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Original Research Article

A Cross-Sectional Assessment of the Efficacy and Safety of High Flow Nasal Cannula Therapy (HFNC) as Primary Mode of Treatment for Children with Respiratory Distress

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Abstract

Objective: To assess efficacy and safety of High flow nasal cannula therapy (HFNC) as primary mode of treatment for children with respiratory distress.

Material & Methods: This cross-sectional study was undertaken at Department of Pediatrics, SKMCH, Muzaffarpur, Bihar, India over a period of one year. Consecutive patients with respiratory distress necessitating admission to PICU, in the age group of 1 month to 16 years of age were included. Children requiring immediate noninvasive (NIV) or invasive ventilation and those with contraindications to HFNC, altered sensorium (GCS<12), apnea and catecholamine resistant shock were excluded.

Results: A total of 220 (100 girls) children were commenced on HFNC therapy. HFNC failure occurred in 20 (9.0%) children at a median (IQR) time of 2 (1.43-21) hours.

Conclusion: HFNC is an effective and safe primary mode of respiratory support in children with respiratory distress. Children who succeed on HFNC show a favorable clinical response within first few hours.

Keywords: Comfort score, Mechanical ventilation, Non-invasive ventilation, SaO2/FiO2 ratio.

Introduction

Acute respiratory distress is the most common cause of pediatric intensive care unit admission. 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 cannulas (HFNCs) are an increasingly used form of non-invasive respiratory support, and they have shown potential in reducing the need for intubation [4-7]. Recently, high-flow nasal cannula(HFNC) therapy has become a popular alternative due to easeof use, perceived greater patient comfort, and the ability to discharge children to general wards while receiving HFNC. [8]

An international survey of 1031 PICU clinicians from 40 countries showed that HFNC is commonly used following extubation, [9] and in observational studies, between 5% and 86% of children started treatment with HFNC following extubation. [10-11]

Retrospective studies have shown that HFNC is useful for conditions like bronchiolitis, asthma, pneumonia and congenital heart disease. The evidence for its safety or usefulness in children is limited [12]. There is paucity of prospective clinical trials on the effectiveness of HFNC in respiratory failure (not due to bronchiolitis) in pediatric intensive care unit (PICU).

This study aimed at assessing the efficacy and safety of HFNC as a primary mode of treatment in respiratory distress in children.

Material & Methods:

This cross-sectional study was undertaken at Department of Pediatrics, SKMCH, Muzaffarpur, Bihar, India over a period of one year. Consecutive patients with respiratory distress necessitating admission to PICU, in the age group of 1 month to 16 years of age were included. Children requiring immediate non-invasive (NIV) or invasive ventilation and those with contraindications to HFNC, altered sensorium (GCS<12), apnea and catecholamine resistant shock were excluded.

Methodology

Respiratory distress was defined as hypoxia (SpO2<94% in room air), tachypnea (as per age) and increased work of breathing (chest wall retractions, use of accessory muscles of breathing and nasal flaring/grunting). HFNC was started as the first line treatment if all the above clinical signs were present. Primary outcome measure was need for 'NIV' or invasive ventilation.

Bronchiolitis was defined as a clinical syndrome of respiratory distress in children less than two years with rhinorrhea followed by lower respiratory infection resulting in wheezing and crept. Children with fever, respiratory distress, tachypnea and infiltrates on chest radiograph were classified as pneumonia. Children with fever, respiratory distress, and tachypnea and chest signs of wheezing and crept but without infiltrates on chest radiograph were classified as LRTI with wheeze.

A respiratory clinical score with the following parameters was calculated: age specific respiratory rate scores 0 to 3, retractions 0 to 3, dyspnea 0 to 3, and wheeze 0 to 3. Total score ranged between 0 for normal and 12 at the extremes [13]. FiO2 was adjusted to keep arterial oxygen concentration between 92-97% to calculate saturation to FiO2 (SF) ratio. HFNC tolerance was assessed using modified COMFORT scale [14]. The scale estimates eight parameters with a 1 (low) to 5 (high) score: alertness, calmness, respiratory response, physical movement, mean arterial pressure, heart rate, muscle tone, and facial tension. The total score can range between 8-40 (score of 17-26 suggesting good comfort).

Respiratory clinical score, SF ratio and modified COMFORT score were calculated before starting HFNC treatment, at 60 to 90 minutes and 12-24 hours afterward. HFNC system (Fisher and Paychex Healthcare, New Zealand) with junior circuit 900PT501 was used. Infant OPT316 or Pediatric OPT318 nasal prongs were selected as per child's age. Flow was initiated at 1-2 L/kg/min for infants and 1 L/kg/min for pediatric patients and adjusted according to patient response and tolerance (max 2 L/kg/ min). Failure on HFNC was defined as need for NIV or invasive ventilation, when clinical deterioration was present. Criteria for intubation were respiratory arrest, refractory hypoxia (SpO2 <90% on 100%

FiO2), exhaustion due to increased work of breathing and inability to protect airway. Criteria for switching to NIV were left to discretion of the attending intensivist.

Statistical analyses were performed using IBM SPSS 23 version (IBM 2015), and significance was assessed at 0.05 level. Comparisons between two groups were made using independent sample Mann Whitney U test and Kruskall Wallis test for continuous measurements. Univariable and multivariable Cox regression models were used to assess the association of HFNC failure with various clinical parameters.

Results:

A total of 220 (100 girls) children were commenced on HFNC therapy. HFNC failure occurred in 20 (9.0%) children at a median (IQR) time of 2 (1.43-21) hours. Clinical characteristics of responders and non-responders to HFNC are presented in **Table I**.

In univariate regression analysis, respiratory clinical score [Hazard ratio (95% CI) 4.2 (2.0-12.3), *P*=0.001]; SF ratio [HR (95% CI) 0.87 (0.93-0.97), *P*=0.011]; and

Table 1: Characteristics of Children as per Response to High Flow Nasal Cannula (HFNC)

	HFNC responders (n=100)	Non-responders (n=20)	P value
Age, n (%)			
<6 mo	38	6	0.01
6-23 mo	60	6	0.001
2-5 y	73	8	0.001
6-12 y	15	5	0.001
13-16 y	2	0	0.001
Diagnosis, n (%)			
Bronchiolitis	87	1	0.001
Pneumonia	62	10	0.001
LRTI with wheezing	72	1	0.001
Acute severe asthma	100	0	0.001
Congenital heart disease 7 (100)		0	0.001
Septic shock	80	4	0.001
Others	100	0	0.001
FiO2 (%)[a]	41	61	0.06
Flow (L/min)[a]	14	14	0.37
PIM2 score (%)[a]	2.5	6	0.01
Mortality	0	3 (17.6)	0.001
Duration of HFNC (h) [a] 48 (41-75)		2	0.001
Respiratory clinical score[a]			
On admission	8	11	0.001
At 60-90 min	8	11	0.001
At 12-24 h	6	11	0.001
SF ratio[a]			
On admission	301 (260-339) 255 (230-320)		0.03
At 60-90 min	342 (272-332) 232 (221-278) ≤0.001		

At 12-24 h COMFORT score[a]	351 (318-370) 251 (199-261) ≤0.001
On admission	26 (30-36) 38 (30-38) ≤0.001
At 60-90 min	26 (26-33) 30 (31-39) ≤0.001
At 12-24 h	24 (25-28) 33 (31-37) ≤0.001

Discussion:

HFNC was effective in preventing intubation in children with respiratory distress in the present study with low failure rate in patients with various respiratory etiologies. The low failure rate on HFNC could be because was started relatively early and preemptively, even in cases of mild to moderate illness.

Patients with shock were also managed successfully on HFNC in this study. The contribution of HFNC in recovery of these patients cannot be quantified since multimodal monitoring and management plays a more important role. However, HFNC helps in decreasing work of breathing in these patients by maintaining functional residual capacity.

Kelly et al. also reported the use of HFNC therapy in 496 children with respiratory distress in the emergency department, including 46% with bronchiolitis, 28% with pneumonia and 8% with asthma. They reported that 8% of the cases failed therapy and required intubation with mechanical ventilation following HFNC therapy [15].

The master protocol efficiently allowed the comparison of HFNC and CPAP in 2 distinct patient populations (acute respiratory failure and postextubation) within the same trial infrastructure. FIRST-ABC was designed as a noninferiority trial, similar to previous RCTs of HFNC, [16-17] rather than a superiority trial, because clinicians indicated willingness to tolerate some additional time to liberation in return for greater patient comfort and ease of use for HFNC. [18] The trial findings were consistent across the primary, subgroup, and sensitivity analyses and clearly showed that HFNC failed to meet noninferiority.

There are no agreed core outcome sets for pediatric respiratory support trials. Treatment failure has been used as the primary outcome in RCTs of HFNC in preterm newborns and bronchiolitis. However, its definition varies between trials; and, in real-world practice, because patients are frequently rescued after treatment failure, it does not usually translate to changes in patient-centered outcomes. [19-21] Although RCTs in adults have focused on reintubation, fewer than 1 in 8 extubated children required reintubation in this trial, and those not reintubated also spent a long time receiving noninvasive respiratory support before achieving unassisted breathing. [22]

Conclusion:

HFNC is an effective and safe primary mode of respiratory support in children with respiratory distress. Children who succeed on HFNC show a favorable clinical response within first few hours.

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