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Original Research Article

# Conventional, NIV and High Flow Nasal Oxygen Therapy in Post-Extubation Hypoxia among Adults Undergoing Abdominal Surgery: An Observational Study in a Tertiary Care Hospital

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**Conflict of interest: Nil**.

**Abstract**

**Background:** Hypoxia is defined as inadequate tissue oxygenation due to either inadequate blood flow or low arterial oxygen content. Hypoxia is one of the most feared critical events during anesthesia and the recovery period. Hypoxia or even hypoxaemia can occur anytime during anesthesia with astonishing suddenness. Severe hypoxaemia can result in death of a patient or leave them with devastating neurological handicaps. Early diagnosis of hypoxia would lead to early correction of this unwanted event, otherwise which might cause postoperative complications or even death.

**Aim:** To compare the efficacy of conventional, non-invasive ventilation and high flow nasal oxygen therapy in the management of post extubation hypoxia among patients undergoing abdominal surgeries.

**Methods:** It was observational cross-sectional study conducted from June 2021 to November 2022 in Anesthesia Intensive Care Unit (AICU), Department of Anesthesiology, Agartala Government Medical College, Agartala, West Tripura. Based on census sampling technique, a sample of 90 patients was selected for the study, out of which 30 patients were grouped in each group A (applied conventional face mask), B (applied NIV/Bi-PAP) and C (applied HFNOC).

**Results:** It was observed that HFNOC applied to those patients where respiratory rate is slightly high than other two groups and correction of tachypnea is much faster in NIV and HFNOC group than conventional facemask. PaO2 (ABG after 120 Minutes) was significantly higher in group C than B and A respectively. PCO2 (ABG after 120 Minutes) was significantly less in in group C than B and A respectively. P/F ratio (ABG after 120 Minutes) was significantly higher in group C than B and A respectively. The mean Patient comfort was significantly higher in Group-C and A compared to Group-B. Dyspnoea VAS was significantly less in in group C than A and B respectively.

**Conclusion:** The present study concluded that HFNOC and NIV is more effective than conventional oxygen therapy in improving oxygenation in patients with post extubation hypoxia.

**Keywords:** Conventional Oxygen Therapy, NIV, High Flow Nasal Oxygen Therapy, Hypoxia

## Introduction:

Hypoxia is defined as inadequate tissue oxygenation due to either inadequate blood flow or low arterial oxygen content. Hypoxia is one of the most feared critical events during anesthesia and the recovery period. Hypoxia or even hypoxaemia can occur anytime during anesthesia with astonishing suddenness. Severe hypoxaemia can result in death of a patient or leave them with devastating neurological handicaps. Early diagnosis of hypoxia would lead to early correction of this unwanted event, otherwise which might cause postoperative complications or even death [1]. Tyler et al. [2] showed that $SaO_2$ decreases significantly in a large number of patients who were transported without supplemental oxygen from the operating room to the recovery room.

On the other hand, immediate post-extubation is a crucial moment in the transition from mechanical ventilation to spontaneous breathing in recovering from general anesthesia given for any surgical procedures. Postoperative respiratory failure is associated with increased perioperative complications such as re-intubation, invasive mechanical ventilation, and healthcare- associated infections, which can lead to increases in mortality, intensive care unit (ICU) and hospital length of stay, delays in hospital discharges, and higher health care resource utilization [3].

Several post-operative pulmonary complications may result in post-operative hypoxemic respiratory failure, including pneumonia, atelectasis, bronchospasm, pneumothorax, and pleural effusion. The incidence of these complications is variable and ranges between 5 and 40% according to the type of surgery, as well as other risk factors including anesthetic technique, duration of surgery, and severity of illness [4]. Cardiac surgery has the highest rate of post-operative respiratory complications (up to 40%), followed by thoracic surgery (30%), while abdominal and vascular surgeries have a low incidence of post-operative pulmonary complications (6–7%) [5].

So most post operative surgical patients routinely receive supplemental oxygen therapy to prevent the potential development of hypoxia or even hypoxemia due to incomplete lung expansion, reduced chest wall & diaphragmatic activity occurred by surgical site pain, consequences of hemodynamic alterations and residual effects of anesthetic drugs, ventilation – perfusion mismatch, alveolar hypoventilation, impaired upper airway patency. Additionally, WHO guideline for reduction of surgical site infection have recommended peri operative high dose oxygen [6].

Options for oxygen therapy include conventional oxygen therapy delivered via nasal cannula (NC) or face masks (FM), via venture mask, non-rebreather mask, oxygen therapy given by High Flow Nasal Cannula (HFNC), non-invasive ventilation (NIV), and finally intubation or mechanical ventilation (MV). Traditional NC and FM (collectively referred to as conventional oxygen therapy or COT) can achieve flow rates of up to 15 L/min. However, these flow rates may be significantly lower than patients' spontaneous inspiratory flow rates and the oxygen is diluted as it is mixed with room air. Consequently, the fraction of inspired oxygen (FiO2) delivered is variable and this is thought to explain why many patients require an escalation of oxygen therapy to NIV or MV. By contrast, humidified high flow nasal cannula (HFNC) oxygen therapy utilizes an air oxygen blend allowing from 21% to 100% FiO2 delivery and generates up to 60 L/min flow rates [7]. Theoretically, HFNC offers significant advantages in oxygenation and ventilation over COT.

Though there are several studies regarding use of HFNC in various setting and situation in relation with anesthesiology, critical care, respiratory medicine, emergency medicine etc. but definitively only a few studies conducted regarding its use in post extubation period for the management of hypoxia & its comparison with other conventional oxygen therapy and non-invasive ventilator oxygen therapy. Thus, this study compares between the effect of high flow nasal oxygen therapy, conventional oxygen therapy and non-invasive ventilation oxygen therapy to manage hypoxia occurred after extubation in adult patients gone under general anesthesia for major abdominal surgeries.

**Aim**

To compare the efficacy of conventional, non-invasive ventilation and high flow nasal oxygen therapy in the management of post extubation hypoxia among patients undergoing abdominal surgeries.

**Material and Methods**

It was observational cross-sectional study conducted from June 2021 to November 2022 in Anesthesia Intensive Care Unit (AICU), Department of Anesthesiology, Agartala Government Medical College, Agartala, West Tripura. Based on census sampling technique, a sample of 90 patients was selected for the study, out of which 30 patients were grouped in each group A (applied conventional face mask), B (applied NIV/Bi-PAP) and C (applied HFNOC).

**Inclusion Criteria**

- Age ≥ 18 years.
- Patients from ASA 1 & 2
- Patients intubated for major abdominal surgery under General Anesthesia.
- Patients belongs to Malampatti class 1 & 2.

**Exclusion Criteria**

- Patients Body Mass Index (BMI) > 30 $kg/m^2$.
- Patient with unstable hemodynamic status.
- Patients having any known respiratory disease like Chronic obstructive pulmonary disease (COPD), any known neurological diseases like Guillain–Barré syndrome, Myasthenia gravis etc.
- Patient with any form of psychiatric disease.
- Patients having any type of oral, facial, or nasal structural abnormality, history of nasal bleeding, nasal blockage.
- Patients having any type of cardiovascular and neurological co morbidities.
- Patient receiving any other form of anesthesia except general anesthesia.
- Patient who will require immediate re-intubation or invasive mechanical ventilation after diagnosis of hypoxia.
- Unwilling to participate in study.

**Data Collection**

Data of the patients fulfilling the inclusion – exclusion criteria was recorded after observing the effect of oxygen supplementation through three modalities that is either conventional face mask or non-invasive ventilation or high flow nasal oxygenation for the management of post extubation hypoxia done by attending AICU consultant.

The settings of the various modalities of oxygen therapy to the hypoxic patients were set by the attending AICU consultant according to the protocol followed by them and it was observed that those who were given oxygen supplementation through conventional face mask available at AICU received moist oxygen @ rate of 6lit/min ($FIO_2$ 0.4) connected to central oxygen pipeline.

The patients received NIV in the form of BiPap, was set in S/T mode with a standard oral-nasal (full-face) mask. The initial expiratory airway pressure was set to 5 cm H2O, the inspiratory airway pressure was initially set to 10 cmH2O. The oxygen flow was set to have the fraction of inspiration oxygen (FiO2) 0.5 and breath rate set at 14/min.

Patients received oxygen through the HFNC was given suitable large-bore nasal prongs selected according to the size of the patients' nostrils. The initial airflow was set at 35 L/min. The HFNC was set to an absolute humidity of 44 mg $H_2O$/L, temperature was set to 37 °C, and FiO2 was 0.7. Data was collected for next 120 mins with 15 mins time interval.

**Statistical Analysis**

For statistical analysis data were entered into a Microsoft excel spread sheet and then analyzed by SPSS (version 27.0; SPSS Inc., Chicago, IL, USA) and Graph Pad Prism version 5. Data had been summarized as mean and standard deviation for numerical variables and count and percentages for categorical variables. T-tests, ANOVA, and chi-square test were performed for comparing data between the groups. P-value < 0.05 was considered for statistically significant.

**Ethical Approval**

Data obtained from this study was kept confidential and used for research purpose only. The protocol was approved by the Institutional Ethics Committee of Agartala Government Medical College & G.B. Pant Hospital, Agartala, West Tripura. The study was conducted after approval from the ethics committee.

**Results**

Mean age of patients in group A was 42.76±11.73 years, group B was 48.10±13.36 years, and group C was 64.36±9.48 years, with statistically significant association of age with group (p<0.0001) showing that there were elderly patients in Group C, middle-aged patients in Group B and comparatively younger patients in Group A.

In group A, 10 (33.3%) patients were Female, and 20 (66.7%) patients were Male. In group B, 17 (56.7%) patients were Female, and 13 (43.3%) patients were Male. In group C, 16 (53.3%) patients were Female, and 14 (46.7%) patients were Male. There was no statistically significant association of Sex with Group (p=0.1474).

In group A, the mean BMI of patients was 27.2733±1.8040. In group B, the mean BMI of patients was 27.0000±1.6599, and in group C, the mean BMI of patients was 27.5333±1.6501. There was no statistically significant association of BMI with Group (p=0.4834).

**Table 1: Distribution of mean $SPO_2$ at different time interval**

| SPO2 (%) | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just Before Therapy Started** | A | 30 | 90.2333 | 1.3566 | 90.0000 | 0.0420 |
| | B | 30 | 90.3000 | 1.2077 | 90.0000 | |
| | C | 30 | 89.5333 | 1.2794 | 90.0000 | |
| **After 15 mins** | A | 30 | 92.5333 | .8996 | 92.0000 | 0.3152 |
| | B | 30 | 92.8667 | .7761 | 93.0000 | |
| | C | 30 | 92.7333 | .8683 | 92.0000 | |
| **After 30 mins** | A | 30 | 94.5000 | 1.1064 | 94.0000 | 0.0011 |
| | B | 30 | 94.8333 | 1.3917 | 94.0000 | |
| | C | 30 | 95.7333 | 1.3374 | 96.0000 | |
| **After 45 mins** | A | 30 | 96.8667 | 2.3450 | 96.0000 | <0.0001 |
| | B | 30 | 97.4000 | 2.3723 | 98.0000 | |
| | C | 30 | 99.4333 | .9714 | 100.0000 | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **After 60 mins** | A | 30 | 97.7333 | 2.0667 | 97.0000 | <0.0001 |
| | B | 30 | 98.2333 | 2.0957 | 100.0000 | |
| | C | 30 | 100.0000 | .0000 | 100.0000 | |
| **After 75 mins** | A | 30 | 99.5000 | .9377 | 100.0000 | 0.0051 |
| | B | 30 | 99.2667 | 1.1725 | 100.0000 | |
| | C | 30 | 100.0000 | .0000 | 100.0000 | |
| **After 90 mins** | A | 30 | 99.9333 | 98.0000 | 100.0000 | 0.0642 |
| | B | 30 | 99.7333 | 98.0000 | 100.0000 | |
| | C | 30 | 100.0000 | 100.0000 | 100.0000 | |
| **After 105 mins** | A | 30 | 99.9333 | 98.0000 | 100.0000 | 0.6083 |
| | B | 30 | 99.9333 | 98.0000 | 100.0000 | |
| | C | 30 | 100.0000 | 100.0000 | 100.0000 | |
| **After 120mins** | A | 30 | 100.0000 | 0.0000 | 100.0000 | 1.0000 |
| | B | 30 | 100.0000 | 0.0000 | 100.0000 | |
| | C | 30 | 100.0000 | 0.0000 | 100.0000 | |

Distribution of mean SPO2 (%) with Group was statistically significant just before start of therapy, after 30, 45, 60, and 75 mins ($p < 0.05$)., whereas it was insignificant after15, 105, and 120 mins ($p > 0.05$).

**Table 2: Distribution of mean PR(BPM) at different time interval**

| PR (BPM) | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just Before Therapy Started** | A | 30 | 113.6333 | 9.7432 | 112.5000 | 0.3130 |
| | B | 30 | 114.9000 | 9.1627 | 118.0000 | |
| | C | 30 | 117.4667 | 10.6179 | 116.0000 | |
| **After 15 mins** | A | 30 | 106.0000 | 7.4741 | 105.5000 | 0.4534 |
| | B | 30 | 105.9667 | 6.6306 | 107.0000 | |
| | C | 30 | 108.2667 | 9.8048 | 108.0000 | |
| **After 30 mins** | A | 30 | 98.0000 | 2.4635 | 98.0000 | 0.3573 |
| | B | 30 | 97.9333 | 5.0305 | 98.5000 | |
| | C | 30 | 96.6667 | 4.1716 | 95.0000 | |
| **After 45 mins** | A | 30 | 91.1333 | 4.4158 | 91.0000 | 0.2744 |
| | B | 30 | 86.9667 | 16.1789 | 89.5000 | |
| | C | 30 | 88.6000 | 4.5758 | 89.0000 | |
| **After 60 mins** | A | 30 | 89.2333 | 5.5689 | 89.0000 | <0.0001 |
| | B | 30 | 86.9333 | 5.2649 | 85.5000 | |
| | C | 30 | 83.0333 | 2.1573 | 83.5000 | |
| **After 75 mins** | A | 30 | 82.5000 | 6.6889 | 82.0000 | 0.0001 |
| | B | 30 | 81.4667 | 6.6371 | 82.0000 | |
| | C | 30 | 75.8333 | 4.0521 | 75.0000 | |
| **After 90 mins** | A | 30 | 80.8667 | 4.2323 | 82.0000 | 0.1155 |
| | B | 30 | 78.8000 | 5.2417 | 80.5000 | |
| | C | 30 | 79.0333 | 2.5929 | 79.5000 | |
| **After 105 mins** | A | 30 | 79.9333 | 2.9470 | 80.0000 | 0.0001 |
| | B | 30 | 80.2000 | 3.6521 | 81.0000 | |
| | C | 30 | 78.4333 | 3.3905 | 78.5000 | |
| **After 120 mins** | A | 30 | 78.5667 | 4.3046 | 80.0000 | 0.0188 |
| | B | 30 | 78.9000 | 4.1800 | 79.0000 | |
| | C | 30 | 76.1667 | 3.4749 | 76.0000 | |

Distribution of mean PR (BPM) with Group was statistically significant at 60, 75, 105, and 120 mins ($p<0.05$), whereas it was insignificant at before starting therapy, after 15, 30, 45, and 90 mins.

**Table 3: Distribution of mean SBP (mm of Hg) at different time interval**

| SBP (mm of Hg) | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just Before Therapy Started** | A | 30 | 149.3333 | 6.1551 | 150.0000 | 0.0346 |
| | B | 30 | 150.3000 | 6.2098 | 151.0000 | |
| | C | 30 | 153.2000 | 5.2680 | 154.0000 | |
| **After 15 mins** | A | 30 | 144.3333 | 4.8447 | 145.0000 | 0.0322 |
| | B | 30 | 146.2667 | 5.2976 | 146.0000 | |
| | C | 30 | 147.6000 | 4.0480 | 148.0000 | |
| **After 30 mins** | A | 30 | 140.6333 | 4.4759 | 141.0000 | 0.0002 |
| | B | 30 | 141.7333 | 4.1600 | 142.0000 | |
| | C | 30 | 144.8667 | 2.9564 | 146.0000 | |
| **After 45 mins** | A | 30 | 137.2333 | 5.0629 | 136.0000 | 0.7532 |
| | B | 30 | 137.4667 | 4.0321 | 138.0000 | |
| | C | 30 | 136.6667 | 3.4173 | 135.0000 | |
| **After 60 mins** | A | 30 | 134.0667 | 5.7412 | 134.0000 | 0.0370 |
| | B | 30 | 134.3333 | 6.0363 | 134.0000 | |
| | C | 30 | 131.0667 | 4.1267 | 130.0000 | |
| **After 75 mins** | A | 30 | 129.5333 | 3.9543 | 130.0000 | 0.0003 |
| | B | 30 | 128.2667 | 4.2258 | 129.0000 | |
| | C | 30 | 125.3333 | 3.6891 | 124.0000 | |
| **After 90 mins** | A | 30 | 129.1333 | 122.0000 | 130.0000 | 0.1212 |
| | B | 30 | 130.2000 | 120.0000 | 131.0000 | |
| | C | 30 | 127.6667 | 120.0000 | 128.0000 | |
| **After 105 mins** | A | 30 | 128.0000 | 4.0684 | 128.0000 | 0.0231 |
| | B | 30 | 129.1333 | 5.0291 | 130.0000 | |
| | C | 30 | 125.9333 | 4.2825 | 124.0000 | |
| **After 120 mins** | A | 30 | 128.8667 | 4.3210 | 129.0000 | 0.1391 |
| | B | 30 | 129.0000 | 4.3232 | 130.0000 | |
| | C | 30 | 127.0000 | 4.2911 | 124.0000 | |

Distribution of mean SBP with Group was statistically significant at just before therapy, 15, 30, 60, 75, and 105 mins ($p<0.05$), whereas it was insignificant at 45, 90, and 120 mins.

**Table 4: Distribution of mean DBP (mm of Hg) at different time interval**

| DBP (mm of Hg) | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just Before Therapy Started** | A | 30 | 98.7333 | 5.2387 | 100.0000 | 0.0113 |
| | B | 30 | 98.0333 | 4.7741 | 99.0000 | |
| | C | 30 | 101.7000 | 4.6915 | 100.0000 | |
| **After 15 mins** | A | 30 | 95.0667 | 4.1600 | 96.0000 | 0.0301 |
| | B | 30 | 94.4000 | 4.5908 | 94.0000 | |
| | C | 30 | 97.3333 | 4.4670 | 98.0000 | |
| **After 30 mins** | A | 30 | 91.7333 | 6.2584 | 90.0000 | 0.4818 |
| | B | 30 | 91.4667 | 5.3287 | 92.0000 | |
| | C | 30 | 90.0000 | 6.2367 | 90.0000 | |
| **After 45 mins** | A | 30 | 90.7000 | 6.7983 | 90.0000 | 0.0250 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | B | 30 | 89.3333 | 7.1503 | 90.0000 | |
| | C | 30 | 86.2000 | 5.2087 | 84.0000 | |
| **After 60 mins** | A | 30 | 83.5333 | 6.7402 | 80.0000 | 0.0115 |
| | B | 30 | 84.0667 | 6.3078 | 83.0000 | |
| | C | 30 | 79.8333 | 4.0521 | 80.0000 | |
| **After 75 mins** | A | 30 | 80.9333 | 4.2906 | 81.0000 | 0.0643 |
| | B | 30 | 81.4667 | 3.1919 | 80.0000 | |
| | C | 30 | 79.3333 | 3.2519 | 80.0000 | |
| **After 90 mins** | A | 30 | 81.6667 | 4.5511 | 80.0000 | 0.0086 |
| | B | 30 | 81.2667 | 5.1323 | 80.0000 | |
| | C | 30 | 78.2667 | 3.8501 | 78.0000 | |
| **After 105 mins** | A | 30 | 80.2000 | 4.6786 | 80.0000 | 0.0186 |
| | B | 30 | 78.4667 | 4.0915 | 80.0000 | |
| | C | 30 | 77.4000 | 2.1107 | 78.0000 | |
| **After 120 mins** | A | 30 | 79.5333 | 3.9543 | 80.0000 | 0.1988 |
| | B | 30 | 79.9333 | 4.5329 | 80.0000 | |
| | C | 30 | 78.1333 | 3.5597 | 78.0000 | |

Distribution of mean DBP with Group was statistically significant at just before therapy, 15, 45, 60, 90, and 105 mins ($p<0.05$), whereas it was insignificant at 30 and 120 mins.

**Table 5: Distribution of mean RR(/minute) at different time interval**

| **RR (/Minute)** | **Group** | **Number** | **Mean** | **SD** | **Median** | **p-value** |
|---|---|---|---|---|---|---|
| **Just Before Therapy Started** | A | 30 | 32.8000 | 3.1991 | 33.5000 | 0.1854 |
| | B | 30 | 32.3000 | 2.3947 | 33.0000 | |
| | C | 30 | 33.5333 | 2.0466 | 34.0000 | |
| **After 15 mins** | A | 30 | 30.9667 | 2.4980 | 31.5000 | 0.8563 |
| | B | 30 | 31.1000 | 1.9888 | 31.0000 | |
| | C | 30 | 31.2667 | 1.7006 | 32.0000 | |
| **After 30 mins** | A | 30 | 25.8000 | 2.0578 | 30.0000 | 0.0037 |
| | B | 30 | 25.6333 | 2.4138 | 30.0000 | |
| | C | 30 | 24.1000 | 1.7879 | 28.0000 | |
| **After 45 mins** | A | 30 | 24.7333 | 2.4059 | 24.5000 | 0.0285 |
| | B | 30 | 24.5333 | 3.0141 | 24.0000 | |
| | C | 30 | 23.1333 | 1.8889 | 23.0000 | |
| **After 60 mins** | A | 30 | 23.6333 | 2.0424 | 24.0000 | 0.0001 |
| | B | 30 | 23.2667 | 2.1485 | 23.5000 | |
| | C | 30 | 21.6000 | 1.1919 | 21.0000 | |
| **After 75 mins** | A | 30 | 22.9333 | 1.5960 | 23.0000 | 0.0665 |
| | B | 30 | 22.0000 | 1.6609 | 22.0000 | |
| | C | 30 | 22.7667 | 1.6333 | 23.0000 | |
| **After 90 mins** | A | 30 | 22.3000 | 1.8223 | 22.0000 | 0.1402 |
| | B | 30 | 21.8667 | 1.7564 | 21.5000 | |
| | C | 30 | 22.7667 | 1.6333 | 23.0000 | |
| **After 105 mins** | A | 30 | 22.1333 | 1.6554 | 22.0000 | 0.7705 |
| | B | 30 | 22.3000 | 1.6006 | 22.0000 | |
| | C | 30 | 22.4667 | 2.0634 | 22.0000 | |
| **After 120 mins** | A | 30 | 20.6667 | 1.3979 | 21.0000 | 0.0001 |
| | B | 30 | 20.7333 | 1.0807 | 21.0000 | |
| | C | 30 | 19.3000 | 1.6640 | 19.0000 | |

Distribution of mean RR with Group was statistically significant at 30, 45, 60, and 120 mins ($p<0.05$), whereas it was insignificant at starting of therapy, 15, 75, 90 and 105 mins.

**Table 6: Distribution of mean pH**

| pH | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just before therapy** | A | 30 | 7.3470 | .0095 | 7.3465 | 0.0608 |
| | B | 30 | 7.3447 | .0129 | 7.3460 | |
| | C | 30 | 7.3399 | .0125 | 7.3405 | |
| **After 120 minutes** | A | 30 | 7.4380 | .0170 | 7.4440 | 0.6079 |
| | B | 30 | 7.4391 | .0192 | 7.4465 | |
| | C | 30 | 7.4344 | .0203 | 7.4450 | |

Distribution of mean pH with Group was not statistically significant just before therapy and at 120 minutes ($p>0.05$).

**Table 7: Distribution of mean $PaO_2$**

| $PaO_2$ | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just before therapy** | A | 30 | 59.9417 | 1.3716 | 60.0450 | 0.0002 |
| | B | 30 | 59.5590 | 1.3802 | 59.6500 | |
| | C | 30 | 58.5750 | .9303 | 58.5900 | |
| **After 120 Minutes** | A | 30 | 159.0577 | 45.7744 | 127.8650 | <0.0001 |
| | B | 30 | 176.5177 | 54.3181 | 178.8600 | |
| | C | 30 | 246.0830 | 37.6483 | 263.9100 | |

Distribution of mean $PaO_2$ with Group was statistically significant just before therapy and at 120 mins ($p<.05$).

**Table 8: Distribution of mean $PCO_2$**

| $PCO_2$ | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just before therapy** | A | 30 | 48.2100 | 1.1081 | 48.2000 | <0.0001 |
| | B | 30 | 48.6200 | 1.2322 | 48.7000 | |
| | C | 30 | 49.9600 | .9947 | 50.2500 | |
| **After 120 minutes** | A | 30 | 40.2567 | 2.0236 | 40.6000 | 0.0005 |
| | B | 30 | 39.1933 | 2.3817 | 39.4500 | |
| | C | 30 | 38.1267 | 1.6337 | 38.3000 | |

Distribution of mean $PCO_2$ with Group was statistically significant just before therapy and at 120 mins ($p<0.05$).

**Table 9: Distribution of mean $HCO_3$**

| $HCO_3$ | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just before therapy** | A | 30 | 23.7633 | .6625 | 23.6000 | <0.0001 |
| | B | 30 | 23.8800 | .9911 | 23.8000 | |
| | C | 30 | 22.8000 | .8898 | 22.6000 | |
| **After 120 minutes** | A | 30 | 24.2167 | .6120 | 24.2000 | 0.2636 |
| | B | 30 | 24.0000 | .7611 | 24.0500 | |
| | C | 30 | 23.9467 | .6367 | 23.7000 | |

Distribution of mean $HCO_3$ with Group was statistically significant just before therapy ($p<0.05$) but insignificant at 120 mins ($p>0.05$).

**Table 10: Distribution of mean P/F**

| P/F | Group | Number | Mean | SD | Median | p-value |
|---|---|---|---|---|---|---|
| **Just before therapy** | A | 30 | 285.4333 | 6.5479 | 286.0000 | 0.0002 |
| | B | 30 | 283.6000 | 6.6051 | 284.0000 | |
| | C | 30 | 278.9000 | 4.4206 | 279.0000 | |
| **After 120 minutes** | A | 30 | 338.2333 | 30.8865 | 319.5000 | <0.0001 |
| | B | 30 | 349.5667 | 33.6162 | 357.5000 | |
| | C | 30 | 384.1667 | 11.8963 | 385.0000 | |

Distribution of mean P/F with Group was statistically significant just before therapy and at 120 mins ($p<0.05$).

As per chi-square, there is no significant association between dryness of mouth, nostrils and group; and change in facial skin color and group. Further, ANOVA test shows distribution of mean Patient comfort with Group and distribution of mean Dyspnoea VAS with Group was statistically significant ($p<0.05$).

## Discussion

As per present study, age was statistically significant with Group. The reason may be that elderly patients are more likely than younger patients to have residual postoperative muscle relaxation, which affects the hypoxic ventilatory response and respiratory muscle strength, increasing the risk of airway obstruction and hypoxemia. Moreover, respiratory reserve decreases with age for elderly patients; low lung capacity, high residual volume, low ventilatory efficiency, low blood vessel elasticity, and low lung perfusion lead to an imbalance in the pulmonary ventilation/blood flow ratio, further increasing the risk of hypoxemia in cases with surgical and anesthesia stress. Similar results were found in a study by Xiuhua Zhang et al (2019) [8].

The increment of SPO2 to 100% was much quick in maximum patients NIV and HFNOC group than the conventional face mask group (45 to 75 minutes vs 90 minutes) and this relation was statistically significant. This might be by reducing the work of breathing, by improving alveolar ventilation associated with increased gas exchange, reducing left ventricular afterload with increase of cardiac output, and by reducing atelectasis. It is also observed that the lowering of pulse rate is also more early in group B and C than group A and this might be due to correction of hypoxia which was earlier in group B and C. We observed that HFNOC applied to those patients where respiratory rate is slightly high than other two groups and correction of tachypnea is much faster in NIV and HFNOC group than conventional facemask. This might be due to improvement in work of breathing and improve in oxygenation.

Compared with conventional face mask oxygen therapy, HFNC and NIV can improve oxygenation first by providing a better matching of gas flow in the case of high inspiratory flow, thereby ensuring higher FIO2 and second by generating of PEEP that may increase end-expiratory lung volume. It is important to discuss the greater improvement in PaO2/FIO2 with NIV and HFNC. In patients with acute hypoxemic respiratory failure, NIV increases functional residual capacity and displaces ventilation up from the lower flat portion of the respiratory system pressure-volume curve into a more linear portion. Through this well-known mechanism, it improves oxygenation. Although studies have demonstrated that HFNC is associated with generation of 2-3 cm H2O positive expiratory pressure [9] but it along with heated and humidified flow it causes much improvement in P/F ratio.

In clinical practice, Sztrymf et al. [10] reported a remarkable tolerance of HFNC over longer use. This excellent tolerance, systematically reported with HFNC during acute hypoxemic failure, is attributable, at least in part, to the heat and humidity supplied by the device. HFNC's design does not lead to a sense of claustrophobia, which significantly improves compliance. At the same time, the heating and humidifying function of HFNC enables the gas delivered to reach an absolute humidity of 44 mg H2O/L and a temperature of 37 °C, which effectively promotes the discharge of secretions while avoiding side effects such as dry mucous membranes. Because of these characteristics, patients can easily tolerate a gas flow rate of up to 50–60 L/min. The better tolerance of HFNC over NIV is clearly seen in comparing the comfort scores between the two groups [11].

Futier E et al (2016) [12] found that high-flow nasal cannula (HFNC) oxygen therapy is attracting increasing interest in acute medicine as an alternative to standard oxygen therapy. Hernández G et al (2016) [13] showed that high-flow conditioned oxygen therapy delivered through nasal cannula and noninvasive mechanical ventilation (NIV) may reduce the need for reintubation. Xu Z et al (2018) [14] observed that high-flow nasal cannula (HFNC) can be used as an initial support strategy for patients with acute respiratory failure (ARF) and after extubation. However, no clear evidence exists to support or oppose HFNC use in clinical practice. They summarized the effects of HFNC, compared to conventional oxygen therapy (COT) and noninvasive ventilation (NIV), on important outcomes including treatment failure and intubation/reintubation rates in adult patients with ARF and after extubation.

Tiruvoipati et al. (2010) [15] compared HFNO and high- flow oxygen via facemask in 50 patients randomized to receive either high-flow oxygen via facemask followed by HFNO or HFNO and then high-flow oxygen via facemask, 30 min after extubation. The gas flow rate (30 liters min 1) and FIO2 (of 30-40%) were maintained throughout the entire study period and during the stabilization period. Oxygenation was no different in either of the devices, while HFNO resulted in being better tolerated (P<0.01).

Considering the observed advantages over conventional face mask oxygen therapy HFNOC and NIV can be considered for post extubation hypoxia, and it was observed that HFNOC is more comfortable, tolerable, and having no facial skin color change than NIV. Advantages of HFNC are that patients can tolerate oral feeding, hold verbal communication, or even ambulate while receiving oxygen therapy. Although no studies assessing these parameters have been published, these unique characteristics of HFNC carry great clinical relevance.

## Conclusion

The present study concluded that HFNOC and NIV is more effective than conventional oxygen therapy in improving oxygenation in patients with post extubation hypoxia. HFNOC and NIV also showed better outcome in correction in hypercapnia, lowering of respiratory rate. Finally, Between HFNOC and NIV, HFNOC is comparatively comfortable and better tolerated.

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