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RESEARCH ARTICLE

HIGH-FLOW NASAL CANNULA THERAPY IN PAEDIATRIC RESPIRATORY DISTRESSWITH HYPOXIA - A RETROSPECTIVE COHORT STUDY

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Abstract

Background: A high-flow nasal cannula (HFNC) is a non-invasive respiratory support device that provides a blend of air-oxygen mixture which is heated and humidified which delivers flow as high as 60 L/min and can deliver oxygen fractions (FiO2) from 21% to 100% through a nasal cannula. The main motto of HFNC is to set a higher oxygen flow than inspiratory demand flow according to the clinical situation. The advantages over other non-invasive modalities are this will lead to washout of the upper airways, decreases dead space and nasal resistance, 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 Paediatric acute respiratory distress with hypoxia in PICU.

Methods: Retrospective cohort study was conducted at a tertiary paediatricintensive care unit between November 1 2023and 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

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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 aetiologies of acute respiratory distress with hypoxia in a paediatric intensive care unit and for all age groups, HFNC could Serve as non-invasive respiratory support for acute respiratory distress or Postextubation management, and reduce the chances of intubation and ventilator associated pneumonia (VAP).

Introduction:-

Acute respiratory distress is the leading cause among children admitted to paediatric Intensive care units. This condition has various pulmonary and non-pulmonary causes and isAssociated with a significant risk of mortality. Invasive mechanical ventilation is used as a supportive management However, it is associated with increased risks ofHospital Acquired infections, lung and airway injuries, length of stayand sedation-related complications. High-flow nasal cannula (HFNC) is accepted as a potent, safe and effective Non-invasive ventilation method over invasive ventilation or endotracheal intubation.

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. This HFNC therapy will help in clearance of secretions and reduce bronchoconstriction. Basic principle of HFNC is to deliver a high flow of oxygen than inspiratory demand according to the clinical situation. The advantages over other non-invasive modalities are This will lead to washout of the upper airways, decreases dead space and nasal resistance.

Objectives: -

1.To elucidate the indications for HFNC therapy in children from 1 month to 18years of age.
2.To evaluate the efficacy and risk Factors for failure of HFNC therapy in Pediatric acute respiratory distress with hypoxia in a pediatric intensive care unit.

Materials and Methods: -

After obtaining approval from institutional Ethical committee study was conducted. Informed consent was taken from either parents or guardians of the patients.

Type of study:
Retrospective cohort study.

Place of study:
The study was conducted in the department of Paediatrics under Paediatric Intensive Care Unit (PICU), Akash institute of medical sciences and research Centre, Devanahalli, Bangalore.

Duration of study:
The study was conducted from November 1 2023 to November 1st2024.

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.

1. Acute respiratory distress was defined as hypoxemia (SpO2 < 94%) and signs of respiratory distress despiteon standard-flow oxygen therapy.
2. The signs of respiratory distress included increased breathing rate and heart rate, colour 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 paediatric intensive care unit and fulfilled the inclusion criteria were studied.

Methodology: -

1. Detailed Clinical information was collected which included detailedhistory,significant past history, vitals at admission,those patients who had respiratory distress with hypoxia were investigated with ABG analysis and recorded.
2. 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.
3. Flow settings were kept between 0 to 15kg at 2 L/ kg,16-30kg up to 35 L,31-50kg upto 40L, and above 50 kg >50 Land humidification was maintained between 34-37C.
4. 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.
5. HFNC settings were set accordingly with clinical examination and saturation.
6. Duration of HFNC,minimum HFNC settings and maximum HFNC settings were noted along with baseline clinical parameters were noted, and later clinical parameters during initialHFNC hours and late HFNC hours were noted and recorded.
7. Final outcomes like transition from HFNC to low flow oxygen or transition to higher oxygen support(intubation or non-invasive ventilation) were noted

Indications for HFNC
Lobar pneumonia,bronchopneumonia,bronchiolitis,asthma,sepsis, others

Failure of standard oxygen therapy (nasal prongs 1-5L, oxygen mask 6-10 L,NRB mask) that is no improvement in clinical 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)**

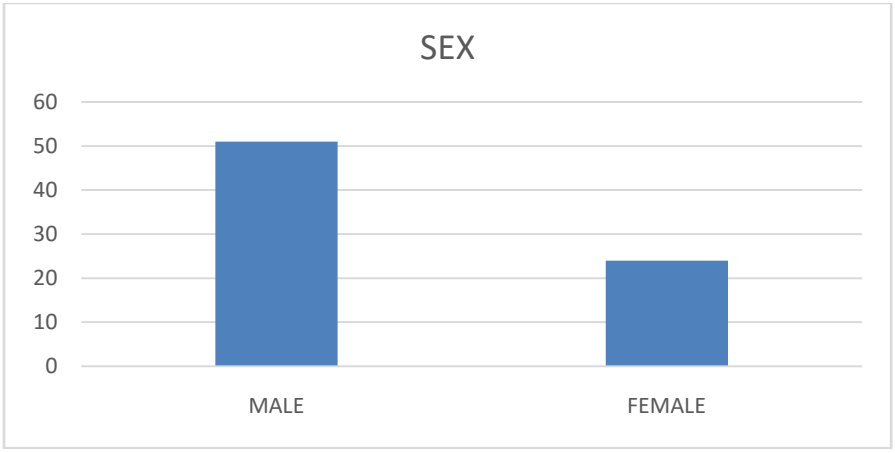
Ethical Considerations:
The study was conducted in accordance with ethical guidelines, and approval was obtained from the institutional Ethics committee. Informed consent was obtained from the parents or guardians of all participating patients.

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 intotwo groups: HFNC respiratory supportsuccess, and HFNCrespiratory support failure. Between-group differences wereanalysed using the chi-square test or Fisher's exact test forcategorical variables, and the student's t-test for normallydistributed continuous variables. The Mann-Whitney testwas used for non-normally distributed data. Associationswith outcomes between the success and failure groups weredetermined using univariate analysis. Receiver operatingcharacteristic (ROC) curves for the initial and lowest S/F ratiowere plotted to predict the failure of HFNC respiratory support.The respective areas under the ROC curves and cut-off valueswere calculated. Statistical analysis was performed using SPSSsoftware, version 23.0. A two-sided $p < 0.05$ was considered to be statistically significant.

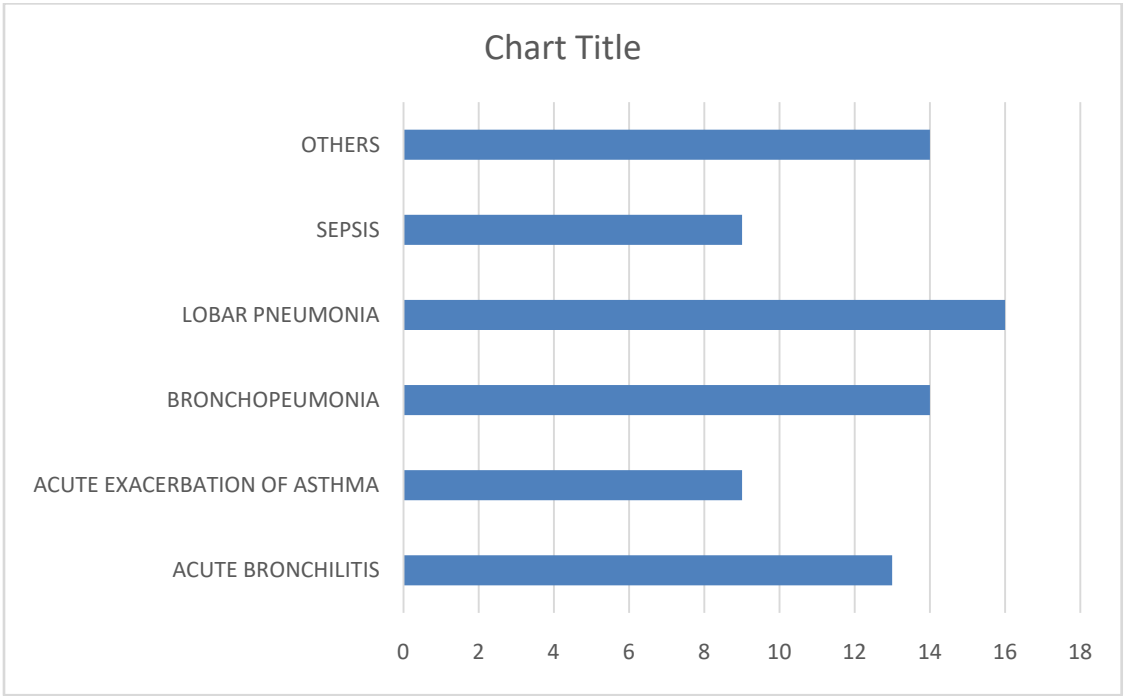
Results: -

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 underlyingmedical history. The most common underlying medical historywas a neurologic disorder (8), followed by asthma/history of wheezing (7), heart disorder (3), malignancy (2) andothers (2) causes.



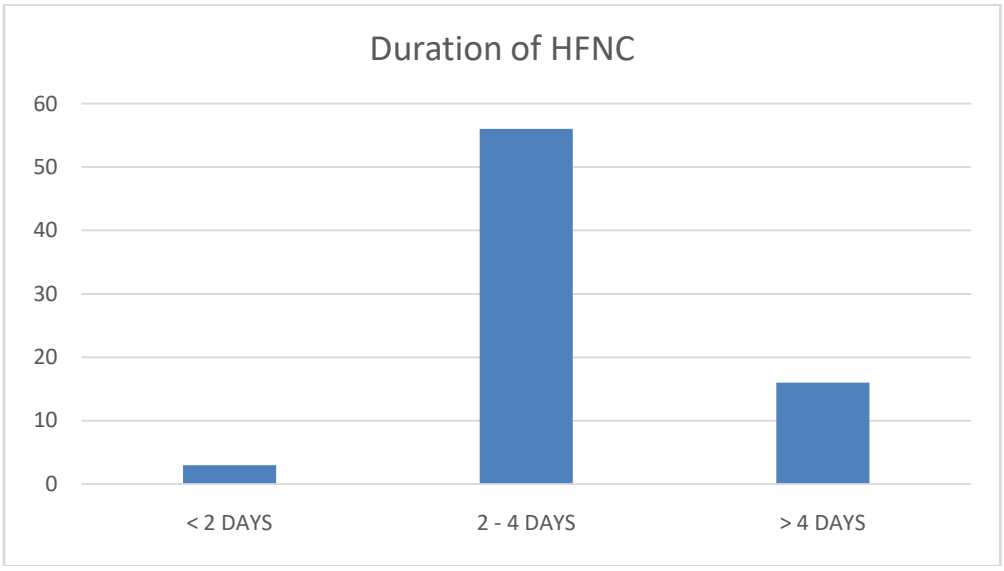
Graph 1:-

The most common indications for which HFNC therapy used wereLobar pneumonia 16 (21.3%), followed by bronchopneumonia 14(18.67%) and Acutebronchiolitis 13(17.3%) and othercauses14(18.67%) which includedCHD 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:-

Characteristics	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,these parameters were reduced significantly after therapy. Ph, po2 and pco2 levels were measured before and after HFNC therapy there was significant improvement in late HFNC and baseline values.

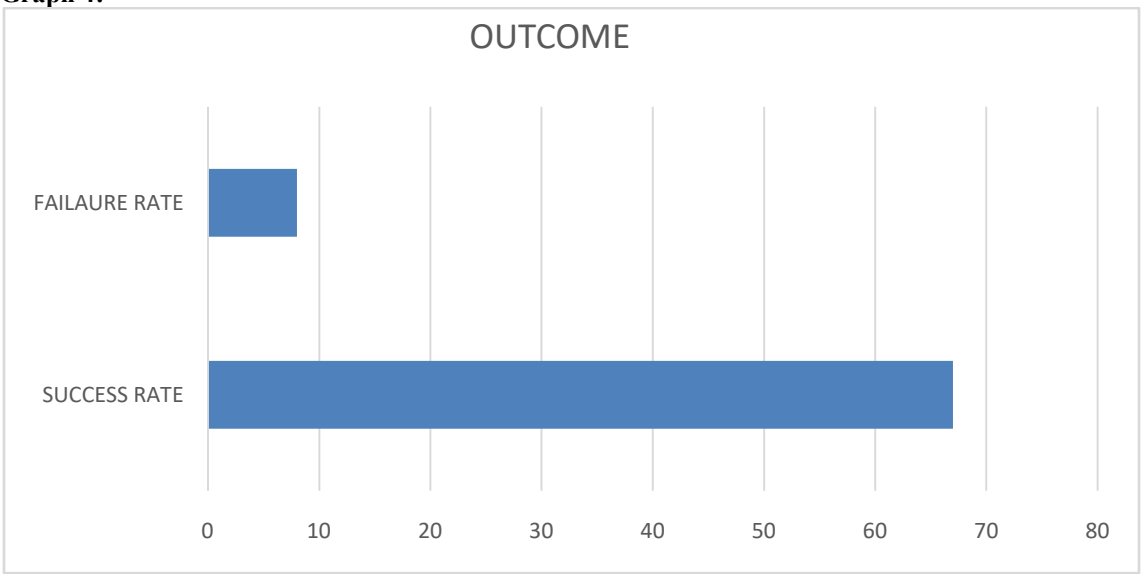
There was significant improvement in scores like spo2/fio2 after HFNC therapy.
Scores with high initial spo2/fio2 were went into failure HFNC were upgraded in them.
Cases with high ROX (spo2/fio2/RR) scores had more success rate.

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:-

This 12 month period Retrospective study described the functions and indications of HFNC in PICU.

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 syndromeor epistaxis with HFNC therapy,

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

Therefore, HFNC therapyappears to be a safe and effective method of non-invasive respiratory support.
Roca et al.proposed an easy bedside tool using SaO2, FiO2 and respiratoryrate to predict the success or failure of HFNC therapy, knownas the ROX index, in this study there was correlation between ROX index and success rate ie higher the score more is the success rate.
As described by kamit et al 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 predictedsuccessful HFNC therapy in our study we found similar results.
Abboud et al.retrospectively analysed children with viral bronchiolitis whofailed HFNC (needing intubation) compared to children whowere successfully treated with HFNCs, and found that improvedrespiratory rate and clearance of repeat pCO2 were predictorsof success .
In this study, higher initial and maximumFiO2 levels and increased RR and lowest S/F ratio were earlyand possible signs of failure requiring escalation of respiratorysupport that is ventilation.

Limitations:-

1. This is a retrospective study with minimal sample size
2. This is single centre study.
3. Lack of control group is another limitation where there is no comparison to study its efficacy.
4. Broad age groups with a small number of cases may further limit the findings of this study.
5. Short follow up where long-term outcomes are not evaluated.

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 It Reduced 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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