HIGH FLOW NASAL CANNULA THERAPY IN A PEDIATRIC INTENSIVE CARE UNIT FOR CHILDREN WITH RESPIRATORY DISTRESS WITH HYPOXIA –A RETROSPECTIVE COHORT STUDY

ABSTRACT

Background: A high-flow nasal cannula (HFNC) is a noninvasive respiratory support device that provides a heated and humidified air-oxygen mixture with airflows as high as 60 L/min and controlled inspired oxygen fractions (FiO2) from 21% to 100% through a nasal cannula inserted in both Nostrils. The basic principle of HFNC is to set a higher oxygen flow than inspiratory demand flow according to the clinical situation. This can lead washout of the upper airways, decreased nasal resistance, and reduced dead space. this study intends to elucidate its indications, efficacy and failure rates in children.

Objectives : To elucidate the indications for HFNC therapy in children of all ages and diagnoses and to evaluate the efficacy and risk Factors for failure of HFNC therapy in children with acute respiratory distress with hypoxia in a pediatric intensive care unit.

Methods: Retrospective cohort study was conducted at a tertiary pediatric intensive care unit between November 1 2023 and November 1 2024 All children from 1 month to 18 years of age with acute respiratory distress with hypoxia on HFNC therapy were eligible. Patient's demographic details, conditions for which HFNC was used, clinical course, vital parameters duration of HFNC, and outcome measures like escalation to higher O2 support or transition to low O2 support were noted.

Results: Out of 325 children, 75 met the eligibility criteria for the study, of whom 51 (68%) were male 24 (32%) were female, and the mean age was 2-3 years. 21 (28%) of the children had underlying disorders. The most common indications for HFNC include: Lobar Pneumonia: 16 cases Bronchiolitis: 13 cases, Sepsis: 9 cases, Acute Exacerbation of Asthma: 9 cases, Poisoning (various types): 4 cases rest included Other conditions . Average Duration of HFNC Therapy: 2-4 days. 57 patients were

downgraded to LFNC and 8 patients were upgraded to higher oxygen support with the failure rate of 10.6% (8 of 75 children) all patients were discharged and there was no in patient mortality.

Conclusions: HFNC therapy could be initiated as The first-line therapy for various etiologies of acute respiratory distress with hypoxia in A pediatric intensive care unit and for all age groups ,HFNC could Serve as noninvasive respiratory support for acute respiratory distress or Post extubation management, and reduce the chances of intubation and ventilator associated pneumonia (VAP).

Keywords: HFNC, Acute Respiratory Distress, ROX score

Introduction:

Acute respiratory distress is a common diagnosis among children admitted to paediatric Intensive care units. This heterogeneous disorder has numerous pulmonary and non-pulmonary causes and is Associated with a significant risk of mortality. Invasive mechanical ventilation is an established effective supportive therapy for acute respiratory distress. However, it is associated with increased risks of nosocomial infections, lung and airway injuries, length of stay and sedation-related complications[1-3]. High-flow nasal cannula (HFNC) is a relatively safe and effective Non invasive ventilation method that was recently accepted as a treatment option for acute respiratory support before endotracheal intubation or invasive ventilation[4-7].

HFNC stands for heated humidified HFNC oxygen therapy. Adjustable (FiO2 21%–100%) heated (34°C–37°C) oxygen with nearly 100% relative humidity can avoid mucosal injury and patient discomfort from cold, dry air. Heated humidification can encourage the clearance of secretions and reduce bronchoconstriction. Basic principle of HFNC is to set a higher oxygen flow than inspiratory demand flow according to the clinical situation. This can lead washout of the upper airways, decreased nasal resistance, and reduced dead space[8-10].

Objectives:

1. To elucidate the indications for HFNC therapy in children of all ages and diagnoses.

2.To evaluate the efficacy and risk Factors for failure of HFNC therapy in children with acute respiratory distress with hypoxia in a pediatric intensive care unit.

Materials and Methods:

After obtaining approval from institutional ethics committee study was conducted.

Type of study:

Retrospective cohort study.

- **Place of study**:

The study was conducted in the department of Paediatrics, Akash institute of medical sciences and research Centre, Devanahalli, Bangalore.

- **Duration of study**:

The study was conducted from November 1 2023 to November 1st 2024.

Inclusion criteria: All children, from 1 month to 18 years of age, with acute respiratory distress with hypoxia who were put on HFNC therapy were eligible.

- Acute respiratory distress was defined as hypoxemia ($SpO_2 < 94\%$) and signs of respiratory distress despite standard-flow oxygen therapy. All patients received standard-flow oxygen therapy.

- The signs of respiratory distress included increased breathing rate and heart rate, color changes, grunting , nose flaring, retractions, wheezing, and sweating

Exclusion criteria:

1)all children below 1 month and more than 18 years.
2)children who are on low flow oxygen supply.
3) children who are on long term ventilatory support.
4) patient who went on Discharge against medical advice.

Sample collection:

- 75 consecutive children aged from 1 month to 18 years who were admitted in our pediatric intensive care unit and fulfilled the inclusion criteria were studied.

Methodology:

- Detailed Clinical information were collected which included detailed history, significant past history, vitals at admission, those patients who had respiratory distress with hypoxia were investigated with ABG analysis and recorded.
- Before starting HFNC appropriate HFNC cannula size was chose that is cannula not covering more than 50% of nares size, because of unexpected increase in airway pressure and air leakage.
- Flow settings were kept between 0 to 15kg at 2 L/ kg,16-30kg upto 35 L,31-50kg upto 40L,and above 50 kg >50 L and humidification was maintained between 34-37C.
- Those with respiratory distress with hypoxia on low flow oxygen therapy were started on HFNC therapy serial vitals monitoring done, clinical improvement noted, watched for worsening of parameters.
- HFNC settings were set accordingly with clinical examination and saturation.
- Duration of HFNC, minimum HFNC settings and maximum HFNC settings were noted along with baseline clinical parameters were noted, and later clinical parameters during initial HFNC hours and late HFNC hours were noted and recorded.
- Final outcomes like transition from HFNC to low flow oxygen or transition to higher oxygen support (intubation or noninvasive ventilation) were noted

Indications for HFNC
Lobarpneumonia,bronchopneumonia,bronchiolitis,asthama,sepsis, others

Failure of standard oxygen therapy(nasal prongs 1-5 L, oxygen mask 6-10 L,NRB mask) that is no improvement in clicical parameters,spo2 <94%

Baseline parameters noted	**Respiratory rate, heart rate, saturation, nasal flare, retractions, VBG,spo2/fio2,ROX score**

Settings of HFNC	**Nasal cannula-1/2 nostril diameter,** **Humidification-34 to 37deg C** **SPO2 -94 TO 97%** **Flow rate-0-15kg :2L/Kg,16-30kg:35L,31-50Kg:40L**

Monitoring of vitals ,clinical parameters and systemic examination

OUTCOME

SUCCESS	**FAILURE**
Clinical improvement **Changed to low flow oxygen support.**	**Worsening of parameters** **Upgraded to high flow oxygen support.** **(Mechanical Ventilation)**

Ethical Considerations:

The study was conducted in accordance with ethical guidelines, and approval was obtained from the institutional Ethics committee.

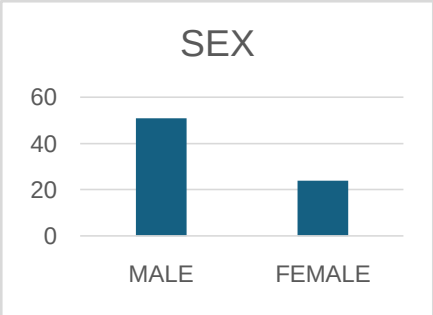
Informed consent was obtained from the parents or guardians of all participating patients.
Confidentiality of patient information was maintained throughout the study

Data analysis:

The patients' characteristics including demographic and HFNC utilization data are presented as percentage (%) or mean ± standard deviation (SD). We divided the patients into two groups: HFNC respiratory support success, and HFNC respiratory support failure. Between-group differences were analysed using the chi-square test or Fisher's exact test for categorical variables, and the Student's t-test for normally distributed continuous variables. The Mann-Whitney test was used for non-normally distributed data. Associations with outcomes between the success and failure groups were determined using univariate analysis. Receiver operating characteristic (ROC) curves for the initial and lowest S/F ratio were plotted to predict the failure of HFNC respiratory support. The respective areas under the ROC curves and cut-off values were calculated. Statistical analysis was performed using SPSS software, version 23.0. A two-sided $p < 0.05$ was considered to be statistically significant.

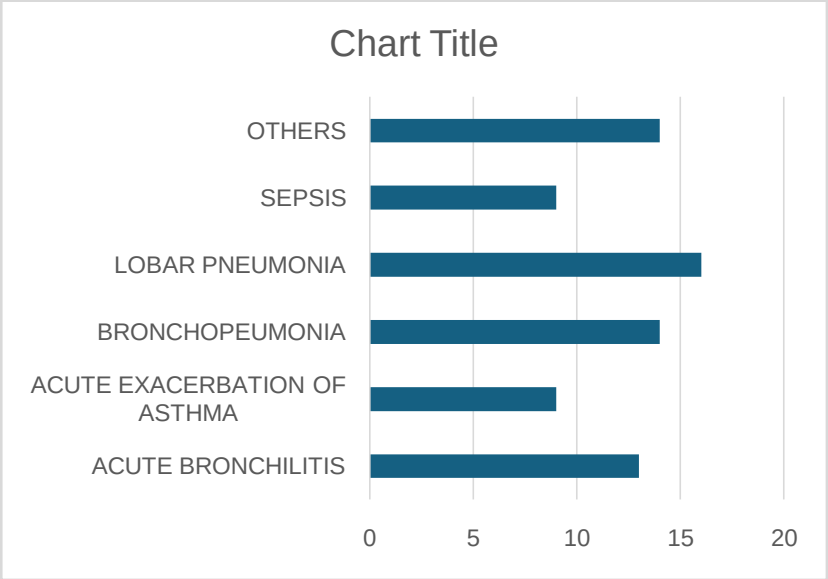
Results:

Out of 325 children 75(23%) children with acute respiratory distress were managed with HFNC therapy during their paediatric ICU stay. 51 (55.9%) of the 75 children were male and 24 of them were female, 21(28%) of the 75 children had an underlying medical history. The most common underlying medical history was a neurologic disorder(8), followed by asthma/history of wheezing(7), heart disorder(3) , malignancy(2) and others(2) causes.



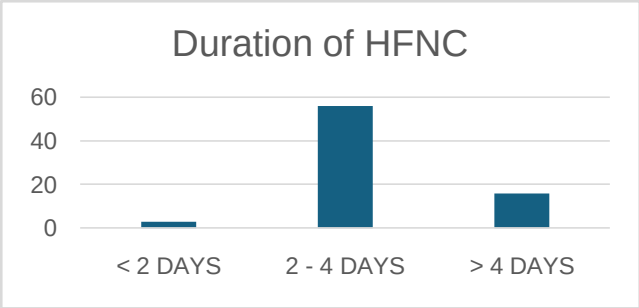
Graph 1.

The most common indications for which HFNC therapy used were Lobar pneumonia 16 (21.3%), followed by bronchopneumonia 14(18.67%) and Acute bronchiolitis 13(17.3%) and other causes 14(18.67%) which included CHD with Respiratory Distress (4), Epilepsy Disorder with sepsis (3), Yellow phosphorus poisoning (3), Dengue shock with pleural effusion (3) and empyema (1) .



Graph 2

As we can see in graph duration of HFNC that is between 2-4 days was the most common duration of HFNC therapy among cohorts few required more than 4 days of therapy .



Graph 3

Table 1

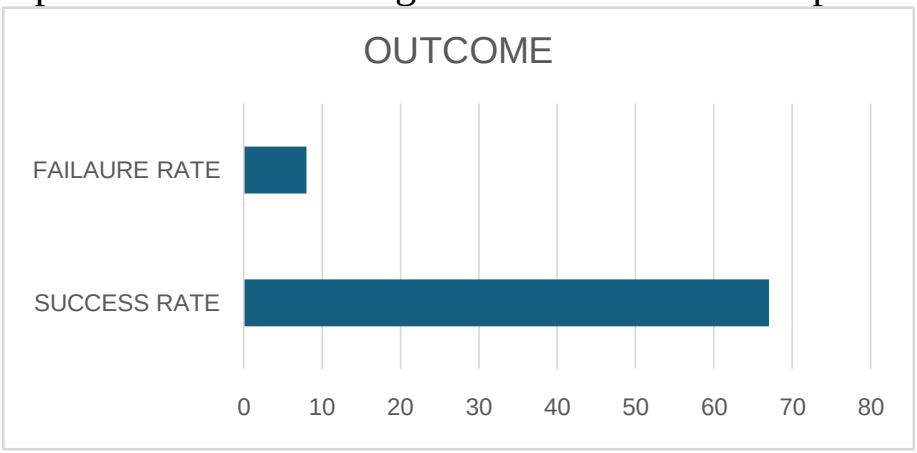
Characterstics	total	success	failure
SEX			
male	**51**	**45**	**6**
female	**24**	**22**	**2**
AGE GROUP			
<23 months	**25**	**22**	**3**
2-4 years	**28**	**26**	**2**
5-12 years	**16**	**14**	**2**
13-17 years	**6**	**5**	**1**
INDICATIONS REQUIRED HFNC			
Lobar pneumonia	**16**	**15**	**1**
Bronchopneumonia	**14**	**12**	**2**
Acute Exacerbation of Asthma	**13**	**13**	**0**
Acute bronchiolitis	**9**	**9**	**0**
Sepsis related Respiratory Distress	**9**	**9**	**0**
Other conditions	**14**	**9**	**5**

There were significant improvements in clinical parameters following HFNC therapy like heart rate, respiratory rate and spo2, Retractions were also noted were reduced significantly. Ph, po2 and pco2 levels were measured before and after HFNC therapy there was significant improvement in late HFNC and baseline values.
There was significant improvement in scores like spo2/fio2 after HFNC therapy scores with high spo2/fio2 were went into failure HFNC were upgraded in them.
Cases with high ROX (spo2/fio2/RR)scores had more success rate.

Outcomes

Among 75 patients receiving HFNC therapy 57 were reduced to low flow oxygen therapy like traditional nasal canula (1-5L), oxygen mask (6-10L),8 were desaturated were escalated to higher oxygen support like noninvasive ventilation or intubation.

All the patients were discharged and There was no inpatient mortality.



Graph 4

DISCUSSION

In this retrospective study, we described the use of HFNC for children with acute respiratory distress at a tertiary paediatric ICU over a 12 months period.

We focused on HFNC as the first-line therapy for various aetiologies of acute respiratory distress with hypoxia and for all age groups.

75 patients met the eligibility criteria for the study, and the failure rate was only 10.6% (8 of 75 children).

In addition, there were no cases of air leak syndrome or epistaxis with HFNC therapy,

HFNC therapy has been used in infants with respiratory distress syndrome and infants with bronchiolitis.it has been shown to decrease respiratory distress and intubation rates, increase patient comfort and ease of use compared with face masks or traditional cannulas, and shorten the length of stay in paediatric intensive care units[12-15].

Therefore, HFNC therapy appears to be a safe and effective method of non-invasive respiratory support. Data collected at baseline revealed that the failure group had significantly higher initial and maximum FiO2 levels than the success group.

Roca et al. proposed an easy bedside tool using SaO2, FiO2 and respiratory rate to predict the success or failure of HFNC therapy, known

as the ROX index, in this study there was correlation between ROX index and success rate ie higher the score more is the success rate.
Kamit et al. reported that a lower SpO2/FiO2 (S/F) ratio at admission was a predictor of HFNC failure, and that achieving S/F > 200 at 60min significantly predicted successful HFNC therapy in our study we found similar results.
Abboud et al. retrospectively analysed children with viral bronchiolitis who failed HFNC (needing intubation) compared to children who were successfully treated with HFNCs, and found that improved respiratory rate and clearance of repeat pCO2 were predictors of success . In our study, higher initial and maximum FiO2 levels and increased RR and lowest S/F ratio were early and possible signs of failure requiring escalation of respiratory support.
Hence every treating doctor must be aware of these findings for successful results.

LIMITATIONS

- This is a retrospective study with a limited cohort of children with acute respiratory distress receiving HFNC therapy
- This is single centre study.
- Broad age groups with a small number of cases may further limit the findings of this study.
- HFNC has been reported to fail to offer adequate PEEP, even at higher flows, for patients with moderate to severe acute respiratory distress syndrome.

CONCLUSION

- HFNC was used frequently over the 12 months study period for children with a wide range of ages and for a variety of indications. We found that HFNC could be initiated as the first-line therapy all age groups of children with various aetiologies of acute respiratory distress in our paediatric ICU. Reduce chances of intubation and its complications like ventilator associated pneumonia and sedation related complications.
- Further prospective studies are needed to confirm the efficacy of HFNC therapy and to evaluate the risk factors of failure in different settings.

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