COMPARISION OF OXYGEN DELIVERY DEVICES IN POST OPERATIVE PATIENTS WITH HYPOXEMIA: AN OPEN LABELLED RANDOMISED CONTROLLED STUDY

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AIIMS, JODHPUR **DR SUSRI MISHRA**

DECLARATION

I hereby declare that the thesis titled **"COMPARISION OF OXYGEN DELIVERY DEVICES IN POST OPERATIVE PATIENTS WITH HYPOXEMIA: AN OPEN LABELLED RANDOMISED CONTROLED STUDY"** embodies the original work carried out by me at All India Institute of Medical Sciences, Jodhpur.

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CERTIFICATE

This is to certify that the thesis titled **"COMPARISION OF OXYGEN DELIVERY DEVICES IN POST OPERATIVE PATIENTS WITH HYPOXEMIA: AN OPEN LABELLED RANDOMISED CONTROLED STUDY"** is the bonafide work of **DR. SUSRI MISHRA** carried out under our guidance and supervision, at Department of Anaesthesiology and Critical Care, All India Institute of Medical Sciences, Jodhpur.

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"It always seems impossible until it's done."

-Nelson Mandela

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Dr. Susri Mishra

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LIST OF ABBREVIATIONS

1.ABG-Arterial Blood Gas

2.AHRF- Acute Hypoxemic Respiratory Failure

3.ANOVA-Analysis of Variance

4.ARF- Acute Respiratory Failure

5.BiPAP- Bilevel Positive Airway Pressure

6.CKD- Chronic Kidney Disease

7.CONSORT- Consolidated Standards of Reporting Trials

8.COPD- Chronic Obstructive Pulmonary Disease

9.COT- Conaventional Oxygen Therapy

10.CPAP-Continuous Positive Airway Pressure

11.CTRI- Clinical Trial Registry of India

12.DM- Diabetes Mellitus

13.EPAP- Expiratory Positive Airway Pressure

14.FiO_2- Fraction of Inspired Oxygen

15.FRC- Functional Residual Capacity

16.HFNC- High Flow Nasal Cannula

17.HME- Heat and Moisture Exchanger

18.HTN- Hypertension

19.ICU-Intensive Care Unit

20.IPAP- Inspiratory Positive Airway Pressure

21.LOS- Length of Stay

22.NIV- Non Invasive Ventilation

23.ODV- Oxygen Delivery Vehicle

24.PACU- Post Anaesthesia Care Unit

25.$PaCO_2$- Partial Pressure of Carbon dioxide

26.PaO_2- Partial Pressure of Oxygen

27.PEEP- Positive End Expiratory Pressure

28.RCT- Randomized Control Trial

29.RR- Relative Risk

30.VM- Venturi Mask

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SUMMARY

Background: Acute hypoxemic respiratory failure (AHRF) is one of the most frequent complications in postoperative patients. Patients who experience postoperative respiratory failure might need to be reintubated. It mainly occurs due to atelectasis, pulmonary edema, aspiration, residual neuromuscular blockade and results in a marked increase in overall length of stay in ICU and hospital; time for rehabilitation; mortality and financial expenditures [4]. The cornerstone of treatment for AHRF is supplemental Oxygen, along with treating the underlying cause.

Methods: We conducted an Open Labelled Randomized control trial with 90 patients and compared three Oxygen Delivery vehicles (ODV) i.e, Non-Invasive Ventilation, High Flow Nasal Cannula and Venturi Mask in postoperative hypoxemic patients. The ODV was selected randomly using a sealed envelope method. These are fixed-performance devices where fixed FiO_2 of 0.5 was set for all the patients in the study. First ABG was taken before applying ODV, and the next ABG was taken after 2 hours of continuous application of ODV. The parameters compared were P/F ratio, PaO_2 , $PaCO_2$, and SpO_2.

Results and Conclusion: The result showed that the change in P/F ratio was similar in all three ODV groups. The mean values of the post-ODV P/F ratio were comparable with the pre-ODV P/F ratio in all three modalities. All three modalities are equally effective for postoperative oxygenation, with none of the ODVs being superior to another ($p>0.05$). Hence the null hypothesis stands true; that is, there is no difference in PaO_2 /FiO_2 ratio (P/F ratio) while using different oxygen delivery devices in PACU for managing hypoxemia.

INTRODUCTION

Postoperative hypoxemia is one of the most common manifestations of respiratory failure after extubation. It is characterized by paO_2/FiO_2 (P/F) ratio of less than 300 with clinical signs of respiratory distress caused due to increased respiratory drive. Atelectasis and pulmonary edema are the most common reasons for postoperative hypoxemia. This results in increased mortality, length of hospital stay, more prolonged healing and recovery, and poor long-term outcomes [2]. Supplemental Oxygen is often used to treat hypoxemia following ventilator support interruption and endotracheal tube removal [8]. In critically unwell patients, various oxygen delivery devices are used. Some examples are face masks, Non-rebreathing masks with a reservoir, Venturi masks, Non Invasive Ventilation, High flow nasal cannulas, etc.

We aimed to compare different oxygen delivery devices with fixed performance like Non-Invasive Ventilation (NIV), High Flow Nasal Cannula (HFNC) and Venturi Mask(VM). Fixed-performance systems deliver a consistent Fio2 regardless of the peak inspiratory flow of a patient.

The Venturi Mask helps in delivering a predetermined FiO_2. It delivers Oxygen at lower flow rates than patients' inspiratory needs; consequently, when the patient's inspiratory flow exceeds the mask's gas flow rate, room air is entrained [8]. The patient receives a predefined and fixed concentration of Oxygen, using the Bernoulli principle (with an increase in the fluid speed, the pressure decreases), described by Daniel Bernoulli in 1738. It uses connectors of different colors with varying sizes of constrictors. Different colors have specific flow rates along with the percentage of Oxygen being delivered, which is mentioned on the connectors. The final concentration of Oxygen for a given gas flow is determined by the size of the constrictor[2]. Despite the patient's respiratory pattern, desired flow is achieved by generating a greater gas flow than the peak inspiratory flow rate.

HFNC is a device that can generate a flow rate of up to 60L/min. It uses an air/oxygen blender to deliver FiO_2 from 21% to 100%.To prevent loss and condensation through a large-diameter nasal cannula, an active heated humidifier warms and humidifies the gas before administering to the patient[1]. Continuous high-flow oxygen delivery produces positive end expiration pressure (PEEP), which improves breathing by maintaining stable FiO2 and flushing away physiologic dead space. Large nasal prongs may cause nasal blockage, and

consistent high flow creates resistance on expiration, producing positive pressure [10]. When respondents' breath spontaneously with their mouths closed, the pressure recorded on the HFNC was substantially higher and linearly associated with the administered flow rate: < 2 cmH2O when the mouth is open and >3 cmH2O when the mouth is closed along with a gas flow rate of 50 L/min [10]. The heating and humidification help in clearance of secretions, decreases bronchospasm, and maintains mucosal integrity [1].

NIV (Non-Invasive Ventilation) has been used to provide mechanical ventilation without using a definitive airway. It provides positive pressure ventilation via a tight sealed face mask, mainly used in the management of hypoxemia, hypercapnic respiratory failure and Acute Respiratory Failure (ARF). Indications of NIV include acute exacerbation of COPD, Cardiogenic pulmonary edema, OSA, Obesity hypoventilation syndrome, weaning from mechanical ventilation, avoidance of post-extubation failure in previously intubated subjects, etc. [7]. Mainly two modes of NIV are used - CPAP (Continuous Positive Airway Pressure) and BiPAP (Bilevel Positive Airway Pressure). BiPAP has two methods of pressure settings; IPAP and EPAP. The difference between the two provides pressure support, which helps deliver the desired tidal volume to the patient. CPAP provides a continuous PEEP (Positive end-expiratory pressure). PEEP enhances Functional residual capacity (FRC), opens up the collapsed alveoli, and increases lung compliance improving oxygenation and work of breathing. Additionally, it lowers left ventricular afterload, boosting cardiac output and hemodynamics [9].

ABG is a valuable investigation to look for dissolved Oxygen and carbon dioxide levels, acid-base balance and pH, and many other useful parameters in our blood. In our study, ABG was the mainstay test used to compare the efficacies of different ODVs.

We hypothesize that there is no difference in PaO_2/FiO_2 ratio (P/F ratio) after using different oxygen delivery devices in the postoperative period for managing hypoxemia in Post Anaesthesia Care Unit (PACU). To evaluate this hypothesis, we performed an open-labeled randomized control trial to test and compare the efficacy of HFNC, NIV, and Venturi Mask in patients having hypoxemia post-extubation.

AIMS AND OBJECTIVES

The aim of the study was to compare PaO_2/FiO_2 ratio (P/F ratio) of post-operative patients developing hypoxemia by using different oxygen delivery devices .

PRIMARY OBJECTIVE

1) Change in P/F ratio after two hours of use of oxygen delivery devices in Post Anaesthesia Care Unit (PACU).

SECONDARY OBJECTIVES

1) Changes in blood gas ($PaCO_2$ and PaO_2) levels

2)Patient comfort and Ease of communication.

4) Oral fluids or food intake.

5) Complaints of any other side effect (nasal crusting, headache, nausea or vomit).

REVIEW OF LITERATURE

1.Lee et al (2016) conducted a systemic review on High flow nasal cannula versus conventional oxygen therapy and non-invasive ventilation in adults with acute hypoxemic respiratory failure. Studies reviewed were selected based on relevance from a systematic literature search conducted in Medline and EMBASE to include all published original research through May 2016. Twelve studies matched the inclusion criteria. Of these, 1 was a multicenter randomized trial, 4 were prospective randomized comparative studies, 1 was a prospective randomized sequential study, and 6 were prospective (sequential intervention or observational) studies. This review suggests that HFNC may be superior to COT in AHRF patients in terms of oxygenation, patient comfort, and work of breathing. It may be reasonable to consider HFNC as an intermediate level of oxygen therapy between COT and NIV. HFNC impact on mortality remained equivocal in all studies, except one that demonstrated a reduction in mortality in the ICU and at 90 days in a subgroup of patients with severe hypoxemia (PaO2:FIO2≤ 200 mmHg). In comparison to NIV, HFNC was found to be either inferior or equivocal in oxygenation and work of breathing; however, HFNC seemed to be better tolerated and was associated with greater comfort than NIV.

2.Chaudhuri et al (2020) comprehensively searched databases (PubMed, Embase, Web of Science) to identify randomized controlled trials (RCTs) that compared the effect of HFNC use with that of COT or NIV in the immediate postoperative period on reintubation, escalation of respiratory support, hospital mortality, ICU and hospital length of stay (LOS), postoperative hypoxemia, and treatment complications. The study included 11 RCTs enrolling 2,201 patients. Ten compared HFNC with COT and one with NIV. Compared with COT use, HFNC use in the postoperative period was associated with a lower reintubation rate (relative risk [RR], 0.32; 95% CI, 0.12-0.88; absolute risk reduction [ARR], 2.9%; moderate certainty) and decreased escalation of respiratory support (RR, 0.54; 95% CI, 0.31-0.94; ARR, 5.8%; very low certainty). Post hoc subgroup analysis suggested that this effect was driven by patients who were obese and/or at high risk (subgroup differences, $P = .06$). No differences were found in any of the other stated outcomes between HFNC and COT. HFNC was also no different from NIV in reintubation rate, respiratory therapy failure, or ICU LOS.

3.Schwabbauer et al (2014) conducted a prospective randomized sequential intervention study to compare the short-term effects of oxygen therapy via a high-flow nasal cannula (HFNC) on functional and subjective respiratory parameters in patients with acute hypoxic respiratory failure in comparison to non-invasive ventilation (NIV) and standard treatment via a Venturi mask. Fourteen patients with acute hypoxic respiratory failure were treated with HFNC (FiO_2 0.6, gas flow 55 l/min), NIV (FiO_2 0.6, PEEP 5 cm H_2O Hg, tidal volume 6–8 ml/kg ideal body weight,) and Venturi mask (FiO_2 0.6, oxygen flow 15 l/min,) in a randomized order for 30 min each. Data collection included objective respiratory and circulatory parameters as well as a subjective rating of dyspnea and discomfort by the patients on a 10-point scale. In a final interview, all three methods were comparatively evaluated by each patient using a scale from 1 (=very good) to 6 (=failed) and the patients were asked to choose one method for further treatment. Outcomes assessed were PaO2, RR, dyspnea and comfort. PaO_2 was highest under NIV (129 ± 38 mmHg) compared to HFNC (101 ± 34 mmHg, p <0.01 vs. NIV) and VM (85 ± 21 mmHg, p <0.001 vs. NIV, p <0.01 vs. HFNC, ANOVA). In contrast, dyspnea was significantly better using a HFNC (2.9 ± 2.1, 10-point Borg scale) compared to NIV (5.0 ± 3.3, p <0.05), whereas dyspnea rating under HFNC and VM (3.3 ± 2.3) was not significantly different. A similar pattern was found when patients rated their overall discomfort on the 10 point scale: HFNC 2.7 ± 1.8, VM 3.1 ± 2.8 (ns vs. HFNC), NIV 5.4 ± 3.1 (p <0.05 vs. HFNC). In the final evaluation patients gave the best ratings to HFNC 2.3 ± 1.4, followed by VM 3.2 ± 1.7 (ns vs. HFNC) and NIV 4.5 ± 1.7 (p <0.01 vs. HFNC and p <0.05 vs. VM). For further treatment 10 patients chose HFNC, three VM and one NIV. Study concluded that in hypoxic respiratory failure HFNC offers a good balance between oxygenation and comfort compared to NIV and Venturi mask and seems to be well tolerated by patients.

4.Parke et al (2011) conducted a study in a cardiothoracic and vascular intensive care unit, to compare nasal high-flow (NHF) oxygen therapy and standard high-flow face mask (HFFM) oxygen therapy in patients with mild to moderate hypoxemic respiratory failure. In a prospective randomized comparative study, 60 patients with mild to moderate hypoxemic respiratory failure were randomized to receive NHF or HFFM.They analyzed the success of allocated therapy, noninvasive ventilation rate, and oxygenation. Significantly more NHF patients succeeded with their allocated therapy (P = .006). The rate of noninvasive ventilation in the NHF group was 3/29 (10%), compared with 8/27 (30%) in the HFFM group (P = .10). The NHF patients also had significantly fewer desaturations (P = .009).The study concluded

that NHF oxygen therapy may be more effective than HFFM in treating mild to moderate hypoxemic respiratory failure.

5. Sztrymf et al (2011)(Intensive Care Med)conducted a prospective observational study to determine the impact of high-flow nasal cannula oxygen (HFNC) on patients with acute respiratory failure (ARF) in comparison with conventional oxygen therapy. Patients with persistent ARF despite oxygen with conventional facemask without indication for immediate intubation were treated with HFNC oxygen. Clinical respiratory parameters and arterial blood gases were compared under conventional and HFNC oxygen therapy.Twenty patients, aged 59 years (38-75 years) and SAPS2 (simplified acute physiology score) 33 (26.5-38), were included in the study. Etiology of ARF was mainly pneumonia (n = 11), sepsis (n = 3), and miscellaneous (n = 6). Use of HFNC enabled a significant reduction of respiratory rate, 28 (26-33) vs 24.5 (23-28.5) breath per minute (*P* = .006), and a significant increase in oxygen saturation, oxygen saturation as measured by pulse oximetry 93.5% (90-98.5) vs 98.5% (95.5-100) (*P* = .0003). Use of HFNC significantly increased Pao_2 from 8.73 (7.13-11.13) to 15.27 (9.66-25.6) kPa (*P* = .001) and moderately increased $Paco_2$, 5.26 (4.33-5.66) to 5.73 (4.8-6.2) kPa (*P* = .005) without affecting pH. Median duration of HFNC was 26.5 (17-121) hours. Six patients were secondarily intubated, and 3 died in the intensive care unit. The study concluded that use of HFNC in patients with persistent ARF was associated with significant and sustained improvement of both clinical and biologic parameters.

6.Frat et al (2015) conducted a Multi Centre Randomized Control Trial on High Flow Oxygen through nasal cannula in acute hypoxemic respiratory failure.performed a multicentre, open-label trial in which they randomly assigned patients without hypercapnia who had acute hypoxemic respiratory failure and a ratio of the partial pressure of arterial oxygen to the fraction of inspired oxygen of 300 mm Hg or less to high-flow oxygen therapy, standard oxygen therapy delivered through a face mask, or non-invasive positive-pressure ventilation. The primary outcome was the proportion of patients intubated at day 28; secondary outcomes included all-cause mortality in the intensive care unit and at 90 days and the number of ventilator-free days at day 28.310 patients were included. The intubation rate (primary outcome) was 38% (40 of 106 patients) in the high-flow–oxygen group, 47% (44 of 94) in the standard group, and 50% (55 of 110) in the noninvasive-ventilation group (P=0.18 for all comparisons). The number of ventilator-free days at day 28 was significantly higher in

the high-flow–oxygen group (24±8 days, vs. 22±10 in the standard-oxygen group and 19±12 in the noninvasive-ventilation group; P=0.02 for all comparisons). The hazard ratio for death at 90 days was 2.01 (95% confidence interval [CI], 1.01 to 3.99) with standard oxygen versus high-flow oxygen (P=0.046) and 2.50 (95% CI, 1.31 to 4.78) with noninvasive ventilation versus high-flow oxygen (P=0.006). The study concluded that in patients with nonhypercapnic acute hypoxemic respiratory failure, treatment with high-flow oxygen, standard oxygen, or non-invasive ventilation did not result in significantly different intubation rates.

7.Vargas et al (2015) conducted a Prospective Sequential Study on physiologic effects of high flow nasal cannula oxygen in critical care subjects. Twelve subjects admitted to the ICU for acute hypoxemic respiratory failure were prospectively included. Four study sessions were performed. The first session consisted of oxygen therapy given through a high-FIO2, non-rebreathing face mask. Recordings were then obtained during periods of HFNC and CPAP at 5 cm H2O in random order, and final measurements were performed during oxygen therapy delivered via a face mask. Each of these 4 periods lasted ∼20 min.Esophageal pressure signals, breathing pattern, gas exchange, comfort, and dyspnea were measured. Compared with the first session, HFNC reduced inspiratory effort (pressure-time product of 156.0 [119.2–194.4] cm H_2O × s/min vs 204.2 [149.6–324.7] cm H_2O × s/min, P < .01) and breathing frequency (P < .01). No significant differences were observed between HFNC and CPAP for inspiratory effort and breathing frequency. Compared with the first session, PaO /FiO_2 increased significantly with HFNC (167 [157–184] mm Hg vs 156 [110–171] mm Hg, P < .01). CPAP produced significantly greater PaO2/FIO2 improvement than did HFNC. Dyspnea improved with HFNC and CPAP, but this improvement was not significant. Subject comfort was not different across the 4 sessions. The study concluded that compared with conventional oxygen therapy, HFNC improved inspiratory effort and oxygenation. In subjects with acute hypoxemic respiratory failure, HFNC is an alternative to conventional oxygen therapy.

8.Maggiore et al (2014) conducted a randomized, controlled, open-label trial on 105 patients with a Pa_{O2}/Fi_{O2} ratio less than or equal to 300 immediately before extubation. The Venturi mask (n = 52) or NHF (n = 53) were applied for 48 hours postextubation. Pa_{O2}/Fi_{O2}SET, patient discomfort caused by the interface and by symptoms of airways dryness (on a 10-point numerical rating scale), interface displacements, oxygen desaturations, need for

ventilator support, and reintubation were assessed up to 48 hours after extubation. From the 24th hour, PaO_2/FiO_2 SET was higher with the NHF (287 ± 74 vs. 247 ± 81 at 24 h; P = 0.03). Discomfort related both to the interface and to airways dryness was better with NHF (respectively, 2.6 ± 2.2 vs. 5.1 ± 3.3 at 24 h, P = 0.006; 2.2 ± 1.8 vs. 3.7 ± 2.4 at 24 h, P = 0.002). Fewer patients had interface displacements (32% vs. 56%; P = 0.01), oxygen desaturations (40% vs. 75%; P < 0.001), required reintubation (4% vs. 21%; P = 0.01), or any form of ventilator support (7% vs. 35%; P < 0.001) in the NHF group. Study concluded that with the Venturi mask, NHF results in better oxygenation for the same set FiO2 after extubation. Use of NHF is associated with better comfort, fewer desaturations and interface displacements, and a lower reintubation rate.

9.Bell et al (2015) conducted a Prospective randomized trial of humidified high flow nasal cannula versus standard oxygen therapy (nasal cannula, Venturi mask, face mask, Non-rebreathing face mask) in emergency department. Primary outcomes were the need to escalate ventilation therapy or a reduction in respiratory rate of 20% or more within 2 h of commencement. One hundred patients were enrolled in the trial. The intervention group receiving HHFNC was associated with a higher proportion of patients with a reduced respiratory rate at 2 h (66.7% *vs* 38.5%, $P = 0.005$) and a lower proportion of patients requiring escalation in ventilation therapy (4.2% *vs* 19%, $P = 0.02$) compared with standard oxygen therapy. The study concluded that use of high flow nasal cannula oxygenation was associated with improved respiratory state in selected patients presenting to the ED with acute undifferentiated shortness of breath.

10.Jones et al (2015) conducted a randomized controlled trial of humidified high flow nasal oxygen for acute respiratory distress in the emergency department. Subjects were adults with hypoxia and tachypnea presenting to a tertiary academic hospital emergency department. The primary outcome was the need for mechanical ventilation in the emergency department. 1,287 patients were screened, 322 met entry criteria and 19 were excluded from analysis. Of these, 165 randomized to HFNC and 138 to standard O_2 were analyzed. Baseline characteristics were similar. In the HFNC group, 3.6% (95% CI 1.5–7.9%) versus 7.2% (95% CI 3.8–13%) in the standard O_2 group required mechanical ventilation in the emergency department ($P = .16$), and 5.5% (95% CI 2.8–10.2%) in HFNC versus 11.6% (95% CI 7.2–18.1%) in the standard O_2 group required mechanical ventilation within 24 h of admission ($P = .053$). There was no difference in mortality or stay. Adverse effects were infrequent;

however, fewer subjects in the HFNC group had a fall in Glasgow coma score due to CO_2 retention, 0% (95% CI 0–3%) versus 2.2% (95% CI 0.4–6%). One in 12 subjects did not tolerate HFNC . HFNC was not shown to reduce the need for mechanical ventilation in the emergency department for subjects with acute respiratory distress compared with standard O_2, although it was safe and may reduce the need for escalation of oxygen therapy within the first 24 h of admission.

11.Stephan et al (2015) conducted Multicenter, randomized, noninferiority trial (BiPOP Study) between June 15, 2011, and January 15, 2014, at 6 French intensive care units. A total of 830 patients who had undergone cardiothoracic surgery, were included when they developed acute respiratory failure. Patients were randomly assigned to receive high-flow nasal oxygen therapy delivered continuously through a nasal cannula (flow, 50 L/min; fraction of inspired oxygen [FIO2], 50%) (n = 414) or BiPAP delivered with a full-face mask for at least 4 hours per day (pressure support level, 8 cm H2O; positive end-expiratory pressure, 4 cm H2O; FIO2, 50%) (n = 416). High-flow nasal oxygen therapy was not inferior to BiPAP: with BiPAP, treatment failure occurred in 91 of 416 patients (21.9%; 95% CI, 18.0%-26.2%) compared with 87 of 414 (21.0%; 95% CI, 17.2%-25.3%) with high-flow nasal oxygen. The risk difference was 0.9% (95% CI, −4.9% to 6.6%; P = .003). No significant differences were found for intensive care unit mortality (23 patients with BiPAP [5.5%] and 28 with high-flow nasal oxygen therapy [6.8%]; P = .66) (absolute difference, 1.2% [95% CI, -2.3% to 4.8%]. Skin breakdown was significantly more common with BiPAP after 24 hours (10% vs 3%; 95% CI, 7.3%-13.4% vs 1.8%-5.6%; P < .001) The study concluded that among patients undergoing cardiothoracic surgery with or at risk for respiratory failure, the use of high-flow nasal oxygen compared with intermittent BiPAP did not result in a worse rate of treatment failure.

12.Rittayamai et al (2014) conducted a randomized crossover study in a 10-bed respiratory care unit in a university hospital. Forty subjects were randomized to receive HFNC or COT for 1 h. The primary outcome was level of dyspnea, and secondary outcomes included change in breathing frequency, subject comfort, adverse events, and rate of hospitalization. Seventeen mechanically ventilated subjects were randomized after extubation to either Protocol A (applied HFNC for 30 min, followed by non-rebreathing mask for another 30 min) or Protocol B (applied non-rebreathing mask for 30 min, followed by HFNC for another 30 min). The level of dyspnea, breathing frequency, heart rate, blood pressure, oxygen

saturation, and patient comfort were recorded. Common causes of acute dyspnea and hypoxemia were congestive heart failure, asthma exacerbation, COPD exacerbation, and pneumonia. HFNC significantly improved dyspnea (2.0 ± 1.8 vs 3.8 ± 2.3, *P* = .01) and subject comfort (1.6 ± 1.7 vs 3.7 ± 2.4, *P* = .01) compared with COT. No statistically significant difference in breathing frequency was found between the 2 groups at the end of the study. HFNC was well tolerated, and no serious adverse events were found. The rate of hospitalization in the HFNC group was lower than in the COT group, but there was no statistically significant difference (50% vs 65%, *P* = .34). HFNC improved dyspnea and comfort in subjects presenting with acute dyspnea and hypoxemia in the emergency department.The study concluded that HFNC may benefit patients requiring oxygen therapy in the emergency room.

13.Tiruvoipati et al (2009) randomized patients to either protocol A (n = 25; HFFM- High flow face mask followed by HFNP- High flow nasal prongs) or protocol B (n = 25; HFNP followed by HFFM) after a stabilization period of 30 minutes after extubation. The primary objective was to compare the efficacy of HFNP to HFFM in maintaining gas exchange as measured by arterial blood gas. Secondary objective was to compare the relative effects on heart rate, blood pressure, respiratory rate, comfort, and tolerance. Patients in both protocols were comparable in terms of age, demographic, and physiologic variables including arterial blood gas, blood pressure, heart rate, respiratory rate, Glasgow Coma Score, sedation, and Acute Physiology and Chronic Health Evaluation (APACHE) III scores. There was no significant difference in gas exchange, respiratory rate, or hemodynamics. There was a significant difference (P = .01) in tolerance, with nasal prongs being well tolerated. There was a trend (P = .09) toward better patient comfort with HFNP. The study concluded that there was no significant difference in gas exchange, respiratory rate, or hemodynamics. There was a significant difference (P = .01) in tolerance, with nasal prongs being well tolerated.

14.Testa et al (2014) conducted randomized, controlled trial in pediatric cardiac surgical patients under 18 months of age. At the beginning of the weaning of ventilation, patients were randomly assigned to either of the following groups: OT or HFNC. Arterial blood samples were collected before and after extubation at the following time points: 1, 6, 12, 24 and 48 h. The primary outcome was comparison of arterial PaCO2 postextubation; secondary outcomes were PaO2 and PaO2/fractional inspired oxygen (FiO2) ratio. Analysis of variance

for repeated measures showed that PaCO2 was not significantly different between the HFNC and OT groups (P = 0.5), whereas PaO2 and PaO2/FiO2 were significantly improved in the HFNC group (P = 0.01 and P = 0.001). The rate of reintubation was not different in the two groups (P = 1.0), whereas the need for noninvasive respiratory support was 15% in the OT group and none in the HFNC group (P = 0.008).

METHODOLOGY

Study setting: Department of Anaesthesiology and Critical Care, AIIMS, Jodhpur

Study design: Prospective, Open Label, Randomized Control Study.

The present study was carried out in the department of Anaesthesiology and Critical Care at AIIMS, Jodhpur after getting approval from institutional ethics committee [Institutional Ethics Committee, All India Institute of Medical Sciences, Jodhpur 342005 (Raj.); Certificate Reference Number: AIIMS/IEC/2021/3354; dated 12/03/2021; approved by Dr Parveen Sharma] and informed written consent from patients. We registered the study prospectively at the clinical trial registry of India (CTRI: www.ctri.nic.in) (Ref. No. CTRI/2021/06/0044371, Date of Registration: 05/07/2021, Patient Enrolment date: 10/07/2021). The study was carried out in 90 patients admitted in the PACU (Post Anaesthesia Care Unit) . Enrolment of patients started in July 2021 and ended in September 2022. All post-operative adult patients of age between 18 to 65 years with hypoxemia who are admitted/kept for monitoring in Post Anaesthesia Care Unit (PACU) after undergoing surgery were enrolled for the study.

INCLUSION CRITERIA:

All post-op adult patients (of age 18 to 65 years) having:

- SpO_2<90% on room air.
- SpO_2<92% on nasal prongs or face mask during their PACU stay.

EXCLUSION CRITERIA:

- Patients with abnormalities of face or who are post-surgery of face, nose or airway
- Patients Post Thoracotomy and Lung surgeries
- Patients with pre-existing pulmonary complications
- Patients who underwent Head and Neck surgery
- Patients having episodes of Vomiting or Haemoptysis
- Patients underwent upper Gastro-intestinal surgery
- Pregnant women
- SpO_2 >92%
- Intubated patients.

DATA COLLECTION

All patients admitted in PACU after undergoing Surgery having SpO_2<90% on room air or SpO_2<92% on nasal prongs/ face mask were enrolled in the study. After explaining about the study in detail to the patient or their relatives and solving their queries an informed consent was taken and then the patients were enrolled in the study. A brief history of the patients was taken regarding relevant comorbidities, duration of illness, medications and the Surgery. Physiological data including vital signs such as heart rate, respiratory rate, blood pressure, pulse oxygen saturation and ABG values which include PaO_2, $PaCO_2$, PaO_2/FiO_2, SaO_2 were also recorded. The Oxygen Delivery Devices (ODV) that we used on patients were fixed performance devices like HFNC, NIV and Venturi Mask so that the delivered Oxygen could be of fixed FiO_2 with all the devices. Type of Oxygen delivery device to be used for the study was randomly selected by the physician, using a sealed envelope method.

High Flow Oxygen (heated and humidified-37°C and 44 mg H_2O/L) was delivered continuously through a nasal cannula with HFNC. The initial flow rate was 50 L/min and the initial Fio_2 was kept at 50%. Bilevel positive airway pressure (BiPAP) was delivered with a tightly sealed face mask and either a ventilator specifically designed for BiPAP or an ICU ventilator in pressure-support mode with added PEEP (positive end-expiratory pressure) of 5cm H_2O was used. We used filters for heat and moisture exchange (HME). Pressure support was increased, starting at 8 cm H_2O, to achieve an exhaled tidal volume of 7-8 mL/kg and a respiratory rate < 25/min. Fraction of inspired oxygen was 50%. Venturi mask having a constrictor that could provide 0.5 FiO_2 was used.

Patients with abnormalities of face or who were post-surgery of face, nose or airway, post thoracotomy and lung surgeries,having pre-existing pulmonary complications and those who underwent Head and Neck surgery were excluded from the study.

Arterial Blood Gas (ABG) values (PaO_2/FiO_2, PaO_2, PaC_{O2}) were recorded 2 hours after administering oxygen therapy or prior to shifting of patient from PACU. FiO_2 was kept fixed at 0.5 (50%).

SAMPLE SIZE:

There were three homogenous groups. Various quantitative variables were compared like P/F ratio,PaO_2,$PaCO_2$,SpO_2 etc. The following results from the study conducted by **Schwabbauer et al (2014)** has been obtained.

TABLE 1: SAMPLE SIZE CALCULATION OF THREE GROUPS

	Group 1 (HFNC)	Group 2 (NIV)	Group 3 (Venturi Mask)
PaO_2	2.3 ± 1.4	4.5 ± 1.7	3.2 ± 1.7

Following formula has been used for the calculation of sample size,

$$n = \frac{[Z(1-\alpha/2) + Z(1-\beta)]^2 2S_p^2}{\mu^2}$$

Considering α= 5%, β= 20%, Confidence Interval= 95% and Power= 80%;

On comparing values of group 2 vs group 3 using the above formula, we got a sample size of 27 in each group. Adding 10% contingency, final sample size for each group was calculated as **30**.

OBSERVATION AND RESULTS

In this study total 132 patients were assessed for eligibility; 28 patients were excluded in the beginning of the study as they did not meet the inclusion criteria and six patients (6) did not give consent. Total 104 patients were enrolled for the study and randomised. However, 7 patients from Venturi Mask group and 7 from NIV group were not included for data analysis as ABG could not be done and some patients did not tolerate ODV. Finally,the data of ninety patients was analyzed and the results were computed.

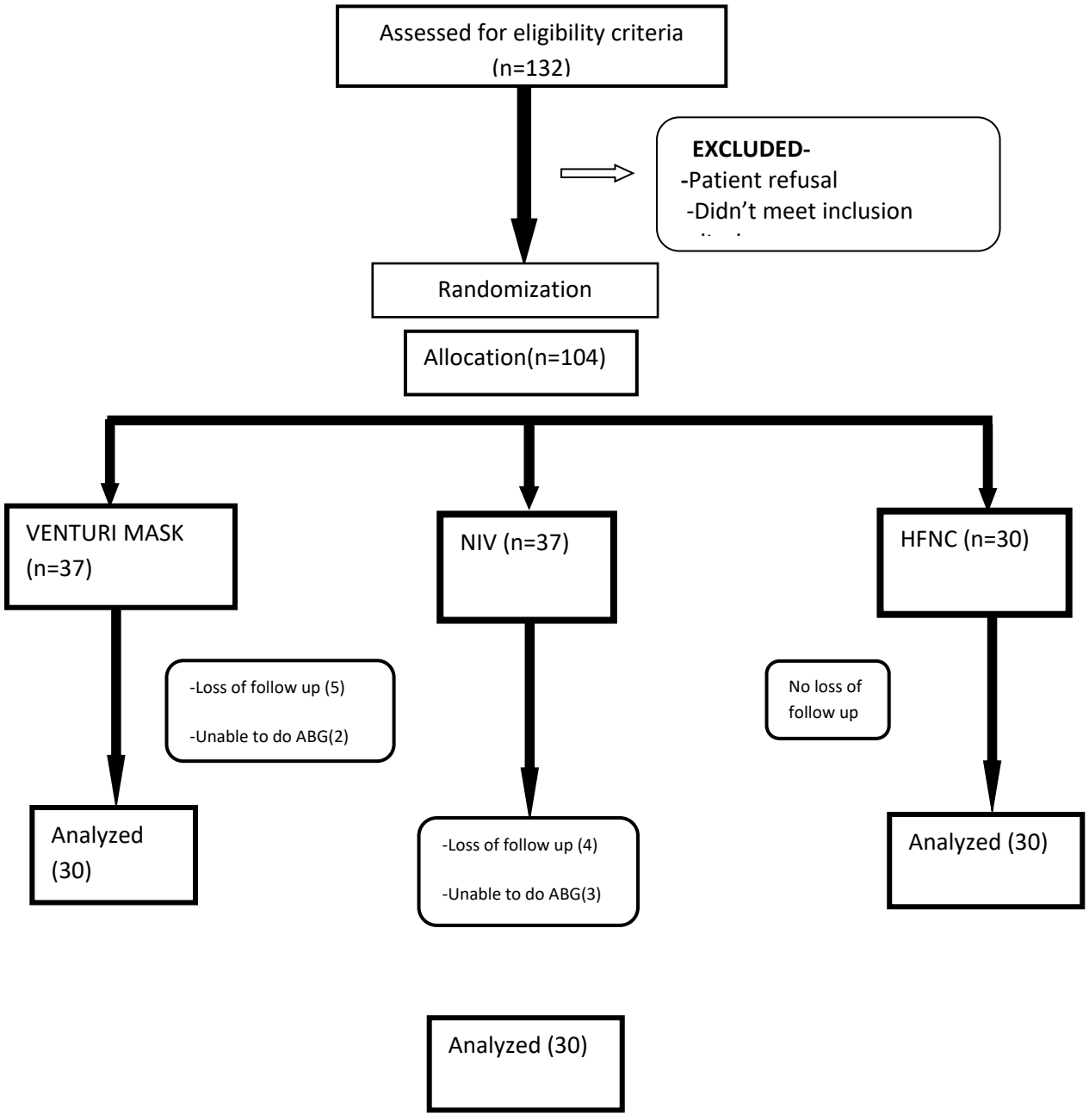

Figure 1: CONSORT figure representing the enrolment and randomization of cases

PATIENT DEMOGRAPHICS

Table 2: Distribution of study population according to different age

	HFNC		NIV		Venturi Mask	
	No.	%	No.	%	No.	%
18-30 yrs	4	13.33	1	3.33	6	20.00
31-50 yrs	12	40.00	13	43.33	15	50.00
>50 yrs	14(1)	46.67	16	53.33	9	30.00
Total	30	100.00	30	100.00	30	100.00
Result (p value)	0.214					

The above table shows the distribution of age in three groups .In HFNC group 4 (13.33%) patients are in 18-30 yrs age range ,12(40%) patients are in 31-50 yrs age range and more then 50 yrs patients are 14(46.67%). In NIV group 1(3.33%) patients are in 18-30 yrs age range ,13(43.33%) patients are in 31-50 yrs age range and more than 50 yrs patients are 16(53.33%). In Venturi Mask group 6(20%) patients are in 18-30 yrs age range ,15(50%) patients are in 31-50 yrs age range and more than 50 yrs patients are 9(30%). The above association shows p- value 0.214 which was statistically non-significant i.e. the study groups were comparable with respect to the age

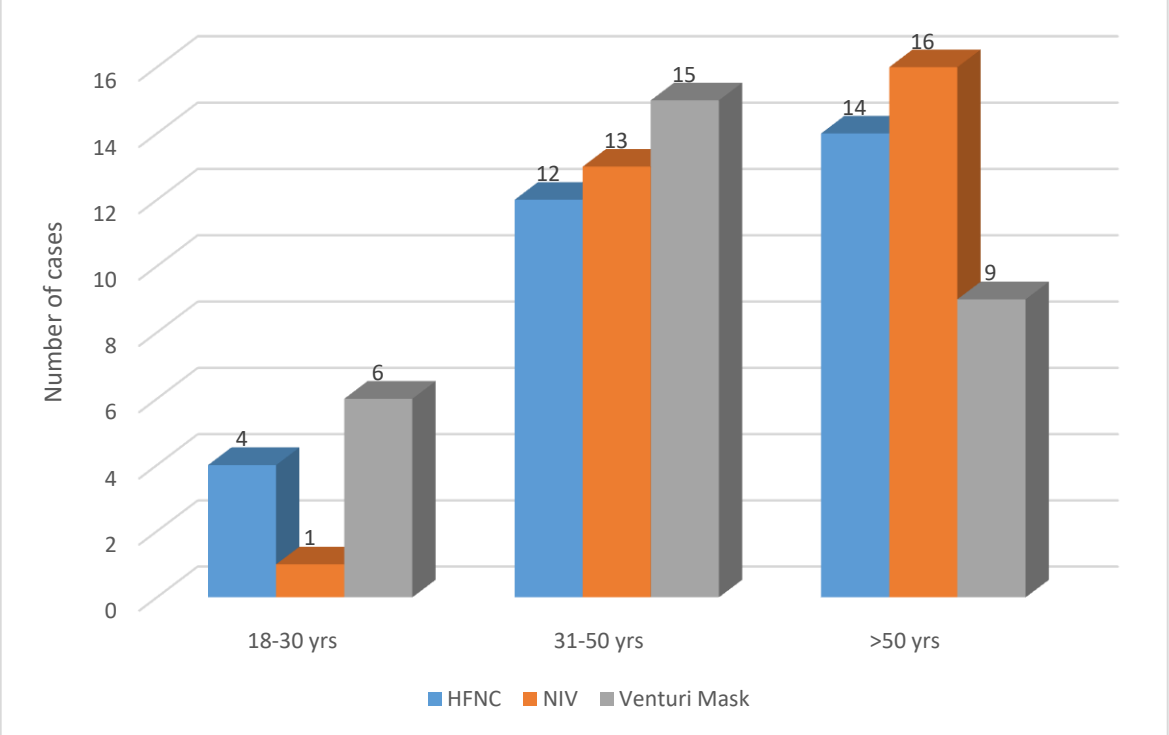

Fig 2: Distribution of patients in different age groups

Table 3: Distribution of study population according to gender :

	HFNC		NIV		Venturi Mask	
Male	19	63.33	20	66.67	18	60.00
Female	11	36.67	10	33.33	12	40.00
Total	30	100	30	100.00	30	100.00
P value	P = 0.866					

The above table shows the distribution of patients according to gender between the study groups. Total 57 patients belonged to Male gender, out of them 19 patients were randomly allocated in group HFNC ,20 in NIV and 18 patients in group Venturi Mask . Remaining 33 patients belonged to Female gender, out of which 11 patients were randomly allocated in group HFNC ,10 in NIV and 12 patients in group Venturi Mask. The chi-square statistic was applied to compare gender between the study groups which showed a p-value of 0.866 and considered to be non- significant i.e. the study groups were comparable with respect to the gender of the patients.

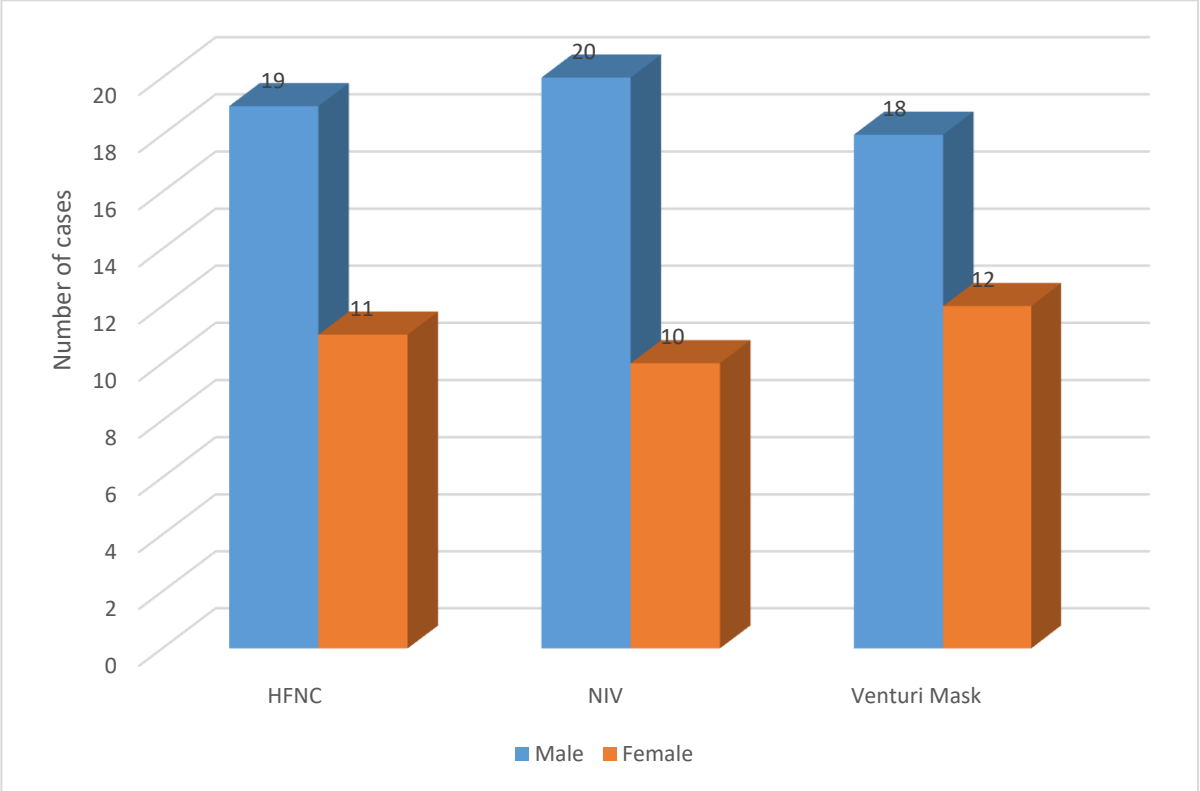

Fig 3: Distribution of patients according to gender.

Table 4: Comparision of SpO_2 in different groups before and after ODV:

	HFNC		NIV		Venturi Mask		Result
	Mean	SD	Mean	SD	Mean	SD	(p value)
SpO2 before (%)	88.60	2.92	83.30	11.57	87.07	4.31	0.018
SpO2 after	98.77	1.74	98.77	1.85	98.70	1.90	0.986

The above table compares the Mean±SD of SpO_2 of different groups before and after application of ODV. The mean ± SD of SpO_2 in HFNC group before and after ODV are 88.6 ± 2.92 and 98.77±1.74 respectively. Whereas the mean ± SD of SpO_2 in NIV group before and after ODV are 83.30 ± 11.57 and 98.77±1.85 respectively. And the mean ± SD of SpO_2 in Venturi Mask group before and after ODV are 87.07 ± 4.31 and 98.77±1.90 respectively. The difference between mean value of the groups was analysed using ANOVA test which showed a P value of 0.986 (after ODV) which was statistically non significant.

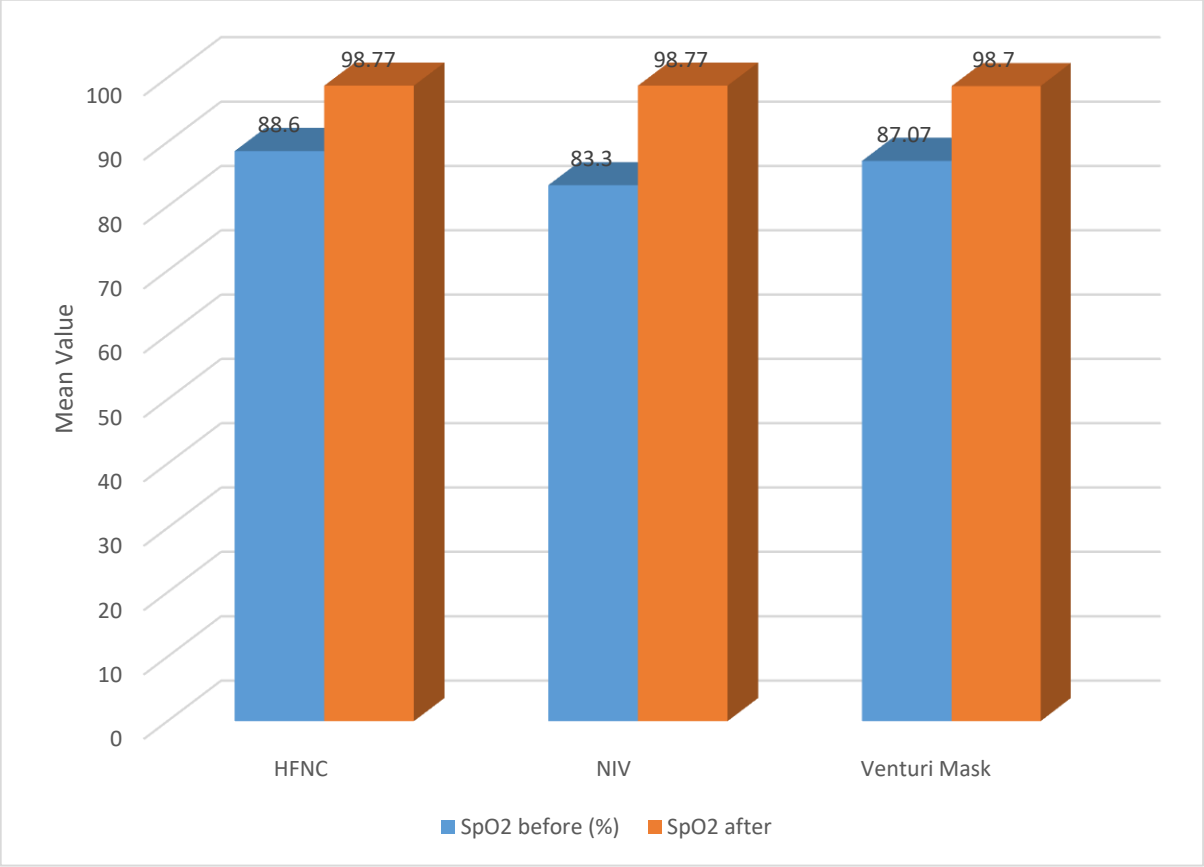

Fig 4: Comparision of SpO_2 in different groups before and after ODV:

Table 5: Comparision of PaO_2 in different groups before and after ODV:

	HFNC		NIV		Venturi Mask		Result
	Mean	SD	Mean	SD	Mean	SD	(p value)
PaO2 before	66.35	10.18	59.43	5.10	62.26	6.28	0.0024*
PaO2 after	159.84	66.83	151.26	44.76	158.48	50.96	0.810*

The above table compares mean±SD of PaO_2 of different groups before and after application of ODV. The mean ± SD of PaO_2 in HFNC group before and after ODV are 66.35 ± 10.18 and 159±66.83 respectively. Whereas the mean ± SD of PaO_2 in NIV group before and after ODV are 59.43 ± 5.10 and 151.26±44.76 respectively. And the mean ± SD of PaO_2 in Venturi Mask group before and after ODV are 62.26 ± 6.28 and 158.48±50.96 respectively. The difference between mean value of the groups was analysed using ANOVA test which showed a P value of 0.810 (after ODV) which was statistically non significant.

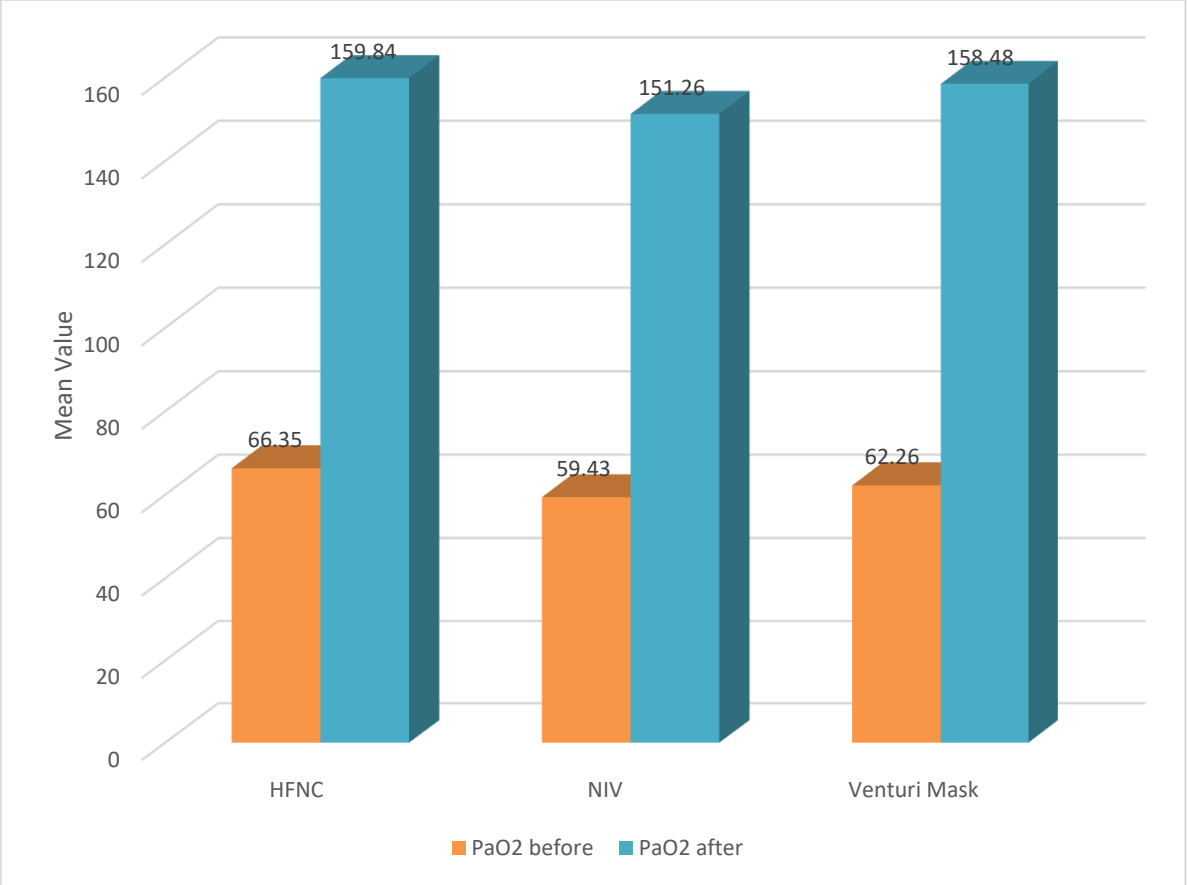

Fig 5: Comparision of PaO_2 in different groups before and after ODV:

Table 6: Comparision of $PaCO_2$ in different groups before and after ODV:

	HFNC		NIV		Venturi Mask		Result (p value)
	Mean	SD	Mean	SD	Mean	SD	
PaCO2 before	46.03	46.29	41.00	5.54	37.35	5.77	0.463**
PaCO2 after	36.83	3.78	37.19	5.19	35.95	3.87	0.526**

The above table compares mean±SD of $PaCO_2$ of different groups before and after application of ODV. The mean ± SD of $PaCO_2$ in HFNC group before and after ODV are 46.03 ± 46.29 and 36.83±3.78 respectively. Whereas the mean ± SD of $PaCO_2$ in NIV group before and after ODV are 41.00 ± 5.54 and 37.19±5.19 respectively. And the mean ± SD of $PaCO_2$ in Venturi Mask group before and after ODV are 37.35 ± 5.77 and 35.95±3.87 respectively. The difference between mean value of the groups was analysed using ANOVA test which showed a P value of 0.526 (after ODV) which was statistically non significant.

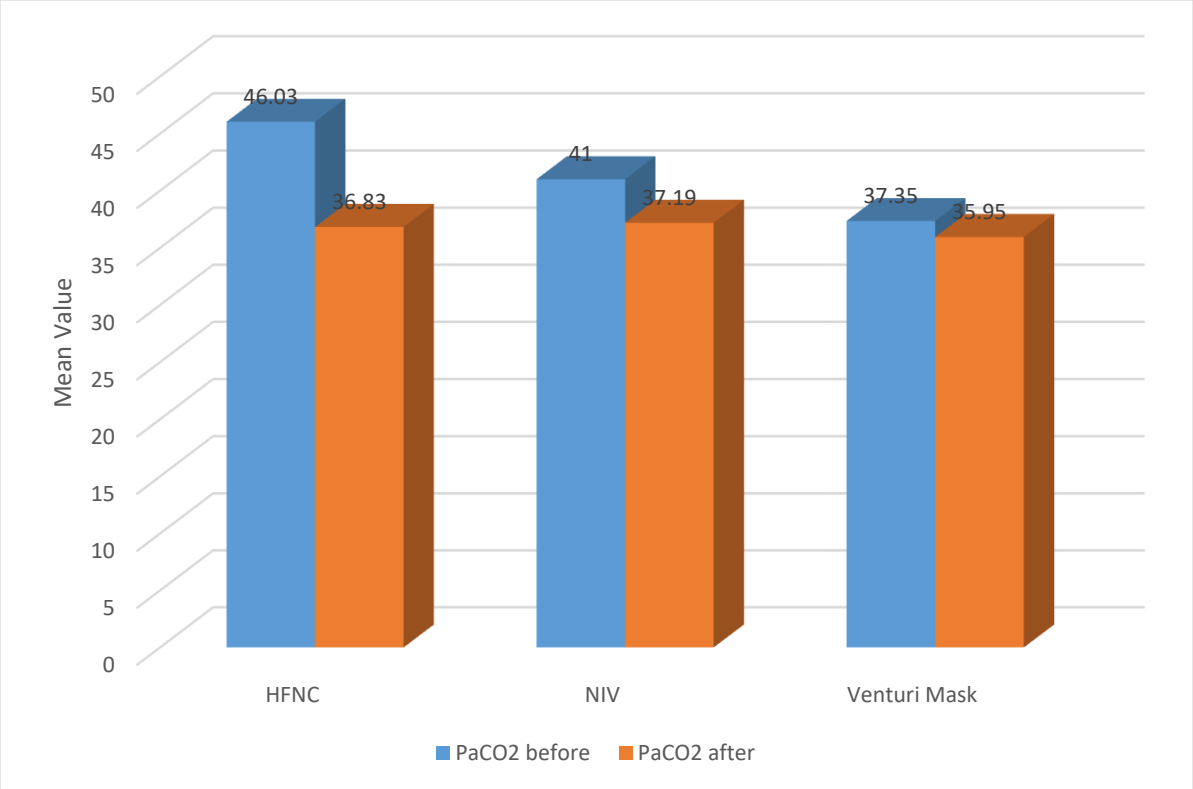

Fig 6: Comparision of PaO_2 in different groups before and after ODV:

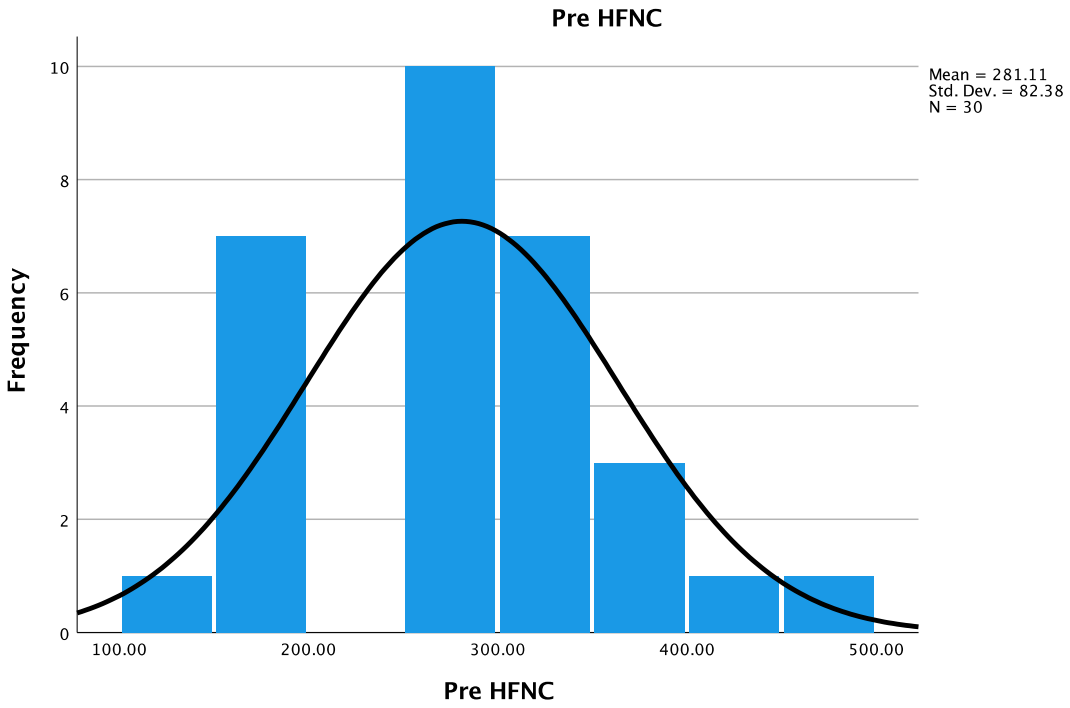

Fig 7: Histogram showing normal distribution of P/F ratio data before HFNC:

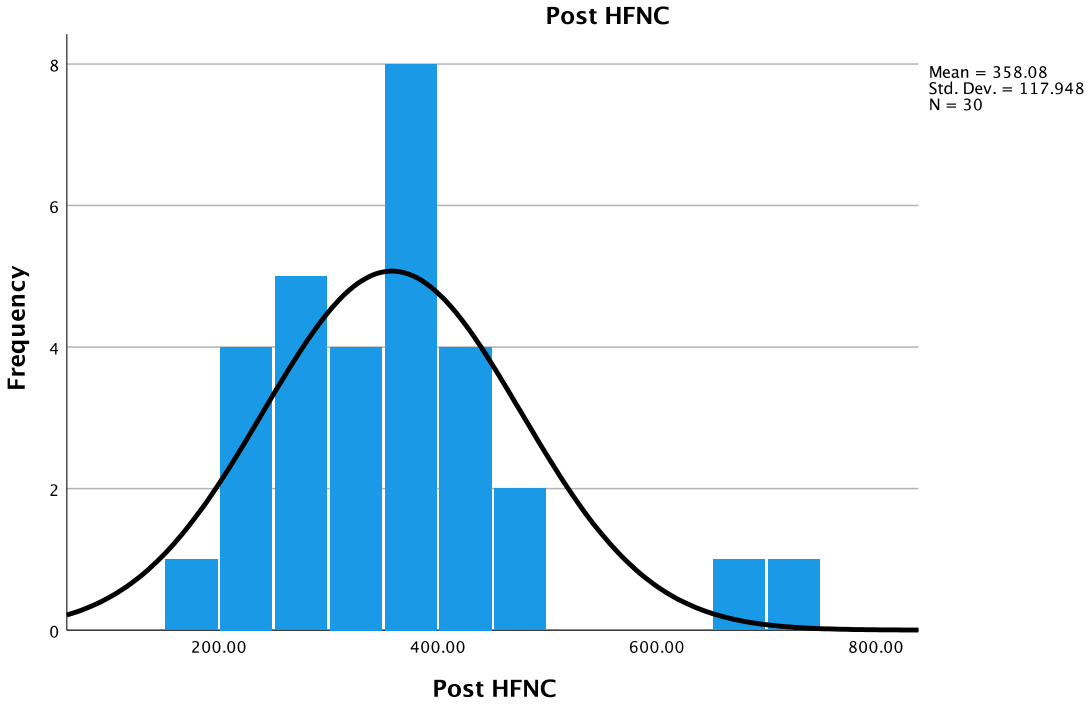

Fig 8: Histogram showing normal distribution of P/F ratio data after HFNC:

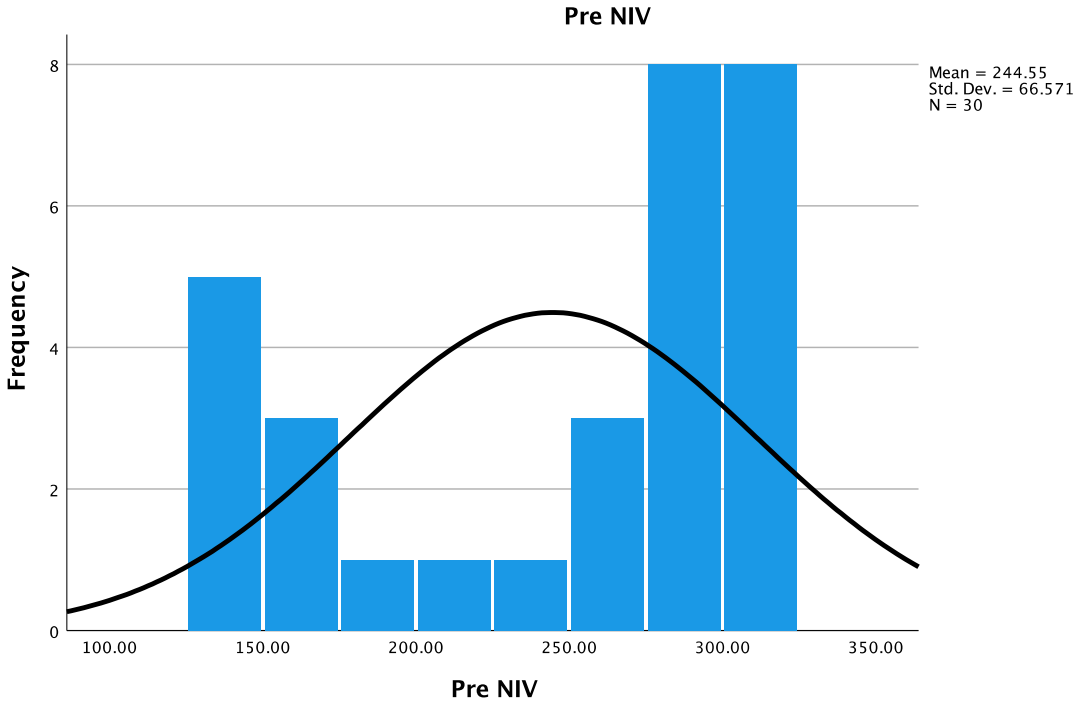

Fig 9: Histogram showing normal distribution of P/F ratio data before NIV:

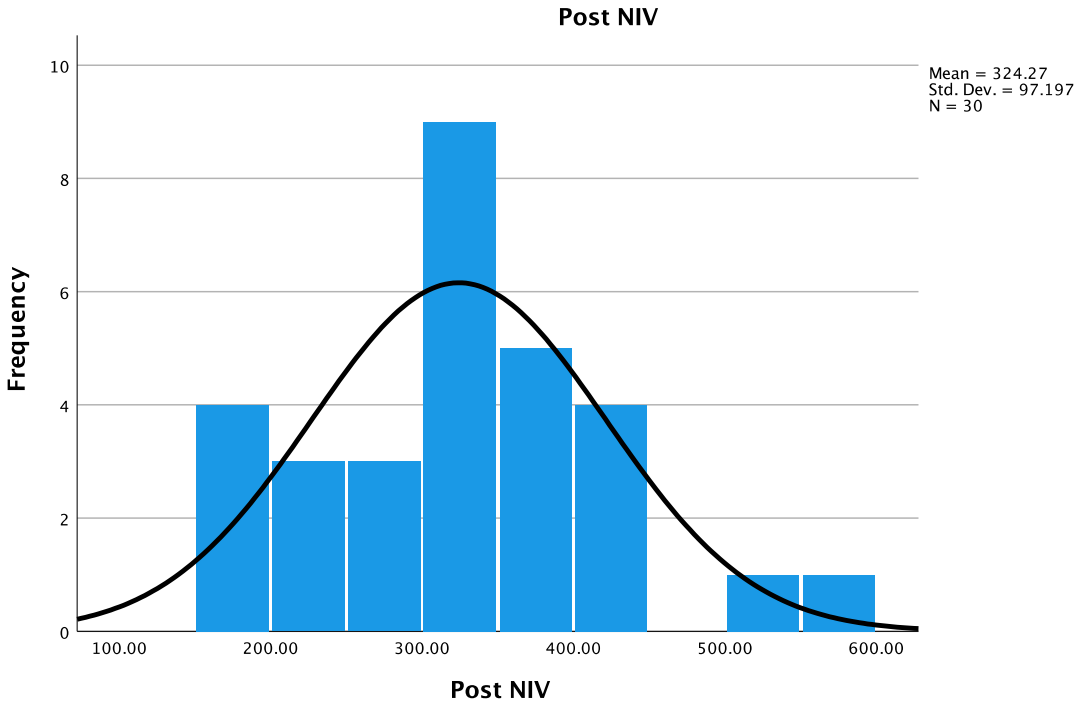

Fig 10: Histogram showing normal distribution of P/F ratio data after NIV:

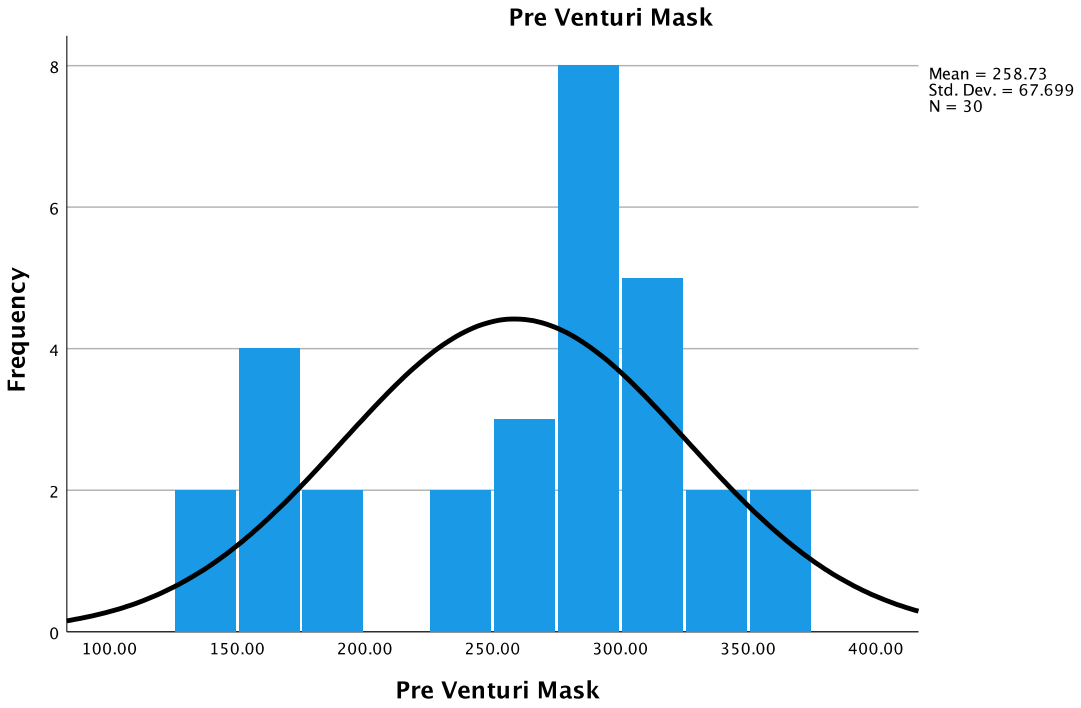

Fig 11: Histogram showing normal distribution of P/F ratio data before Venturi Mask:

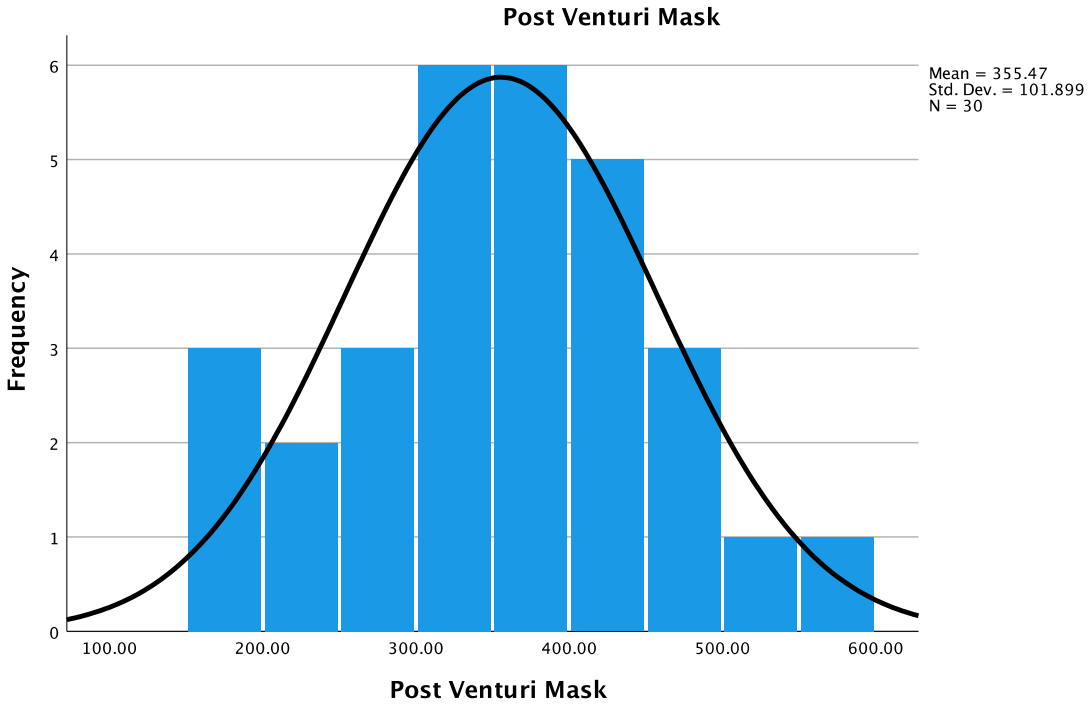

Fig 12: Histogram showing normal distribution of P/F ratio data after Venturi Mask:

Table 7: Comparision of Mean, Median and Mode of P/F ratio in different groups before and after ODV:

Statistics							
		Pre HFNC	**Post HFNC**	**Pre NIV**	**Post NIV**	**Pre Venturi Mask**	**Post Venturi Mask**
N	Valid	30	30	30	30	30	30
Mean		281.1120	358.0767	244.5467	324.2667	258.7290	355.4683
Std. Error of Mean		15.04055	21.53420	12.15419	17.74559	12.36018	18.60411
Median		294.0000	372.4000	276.5000	324.0000	281.1850	351.5000
Mode		310.00	193.50[a]	140.90[a]	315.00[a]	300.00	340.00
a. Multiple modes exist. The smallest value is shown							

The above table shows a mean P/F ratio of 281.11 in Pre HFNC group and 358.07 in Post HFNC group, 244.54 in pre NIV and 324.26 in post NIV group, 258.72 in pre Venturi Mask and 355.46 in post Venturi Mask group. The median P/F ratio is 294.0 in Pre HFNC group and 372.4 in Post HFNC group, 276.5 in pre NIV and 324.0 in post NIV group, 281.18 in pre Venturi Mask and 351.5 in post Venturi Mask group**.** Whereas the Mode is 310.0 in Pre HFNC group and 193.5 in Post HFNC group, 140.9 in pre NIV and 315.0 in post NIV

Table 8: Comparison of Mean ±SD of P/F ratio in different groups before and after ODV

	HFNC		NIV		Venturi Mask		
	Mean	SD	Mean	SD	Mean	SD	Result (p value)
P/F before ODV	281.11	82.38	244.55	66.57	258.73	67.70	0.150
P/F after 2hrs of ODV	358.08	117.95	357.60	220.67	355.47	101.90	0.997

Mean±SD of P/F ratio before HFNC is 281.11± 82.38 and after HFNC is 358.08± 117.95. Whereas the Mean±SD of P/F ratio before NIV is 244.55± 66.57 and after NIV is 357.60± 220.67. And the Mean±SD of P/F ratio before Venturi Mask is 258.73± 67.70 and after Venturi Mask is 355.47± 101.90. The difference between mean value of the groups was analyzed using ANOVA test which showed a P value of 0.150 before ODV and 0.997 after

ODV which was statistically non significant. Hence all the groups are comparable and no ODV is superior than other.

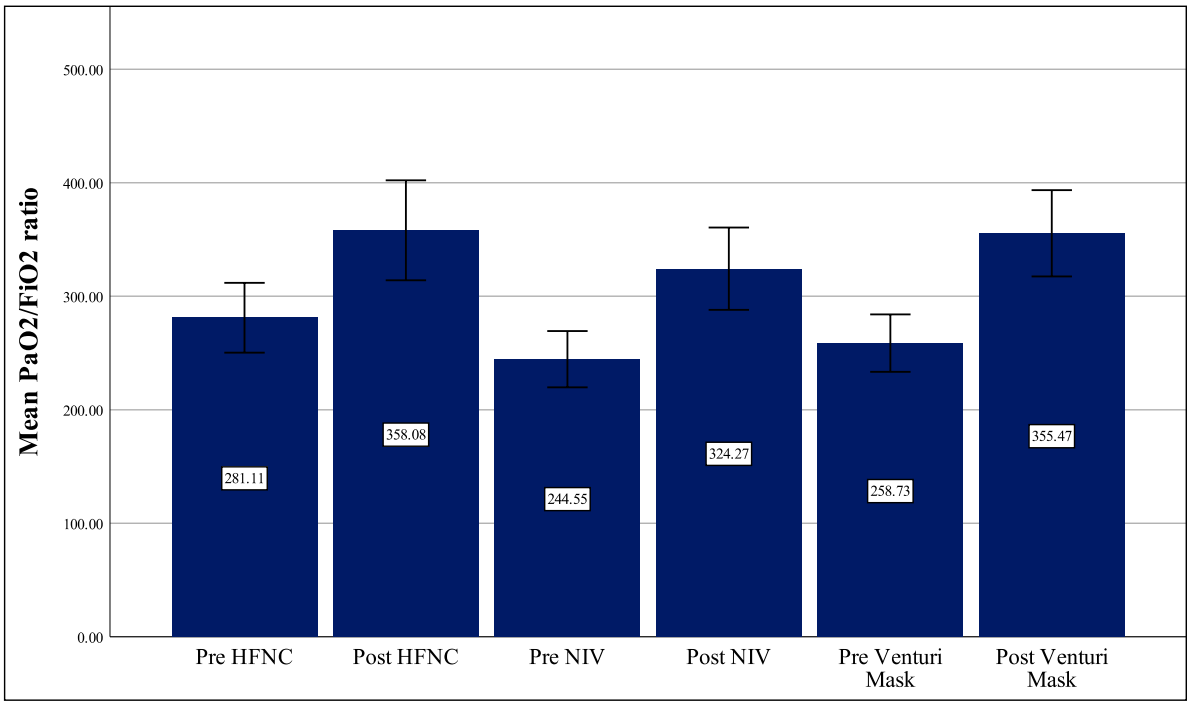

Fig 13: Bar chart showing Mean value of P/F ratio prior to applying ODV and after 2 hours of ODV:

Table 9: Paired t-test comparing Mean±SE of P/F ratio after applying ODV

Paired Samples Test									
		Paired Differences				t	df	Significance	
		Mean	Std. Error Mean	95%CI of the Difference				One-Sided p	Two-Sided p
				Lower	Upper				
Pair 1	Post HFNC - Pre HFNC	76.96	18.94532	38.21714	115.71220	4.062	29	<.001	<.001
Pair 2	Post NIV - Pre NIV	79.72	14.18466	50.70911	108.73089	5.620	29	<.001	<.001
Pair 3	Post Venturi Mask - Pre Venturi Mask	96.73	15.25423	65.54094	127.93773	6.342	29	<.001	<.001

Paired t-test was used to compare P/F ratio after applying ODV. The Mean±SE in HFNC group was 76.96±18.94, in NIV group was 79.72±14.18 and in VM group was 96.73±15.25.The test shows significant improvement in P/F ratio after applying ODV i.e two sided P<0.001.

Table 10: Paired samples Effect Sizes

			Standardizer[a]	Point Estimate	95% Confidence Interval	
					Lower	Upper
Pair 1	Post HFNC – Pre HFNC	Cohen's d	103.76779	.742	.332	1.142
		Hedges' correction	106.55145	.722	.323	1.112
Pair 2	Post NIV – Pre NIV	Cohen's d	77.69258	1.026	.576	1.464
		Hedges' correction	79.77675	.999	.561	1.426
Pair 3	Post Venturi Mask - Pre Venturi Mask	Cohen's d	83.55084	1.158	.687	1.617
		Hedges' correction	85.79217	1.128	.669	1.574

a. The denominator used in estimating the effect sizes.
Cohen's d uses the sample standard deviation of the mean difference.
Hedges' correction uses the sample standard deviation of the mean difference, plus a correction factor.

One-way ANOVA test to find out the best modality of ODV to improve P/F ratio:

Table 11: ANOVA keeping Pre-Venturi as dependent variable

		Sum of Squares	df	Mean Square	F	Sig.
Post HFNC	Between Groups	401638.014	28	14344.215	7.969	.274
	Within Groups	1800.000	1	1800.000		
	Total	403438.014	29			
Post NIV	Between Groups	208446.147	28	7444.505	.114	.994
	Within Groups	65522.000	1	65522.000		
	Total	273968.147	29			
Post Venturi Mask	Between Groups	292307.091	28	10439.539	1.185	.634
	Within Groups	8811.281	1	8811.281		
	Total	301118.372	29			

The one way ANOVA test was applied to compare the improvement in P/F ratio between the groups using different types of Oxygen Delivery Vehicle (ODV) keeping patients in Venturi group as dependent variables. It was observed that the mean change in P/F ratio with all types of ODV was similar to each other and the difference in mean between the three groups was statistically not significant ($p>0.05$).

Table 12: ANOVA effect sizes(2)

		Point Estimate	95% Confidence Interval	
			Lower	Upper
Post HFNC	Eta-squared	.996	.000	.973
	Epsilon-squared	.871	-28.000	.229
	Omega-squared Fixed-effect	.867	-14.000	.223
	Omega-squared Random-effect	.189	-.034	.010
Post NIV	Eta-squared	.761	.000	.000
	Epsilon-squared	-5.936	-28.000	-28.000
	Omega-squared Fixed-effect	-4.790	-14.000	-14.000
	Omega-squared Random-effect	-.030	-.034	-.034
Post Venturi Mask	Eta-squared	.971	.000	.828
	Epsilon-squared	.151	-28.000	-3.994
	Omega-squared Fixed-effect	.147	-14.000	-3.407
	Omega-squared Random-effect	.006	-.034	-.028
a. Eta-squared and Epsilon-squared are estimated based on the fixed-effect model.				
b. Negative but less biased estimates are retained, not rounded to zero.				

Though the study was a randomized control trial but still there existed a possibility of error in data analysis due to more sick patients in one particular group. To rule such possibility, the P/F ratio measured immediately after randomization prior to applying any of ODV was compared with the mean change in P/F ratio after using the ODV keeping the patients in each group as dependent variable.

Table 13: ANOVA keeping Pre HFNC as dependent variable

		Sum of Squares	df	Mean Square	F	Sig.
Post HFNC	Between Groups	387596.014	28	13842.715	.874	.706
	Within Groups	15842.000	1	15842.000		
	Total	403438.014	29			
Post NIV	Between Groups	210600.147	28	7521.434	.119	.993
	Within Groups	63368.000	1	63368.000		
	Total	273968.147	29			
Post Venturi Mask	Between Groups	272617.591	28	9736.343	.342	.902
	Within Groups	28500.781	1	28500.781		
	Total	301118.372	29			

The one way ANOVA test was applied to compare the improvement in P/F ratio between the groups using different types of Oxygen Delivery Vehicle (ODV) keeping patients in HFNC group as dependent variables. Here also, the mean change in P/F ratio with all types of ODV

was similar to each other and the difference in mean between the three groups was statistically not significant (p>0.05).

Table 14: ANOVA Effect Sizes[a,b](2)

		Point Estimate	95% Confidence Interval	
			Lower	Upper
Post HFNC	Eta-squared	.961	.000	.770
	Epsilon-squared	-.139	-28.000	-5.678
	Omega-squared Fixed-effect	-.134	-14.000	-4.615
	Omega-squared Random-effect	-.004	-.034	-.030
Post NIV	Eta-squared	.769	.000	.000
	Epsilon-squared	-5.708	-28.000	-28.000
	Omega-squared Fixed-effect	-4.635	-14.000	-14.000
	Omega-squared Random-effect	-.030	-.034	-.034
Post Venturi Mask	Eta-squared	.905	.000	.449
	Epsilon-squared	-1.745	-28.000	-14.987
	Omega-squared Fixed-effect	-1.594	-14.000	-9.661
	Omega-squared Random-effect	-.022	-.034	-.033
a. Eta-squared and Epsilon-squared are estimated based on the fixed-effect model.				
b. Negative but less biased estimates are retained, not rounded to zero.				

Table 15: ANOVA keeping Pre NIV as dependant variable

		Sum of Squares	df	Mean Square	F	Sig.
Post HFNC	Between Groups	375686.809	27	13914.326	1.003	.618
	Within Groups	27751.205	2	13875.603		
	Total	403438.014	29			
Post NIV	Between Groups	264905.647	27	9811.320	2.165	.365
	Within Groups	9062.500	2	4531.250		
	Total	273968.147	29			
Post Venturi Mask	Between Groups	277137.987	27	10264.370	.856	.674
	Within Groups	23980.385	2	11990.192		
	Total	301118.372	29			

The one way ANOVA test was applied to compare the improvement in P/F ratio between the groups using different types of Oxygen Delivery Vehicle (ODV) keeping patients in NIV group as dependent variables.The mean change in P/F ratio with all types of ODV was similar to each other and the difference in mean between the three groups was statistically not significant (p>0.05).

Table 16: ANOVA Effect Sizes[a,b](3)

		Point Estimate	95% Confidence Interval	
			Lower	Upper
Post HFNC	Eta-squared	.931	.000	.725
	Epsilon-squared	.003	-13.500	-2.981
	Omega-squared Fixed-effect	.003	-9.000	-2.621
	Omega-squared Random-effect	.000	-.034	-.028
Post NIV	Eta-squared	.967	.000	.867
	Epsilon-squared	.520	-13.500	-.928
	Omega-squared Fixed-effect	.512	-9.000	-.870
	Omega-squared Random-effect	.037	-.034	-.018
Post Venturi Mask	Eta-squared	.920	.000	.683
	Epsilon-squared	-.155	-13.500	-3.603
	Omega-squared Fixed-effect	-.149	-9.000	-3.109
	Omega-squared Random-effect	-.005	-.034	-.029
a. Eta-squared and Epsilon-squared are estimated based on the fixed-effect model.				
b. Negative but less biased estimates are retained, not rounded to zero.				

The result showed that the change in P/F ratio was similar in all three ODV groups.The comparison of mean values of P/F ratio post ODV with that of pre ODV values of P/F ratio showed that all three modalities are equally effective for post operative oxygenation and none of the ODV is superior to other as the difference in mean change in P/F ratio between the groups is statistically non-significant (p>0.05).

Table 17: Patient comfort score represented as Median (IQR)

	HFNC		NIV		Venturi Mask	
	No.	%	No.	%	No.	%
Score 1	9	30.00	0	0.00	5	16.67
Score 2	15	50.00	1	3.33	17	56.67
Score 3	2	6.67	2	6.67	6	20.00
Score 4	4	13.33	27	90.00	2	6.67
Total	30	100.00	30	100.00	30	100.00
Median (IQR) (Range)	2 (1,2) (1-4)		4 (4,4) (2-4)		2 (2,3) (1-4)	
Result (p value)	p<0.001*					

The above data are being represented as Median (IQR)**.** In the group HFNC 9(30%) had comfort score 1, 15(50%) had score 2, 2 (6.67%) had score 3, and 4(13.33%) had score 4. In the group NIV none had comfort score 1, 1(3.33%) had score 2, 2(6.67%) had score 3 and 27 (90%) had score 4. In the group Venturi Mask 5 (16.67%) had comfort score 1, 17(56.67%) had score 2, 6(20%) had score 3 and 2 (6.67%) had score 4. The Median (IQR) (Range) of HFNC group was 2(1,2)(1-4), NIV group was 4(4,4)(2-4) and of Venturi Mask group was 2(2,3)(1-4). Chi square testwas applied and the resultant p value was <0.001 which was statistically significant. The data depicts that patients on NIV had maximum discomfort and difficulty in communication (Score 4).

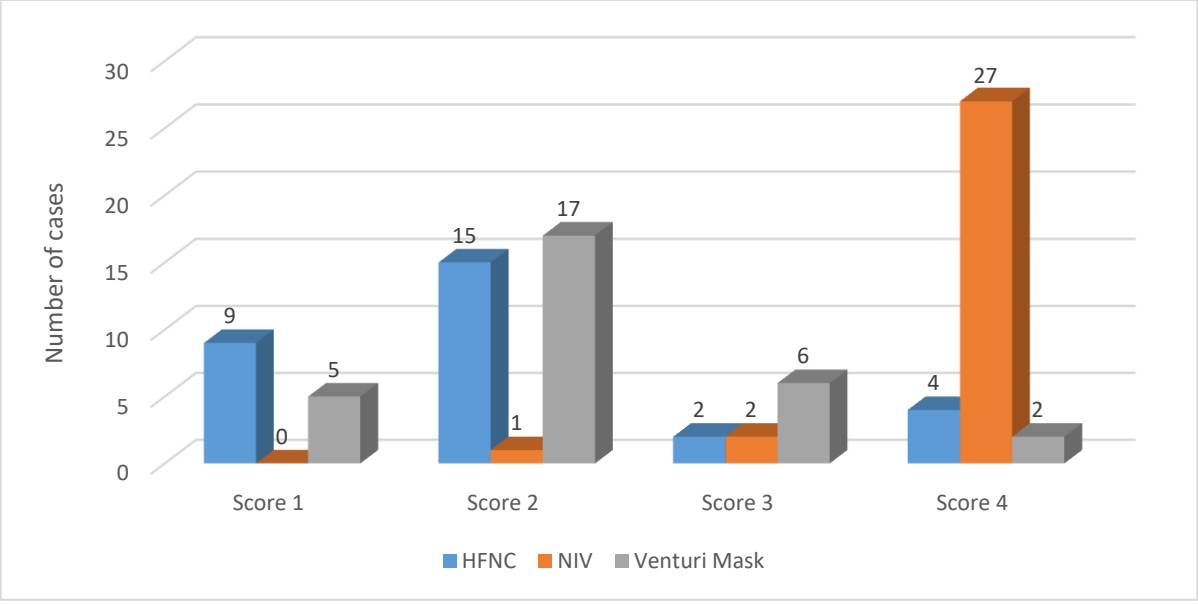

Fig 14: Comparision of Comfort Scores in different groups

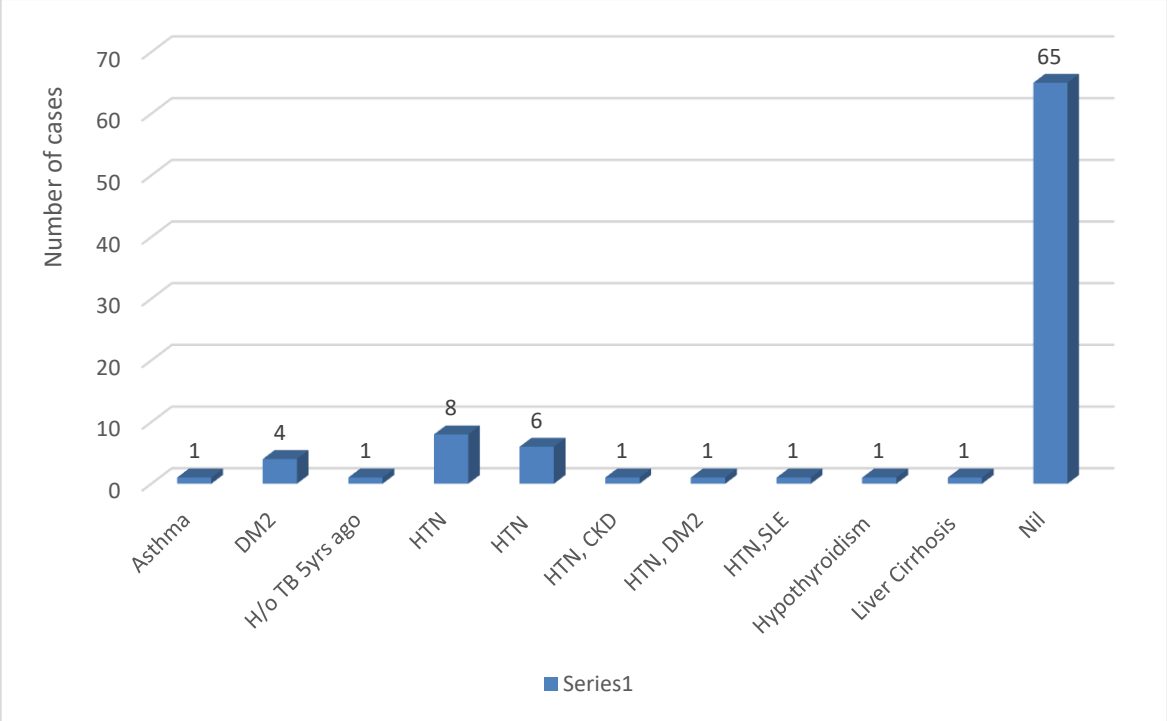

Fig 15: Bar graph showing associated comorbidities in study groups

The above bar graph shows that 15% of the patients had HTN, 4% had DM, 1% had Asthma.72% of the patients included in the study had no known comorbidities

DISCUSSION

Acute hypoxemic respiratory failure(AHRF) is one of the most frequent complications in post operative patients. Patients who experience postoperative respiratory failure might need to be reintubated. It mostly occurs due to atelectasis, pulmonary edema, aspiration, residual neuromuscular blockade and results in a marked increase in overall length of stay in ICU and hospital; time for rehabilitation; mortality and financial expenditures[4]. The cornerstone of treatment for AHRF is supplemental oxygen, along with treating the underlying cause[1]. Most physicians would prefer using NIV in these patients to avoid reintubation when COT fails in a patient postoperatively or the patient is assessed to be at high risk for failure[15].However, NIV is poorly tolerated by most of the patients and require close monitoring. Studies advice that noninvasive ventilation should be used to treat severe hypoxemia in ICUs or other healthcare settings with high levels of supervision and quick accessibility to trained personnel in invasive airway management[12]. Whereas other high flow devices like HFNC and Venturi Mask are better tolerated and may not require high level of monitoring.

Many studies have been conducted to compare efficiency of different oxygen delivery devices in AHRF. Study done by **Maggiore et al** concluded that HFNC was a better oxygenation device when compared to Venturi Mask in post extubation patients[8].

A systemic review done by **Lee et al** compared efficacy of High flow nasal cannula with Non-invasive ventilation and conventional oxygen therapy (COT) in adults with hypoxemic respiratory failure. The study concluded that patients were more comfortable with HFNC and could tolerate it better when compared with NIV or COT in most of the studies and considered it as an intermediate level of assistance for respiration that falls in between of non-invasive ventilation and COT (facial masks and nasal cannulas)[1].

Our study's primary goal was to establish treatment plans, monitor therapeutic effects, and guide clinical decision-making. Improved oxygenation, early discharge from PACU and patient comfort were given utmost priority.

We conducted an Open Labelled Randomized control trial with 90 patients and compared three Oxygen Delivery Vehicle (devices) i.e Non Invasive Ventilation, High Flow Nasal Cannula and Venturi Mask in post operative hypoxemic patients. The ODV was selected randomly using a sealed envelope method. These devices were chosen as they were fixed

performance devices and we could set a fixed FiO_2 of 0.5 irrespective of the device used for all the patients in the study. More-over we could not find any study which had compared the efficacy of the above mentioned devices. ABG was the mainstay investigation used to draw conclusion. First ABG was taken before applying ODV and the next ABG was taken after 2 hours of continuous application of ODV. The parameters used were P/F ratio, PaO_2, $PaCO_2$ and SpO_2.

The study performed by **Schwabbauer et al** evaluated the transient effects of high-flow nasal cannula (HFNC) oxygen therapy on functional and individual respiratory parameters in patients with AHRF and compared it to routine treatment via NIV and Venturi mask[2]. Under NIV PaO_2 was highest when compared to Venturi Mask and HFNC where $p < 0.01$. Whereas the Mean ± SD of $PaCO_2$ after use of VM was 37 ± 6, HFNC was 37 ± 5 and NIV was 39 ± 7.The p value was >0.05 and hence insignificant.

In our study the mean ± SD of PaO_2,2 hours after ODV in HFNC group was 159±66.83, in NIV group 151.26±44.76 and in Venturi Mask group 158.48±50.96. On comparing the mean±SD of PaO_2 of different groups 2 hours after application of ODV post extubation, the p value was 0.81 (p value> 0.05) and hence insignificant. The possible explanation for the higher PaO2 with HFNC as compared to a Venturi mask, could be the higher delivered gas flows (up to 60 L/min) in HFNC. The intended FiO2 of 0.5 in a Venturi Mask with an oxygen flow of 10-15 L/min can only be reached with a total gas flow of less than 30 L/min. Often significantly greater inspiratory gas flows are generated in acute hypoxic respiratory failure. This results in an extra room-air admixture during inspiration, particularly in loose fitting masks like Venturi systems and other masks, which lowers FiO2[3].

The mean ± SD of $PaCO_2$, 2 hours after HFNC was 36.83±3.78, NIV was 37.19±5.19 and Venturi Mask was 35.95±3.87. The improvement in breathing efficiency and decrease in anatomic deadspace caused by the increase in tidal volume account for the drop in PaCO2 with HFNC and VM. Improvement in inspiratory air-flow dynamics adds to it.[8]

Stephan et al conducted a study in patients with acute respiratory failure after cardiothoracic surgery to compare the efficacy of HFNC and BiPAP. On evaluating different respiratory parameters from day 1 to day 3;PaO2/FIO2 improved in both groups, but the increment was remarkebly higher with BiPAP (P value was < .001)[11]. Not much significant difference was found between the $PaCO_2$ values from day 1 to day 3 in the two groups as P value was >0.05 (p value=0.2).

Our study showed that neither of the Oxygen Delivery Vehicles used i.eNon Invasive Ventilation, High Flow Nasal Cannula and Venturi Mask were superior to each other as on comparing the Mean± SD of P/F ratio we got a p value of 0.150 before ODV and 0.997 after ODV which was statistically non significant (p >0.05). Though the study was a randomized control trial but still there existed a possibility of error in data analysis due to more sick patients in one particular group. To rule such possibility, the P/F ratio measured immediately after randomization prior to applying any of ODV was compared with the mean change in P/F ratio after using the ODV keeping the patients in each group as dependent variable using one way ANOVA test. The mean change in P/F ratio with all types of ODV was similar to each other and the difference in mean among the three groups was not significant i.e p value >0.05.

Similarly the mean ± SD of $PaCO_2$ in HFNC group before and after ODV were 46.03 ± 46.29 and 36.83±3.78 respectively, in NIV group before and after ODV were 41.00 ± 5.54 and 37.19±5.19 respectively and in Venturi Mask group before and after ODV were 37.35 ± 5.77 and 35.95±3.87 respectively. On analyzing the difference between mean value of the groups, it showed a p value of 0.526 (after ODV) which was statistically non-significant. Hence all the groups were comparable and no ODV was superior than other.

In the study done by **Schwabbauer et al** a Numeric rating scale (NRS) with 10 points was used to grade general pain and discomfort from the oxygen application, with lower values indicating less discomfort[2]. On comparing the Mean± SD of the NRS scores, it was found that patient discomfort was minimal with Venturi Mask and HFNC and highest with NIV with a p value of <0.05. In our study we came up with a Comfort score where different scores were given according to the patient comfort and ease of communication. Lower scores indicated more comfort and better communication. 90% of the patients in NIV group had a Comfort Score 4 (very uncomfortable and unable to communicate) whereas only 6.67% in Venturi Mask group and 13.33% in HFNC group had Score 4. By delivering heated and humidified air, HFNC supposedly increases patient tolerance, ease and comfort by reducing bronchospasm due to the effect of dry and cold air on muscarinic receptors in nasal mucosa. 30% of the patients in HFNC group and 16.67% of Venturi Mask group had Comfort Score 1(Very comfortable and easy communication). Active humidification remarkably improves patients' comfort by diminishing upper respiratory tract dehydration symptoms[2].

Often prolonged respiratory support is needed for patients with AHRF. Mostly we use a combination of HFNC and NIV in these patients to escape reintubation and enhance oxygenation[2]. In our study since P/F ratio after 2 hours of application of all three ODV were comparable, hence we can use any of these devices to ameliorate oxygenation.

LIMITATIONS

Our study was designed as a short term experimental study and has certain limitations as follows:

1. The duration of intervention was for only 2 hours. However, it could have been difficult to make direct comparisons of different parameters for longer durations.

2. The FiO_2 to be delivered was not decided according to the patients need. We had kept FiO_2 fixed at 0.5 irrespective of the device used and the patient's requirement.

3. Assessment of the patient's discomfort was subjective. However, the numerical scale we used has a better reliability for measuring acute discomfort than a visual analog scale or verbal scale.

4. As the patients were kept nil by mouth for two hours in post-operative period, so the ease of taking oral fluids or oral diet with use of different ODV could not be assessed in these patients.

CONCLUSION

Among HFNC, NIV and Venturi Mask, none of the devices proved to be superior than the other for use in post operative hypoxemia. The ABG parameters were proven to be comparable. Hence the null hypothesis stands true, that is there is no difference in PaO_2/FiO_2 ratio (P/F ratio) while using different oxygen delivery vehicles (devices) in PACU for managing hypoxemia.

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ANNEXURE I

अखिल भारतीय आयुर्विज्ञान संस्थान, जोधपुर
All India Institute of Medical Sciences, Jodhpur
संस्थागत नैतिकता समिति
Institutional Ethics Committee

No. AIIMS/IEC/2021/ 3519 **Date: 12/03/2021**

ETHICAL CLEARANCE CERTIFICATE

Certificate Reference Number: **AIIMS/IEC/2021/3354**

Project title: **"comparison of oxygen delivery devices in post operative patients with hypoxemia: An open labelled randomised controlled study"**

Nature of Project:	**Research Project Submitted for Expedited Review**
Submitted as:	**M.D. Dissertation**
Student Name:	**Dr. Susri Mishra**
Guide:	**Dr. Nikhil Kothari**
Co-Guide:	**Dr. Pradeep Bhatia, Dr. Shilpa Goyal, Dr. Ankur Sharma, Dr. Darshana Rathod & Dr. Tanvi Meshram**

Institutional Ethics Committee after thorough consideration accorded its approval on above project.

The investigator may therefore commence the research from the date of this certificate, using the reference number indicated above.

Please note that the AIIMS IEC must be informed immediately of:

- Any material change in the conditions or undertakings mentioned in the document.
- Any material breaches of ethical undertakings or events that impact upon the ethical conduct of the research.

The Principal Investigator must report to the AIIMS IEC in the prescribed format, where applicable, bi-annually, and at the end of the project, in respect of ethical compliance.

AIIMS IEC retains the right to withdraw or amend this if:

- Any unethical principle or practices are revealed or suspected
- Relevant information has been withheld or misrepresented

AIIMS IEC shall have an access to any information or data at any time during the course or after completion of the project.

Please Note that this approval will be rectified whenever it is possible to hold a meeting in person of the Institutional Ethics Committee. It is possible that the PI may be asked to give more clarifications or the Institutional Ethics Committee may withhold the project. The Institutional Ethics Committee is adopting this procedure due to COVID-19 (Corona Virus) situation.

If the Institutional Ethics Committee does not get back to you, this means your project has been cleared by the IEC.

On behalf of Ethics Committee, I wish you success in your research.

Dr. Praveen Sharma
Member Secretary

Member secretary
Institutional Ethics Committee
AIIMS,Jodhpur

ANNEXURE II

All India Institute of Medical Sciences

Jodhpur, Rajasthan

(Informed Consent Form)

TITLE: **COMPARISION OF OXYGEN DELIVERY DEVICES IN POST OPERATIVE PATIENTS WITH HYPOXEMIA: AN OPEN LABELLED RANDOMISED CONTROLED STUDY**

Name of PG Student: Dr.SUSRI MISHRA Telephone no: 7978117806

Patient Identification No: _____

I,_____, s/o,d/o,r/o,_____

Resident of _____give my full, free, voluntary consent to be a part of the study" Title: **COMPARISION OF OXYGEN DELIVERY DEVICES IN POST OPERATIVE PATIENTS WITH HYPOXEMIA: AN OPEN LABELLED RANDOMISED CONTROLED STUDY**" , the procedure and nature of which has been explained to me in my own language to my full satisfaction. I confirm that I have had the opportunity to ask questions. I understand that my participation is voluntary, and I am aware of my right to opt out of the study at any time without giving any reason. I understand that the information collected and any of my medical records may be looked at by responsible individual from AIIMS Jodhpur or from regulatory authorities. I give permission for these individuals to have access to my records.

Date: _____ _____

Place: _____ Signature/Left thumb impression

This to certify that the above consent has been obtained in my presence.

Date: _____ _____

Place: _____ Signature of PG Student

Witness 1 Witness 2

_____ _____

Signature Signature

Name Name

ANNEXURE III

अखिल भारतीय चिकित्सा विज्ञान संस्थान, जोधपुर, राजस्थान

सूचितसहमचतप्रपत्र

थीडसस / डनबंधकाशीर्षक: **COMPARISION OF OXYGEN DELIVERY DEVICES IN POST OPERATIVE PATIENTS WITH HYPOXEMIA: AN OPEN LABELLED RANDOMISED CONTROLED STUDY**

पीजी छात्र का नाम:SUSRI MISHRA टेल न: 7978117806

रोगी / स्वयं सेवक पहचान संख्या: _____

मैं, _____पुत्र/पुत्री_____

पता_____

अध्ययन **COMPARISION OF OXYGEN DELIVERY DEVICES IN POST OPERATIVE PATIENTS WITH HYPOXEMIA: AN OPEN LABELLED RANDOMISED CONTROLED STUDY**

" का एक भाग बनने के डलए मेरी पूर्ष, स्वतंत्र, स्वैस्टिक सहमडत दें, डजसकीप्रडियाऔरप्रकृडतमुझेअपनीपूरीसंतुडिकेडलएअपनीभार्ामेंसमझाईगईहै।मैंपुडिकराहंडकमुझेप्रश्नपूछनेकाअवस रडमलाहै।

मैंसमझताहंडकमेरीभागीदारीस्वैस्टिकहैऔरमुझेडकसीभीकारर्डदएडबनाडकसीभीसमयअध्ययनसेबाहरडनकलनेकेमेरेअड धकारकीजानकारीहै।

मैंसमझताहंडकमेरेऔरमेरेमेडिकलररकॉिषकेबारेमेंएकडत्रतकीगईजानकारीकोएम्सजोधपुरयाडवडनयामकप्राडधकरर्ो सेडजम्मेदारव्यस्टिद्वारादेखाजासकताहै।मैंइनव्यस्टियोंकोअपनेअडभलेखोंतकपहंचकेडलएअनुमडतदेताहं ।

तारीख: _____ _____

जगह: _____ हस्ताक्षर / बाएंअंगूठेकाछाप

यहप्रमाडर्तकरनेकेडलएडकमेरीउपस्टस्थडतमेंउपरोिसहमडतप्राप्तकीगईहै ।

तारीख: _____ _____

जगह: _____ पीजीछात्रकेहस्ताक्षर

गवाह 1 गवाह 2

_____ _____

हस्ताक्षर हस्ताक्षर

नाम_____ नाम_____

ANNEXURE IV

PATIENT INFORMATION SHEET

1. Risks to the patients: No interventions or life-threatening procedure will be done.
2. Confidentiality: Your participation will be kept confidential. Your medical records will be treated with confidentiality and will be revealed only to doctors/ scientists involved in this study. The results of this study may be published in a scientific journal, but you will not be identified by name.
3. Provision of free treatment for research related injury. Not applicable.
4. Compensation of subjects for disability or death resulting from such injury: Not Applicable
5. Freedom of individual to participate and to withdraw from research at any time without penalty or loss of benefits to which the subject would otherwise be entitled.
6. You have complete freedom to participate and to withdraw from research at any time without penalty or loss of benefits to which you would otherwise be entitled.
7. Your participation in the study is optional and voluntary.
8. The copy of the results of the investigations performed will be provided to you for your record.
9. You can withdraw from the project at any time, and this will not affect your subsequent medical treatment or relationship with the treating physician.
10. Any additional expense for the project, other than your regular expenses, will not be charged from you.

ANNEXURE V

अखिल भारतीय चिकित्सा विज्ञान संस्थान, जोधपुर, राजस्थान

रोगी सूचना पत्रक

1. रोगियों के लिए जोखिम: कोई हस्तक्षेप या जीवन-धमकी प्रक्रिया नहीं की जाएगी।

2. गोपनीयता: आपकी भागीदारी को गोपनीय रखा जाएगा। आपके मेडिकल रिकॉर्ड को गोपनीयता के साथ इलाज किया जाएगा और केवल इस अध्ययन में शामिल डॉक्टरों / वैज्ञानिकों को पता चलेगा। इस अध्ययन के परिणाम एक वैज्ञानिक पत्रिका में प्रकाशित हो सकते हैं, लेकिन आपको नाम से पहचाना नहीं जाएगा।

3. अनुसंधान संबंधी चोट के लिए नि: शुल्क उपचार की व्यवस्था। लागू नहीं।

4. ऐसी चोट से उत्पन्न विकलांगता या मृत्यु के लिए विषयों का मुआवजा: लागू नहीं है

5. किसी भी समय दंड या लाभों के नुकसान के बिना किसी भी समय भाग लेने के लिए व्यक्ति को स्वतंत्रता लेने और अनुसंधान से वापस लेने के लिए स्वतंत्रता, जिसके तहत विषय अन्यथा हकदार होगा

6. आपको जुर्माना या लाभ के नुकसान के बिना किसी भी समय भाग लेने और अनुसंधान से वापस लेने की पूरी आजादी है, जिस पर आप अन्यथा हकदार होंगे।

7. अध्ययन में आपकी भागीदारी वैकल्पिक और स्वैच्छिक है।

8. प्रदर्शन की जांच की परिणामों की प्रति आपके रिकॉर्ड के लिए आपको उपलब्ध कराई जाएगी।

9. आप किसी भी समय परियोजना से वापस ले सकते हैं, और यह आपके बाद के चिकित्सा उपचार या उपचार चिकित्सक के साथ संबंध को प्रभावित नहीं करेगा।

10. परियोजना के लिए कोई भी अतिरिक्त व्यय, आपके नियमित खर्चों के अलावा, आपसे शुल्क नहीं लिया जाएगा।

ANNEXURE VI

CASE RECORD FORM

PATIENT DETAILS

Patient's sticker:

Height: Weight:

Diagnosis: Comorbidities

Duration of illness Name of Surgery:

Time at which last feed taken by the patient:

Time at which patient was shifted to PACU:

Time at which patient was started on HFNC/ Venturi Mask/ NIV:

FINAL OUTCOME:

Type of Oxygen delivery device used:

Total duration on HFNO/NIV/Venturi Mask in PACU:

Parameters assessed according to ABG reports	Immediately after shifting the patient to PACU/before starting the oxygen therapy	After 1 hour of starting the oxygen therapy	After 2 hoursof starting the oxygen therapy	Prior to shifting
PaO_2/FiO_2 ratio				
$PaCO_2$				
SpO_2				
PaO_2				

-Patient Comfort and Ease of Communication (Scoring out of 4):

1-Very comfortable and easy communication

2-Uncomfortable and easy communication

3- Uncomfortable and difficult to communicate

4- Very uncomfortable and Unable to communicate

-Condition of the patient at the end of Oxygen therapy: Improved / Not improved

ANNEXURE VII

MASTER CHART

Name	Age	Sex	Date	Patient ID	Height (cm)	Weight (kg)	Diagnosis	Comorbidities	Duration of illness	Surgery	Last feed time	Shifted to PACU	ODV started at	Type of ODV	Duration of ODV (hrs)	P/F before ODV	PaCO2 before	SpO2 before (%)	PaO2 before	P/F after 2hrs of ODV	PaCO2 after	SpO2 after	PaO2 after	Patient comfort SCORE	Condition of patient post therapy
Aakash Dhakar	21	1	24/4/21	2018/07/014680	168	62	Acute Appendicitis	Nil	2 weeks	Lap Appendicectomy	11:00PM (23/4)	8:50 AM	9:00 AM	HFNC	2	280.1	290	89	60	306.1	42	96	71.5	2	Improved
Prem Lata	32	0	23/6/21	2013/12/006440	154	62	Ca Rt Breast	HTN	6 months	Rt MRM	10:00 PM (22/6)	4:00 PM	4:05 PM	Venturi Mask	3	285.6	37.5	89	60	353	35	99	176.5	1	Improved
Dala Ram	56	0	18/7/21	2021/07/010019	172	90	Intestinal Obstruction	DM2	20days	Diagnostic Laproscpy	7:00:00 PM (15/7)	5:00 PM	5:15 PM	Venturi Mask	2	320	28	90	64	400	28	100	180	2	Improved
Neema Ram	30	0	26/7/21	2021/07/014211	176	66	Small bowel obstruction	Nil	7 days.	Exp lap	6:00 pm (25/7/21)	12:00 pm (26/7/21)	12:05 PM	Venturi mask	2	312. 8	32.6	90	65.7	406.6	36	95	122	2	Improved
Girraj Prasad	51	0	26/7/21	2021/07/008250	168	72	D3 fracture	Nil	8 days	Screw fixation	8:00:00 AM (25/7/21)	1:00PM(26/7/21)	1:05 PM	HFNC	2	358.5	37.4	89	75.3	380	40.3	99	266	2	Improved
Luni Devi	65	1	2/10/21	2021/04/008613	158	64	PMMC flap dysfunction	DM2	2days	Flap reconstruction	12:00 AM(2/10/21)	11:00 AM	11:05 AM	Venturi Mask	2	334	33.1	90	70	488.3	34.7	98	146.5	1	Improved
Gulab Kannar	52	1	3/10/21	2019/03/003129	155	78	Epidermoid cyst	Nil	2days	Sub occipital craniotomy	9:00PM (3/10/21)	5:30 PM	5:40 PM	Venturi Mask	2	276	27.3	89	58	309	32.5	99	309	2	Improved
Sugan Kanwar	51	1	4/10/21	2021/09/009096	160	54	Cervical spondylosis	nil	2yrs	C1 laminectomy	9:00PM(4/10/21)	4:00 PM	4:10 PM	NIV	2	304	36.4	90	64	315	32	99	126	4	Improved
Siya Ram	62	0	21/10/21	2021/10/012934	168	78	Necrotizing fascitis	nil	2months	NSTI	11:00PM(20/10/21)	3:30 PM	3:40 PM	HFNC	2	329.8	31.2	89	69.2	479.6	33.3	100	119.9	1	Improved
Dharmaram	61	0	28/10/21	2021/10/017395	160	55	Small Intestinal adhesion	nil	2yrs	Diagnostic Lap	9:00PM(28/10/21)	11:00 AM	11:10 AM	HFNC	2	484.4	35.1	97	101.8	707.8	40.4	100	353.9	2	Improved
Bheraram Bheel	62	0	2/11/21	2021/10/012729	171	72	Diabetic foot	DM2	15days	Above knee amputation	8:00PM(1/11/21)	12:30PM(2/11/21)	12:45 PM	Venturi Mask	2	363	32.5	90	76.3	350	37.6	99	105	1	Improved
Madi Banu	65	2	2/11/21	2021/09/014053	160	59	Uterine Ca	HTN, DM2	6months	Total hysterectomy	9:00PM(1/11/21)	2:45PM(2/11/21)	14:50PM	HFNC	2	332.6	45.1	91	69.8	256	44.9	99	128.4	2	Improved
Kehra Ram	60	0	7/11/21	2021/02/011520	168	54	Pseudo aneurysm of brachiocephalic fistula	HTN, CKD	2months	Exploration and repair	2:00PM(6/11/21)	6:30 PM	6:40 PM	HFNC	2	167.5	39.2	91	67	390	36.5	99	195	1	Improved
Madhu Das	64	0	14/11/21	2021/11/008341	164	74	Ca Colon	nil	3months	Lap Colostomy	6:00PM (14/11/21)	12:15 PM	12:20 PM	HFNC	2	196	30.5	90	59	385	34	98	192	1	Improved
Prag Singh	65	0	21/11/21	2021/11/010593	162	74	Cholecystitis	nil	15days	Lap cholecystectomy	12:00PM(20/11/21)	2:40PM(21/11/21)	2:50 PM	HFNC	2	353.1	35.6	90	74	370	31.4	99	185.1	2	Improved
Laxman Choudhary	43	0	28/11/21	2021/10/009983	162	65	Rt parieto-temporal SOL	Nil	1yr	Craniectomy and decompression	10:00PM(27/11/21)	5:10 PM	5:20 PM	HFNC	2	328.57	37.6	89	69	431	37.7	100	90.6	1	Improved
Doulat Ram	55	0	29/11/21	2021/11/015327	164	64	Diabetic foot	DM2	2months	Rt great toe amputation	4:00PM(28/11/21)	4:30 PM	4:40 PM	HFNC	2	293	29.2	88	58.6	374.8	32.6	99	187.4	1	Improved
Mukesh Kumar	55	0	2/12/21	2021/11/012925	172	72	P/o/c/o mesh hernioplasty	nil	10days	Mesh removal &debridement	12:00AM(2/12/21)	10:50 AM	11:05 AM	HFNC	2	407.5	44	95	85	389.2	42.5	100	194.6	1	Improved
Mahendra Singh	65	0	2/12/21	2021/11/015304	168	77	Subhepatic abscess	nil	1month	Abscess drainage	10:00PM(1/12/21)	5:00 PM	5:15 PM	HFNC	2	316	42.9	89	66.4	201.6	34.3	97	121.6	2	Improved
Asha Devi	58	1	13/12/21	2021/12/000997	155	52	Pseudocyst of pancreas	nil	3months	Robotic cystogastrostomy	10:00PM(12/12/21)	1:50 PM	2:00 PM	HFNC	2	337.2	39.2	90	70	650	39.6	100	325	1	Improved
Kaja Ram	56	0	19/12/21	2021/10/014313	155	65	SDH & brain abscess	nil	5months	Burr hole & abscess drainage	8:00PM(18/12/21)	6:35PM(19/12/21)	6:50 PM	HFNC	2	310	39.9	90	65	210	35.4	98	84	4	Improved
Pankaj	24	0	15/1/22	2022/01/026747	175	84	Lt pubic rami fracture	nil	15day	Tens nail fixation	7:00PM(14/1/22)	10:30AM (15/1/22)	10:50 AM	HFNC	2	377.14	41.7	90	79.2	285.2	36	99	114	2	Improved
Ratana Ram	64	0	18/1/22	2022/01/028340	170	64	Ca Pancreas	Nil	2months	Distal pancreactomy and cholecystectomy	9:00PM(17/1/22)	4:40PM(18/1/22)	4:50 PM	HFNC	2	310	31.2	89	62.3	388	38.2	98	194	4	Improved
Suryakanta	44	0	7/2/22	2020/12/004327	166	51	Graft rejection post Renal transplant	HTN	2yrs	Graft nephrectomy	9:00 PM (6/2/22)	12:20 PM(7/2/22)	12:30 PM	Venturi Mask	2	352	37	90	74	312	33.3	100	156	4	Improved
Anish Kumar	28	0	9/2/22	2022/02/004674	170	51	Machine cut injury Lt UL	Nil	1day	LD flap coverage	8:00 AM	9:25 PM	9:45 PM	Venturi Mask	2	307.6	42.7	89	64.6	377	39.7	100	188.5	1	Improved
Deepak	18	0	18/3/22	2022/02/001841	164	39	P/o/c/o exploratory lap	Nil	3months	Feeding jejunostomy	8:00AM(17/3/22)	9:45AM(18/3/22)	10:00 AM	HFNC	2	132.5	48.7	88	53	217.5	43.8	98	87	4	Improved
Dharmendra	34	0	23/3/22	2022/03/015963	174	84	Crush injury Rt LL	Nil	2days	Wound debridement	11:00 AM	11:00 PM	12:10 AM	HFNC	2	168.75	43.5	86	67.5	270	43	98	108.4	2	Improved
Amra Ram	33	0	3/4/22	2022/03/017561	172	54	Testicular Ca	nil	3months	U/L high inguinal orchidectomy	9:00 AM	8:30 PM	8:50 PM	Venturi Mask	2	158.75	32.1	84	63.5	178.5	31	92	71.3	2	Improved
Ukiya Bai	46	1	24/4/22	2022/04/013690	158	37	Biliary Pancreatitis	nil	1month	Biliary Peritonitis	8:00PM(23/4/22)	1:10PM(24/4/22)	1:15 PM	HFNC	2	183	36.7	90	73	193.5	37.3	92	77.4	3	Improved
Thumri Lal	64	1	26/4/22	2020/05/001717	160	52	Biliary cystadenoma	nil	2months	Cyst deroofing	9:00PM(25/4/22)	2:45PM(26/4/22)	2:51 PM	Venturi Mask	2	172.5	29.7	89	69	155.2	33.5	96	77.6	3	Improved
Dhudi	44	0	28/4/22	2022/02/016304	152	45	Umbilical hernia	HTN	1month	Hernioplasty	9:00 PM (27/4/22)	12:35PM (28/4/22)	12:50 PM	Venturi Mask	2	180.75	40.4	90	72.3	164	35.5	96	82	2	Improved
Anju	43	0	7/6/22	2022/05/007210	170	78	Grade2 hemorrhoids	Liver Cirrhosis	6months	Hemorrhoiectomy	7:00PM (6/6/22)	4:00PM(7/6/22)	4:10 PM	Venturi Mask	2	175	36	89	70	240	34	99	120	2	Improved
Ramu	41	0	7/6/22	2015/07/010725	170	66	Lt inguinal hernia	H/o TB 5yrs ago	8months	Hernia repair	7:00 AM	8:30 PM	8:35 PM	HFNC	2	170	35	88	68	280	32	100	140	2	Improved
Mohd Irfan	32	0	9/6/22	2022/05/020771	174	78	Post traumatic raw area Lt leg	Nil	10days	LD free Flap	9:00PM(8/6/22)	9:00PM (9/6/22)	9:35 PM	NIV	2	162.5	39	88	65	260	34	97	130	4	Improved
Ganesh Ram	43	0	10/6/22	2022/06/004790	179	56	Raw area of lt temporal region	nil	7days	Debridement and coverage	11:00PM(9/6/22)	4:00PM(10/6/22)	4:15 PM	Venturi Mask	2	155	43	88	62	264	36	99	132	2	Improved
Dr. Gourav	40	0	14/6/22	2022/06/008996	180	82	Closed fracture dislocated femur head	HTN	5days	Right THR	10:00 PM(13/6/22)	5:30PM(14/6/22)	5:40 PM	NIV	2	162.5	37	86	65	225	34	99	135	4	Improved
Lichhami Devi	44	1	14/6/22	2022/01/025841	154	54.9	Rt chronic otitis media	Nil	7months	Rt Cortical mastoidectomy	8:00PM(13/6/22)	5:15PM(14/6/21)	5:30 PM	HFNC	2	180	40	89	72	224	36	100	112	2	Improved
Hamant	36	0	18/6/22	2022/05/021806	168	72	Biliary Peritonitis	HTN	1 month	Exploratory Laparotomy	CRTS (16/6/22)	1:55PM(18/6/22)	2:10 PM	NIV	2	187	33.3	75	53.8	209.7	33.8	94	73.4	4	Improved
Madhu Devi	45	1	17/6/22	2022/05/012376	151	54	Cholelithiasis	Nil	6days	Cholecystectomy and feeding jejunostomy	8:00PM(16/6/22)	6:20PM(17/6/22)	6:26 PM	Venturi Mask	2	300	34.2	89	60.2	476.75	33.3	100	190.7	2	Improved
Samudi	57	1	25/6/22	2021/12/012111	152	67	Caecal Volvulus	HTN,SLE	10days	Right hemicolectomy	9:00AM(23/6/22)	8:30PM(25/6/22)	8:50 PM	Venturi Mask	2	335	37	89	67	440	33	100	220	1	Improved
Umesh Yadav	45	0	25/6/22	2022/06/017150	160	62	Splenic laceration	Nil	3days	Splenic artery embolization	9:00AM(22/6/22)	7:00PM(25/6/22)	7:15 PM	HFNC	2	256	36.2	85	53.8	297	33	99	118.7	2	Improved
Kelki	63	1	26/6/22	2022/06/003989	156	80	Post Hernioplasty	Nil	1 month	Laproscopy	8:00AM (25/6/22)	12:00PM(26/6/22)	12:10 PM	NIV	2	318	47.9	89	66.8	361.3	40.9	100	108.4	4	Improved
Khiya Ram	62	0	28/6/22	2022/05/019373	152	58	Distal Cholangiocarcinoma	Nil	20 days	Robotic Whipples	7:00PM(27/6/22)	4:30PM(28/6/22)	4:40 PM	HFNC	2	271.7	35.1	85	57.1	340	33.4	96	170	3	Improved
Faqeero Lal	30	0	29/6/22	2022/06/02244	173	74	Torn off Serratus Ant Muscle	Nil	1 day	Muscle Repair	8:00AM (29/6/22)	1:00PM(29/6/22)	1:10 PM	Venturi Mask	2	134	38.4	89	59	238	35.6	99	119.2	2	Improved
Roshan Husain	42	0	30/6/22	2022/06/007702	178	79	OA of b/l Hip	HTN	10 years	B/L THA	8:30PM(29/6/22)	8:00PM(30/6/22)	8:10 PM	NIV	2	287.6	34	89	60.4	530	33	100	212	4	Improved
Sandeep Kakra	58	0	30/6/22	2022/09/009196	166	69	Rt Inguinal Hernia	Nil	2 months	Open Hernioplasty	9:00 PM(29/6/22)	4:00PM(30/6/22)	4:15 PM	NIV	2	288	43	87	57.6	315	35	100	126.4	4	Improved
Ganpat Soni	36	0	30/6/22	2022/06/019302	170	80	SDH	Nil	1day	FTP decompressive craniectomy	4:00PM(29/6/22)	1:00AM(30/6/22)	1:15 AM	Venturi Mask	2	136.8	50	88	60.2	397.4	42	100	198.7	4	Improved
Ahammed Khan	35	0	5/7/22	2022/07/002206	172	86	Post RTA Crush injury		1day	AKA Amputation and UL debridement	9:30AM(5/7/22)	8:20PM(5/7/22)	8:35 AM	NIV	2	290.4	47	87	60.4	428	46.4	100	214	4	Improved
Badri Narayan	65	0	8/7/22	2022/07/001412	169	84	Cauda equine syndrome	HTN	1 month	TLIF	8:30PM(7/7/22)	12:25 PM(8/7/22)	12:35 PM	NIV	2	140.9	52	84	62	325	45	100	195	4	Improved
Santosh Devi	32	1	8/7/22	2019/12/008081	150	52	B/L CSOM	Nil	7 months	Cortical Matoidectomy	7:00PM(7/7/22)	11:00AM(8/7/22)	11:20 AM	HFNC	2	296.5	37.6	87	59.3	318	33.5	100	127	2	Improved
Dheeraj Kanwar	56	1	10/7/22	2021/10/009180	174	72	Splenic Laceration	HTN	2 days	Splenic artery embolization	8:00PM(9/7/22)	6:30PM(10/7/22)	6:45 PM	Venturi Mask	2	300	40	89	63.1	344	38	100	172	2	Improved
Mohani Devi	39	1	11/7/22	2022/06/007661	154	59.6	Fibroid Uteus	Nil	6 months	Myomectomy	7:30PM(10/7/22)	12:30:00 PM(11/7/22)	12:40 PM	Venturi Mask	2	280.47	36	84	58.9	385	35.2	100	184	3	Improved
Manju	37	1	13/7/22	2022/07/011603	163	40	Periampullary NET	Nil	5months	Lap Whipples	8:30PM(12/7/22)	7:00PM(13/7/22)	7:10 PM	NIV	2	257	44.3	83	54	364	43.2	99	182	4	Improved
Soni Devi	65	1	16/7/22	2022/07/010800	156	78	Insect bite rt UL	Asthma	2 days	Debridement	8:30PM(15/7/22)	3:20PM(16/7/22)	3:30 PM	NIV	2	314	52	89	66	332.5	49	98	133	4	Improved
Dileep Adaniya	26	0	19/7/22	2022/07/010304	172	77	Anterolisthesis D11-12	Nil	6days	Decompression and fixation	8:30PM(18/7/22)	3:10PM(19/7/22)	3:20 PM	Venturi Mask	2	257	46.4	86	54	565	42.3	100	226	2	Improved
Jhamu Devi	24	1	24/7/22	2022/07/016360	154	45	Perforated appendix	Nil	2yrs	Lap appendicectomy	9:00AM(23/7/22)	6:40AM(24/7/22)	6:47 AM	Venturi Mask	2	281.9	44	88	59.2	532.5	42	100	213	2	Improved
Nabiyon Nisha	41	1	30/7/22	2022/07/011264	162	44	Cholecystitis	Nil	15 days	Lap Cholecystectomy	5:00PM(30/7/22)	12:20AM(31/7/22)	12:30 AM	NIV	2	266	39	87	56	412	35	100	165	4	Improved
Ritu Kanwar	38	1	31/7/22	2022/06/012476	168	52	Parathyroid adenoma	HTN	6 months	Parathyroidectomy	8:30PM(30/7/22)	3:15PM(31/7/22)	3:25 PM	Venturi Mask	2	287	33.6	89	60.3	393	33.2	99	118	3	Improved
Anchi Devi	48	1	2/8/22	2022/07/010508	162	80	Adnexal mass (dermoid)	Nil	1 year	Dermoid excision	7:00PM(1/8/22)	11:30AM(2/8/22)	11:45 AM	NIV	2	214	44	26	45	292	40.9	100	175.4	4	Improved
Dhula Ram	60	0	3/8/22	2022/07/018169	178	66.6	Lt RCC	Nil	15days	Lap radical nephrectomy	8:30PM (2/8/22)	1:00PM(3/8/22)	1:10 PM	NIV	2	286	46	88	60.2	560	42.6	100	280	4	Improved
Sonu Saini	29	1	4/8/22	2022/07/005490	162	59	Hiatal Hernia	Nil	1 month	Lap fundoplication	7:40PM (3/8/22)	12:10 PM (4/8/22)	12:25 PM	HFNC	2	285	38.2	89	59.9	312	37	99	156	2	Improved
Mirdul Parihar	30	0	12/8/22	2022/08/007734	178	110	L4-5 PIVD	Nil	7 days	Microdisectomy	9:00PM(11/8/22)	4:30 PM (12/8/22)	4:40 PM	NIV	2	304.7	43.2	87	64	348	39	100	174	4	Improved
Govind Pyari	65	1	17/8/22	2020/12/00113	167	66.2	Ca Endometrium	HTN	1 year	TLH BSO	8:30PM(16/8/22)	1:15PM(17/8/22)	1:25 PM	NIV	2	301	46	87	63.4	204	45	98	102	4	Improved
Badri Narayan	65	0	8/7/22	2022/07/001412	169	84	Cauda equine synd	HTN	1 month	TLIF	8:30PM (7/7/22)	12:25PM(8/7/22)	12:35 PM	NIV	2	140.9	52	84	62	195	45	100	195	4	Improved
Yakub Khan	47	0	1/9/22	2022/09/019534	173	89	Achalasia Cardia	HTN	10 years	Heller's myotomy	12:00PM(31/8/22)	3:14PM(1/9/22)	3:20 PM	NIV	2	157.5	37	86	63	198	34	97	99.9	4	Improved
Chhagan	30	0	5/9/22	2022/09/002634	171	72	Rt temporal EDH	Nil	8 hours	Craniotomy	7:00PM(4/9/22)	9:30AM(5/9/22)	9:40 AM	Venturi Mask	2	241.4	47	69	50.7	340	43	100	136	2	Improved
Gajro Devi	54	1	5/9/22	2022/08/003951	161	53.2	AUB	Nil	6 months	Total lap hysterectomy	8:00PM(4/9/22)	12:20PM(5/9/22)	12:25 PM	NIV	2	301.9	38	86	63.4	410	34	100	164	2	Improved
Babli	44	1	7/9/22	2022/08/014779	157	45.8	Pseudoaneurysm of Femoral Art	Hypothyroidism	1 year	Flap coverage	9:30PM(6/9/22)	4:00PM(7/9/22)	4:10 PM	HFNC	2	150.5	39	87	60.2	395	38	100	158	1	Improved
Niranjan Swarup	55	0	8/9/22	2022/09/000703	176	98	UB mass	HTN	3 months	TURBT	8:30PM(7/9/22)	12:15PM(8/9/22)	12:24 PM	NIV	2	264	41	74	55.6	336	38	100	168	4	Improved
Prithvi Singh	62	0	9/9/22	2022/08/004230	179	74	Ca appendix	Nil	5 months	Debulking	8:30PM(8/9/22)	12:32PM(9/9/22)	12:40 PM	Venturi Mask	2	287.6	38	86	60.4	462	36.3	100	185	2	Improved
Pappu Bhati	51	0	10/9/22	2022/09/004583	173	65	Thigh NSTI	Nil	7 days	Redebridement	9:00AM(10/9/22)	11:10PM(10/9/22)	11:18 PM	NIV	2	130	37	83	58.5	166	33.2	94	83	4	Improved
Padma Gupta	45	0	11/9/22	2022/04/004020	161	57	Rectovaginal prolapse	Nil	1 year	Rectopexy	9:00PM(10/9/22)	1:00PM(11/9/22)	1:15 PM	HFNC	2	297	37.3	84	59.5	404	37.2	100	202	2	Improved
Ram Jeewan	58	0	12/9/22	2022/08/014890	169	80	Inguinal hernia	Nil	6 months	Hernioplasty	8:30PM(11/9/22)	4:25PM(12/9/22)	4:40 PM	NIV	2	144	39	89	57.6	372	33	99	186	3	Improved
Nujhat Parvin	44	1	13/9/22	2022/06/019588	153	68.7	AUB	Nil	6 months	Robotic hysterectomy	8:30PM(12/9/22)	2:35PM(13/9/22'	2:45 PM	HFNC	2	275	34	83	55	412	33.4	100	165.6	2	Improved
Kamal Barupal	35	0	14/9/22	2022/07/011942	174	72	Lt frontal glioma	Nil	4 months	Craniotomy and lobectomy	9:00PM(13/9/22)	4:30PM(14/9/22)	4:40 PM	Venturi Mask	2	153.5	31	88	61.4	332	30	99	166	2	Improved
Sharwan Rathore	35	0	15/9/22	2022/08/019173	174.5	79	Ventral hernia	Nil	1 year	Lap Hernioplasty	7:30PM(14/9/22)	11:45PM(15/9/22)	11:50 PM	NIV	2	307	38	81	61.4	323	35.4	98	129.2	4	Improved
Anjli	38	1	19/9/22	2022/09/013206	159	63	MCA Aneurysm rupture	Nil	1 day	Endovascular coiling	2:30PM(18/9/22)	1:15PM(19/9/22)	1:25 PM	HFNC	2	295	35.4	86	59.2	415	34	100	166	4	Improved
Paras Mal	49	0	20/9/22	2022/09/005942	169	53	Calcific pancreatitis	Nil	1 month	Pancreatoduodenectomy	9:00PM(19/9/22)	7:20PM(20/9/22)	7:30 PM	Venturi Mask	2	246	42	78	49.3	283.3	42.4	96	170	3	Improved
Suki Devi	34	1	20/9/22	2022/06/000075	154	46	Achalsia Cardia	Nil	7 months	Heller's myotomy	8:30PM(19/9/22)	4:45PM(20/9/22)	4:55 PM	Venturi Mask	2	295	39	87	59.5	430	37	99	129	2	Improved
Deep Mala	40	1	22/9/22	2022/09/14632	166	68	Periampullary Ca	Nil	2 months	Pancreaticoduodenectomy	8:00PM(21/9/22)	7:30PM(22/9/22)	7:40 PM	HFNC	2	291	34.4	85	61.3	460	34.1	100	184	1	Improved
Pancham Singh	61	0	23/9/22	2022/04/006653	177	68	Hiatal hernia	Nil	8 months	Lap Fundoplication	9:30PM(22/9/22)	4:40PM(23/9/22)	4:50 PM	NIV	2	240	36	79	48.4	258	32	99	129	4	Improved
Nivaji	66	1	25/9/22	2022/08/017736	168	55	Supraumbilical hernia	Nil	8 months	Herniorhaphy	8:30PM(24/9/22)	4:15PM(24/9/22)	4:25 PM	Venturi Mask	2	274	35.7	87	57.6	340	34.8	98	136	2	Improved
Kishor Chand	44	0	26/9/22	2014/11/006176	170	84	Cholelithiasis	Nil	20 days	Cholecystectomy	9:00PM(25/9/22)	6:25PM(26/9/23)	6:40 PM	Venturi Mask	2	274.2	44.2	83	57.6	297.5	40.4	99	119.3	3	Improved
Dhalki Devi	43	1	26/9/22	2022/08/005213	151	42.2	CBD injury	Nil	2 months	Hepatico jejunostomy	9:30PM(25/9/22)	7:40PM(26/9/22)	7:55 PM	NIV	2	133	38.7	79	53.2	171	34	94	85.6	4	Improved
Raju Solanki	43	0	26/9/22	2022/03/010656	169	62.4	Anal incontinence	Nil	4 weeks	Gracilis Augmentation	8:00PM(25/9/22)	3:40PM(26/9/22)	3:50 PM	NIV	2	276	43.7	85	58	392	36.7	100	157.5	4	Improved
Ranjitaram	64	0	27/9/22	2022/09/017087	172	60	Rt RCC	Nil	3 months	Lap Nephrectomy	8:30PM(26/9/22)	1:20PM(27/9/22)	1:30 PM	NIV	2	277	38.6	87	58.3	308	32.2	99	154	3	Improved
Poonam Parwani	35	1	28/9/22	2016/05/002843	157	62	Infra umbilical hernia	Nil	15 months	IPOM	9:00PM(1/10/22)	11:00AM(2/10/22)	11:10 AM	Venturi Mask	2	285	32	86	60.1	410	33.3	100	205	3	Improved
Neta Ram	54	0	29/9/22	2019/06/018994	173	71	Rt renal stone	Nil	5 months	Rt RIRS URSL	9:30PM(28/9/22)	11:20AM(29/9/22)	11:40 AM	NIV	2	282	34	86	56.4	322.5	30.4	99	129	4	Improved
Urmila Devi	61	0	29/9/22	2022/11/009280	158	80	Appendicitis	HTN	2 months	Lap appendicectomy	7:30PM(29/9/22)	6:20PM(29/9/22)	6:30 PM	NIV	2	289.5	33	88	60.8	385	32	100	154	4	Improved
Mamta Mangal	44	1	30/9/22	2022/01/035998	160	69	Ca breast	Nil	7 months	Rt MRM	9:00PM(29/10/22)	6:45PM(30/9/22)	7:00OPM	NIV	2	310	40	90	62.6	1410	37	100	172	4	Improved