Original Article

Comparison of Nasal Continuous Positive Airway Pressure and Heated Humidified High Flow Nasal Cannula in Premature Neonates with Respiratory Distress Syndrome

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Abstract

Objective: To compare the clinical efficacy and safety of nasal continuous positive airway pressure (NCPAP) and heated humidified high-flow nasal cannula (HHHFNC) as primary respiratory support modalities for preterm neonates with respiratory distress.

Material and Methods: This comparative study was conducted at Department of Pediatrics Unit II, Services Hospital, Lahore. It is a public sector tertiary care hospital. This comparative study included 74 preterm neonates diagnosed with respiratory distress syndrome (RDS), allocated into two groups: NCPAP (n = 34) and HHHFNC (n = 40). Data on key clinical parameters such as respiratory rate, cyanosis relief, apnea, and mortality were recorded. Complications including necrotizing enterocolitis (NEC), sepsis, and shock were also assessed. Quantitative variables were analyzed using independent t-tests, while qualitative variables were compared using chi-square tests.

Results: Both NCPAP and HHHFNC demonstrated efficacy in stabilizing neonates. Mortality rates were low and comparable between groups (NCPAP: 5.9%, HHHFNC: 2.5%; p>0.05). Severe RDS was more frequent in the HHHFNC group (12.5%) compared to NCPAP (5.9%; p>0.05). NEC occurred exclusively in the NCPAP group (11.8%; p =0.03), indicating a significant safety advantage with HHHFNC. Respiratory rates were higher in the HHHFNC group (82.1±12.5) versus NCPAP (75.4±10.2;p=0.02). Additionally, HHHFNC was superior in relieving cyanosis, achieving an 80.0% success rate compared to 32.4% with NCPAP (p< 0.05).

Conclusion: HHHFNC is an effective alternative to NCPAP for preterm neonates with respiratory distress. It offers advantages such as reduced NEC rates, better oxygenation management, and support for severe RDS cases. These findings support the inclusion of HHHFNC in neonatal care protocols, particularly in resource-constrained settings.

Keywords: Respiratory Distress Syndrome, Neonates, NCPAP, HHHFNC, Necrotizing Enterocolitis, Neonatal Care.

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Introduction

Newborn mortality is a significant health concern all over the world, with about 4 million newborn deaths annually in under-developed countries.[1] Among these, more than one million deaths occur soon after birth, mostly due to respiratory complications.[2] Almost 34% of late preterm neonates are admitted to the neonatal intensive care unit (NICU) immediately after birth due to difficulty in breathing, and it is even higher in those who are born before 34 weeks of gestation.[3] Respiratory distress syndrome (RDS) is the most common cause of respiratory distress, responsible for almost half of

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cases in preterm neonates and is a leading cause of neonatal death.[4,5] RDS is due to insufficient production of surfactant, leading to respiratory distress, increased respiratory rate characterized by retractions (suprasternal, intercostal, and subcostal), cyanosis, grunting, and reluctance to feed. It may cause ventilation-perfusion mismatch, atelectasis, and both type 1 and type 2 respiratory failure[6]. Studies have shown an increased incidence of RDS in male neonates as compared to females, signifying sex as an important risk factor.[7]

Infant mortality rate of 11.5 per 100,000 live births has been reported in United States in 2019 due to RDS.[8] However, the neonatal death burden is disproportionately higher in regions such as sub-Saharan Africa and Southern Asia, which jointly accounted for 80% of neonatal mortality world-wide.[8] For the last two decades, development in perinatal care has improved neonatal outcomes significantly. Among these advancements, the use of nasal continuous positive airway pressure (NCPAP) has evolved as an important intervention for neonates having respiratory distress.[10] NCPAP provides continuous positive pressure, assisting in alveolar recruitment and reducing the risk of bio-trauma and volu-trauma related with mechanical ventilation and surfactant replacement therapy[11]. A study conducted in Nepal highlighted the primary benefits of bubble CPAP when applied within the first 24 hours after birth.[12] Other research from underdeveloped regions has similarly demonstrated the survival benefits of CPAP compared to oxygen therapy alone, with survival rates in Pakistan ranging from 71% to 93.3%.[13]

However, despite its effectiveness, NCPAP is not without challenges. Common issues include maintaining the positioning of nasal prongs and the risk of nasal trauma. To address these limitations, heated and humidified high-flow nasal cannula (HHHFNC) therapy has been increasingly implemented in NICUs worldwide. HHHFNC can deliver up to 100% humidified and heated oxygen at a flow rate of up to 60 liters per minute, administering precise oxygen delivery that matches the patient's peak inspiratory flow needs.[10,11] This form of therapy helps in improving secretion clearance, decreasing airway inflammation, and conserving energy, especially in acute respiratory failure.[14]

With improvement in neonatal respiratory care, this study intended to compare the clinical efficacy, safety profile, and overall outcomes of NCPAP and HHHFNC as primary modes of respiratory support in preterm infants with respiratory distress.

The results of this study are expected to contribute to the development of evidence-based neonatal guidelines for the management of respiratory distress. Establishing clear recommendations can improve neonatal care protocols, optimize resource utilization, and ultimately enhance neonatal outcomes in both developed and underdeveloped healthcare settings.

Material and Methods

This comparative study was conducted at Department of Pediatrics Unit II, Services Hospital, Lahore. It is a public sector tertiary care hospital. Ethical approval Ref:IRB/2019/SIMS Dated:20-12-2019 was taken from institutional review board. A sample size of 74 patients was selected via simple random convenience sampling and were allocated into two groups ie CPAP group and HHHNFC group. All premature infants born at less than 34 weeks of gestation having respiratory distress were included in this study. Gestational age was calculated based on the mother's last menstrual period or early pregnancy ultrasound scan or new Ballard score. Babies in CPAP group had bubble CPAP with bi-nasal prongs. PEEP was started at 5cm of water and adjusted to minimize chest retractions. FiO2 was adjusted to maintain SpO2 between 87% and 95%. The flow was titrated to the minimum to produce continuous bubbling in the bubble chamber. Babies in HHHFNC group had heated humidified high flow nasal cannula. FiO2 was adjusted to maintain SpO2 between 87% and 95%. Infants diagnosed to have failed CPAP/ failed HHHNFC were shifted on mechanical ventilation. The surfactant was administered by the INSURE technique (Intubate, Surfactant, and Extubate) after 3 to 5 minutes of intermittent positive pressure ventilation) to those babies who remained hypoxic i.e. SpO2 87% despite FiO2 >70% and PEEP >7cm of water, who had severe retractions on PEEP>7cm of water, who had prolonged (>20 seconds) or recurrent apneas (>2 episodes within 24 hours associated with bradycardia) requiring a bag and mask ventilation.

The severity of respiratory distress syndrome was measured by using Downs score at 15 to 20 minutes

of starting CPAP/ HHHFNC for respiratory distress syndrome (RDS) and along with radiological evidence showing mild granularity of lungs labeled as mild RDS, generalized granularity of lungs with air bronchograms with preserved cardiac borders labeled as moderate RDS and white out lungs with loss of cardiac borders labeled as severe RDS.

The data was analyzed through SPSS v22. Qualitative variables were shown as frequencies and quantitative variables gestational age, weight will be presented as mean and standard deviations. Data will be stratified and compared between infants with CPAP and HHHFNC.

Independent sample t-test was used to compare quantitative variable between groups. Chi-square was used to find the significance of study parameters on a categorical scale between two or more groups, the non-parametric setting for qualitative data analysis. P-value < 0.05 will be considered significant.

Results

We have analyzed the comparative outcomes of nasal continuous positive airway pressure (NCPAP) and heated humidified high-flow nasal cannula (HHHFNC) in neonates with respiratory distress. The birth weight distribution indicated that 67.6% of the NCPAP group and 60.0% of the HHHFNC group were classified as very low birth weight (VLBW), while 32.4% of the NCPAP group and 40.0% of the HHHFNC group were extremely low birth weight (ELBW). The severity of respiratory distress syndrome (RDS) was higher in the HHHFNC group, with 12.5% of cases being severe compared to 5.9% in the NCPAP group. Downe's score after 15-20 minutes of therapy showed a higher proportion of neonates with scores >7 (indicating impending respiratory failure) in the HHHFNC group (15.0%) versus the NCPAP group (5.9%).

Mortality rates were low and comparable, with 5.9% in the NCPAP group and 2.5% in the HHHFNC group. Incidences of apnea, sepsis, and shock were more frequent in the NCPAP group. Remarkably, necrotizing enterocolitis was observed only in the NCPAP group (11.8%), suggesting a potential safety advantage of HHHFNC in this context. The assessment of respiratory rate revealed that 20.6% of the NCPAP group and 35.0% of the HHHFNC group had rates >80/min. Cyanosis relieved by oxygen was notably higher in the HHHFNC group (80.0%) than the NCPAP group (32.4%). Overall, both modalities provided effective respiratory support, but HHHFNC demonstrated certain clinical advantages in specific parameters.

Table 1: *Chi-square results of qualitative variables*

Parameter	NCPAP (Count/Median)	HHHFNC (Count/Median)	P-value (Chi-Square/T-tes
Male (%)	60% (20)	55% (22)	0.67
Female (%)	40% (14)	45% (18)	0.67
Severe RDS	2	5	0.12
Mortality	2	1	0.34
Apnea	4	2	0.21
Shock	3	1	0.18
Necrotizing Enterocolitis	4	0	**0.03**
Sepsis	3	1	0.19
Cyanosis relieved by O2	11	32	**<0.01**
No Grunting	25	25	0.92
Duration of Hospital Stay (days)	12 (median)	9 (median)	**0.02**
Feed Established by Day 5	28	36	0.08
Discharge by Day 7	30	38	**0.01**

Gestational Age and Birth Weight were comparable between the groups with no significant differences (P = 0.25 and P = 0.40, respectively). Gender Distribution was balanced between groups (P = 0.67). Clinical outcomes favored HHHFNC for shorter hospital stay (P = 0.02) and earlier discharge by Day 7 (P = 0.01). NEC was significantly higher in the NCPAP group (P = 0.03), with no cases observed in

Table 2: *T-test results of Quantitative variables*

Parameter	NCPAP (Mean ± SD)	HHHFNC (Mean ± SD)	P-value (Chi-Square)
Gestational Age (weeks)	32.5 ± 1.5	32.8 ± 1.8	0.25
Birth Weight (grams)	1400 ± 250	1380 ± 300	0.4
Respiratory rate	75.4 ± 10.2	82.1 ± 12.5	0.02**

the HHHFNC group.

The t-test for respiratory rate indicates a significant difference (P = 0.02), with HHHFNC showing a higher mean respiratory rate compared to NCPAP.

Fig 1 shows bar chart illustrating the comparative outcomes of NCPAP and HHHFNC across various clinical parameters. This visual representation highlights differences in birth weight distribution, severity of RDS, mortality, and incidence of necrotizing enterocolitis between the two groups.

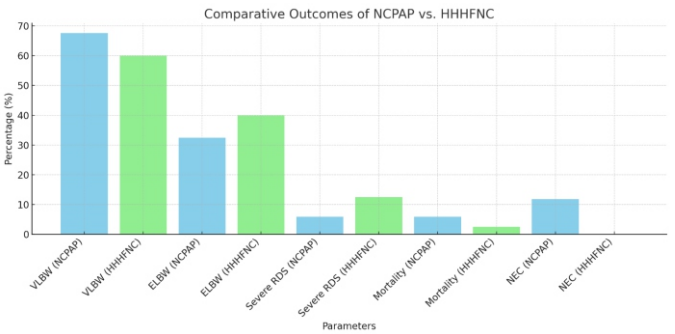

Figure-1: *Comparative outcomes of NCPAP and HHHFNC across various clinical parameters.*

Discussion

The findings of this study comparing the efficacy and safety profiles of nasal continuous positive airway pressure (NCPAP) and heated humidified high-flow nasal cannula (HHHFNC) in managing neonatal respiratory distress provide substantial insights for clinicians. Both methods have been shown to effectively support neonatal breathing, with differences that may influence clinical decision-making.

The study revealed low mortality rates in both groups, with a slightly reduced rate in the HHHFNC group (2.5%) compared to the NCPAP group (5.9%). Recent studies have corroborated these findings, indicating that both NCPAP and HHHFNC are viable non-invasive options for neonatal respiratory support with high survival rates.[11] Although the difference in mortality did not reach statistical significance, these outcomes reinforce the potential reliability of HHHFNC in supporting critically ill neonates.

The incidence of apnea and sepsis was lower in the HHHFNC group, aligning with findings from trials indicating that high-flow nasal cannula therapy reduces apnea rates compared to traditional CPAP.[12]

The absence of necrotizing enterocolitis (NEC) in the HHHFNC group, contrasted with an 11.8% occurrence in the NCPAP group, is particularly notable. Recent meta-analyses have suggested that while NCPAP is effective, its use may be associated with increased risks of gastrointestinal complications, including NEC, due to higher pressure gradients.[13] The protective effect observed with HHHFNC warrants further investigation, as it may have implications for neonatal gastrointestinal health.

While respiratory rate and retraction profiles were comparable between groups, the HHHFNC group showed a higher proportion of infants presenting with a respiratory rate above 80/min (35.0%) compared to the NCPAP group (20.6%). This may indicate that HHHFNC was often applied to more severely affected infants or those with greater initial distress. The higher occurrence of cyanosis relieved by oxygen in the HHHFNC group (80.0%) suggests that HHHFNC may facilitate better oxygenation management in neonates with fluctuating oxygen requirements.[14]

In terms of physical examination findings, the proportion of infants with no air entry was higher in the NCPAP group (18.2%) compared to the HHHFNC group (7.5%). This observation aligns with clinical practice where higher-pressure CPAP settings may contribute to reduced comfort and effective ventilation.[15] Additionally, the grunting scores showed similar distribution, indicating comparable effectiveness of both methods in alleviating this symptom of respiratory distress.

Neither group exhibited significant intracranial complications, with only a single case of intraventricular hemorrhage reported in the HHHFNC group. This is consistent with recent literature suggesting that both methods have a low incidence of neurological adverse effects[16]. The findings on shock also suggest that HHHFNC is associated with a lower incidence of critical outcomes, supporting its use as a safe alternative to NCPAP.[16]

The differences observed in the incidence of NEC, apnea, and cyanosis, alongside other respiratory parameters, suggest nuanced clinical indications for the use of HHHFNC versus NCPAP. For neonates with conditions predisposing them to gastrointestinal complications or needing more flexible oxygen

management, HHHFNC may offer advantages. However, NCPAP continues to provide robust support for those who can tolerate higher pressures without associated complications.

Conclusion

This study compares NCPAP and HHHFNC for neonatal respiratory distress. Both methods were effective, with similar mortality rates. However, HHHFNC reduced necrotizing enterocolitis significantly and supported higher respiratory rates, showing potential advantages in severe cases. These findings advocate for HHHFNC as a safer, flexible alternative, enhancing neonatal care in resource-limited settings.

Conflict of Interest *None*

Funding Source *None*

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Authors Contribution

TF: Conceptualization of Project
FA, TF: Data Collection
OR, TF: Literature Search
MA, IS, TF: Statistical Analysis
TF, OS, SR: Drafting, Revision
RM, TF, SR: Writing of Manuscript