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Comparison of High-Flow Nasal Cannula Vs. Conventional Oxygen Therapy in Postextubated Adults

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HIGHLIGHTS

1. High-flow nasal cannula improves oxygenation efficiency.
2. Conventional oxygen therapy may delay recovery.
3. Postextubated patients benefit from quicker weaning.
4. High-flow therapy reduces reintubation risk.
5. Conventional therapy less effective in preventing hypoxemia.

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ABSTRACT

Introduction: Postextubation is a critical period for patients transitioning from mechanical ventilation, often associated with risks like respiratory failure, necessitating reintubation.Conventional oxygen therapy (COT), using non-rebreather masks, provides oxygen at limited flow rates, often resulting in discomfort and suboptimal outcomes. High-flow nasal cannula (HFNC) oxygen therapy offers a promising alternative by delivering heated, humidified oxygen at high flow rates, improving oxygenation and comfort. **Objective:** This study aims to compare the effects of HFNC and COT on reintubation rates, post-extubation respiratory failure, patient comfort, and length of ICU stay in adult postextubated patients. **Methods:** A prospective, randomized comparative study was conducted on patients in the ICU who were extubated after passing a spontaneous breathing trial. A total of 128 patients were divided into two groups: Group H received HFNC therapy, while Group C received COT. Data were collected on reintubation rates within 24 hours, post-extubation respiratory failure, patient comfort, and ICU stay duration. **Results:** Group H had significantly lower reintubation rates (0% vs. 17.18%, $p<0.001$), lower incidence of post-extubation respiratory failure (3.12% vs. 17.18%, $p=0.019$), and higher patient comfort (98.43% vs. 82.81%, $p=0.004$) compared to Group C. The mean ICU stay was shorter in Group H (7.73±6.09 days) than Group C (9.05±4.16 days, $p<0.001$). **Conclusion:** HFNC therapy significantly reduces the risk of reintubation, post-extubation respiratory failure, and improves patient comfort compared to conventional oxygen therapy. It also results in a shorter ICU stay, making it a preferable option for respiratory support post-extubation.

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INTRODUCTION

The postextubation period is a critical phase for patients who have been mechanically ventilated, marked by a variety of challenges, including the risk of respiratory failure, which can necessitate reintubation if not properly managed[1]. During this phase, factors such as compromised respiratory mechanics, weakened respiratory muscles, and underlying lung conditions can lead to complications like hypoxemia, hypercapnia, and atelectasis. Patients with pre-existing lung disease or those who have undergone prolonged intubation are particularly vulnerable to post-extubation respiratory failure[2]. This type of failure is associated with poorer clinical outcomes, extended ICU stays, and increased mortality rates. Therefore, ensuring appropriate oxygen support during this period is critical for preventing respiratory deterioration and maintaining patient stability as they transition off mechanical ventilation[3].

Oxygen therapy plays a fundamental role in managing care during the postextubation phase. Conventional methods of oxygen delivery include nasal prongs, simple face masks, and non-rebreather masks[4]. These methods deliver supplemental oxygen at varying flow rates and concentrations, depending on the patient's respiratory function. Nasal prongs provide low-flow oxygen for patients needing minimal supplementation, while simple face masks offer higher concentrations of oxygen but may cause discomfort when used for extended periods[5]. Non-rebreather masks, on the other hand, are capable of delivering even higher concentrations of oxygen, making them useful for patients with more severe hypoxemia[6].

Despite its widespread use, conventional oxygen therapy has notable limitations. One of the main issues is inadequate oxygenation due to low flow rates or poor mask fit, which can exacerbate hypoxemia and increase the risk of respiratory failure[7]. Additionally, the discomfort associated with these devices, including dry mucous membranes and skin irritation, can reduce patient compliance, especially during prolonged use. In severe cases, conventional oxygen therapy may not provide sufficient respiratory support, leading to higher rates of reintubation. This has prompted the search for more effective oxygen delivery methods that can improve post extubation outcomes[8].

High-Flow Nasal Cannula (HFNC) oxygen therapy has emerged as an advanced respiratory support system that delivers heated, humidified oxygen at high flow rates through specialized nasal prongs[9]. Unlike conventional oxygen therapy, HFNC provides oxygen at adjustable flow rates of up to 60 liters per minute, allowing for precise control of both oxygen concentration and flow. The oxygen is warmed and humidified, which enhances mucociliary function and reduces airway irritation, offering greater comfort to patients[10].

The mechanism of HFNC goes beyond simple oxygen delivery. It generates a small amount of positive end-expiratory pressure (PEEP), which helps keep the airways open and prevents alveolar collapse, thereby improving gas exchange[11]. Additionally, the high flow rates help clear nasopharyngeal dead space, reducing the effort required to breathe and enhancing overall oxygenation efficiency. These features make HFNC a promising alternative to conventional oxygen therapy for postextubated patients[12].

One of the key advantages of HFNC is its ability to improve oxygenation. By delivering oxygen at higher flow rates and generating mild positive pressure, HFNC is particularly beneficial for patients with compromised respiratory function[13]. Moreover, studies suggest that HFNC lowers the likelihood of reintubation, particularly in patients at high risk of respiratory failure. By supporting spontaneous breathing and preventing respiratory decompensation more effectively than traditional methods, HFNC contributes to better clinical outcomes for postextubated patients[14].

Another significant advantage of HFNC is its enhanced patient comfort. The heated and humidified oxygen delivered through the device helps reduce the discomfort typically associated with cold, dry oxygen from nasal prongs or face masks, making HFNC more tolerable for extended use. The increased comfort associated with HFNC can also improve patient compliance, reducing the need for additional interventions[15].

HFNC offers several advantages, such as better oxygenation, patient comfort, and reduced need for reintubation, making it an attractive option for respiratory support after extubation[16]. However, despite these promising outcomes, there is no clear consensus on the best oxygen therapy approach for postextubation care. Conventional oxygen therapy, though widely used, has limitations in providing adequate support for high-risk patients, prompting some clinicians to turn to HFNC[17].

The main challenge with HFNC adoption lies in the absence of standardized criteria for its use, which makes it difficult to implement consistently across clinical settings[18]. To address this, there is a growing call for larger, multicentre randomized controlled trials comparing HFNC and conventional oxygen therapy. These studies could guide clinical practice, improving postextubation care and patient outcomes more effectively[19].

The primary objective is to compare the effect of High-Flow Nasal Cannula (HFNC) and conventional oxygen therapy (non-rebreather mask) on the rate of reintubation within 24 hours of extubation. The secondary objective is to assess the impact of HFNC and conventional oxygen therapy on post-extubation respiratory failure, patient comfort, and the duration of ICU stay.

MATERIALS AND METHODS

Data was collected from ICU patients who received either high-flow nasal cannula (Fisher & Paykel) or non-rebreather mask oxygen therapy immediately after planned extubation in the Department of Anaesthesiology and Critical Care, ESIC-Medical College-PGIMSR, Bangalore, between 1st March 2021 and 30th August 2022. This prospective randomized comparative study included patients over 18 years, mechanically ventilated for over 24 hours, who passed a spontaneous breathing trial and were at high risk of reintubation. Exclusion criteria included non-cooperative, tracheostomy, pregnant, hypercapnic patients, and those with a Glasgow Coma Score of 12 or less.

RESULTS

Table 1: Demographic Characteristics-Frequency Distribution in Two Groups of Patients

Demographic Characteristics	Group H	Group C	P value
Age (Mean ± SD)	51.41±13.54	52.91±9.93	0.477
Gender (M:F)	42:22	34:30	0.208
BMI (Mean ± SD)	27.79±4.16	28.76±2.77	0.131

The mean age of participants in the HFNC group was 51.41±13.54 years, and in the COT group, it was 52.91±9.93 years, with no statistically significant difference (P=0.477). The HFNC group had 42 males and 22 females, while the COT group had 34 males and 30 females, with no significant difference in gender distribution (P=0.208). The mean BMI was 27.79±4.16 in the HFNC group and 28.76±2.77 in the COT group, also showing no significant difference (P=0.131).

Table 2: Number of High-Risk Factors for Reintubation-Frequency Distribution in Two Groups of Patients

Number of High Risk Factors for Reintubation	Group H	Group C	P Value
0	33	30	0.883
1	20	28	0.273
2	9	6	0.583
3	2	0	0.496

The number of high-risk factors for reintubation was comparable between Group H and Group C, with no statistically significant difference observed between the two groups. This indicates that the distribution of risk factors was similar across both groups, suggesting that neither group had a higher predisposition for reintubation based on the high-risk factors evaluated.

Table 3: Underlying Medical Conditions-Frequency Distribution in Two Groups of Patients

Underlying Medical Conditions	Group H (N=63)	Group C (N=63)	P Value
Hypertension	23	33	0.106
Diabetes Mellitus	22	31	0.149
COPD	7	9	0.791
Heart Disease	8	6	0.777
Chronic Liver Disease	4	5	1.000
CKD	3	6	0.491
CLD	3	2	1.000
Malignancy	4	1	0.364
Cor Pulmonale	2	0	0.496
Hepatic Encephalopathy	1	1	1.000
Cor Pulmonale	2	0	0.496
Old CVA	1	1	1.000
Cerebro Vascular Disease	0	1	1.000
OSA	1	0	1.000

The underlying medical conditions in Group H and Group C were comparable, with no statistically significant difference observed between the two groups. This suggests that both groups had a similar distribution of medical conditions, indicating that underlying health issues did not significantly vary and were balanced across both groups in the study.

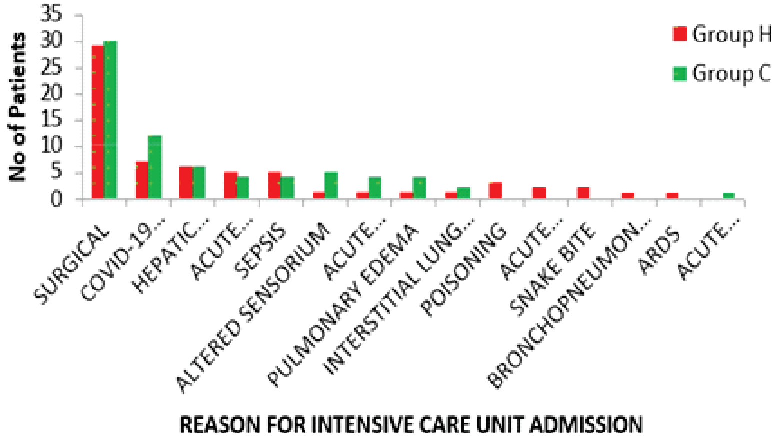

Figure 1: Reason for Intensive Care Unit Admission.

The reasons for intensive care unit admission were comparable between Group H and Group C, with no statistically significant difference observed. This indicates that the distribution of ICU admission causes was similar across both groups, suggesting that neither group had a higher incidence of specific admission reasons.

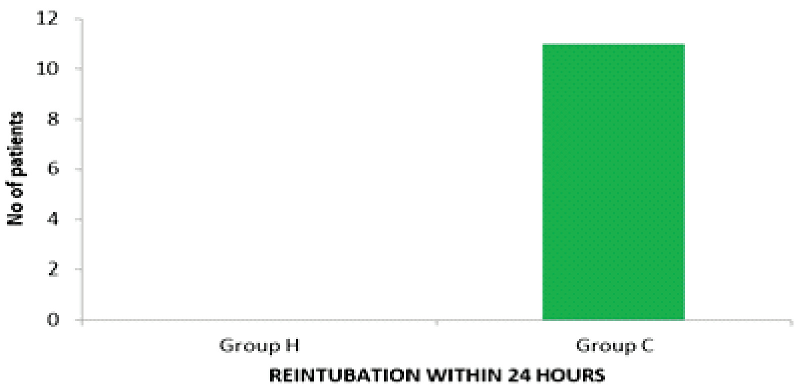

Figure 2: Reintubation Within 24 Hours.

In Group C, 11 out of 64 participants (17.18%) required reintubation within the first 24 hours post-extubation, while none (0%) in Group H were reintubated. There was a statistically significant difference in the reintubation rates between the two groups ($P \leq 0.001$), indicating that participants in Group H had significantly lower rates of reintubation compared to Group C.

Table 4: Comparison of Secondary Outcomes-Frequency Distribution in Two Groups of Patients

Secondary Outcomes	Group H	Group C	P value
Post Extubation Respiratory Failure	2 (3.12%)	11 (17.18%)	0.019
Patient Comfort	63 (98.43%)	53 (82.81%)	0.004
Length of ICU Stay in Days (Mean ± SD)	7.73±6.09	9.05±4.16	<0.001

In the COT group, 11 out of 64 patients (17.18%) experienced post-extubation respiratory failure, compared to 2 out of 64 patients (3.12%) in the HFNC group. This represents a statistically significant difference in post-extubation respiratory failure between the two groups (P=0.019), with the HFNC group showing a lower incidence of respiratory failure.

Table 5: Oxygen Flow Rate-Comparison in Two Group of Patients

Oxygen flow rate	Group H	Group C	P Value
Initial Flow Rate, L/Min	30±0	9.61±2.7	<0.001
Maximum Flow Rate, L/Min	38.91±4.31	11.94±4.58	<0.001
Final Flow Rate At 24hours, L/Min	30.4±3.125	9.55±3.6	<0.001

The mean initial flow rate in the HFNC group was 30±0 L/min, compared to 9.61±2.7 L/min in the COT group, showing a statistically significant difference (P<0.001). The mean maximum flow rate was 38.91±4.31 L/min in the HFNC group and 11.94±4.58 L/min in the COT group, with a significant difference (P<0.001). Additionally, the mean final flow rate was 30.4±3.125 L/min in the HFNC group and 9.55±3.6 L/min in the COT group, also significantly different (P<0.001).

DISCUSSION

Oxygen therapy is essential for maintaining oxygen demand and preventing respiratory failure in post-extubation patients. Non-rebreather masks (NRM) deliver oxygen up to 15 lpm, but this may be inadequate for patients needing higher flow. HFNC has gained popularity, especially post-COVID, due to its clinical benefits. It delivers precise oxygen concentrations (FiO2 0.21 to 1.00) with flow rates up to 60 lpm and provides humidification, reducing breathing effort and preventing hypoxemia. HFNC also minimizes CO2 rebreathing, improves gas exchange, and reduces airway dryness. This study compares the clinical outcomes of HFNC and conventional oxygen therapy in post-extubation patients[20].

The reintubation rate varies from 11% to 23%, and since over half of extubation failures occur within the first 24 hours (median reintubation time of 22 hours), we used this timeframe to assess reintubation rates. In our study, 11 out of 64 patients (17.18%) in the COT group required reintubation, while none (0%) in the HFNC group were reintubated within 24 hours post-extubation. A large cohort study by Nithya Menon et al. (2012) identified older age, male gender, and initial illness severity as key risk factors for reintubation, which were comparable between our groups. Despite these similarities, the lower reintubation rate in the HFNC group aligns with findings by Hernández et al. (2016) and Frat et al. (2015). However, other studies like those by Maggiore et al. (2014) and Raoof et al. (2020) reported either no reduction or higher reintubation rates with HFNC, likely due to between-group heterogeneity and smaller sample sizes. Additionally, we evaluated post-extubation respiratory failure, patient comfort, and ICU stay duration[21,22,23,24,25].

There is no general consensus on the risk factors predicting extubation failure, as different investigators define their own criteria. We defined post-extubation failure as respiratory acidosis (pH < 7.35 with PaCO2 >45mmHg), hypoxemia (SPO2 <90% or PaO2 <60 mmHg with FiO2 >0.5), tachypnea >35 breaths/min, signs of respiratory muscle fatigue, or low consciousness. Studies suggest extubation failure occurs in 10-20% of patients. In our study, 11 out of 64 (17.18%) in the COT group and 2 out of 64 (3.12%) in the HFNC group experienced post-extubation respiratory failure. Similar results were observed by Fernández et al., with 20% in the HFNC group and 27% in the COT group[26].

Patient discomfort, related to the interface and airway dryness, was assessed by asking if patients felt comfortable. In our study, 53 out of 64 (82.81%) in the COT group and 63 out of 64 (98.43%) in the HFNC group reported comfort. HFNC, with smaller cannulae and humidification, proved superior. Similar findings were seen in other studies.

In our study, the ICU stay was 9.05±4.16 days in the COT group and 7.73±6.09 in the HFNC group, with a statistically significant but clinically insignificant difference. Fernández et al. found both differences to be insignificant. Although HFNC required higher flow rates, this contributed to better clinical outcomes [26].

CONCLUSION

High-Flow Nasal Cannula (HFNC) oxygen therapy demonstat ed better clinical outcomes compared to conventional non-rebreather mask oxygen therapy in adult post-extubated patients.

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