess improvement in children after initiating HFNC, similar findings were reported by Shah et al.[11] COMFORT score and saturation to FiO_2 (SF

The S / F ratio also increased with HFNC support, with initial S / F significantly lower in failure cases compared to successful cases. Improvement in S / F ratio was greater in successful cases, making it a good predictor of failure. According to Kamit et al, HFNC failure was predicted by a lower SpO_2 / FiO_2 (S / F) ratio at admission, while effective HFNC therapy was strongly predicted by reaching S / F > 200 at 60 minutes.[15] This is similar to the study conducted by Chang et al.[12] In the study conducted by Shah et al, the non-responders had a lower S / F ratio (236 - 323) as compared to the responders (262 - 330) at the time of admission.[11]

According to the systematic review and meta-analysis done by Junhai et al on the value of ROX index in predicting the outcome of HFNC therapy, a value that is less than 5 was found to be a predictor of HFNC failure.[16] In our study, even children who succeeded on HFNC therapy had an average ROX index of 4.185 ± 0.703, which improved at 60 - 90 mins (5.404 ± 0.92) and 12 - 24 hours (6.880 ± 0.993). Improvement in ROX index by 60 - 90 minutes was less in failure cases, suggesting it as a predictor of failure. However in the study conducted by Chang et al, no significant difference was found between the two groups.[12] It is difficult to use ROX index as a predictor in HFNC therapy in children as their respiratory rate varies with age and the ROX index has not been adjusted according to age.Tolerance to HFNC therapy was assessed using a comfort score, with good comfort between 13 - 26.

Tolerance improved in children by 60 - 90 minutes and most children tolerated HFNC well. There was no notable improvement in comfort score among children who failed HFNC therapy as compared to those who succeeded. This is probably due to the fact that children who failed HFNC tend to have a higher heart rate and BP fluctuations as well as increased respiratory effort. A study conducted by Shah et al on HFNC also showed children who responded to HFNC therapy had lower comfort score as compared to those who did not respond.[11]

Children who did not respond to HFNC had higher initial settings. ICU stay duration was significantly higher in children who failed HFNC therapy. This is similar to the studies conducted by Chang et al which showed that the failure group had significantly higher initial and maximum FiO_2 levels and longer PICU stay than the success. Most children who failed HFNC were stepped up within 24 hours and the reason for stepping up support included worsening respiratory distress and falling saturation.[12] In a study conducted in India the children who failed HFNC therapy were upgraded within 1.75 - 24 hours and those that succeeded required HFNC for about 41 - 75 hours.[11]

This is a small study demonstrating the efficacy of HFNC in ARD. The strengths of the study are its prospective nature and the classification of disease severity using a clinical scoring system. However, is was a single-centre study, lacking a control group for comparison. Additionally, tolerance to HFNC therapy was not compared to other respiratory supports such as CPAP or BiPAP. It would be prudent to do research to find the cut off for ROX index to predict the success and failure of HFNC. Hence, further, larger, multi centred trials on this field should be considered in the future.

Conclusions

HFNC is an effective and safe mode of respiratory support for children with ARD with various respiratory aetiologies in all age groups. The most common cause of failed HFNC therapy was pneumonia. The clinical parameters (Respiratory clinical score, S / F ratio) in the first few hours is a good indicator of HFNC failure.

Funding Source: None

Conflict of Interest: None

References

1. Challands J, Brooks K. Paediatric respiratory distress. BJA education. 2019 Nov 1;19(11):350-6
DOI: 10.1016/j.bjae.2019.07.004
PMID: 33456857 PMCID: PMC7807856

2. Franklin D, Schibler A. Nasal high-flow therapy in infants and children. Pediatr Respirol Crit Care Med. (2018) 2:2-6
DOI: 10.4103/prcm.prcm_22_17

3. Fedor KL. Noninvasive respiratory support in infants and children. Respir Care. (2017) 62:699-717
DOI: 10.4187/respcare.05244
PMID: 28546373

4. Lee MJr, Nagler J. High-flow nasal cannula therapy beyond the perinatal period. Curr Opin Pediatr. (2017) 29:291- 6
DOI: 10.1097/MOP.0000000000000494
PMID: 28333694

5. Zhao H, Wang H, Sun F, Lyu S, An Y. High-flow nasal cannula oxygen therapy is superior to conventional oxygen therapy but not to noninvasive mechanical ventilation on intubation rate: a systematic review and meta-analysis. Crit Care. (2017) 21:184
DOI: 10.1186/s13054-017-1760-8
PMID: 28701227 PMCID: PMC5508784

6. Mikalsen IB, Davis P, Øymar K. High flow nasal cannula in children: a literature review. Scand J Trauma Resusc Emerg Med. (2016) 24:93
DOI: 10.1186/s13049-016-0278-4
PMID: 27405336 PMCID: PMC4942966

7. Mile'si C, Boubal M, Jacquot A, Baleine J, Durand S, Odena MP, et al. High_flow nasal cannula: recommendations for daily practice in pediatrics. Ann Intensive Care. 2014;4:29
DOI: 10.1186/s13613-014-0029-5
PMID: 25593745 PMCID: PMC4273693

8. Hutchings FA, Hilliard TN, Davis PJ. Heated humidified high flow nasal cannula therapy in children. Arch Dis Child. 2015;100:571- 5
DOI: 10.1136/archdischild-2014-306590
PMID: 25452315

9. Dysart K, Miller TL, Wolfson MR, Shaffer TH. Research in high flow therapy: mechanisms of action. Respir Med. (2009) 103:1400- 5
DOI: 10.1016/j.rmed.2009.04.007
PMID: 19467849

10. Coletti KD, Bagdure DN, Walker LK, Remy KE, Custer JW. High-Flow Nasal Cannula Utilization in Pediatric Critical Care. Respir Care. 2017 Aug;62(8):1023-1029.
DOI: 10.4187/respcare.05153
PMID: 28588119

11. Chang CC, Lin YC, Chen TC, Lin JJ, Hsia SH, Chan OW, Lee EP. High-flow nasal cannula therapy in children with acute respiratory distress with hypoxia in a pediatric intensive care unit-a single center experience. Front Pediatr. 2021 May 7;9:664180
DOI: 10.3389/fped.2021.664180
PMID: 34026694 PMCID: PMC8139340

12. Shah S, Kaul A, Bhosale R, Shiwarkar G. High Flow Nasal Cannula Therapy as a Primary Mode of Respiratory Support in a Pediatric Intensive Care Unit. Indian Pediatr. 2021 Jan;58(1):41-3
DOI: 10.1007/s13312-021-2095-8
PMID: 33034300

13. Wraight TI, Ganu SS. Ganu High-flow nasal cannula use in a paediatric intensive care unit over 3 years. Crit Care Resusc. 2015;17(3):197-201
DOI: 10.1016/S1441-2772(23)01488-6
PMID: 26282258

14. Asseri AA, Al Qahtani YA, Alhanshani AA, Ali GH, Alhelali I. Indications and safety of high flow nasal cannula in pediatric intensive care unit: retrospective single center experience in Saudi Arabia. Pediatric Health, Medicine and Therapeutics. 2021 Aug 31:431-7
DOI: 10.2147/PHMT.S321536
PMID: 34512073 PMCID: PMC8418355

15. Kamit Can F, Anil AB, Anil M, Zengin N, Durak F, Alparslan C, et al. Predictive factors for the outcome of high flow nasal cannula therapy in a pediatric intensive care unit: Is the SpO2/FiO2 ratio useful? J Crit Care. (2018) 44:436-44
DOI: 10.1016/j.jcrc.2017.09.003
PMID: 28935428

16. Junhai Z, Jing Y, Beibei C, Li L. The value of ROX index in predicting the outcome of high flow nasal cannula: a systematic review and meta-analysis. Respir Res. 2022 Dec;23(1):33
DOI: 10.1186/s12931-022-01951-9
PMID: 35177091 PMCID: PMC8851822,

17. Liu LL, Gallaher MM, Davis RL, Rutter CM, Lewis TC, Marcuse EK. Use of a respiratory clinical score among different providers. Pediatr Pulmonol. 2004;37:243-8
DOI: 10.1002/ppul.10425
PMID: 14966818

18. Bruce Ambuel. Assessing Distress in Pediatric Intensive Care Environments: The COMFORT Scale. Ournal Pediatr Psychol. Vol. 17, No. 1(1992,):95-109
DOI: 10.1093/jpepsy/17.1.95
PMID: 1545324