Original Article

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# Analysis of the Profile and Outcome of Children those Received Oxygen Support through High-flow Nasal Cannula in a Rural Medical College Hospital

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## Abstract

**Background:** Oxygen therapy remains the first-line intervention for children admitted with respiratory distress. Heated humidified high-flow nasal cannula (HHHFNC) oxygen therapy represents a new alternative to conventional oxygen therapy. HFNC generates flows up to 60 L/min, yet using a nasal cannula as an interface to the patient. Heating and humidification of gas mixtures allow comfortable delivery of flow rates that match or exceed the patient's inspiratory flow rate.

**Materials and Methods:** Children with moderate to severe respiratory distress admitted over a period of 1-year from January 2014 to December 2014.

**Results:** Out of 52 children, who received humidified high-flow oxygen therapy, 40 (76.92%) were infants below 1 year of age. 31 (59.62%) children were males. The major cause for respiratory distress needing initiation of oxygen therapy with high-flow nasal cannula is respiratory cause contributing to 69.23% followed by cardiac causes which contribute 13.46% of cases who received humidified high-flow nasal oxygen. Among the respiratory system diseases, bronchopneumonia is the leading cause which makes 52.78%. Moreover, 28 children (53.85%) received humidified high-flow nasal oxygen therapy for a total duration of 1-4 days. 40 (76.92%) children recovered completely and did not need any further intervention in the form of ventilation or referral to higher center. 9 (17.31) failed therapy and required intubation.

**Conclusion:** Use of HHHFNC for oxygen administration is feasible for infants with moderate-severe bronchiolitis in a general pediatric ward. HHHFNC therapy provided efficient respiratory support and oxygen delivery in infants with respiratory distress in our Paediatric Intensive Care Unit, and its introduction coincided with a significant reduction in the need for intubation of infants with viral bronchiolitis.

**Key words:** Children, Heated humidified high-flow nasal cannula, Oxygen, Respiratory distress, Rural medical college hospital

## INTRODUCTION

Administration of supplementary oxygen forms an essential part of the management of respiratory distress. Nasal cannulae are a well-established mode of delivery of oxygen therapy, but the amount of oxygen that can be delivered has traditionally been limited by poor tolerance of flow rates >2 L/min in children. The heating (to body temperature) and humidification (to >99% relative humidity) of oxygen and air mixtures allow comfortable delivery at flow rates which match or exceed the patient's inspiratory flow rate, thus limiting entrainment of room air. This is known as heated humidified high-flow nasal cannula (HHHFNC) therapy.

In addition to improving oxygenation, HHHFNC therapy may improve the efficiency of ventilation, reduce work of breathing, and avoid the need for intubation.[1-3] Furthermore, the inspired oxygen concentration can be titrated to the patient's need; anecdotally, it is better

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tolerated by the patient; and potentially, continuous positive airway pressure can be delivered.[1,4-6]

There is currently no single, simple definition of high flow. In infants, it usually refers to the delivery of oxygen or an oxygen/room air blend at flow rates >2 L/min.[7] Some authors adjust the flow rates on body weight and recommend using 2 L/kg/min, which provides a degree of distending pressure[8-10] and reduces the work of breathing.[11] In children, flow rates >6 L/min are generally considered high flow.[12] High flow presents several advantages over conventional "low-flow" oxygen therapy in terms of humidification, oxygenation, gas exchange, and breathing pattern.

It is proposed that HHHFNC therapy reduces work of breathing and improves efficiency of ventilation through several mechanisms as follows:[1]

- Washout of nasopharyngeal dead space leading to improved alveolar ventilation
- Reduction in the inspiratory resistance associated with the nasopharynx
- Improvement in conductance and pulmonary compliance by supplying adequately warmed and humidified gas
- Reduction in metabolic work associated with gas conditioning
- May provide positive distending pressure for lung recruitment.

Despite the advantages of this technique, the quality of the literature dealing with a pediatric population remains poor. The Cochrane Library deemed that no study was able to provide indications and guidelines for HHHFNC therapy in pediatric patients with a high level of evidence.8 Similar conclusions were expressed about the use of HHHFNC in the specific situation of infants with acute viral bronchiolitis.[13] In 2014, recommendations are still based on extrapolations from observational or physiological studies but not on evidence. For clinical practice, HHHFNC seems feasible in most of the populations currently managed with noninvasive ventilation, and sometimes, it appears to be better tolerated.

The objective of this study was to analyze the profile and outcome of children who were given high-flow humidified oxygen therapy as the first line therapy in a rural medical college hospital.

## MATERIALS AND METHODS

### Study Center

This study was conducted in the Paediatric Intensive Care Unit (PICU) of a Rural Medical College Hospital, which is equipped with a high-flow heated humidified nasal cannula machine and 2 ventilators with 24 h monitoring by 1 Assistant Professor, 1 Senior Resident, 1 Junior Resident, and 2 Staff Nurses.

### Sampling

This was a retrospective study conducted for 1-year from January 2014 to December 2014. The data were compiled from the information entered in the high-flow nasal cannula utility register and nominal registers. All the children who were given initiation of oxygen therapy with humidified high-flow nasal cannula for moderate to severe respiratory distress were included in the study. The method of assessment of severity of respiratory distress was adapted from the World Health Organization management of acute respiratory tract infections in children (Table 1). The parameters analyzed were age and sex of the children who received HHHFNC therapy, etiology of respiratory distress, duration of oxygen therapy through high-flow nasal cannula, and outcome of the intervention. The results were analyzed by tabular columns.

## RESULTS

A total of 52 children had received humidified high-flow nasal oxygen therapy as the initial method of oxygen supplement for treating respiratory distress during the study period of 1-year. Out of them, 40 were infants that make 76.92% and 12% children were more than or equal to 1 year of age making 23.08% of the children received HHHFNC therapy (Table 2).

Among these 52 children, 31 were males and 21 were females contributing 59.62 and 40.38, respectively (Table 3).

On analyzing the etiology for the respiratory distress, we found 36, out of 52 cases, were respiratory system disorders. So, 69.23% of the cases received HHHFNC therapy because of respiratory system pathologies. 7 cases (13.46%) were having cardiac diseases. 6 babies with neurologic diseases and 3 cases of miscellaneous causes received HHHFNC oxygen therapy contributing to 11.54% and 5.77% of the total recipients (Table 4).

The leading respiratory system cause was bronchopneumonia. 22 children had bronchopneumonia that made 61.12% of the respiratory causes and 42.31% of the total cases with the need for HHHFNC therapy. Out of 22 children with bronchopneumonia, 1 had associated parapharyngeal abscess and 2 had associated stridor. The second common respiratory cause was bronchiolitis ($n = 8$) which contributed to 22.22% of the respiratory causes and 15.38% of total cases. Then, 2 children had empyema which was 5.56% of respiratory causes. Rest of the respiratory system disorders treated with

**Table 1: Assessment of breathing difficulty adapted from who management of acute respiratory infections in children (Who, Geneva,1995)**

| Assessment of severity (breathing difficulty) | | | |
|---|---|---|---|
| **Respiratory distress** | **Mild** | **Moderate** | **Severe** |
| Oxygen saturation in room air(%) | >95 | 92-95 | < 92 |
| Chest wall in-drawing | None/mild | Moderate | Severe |
| Nasal flaring | Absent | May be present | Present |
| Grunting | Absent | Absent | Present |
| Apnea | None | Absent | Present |
| Feeding difficulty | Normal | Approximately half of normal intake | Less than half normal intake |
| Behavior | Normal | Irritable | Lethargic |
| | | | Unresponsive |
| | | | Flaccid |
| | | | Decreased level of consciousness |
| | | | Inconsolable |

**Table 2: Age-wise distribution of children given oxygen through high-flow nasal cannula**

| Total no of children given oxygen through high-flow cannula | <1 year of age | ≥1 year of age |
|---|---|---|
| 52 | 40 (76.92) | 12 (23.08) |

**Table 3: Gender-wise distribution of children given oxygen through high-flow nasal cannula**

| Total no of children given oxygen through high-flow cannula | Male | Female |
|---|---|---|
| 52 | 31 (59.62) | 21 (40.38) |

**Table 4: Etiological break up of children given high-flow oxygen therapy**

| Etiology | *N* (%) |
|---|---|
| Respiratory causes | 36 (69.23) |
| Cardiac causes | 7 (13.46) |
| Neurologic causes | 6 (11.54) |
| Miscellaneous | 3 (5.77) |
| Total | 52 (100) |

high-flow therapy were one case each of consolidation, collapse with consolidation, acute laryngotracheobronchitis and pneumothorax, each being 2.78% (Table 5).

A total of 7 children with heart diseases were treated with HHHFNC therapy for respiratory distress. 6 children had congenital heart diseases and 1 child had rheumatic heart disease. Out of 6 congenital heart disease cases, 2 were ventricular septal defect with atrial septal defect with

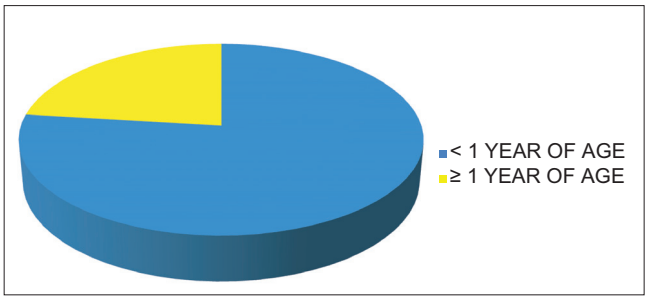


**Figure 1: Age-wise distribution of children received oxygen through high-flow nasal cannula**


**Figure 2: Gender-wise distribution of children given oxygen through high-flow nasal cannula**

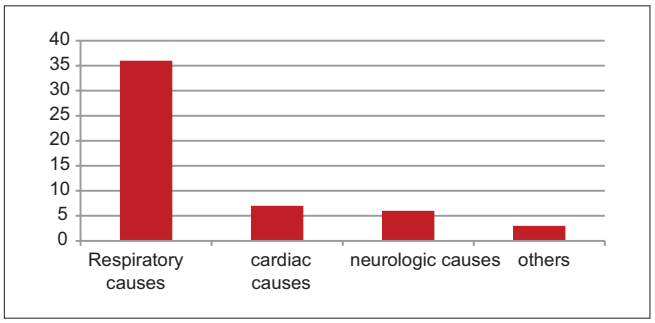


**Figure 3: Etiological break up of children given high-flow oxygen therapy**

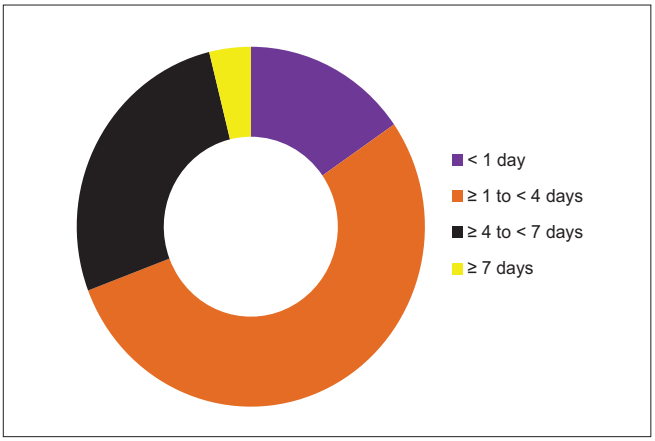


**Figure 4: Break up according to duration of high-flow oxygen therapy**

congestive cardiac failure and two children had isolated ventricular septal defect each group making 33.33% of cardiac cases who received HHHFNC. One child with cyanotic spell and one child with large atrial septal defect with congestive cardiac failure too were benefitted with high flow (Table 6).

There were 6 children with central nervous system (CNS) diseases who were supported with HHHFNC therapy. 2 children with cerebral palsy with seizures, 2 children with acute CNS infections, and 2 children with idiopathic status epilepticus were treated, each group being 33.33% of the total neurological causes (Table 7).

About 2 children with acute diarrheal disease had been received in a state of shock and had been given HHHFNC and 1 child with septic shock also was benefitted (Table 8).

Out of the total 52 children, 8 (15.38%) had received HHHFNC oxygen therapy for <1 day, 28 children (53.85%) received for 1-4 days, 14 children (26.92) for 4-7 days, and 2 children (3.85%) received for more than 7 days (Table 9).

Among the 52 recipients of HHHFNC oxygen therapy, 40 children recovered completely. This made 76.92% recovery during the study period. 9 children required further intubation and mechanical ventilation and among them 3 babies recovered and 6 succumbed to the illness. The mortality percentage was 11.54% (Table 10).

About 9 children needed intubation and assisted mechanical ventilation. Failure of HHHFNC is need for intubation for further management. The therapy failure was noted in 17.31% of children.

Among them, 3 children were extubated and discharged, but 6 children expired. The children who recovered with ventilation were a case of empyema, a case of bronchiolitis with subglottic stenosis and a case of acute CNS infection.

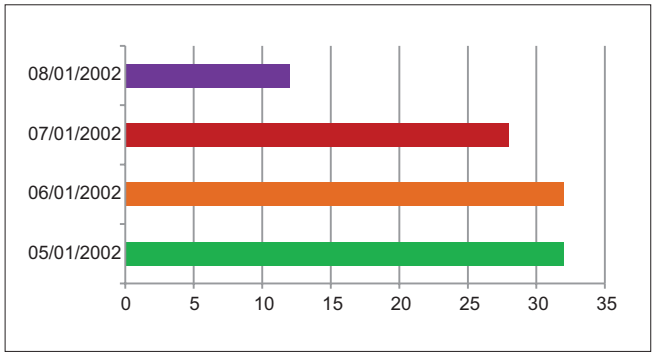


**Figure 5: Break up according to outcome of children given high-flow oxygen therapy**

The 6 children who could not be revived were as follows. A 7-month-old and a 10-month-old male infants with idiopathic status epilepticus; a 75-day-old female child with severe bronchiolitis; a 2-month-old male infant with bronchopneumonia; a 5-year-old male child with

**Table 5: Breakup of respiratory causes**

| Disease | *N* (%) | Percentage |
|---|---|---|
| Acute laryngotracheobronchitis | 1 (2.78) | |
| Bronchiolitis | 7 (19.44) | 22.22 |
| Bronchiolitis with seizures | 1 (2.78) | |
| Bronchopneumonia | 19 (52.78) | 61.12 |
| Bronchopneumonia with parapharyngeal abscess | 1 (2.78) | |
| Bronchopneumonia with stridor | 2 (5.56) | |
| Collapse consolidation | 1 (2.78) | |
| Consolidation | 1 (2.78) | |
| Empyema | 2 (5.56) | |
| Pneumothorax | 1 (2.78) | |
| Total | 36 (100) | |

**Table 6: Breakup of cardiac causes**

| Disease | *N* (%) |
|---|---|
| Cyanotic spell | 1 (16.67) |
| Rheumatic heart disease with congestive cardiac failure | 1 (16.67) |
| VSD/congestive cardiac failure | 2 (33.33) |
| VSD/ASD/congestive cardiac failure | 2 (33.33) |
| Atrial septal defect/congestive cardiac failure | 1 (16.67) |
| Total | 7 (100) |

**Table 7: Breakup of neurological causes**

| Disease | *N* (%) |
|---|---|
| Cerebral palsy with seizures | 2 (33.33) |
| Acute CNS infections | 2 (33.33) |
| Idiopathic status epilepticus | 2 (33.33) |
| Total | 6 (100) |

CNS: Central nervous system

**Table 8: Breakup of miscellaneous causes**

| Disease | *N* (%) |
|---|---|
| Acute diarrheal disease with shock | 2 (66.66) |
| Septicemia with shock | 1 (33.33) |
| Total | 3 (100) |

**Table 9: Break up according to duration of high-flow oxygen therapy**

| Duration | *N* (%) |
|---|---|
| <1 day | 8 (15.38) |
| ≥1 to <4 days | 28 (53.85) |
| ≥4 to <7 days | 14 (26.92) |
| ≥7 days | 2 (3.85) |
| Total | 52 (100) |

**Table 10: Break up according to outcome of children given high-flow oxygen therapy**

| Outcome | *N* (%) | Percentage |
|---|---|---|
| Recovered | 40 (76.92) | |
| Ventilated and recovered | 3 (5.77) | 17.31 |
| Ventilated and expired | 6 (11.54) | |
| Referred to higher center | 3 (5.77) | |
| Total | 52 (100) | |

consolidation who was a known case of Type I diabetes mellitus; and a 7-year-old female child with acute rheumatic carditis with congestive cardiac failure.

Out of the 3 children who were referred to the higher center for further expert management, 2 had septicemia with shock, and one child had empyema. They all survived (Figures 1-5).

## DISCUSSION

In our study, the most common final diagnosis was bronchopneumonia ($n$ = 22, 42.31) and the second common being bronchiolitis ($n$ = 8, 15.38%).

Kelly *et al.* reported a similar case study, which included 498 cases. The most common final diagnosis was acute bronchiolitis ($n$ = 231, 46%), followed by pneumonia ($n$ = 138, 28%) and asthma ($n$ = 38, 8%).[14]

Two observational studies have shown improvement in physiological parameters in children receiving HHHFNC therapy. Respiratory distress scores significantly improved as HHHFNC therapy flow rates increased in infants with bronchiolitis and older children requiring oxygen therapy.[6,8] In another cohort of pediatric patients (median age 6.5 months) receiving HHHFNC therapy on a PICU, measured work of breathing significantly decreased as HHHFNC therapy increased from 2 to 8 L/min.[15]

In the study by Schibler *et al.*, out of the 298 cases, the most common diagnosis was bronchiolitis ($n$ = 167). 11 cases were cardiac cases, and 7 were neurometabolic cases. All were given HHHFNC therapy as the initial mode of oxygen support.[3]

In our study, the failure rate was 17.31% ($n$ = 9). Out of 52 children, 9 needed escalation to invasive ventilation.

In the study by Kelly *et al.*, of the 498 patients, 42 (8%) of patients failed therapy and required intubation following HFNC trial.[14]

Schibler *et al.* reported that, overall, 56 (19%) infants receiving HHHFNC therapy needed escalation to other noninvasive and 36 (12%) to invasive ventilation.[3]

In our study, the common cause for escalation to invasive ventilation was respiratory system disorder ($n$ = 5), followed by neurological cause ($n$ = 3) 55.56% and 50%, respectively. 2 out of 8 cases of bronchiolitis required ventilator support. Therefore, 25% of bronchiolitis cases required ventilatory support in our study.

Kelly *et al.* conclude that a final diagnosis of bronchiolitis was observed to be protective with respect to intubation (odds ratio, 0.40; 95% confidence interval, 0.17–0.96).[14]

In the study by Schibler *et al.*, of the infants with a primary diagnosis of viral bronchiolitis, only 6 (4%) required escalation to invasive ventilation. There was a significantly greater incidence of invasive ventilation in the cardiac ($n$ = 12, 50%) and other ($n$ = 7, 41%) groups compared with the bronchiolitis ($n$ = 6, 4%) and lung disease without peripheral airway obstruction ($n$ = 8, 12%) groups ($P$ = 0.05). Most of the cardiac infants needed intubation for a cardiac surgical procedure or cardiac failure.[3]

Bressan *et al.* reported that out of 27 infants with bronchiolitis who were included in the study no escalation to other forms of respiratory support was recorded.[16]

## CONCLUSION

Use of HHHFNC for oxygen administration is feasible for infants with moderate-severe bronchiolitis in a general pediatric ward. HHHFNC therapy provided efficient respiratory support and oxygen delivery in infants with respiratory distress in our PICU, and its introduction coincided with a significant reduction in the need for intubation of infants with viral bronchiolitis. Further, research is required to establish safety and efficacy of HHHFNC definitively.

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