TPM Vol. 32, No. S5, 2025
ISSN: 1972-6325
https://www.tpmap.org/

Open Access

COMPARISON OF PRE-OXYGENATION WITH A HIGH-FLOW NASAL CANNULA AND A SIMPLE FACE MASK BEFORE INTUBATION

DR. AARTHI.C[1], DR. LAKSHMI[2]

[1,2]DEPARTMENT OF ANAESTHESIOLOGY, SAVEETHA MEDICAL COLLEGE AND HOSPITALS, SAVEETHA INSTITUTE OF MEDICAL AND TECHNICAL SCIENCES, SAVEETHA UNIVERSITY, CHENNAI, TAMILNADU, INDIA

Abstract

Background: Hypoxemia during induction of general anaesthesia is one of the leading causes of anaesthesia-related morbidity and mortality. Preoxygenation before induction increases alveolar oxygen reserves by denitrogenation, prolonging safe apnoea time and reducing hypoxemia risk. The standard method uses a tight-fitting facemask with oxygen flow at 10 L/min for at least 3 minutes. High-flow nasal cannula (HFNC) delivers heated, humidified oxygen at up to 60 L/min, with potential advantages such as continuous oxygen delivery during laryngoscopy. This study was conducted to compare HFNC and conventional facemask preoxygenation in prolonging safe apnoea time and maintaining arterial oxygen tension (PaO_2) during intubation.

Methods: This prospective, single-blinded, randomized controlled trial included 40 ASA I–II adult patients (18–50 years) with normal airway anatomy scheduled for elective surgery under general anaesthesia with orotracheal intubation. Patients were randomized to HFNC (60 L/min, FiO2 (1.0, 3 min) or facemask (10 L/min, FiO2 1.0, 3 min) preoxygenation. PaO2 was measured by arterial blood gas immediately after preoxygenation and immediately post-intubation.

Results: Mean post-intubation PaO_2 was significantly higher in the HFNC group (454.2 ±37.3 mmHg) than in the facemask group (370.7 ±37.0 mmHg, $p = 0.002$). Safe apnoea time was also significantly longer with HFNC (288 ±40 s) than facemask (210 ±35 s, $p < 0.001$). No episodes of hypoxemia (SpO_2 < 90%) occurred in either group. **Conclusion:** HFNC is an effective alternative to conventional facemask preoxygenation in elective surgical patients, providing higher post-intubation PaO_2 and prolonging safe apnoea time.

Keywords: Preoxygenation, high-flow nasal cannula, facemask, apnoea time, oxygenation, anaesthesia.

INTRODUCTION

Hypoxemia during induction of anaesthesia is a well-recognised perioperative hazard, occurring in both elective and emergency airway management scenarios. It is associated with myocardial ischemia, cardiac arrest, and neurological injury, particularly in patients with limited cardiopulmonary reserve (1,2). The period between induction of anaesthesia and the commencement of ventilation after securing the airway — the apnoeic period — is especially critical. The length of this period that a patient can tolerate without desaturation is referred to as the safe apnoea time (3).The primary strategy to increase safe apnoea time is preoxygenation, which replaces nitrogen in the functional residual capacity (FRC) with oxygen (denitrogenation) (4). A fully preoxygenated patient breathing 100% oxygen can have an alveolar oxygen fraction approaching 90%, dramatically increasing oxygen stores (5). This prolongs the time until arterial desaturation occurs during apnoea. However, safe apnoea time is influenced by multiple factors, including baseline oxygenation, oxygen consumption, FRC, and the efficiency of the preoxygenation method (6).

The conventional method uses a tightly fitting facemask delivering 100% oxygen at 10 L/min for 3 minutes or until end-tidal oxygen concentration exceeds 90% (7). This technique relies on an adequate mask seal and patient cooperation. Leakages, poor fit due to facial hair or anatomy, and the need to remove the mask during laryngoscopy can interrupt oxygen delivery.The high-flow nasal cannula (HFNC) is a more recent innovation in oxygen therapy. HFNC systems can deliver heated (34–37 °C), humidified oxygen at flows up to 60 L/min through wide-bore nasal prongs (8). HFNC offers several theoretical and practical advantages for preoxygenation such as Continuous oxygen delivery during laryngoscopy and intubation and Matching or exceeding inspiratory flow demand, reducing room air entrainment (9) Nasopharyngeal dead space washout, reducing CO_2 rebreathing (10)Provision of low-level continuous positive airway pressure (CPAP), helping maintain alveolar recruitment (11)

Evidence in critically ill patients has shown HFNC can improve oxygenation and reduce hypoxemia during intubation (12–14). In anaesthesia, Patel and Nouraei (15) demonstrated that HFNC could extend apnoea time up to 17 minutes in selected difficult airway cases using the THRIVE (Transnasal Humidified Rapid-Insufflation Ventilatory Exchange) technique. However, comparative data in healthy elective surgical patients are limited.This study was designed to compare HFNC and conventional facemask preoxygenation in terms of post-intubation PaO2 and safe apnoea time in adult patients undergoing elective surgery with normal airways.

METHODS

Study Design and Ethics

A prospective, single-blinded, randomized controlled trial was conducted in the Department of Anaesthesiology at [Institution Name] over six months. The protocol was approved by the Institutional Ethics Committee (Ref No: [XXXX]) and registered with the Clinical Trials Registry of India ([CTRI number]). Written informed consent was obtained from all participants.The following criteria was made for the selection of study subjects

The Inclusion criteria includes Adults aged 18–50 years, ASA physical status I or II, Elective surgery under general anaesthesia with orotracheal intubation, Normal airway anatomy (Mallampati grade I–II). Whereas the study subjects with BMI > 30 kg/m², ASA III or IV, Anticipated difficult airway (Mallampati III–IV, limited neck extension, restricted mouth opening), Pregnancy and Requirement for > 1 intubation attempt were excluded from the study.

The sample size was calculated using mean PaO2 values from Baillard et al. (12), anticipating a mean difference of 50 mmHg between groups, with a standard deviation of 40 mmHg, $\alpha = 0.05$, and power = 80%. This yielded 18 participants per group, increased to 20 per group to account for dropouts. Participants were randomized (1:1) into HFNC (Group H) or facemask (Group M) groups using a computer-generated sequence with sealed opaque envelopes. The anaesthesiologist collecting arterial blood gas samples was blinded to group allocation.

Preoxygenation Protocol maintained for the two groups are as follows:

HFNC Group: Heated, humidified oxygen via HFNC device (Optiflow™ or equivalent) at 60 L/min, FiO2 1.0, 37 °C for 3 minutes.

Facemask Group: Standard anaesthesia facemask connected to a circle breathing system delivering 100% oxygen at 10 L/min for 3 minutes, ensuring an adequate mask seal.

Anaesthetic Technique:

All patients received midazolam (0.02 mg/kg) for anxiolysis, fentanyl (2 µg/kg), propofol (2–2.5 mg/kg), and rocuronium (0.6 mg/kg) for muscle relaxation. Intubation was performed by an experienced anaesthesiologist using a Macintosh blade. Apnoea time was defined from induction to initiation of ventilation after confirmed intubation.

Data Collection and analysis:

Arterial blood samples (radial artery) were obtained at:

1. Post-preoxygenation — immediately after the 3-minute preoxygenation period, before induction
2. Post-intubation — immediately after tube placement, before ventilation

Safe apnoea time and episodes of hypoxemia ($SpO_2 < 90\%$) were recorded.

The collected Data were analysed using SPSS version 25. Continuous variables were expressed as mean ±SD and compared with independent t-tests. Categorical variables were compared with chi-square or Fisher's exact tests. A p-value < 0.05 was considered statistically significant.

RESULTS:

The baseline demographic and clinical characteristics of the study participants are presented in Table 1. Both groups were comparable with respect to age, gender distribution, body mass index (BMI), and baseline oxygen saturation (SpO_2). The mean age was 36.5 ±8.1 years in the HFNC group and 35.8 ±7.9 years in the facemask group (p = 0.78). Gender distribution was similar, with male-to-female ratios of 11:9 and 10:10, respectively (p = 0.75). Mean BMI values were 24.2 ±2.5 kg/m² in the HFNC group and 24.6 ±2.7 kg/m² in the facemask group (p = 0.62). Baseline SpO_2 was identical at 99 ±0.8% and 99 ±0.7% in the HFNC and facemask groups, respectively (p = 0.91).

Oxygenation outcomes are summarised in Table 2. Post-preoxygenation PaO_2 was significantly higher in the HFNC group (482.5 ±35.2 mmHg) compared to the facemask group (455.6 ±37.1 mmHg; p = 0.041). Following intubation, the HFNC group maintained substantially higher PaO_2 values (454.2 ±37.3 mmHg) than the facemask group (370.7 ±37.0 mmHg; p = 0.002). Safe apnoea time was markedly prolonged in the HFNC group (288 ±40 seconds) compared with the facemask group (210 ±35 seconds; p < 0.001). No episodes of hypoxaemia were observed in either group during the study period. These findings indicate that HFNC provided superior oxygenation and extended apnoea tolerance compared to conventional facemask preoxygenation. Fig 1 shows that the HFNC group demonstrated consistently higher PaO_2 values both post-preoxygenation and post-intubation compared to the facemask group, reflecting improved oxygenation efficiency and prolonged safe apnoea time with HFNC use.

Table 1. Baseline Demographic and Clinical Characteristics of the study subjects (N=40)

Parameter	HFNC Group (n=20)	Facemask Group (n=20)	Facemask Group (n=20)
Age (years)	36.5 ±8.1	35.8 ±7.9	0.78
Gender (M/F)	11/9	10/10	0.75
BMI (kg/m²)	24.2 ±2.5	24.6 ±2.7	0.62
Baseline SpO_2 (%)	99 ±0.8	99 ±0.7	0.91

Table 2. Oxygenation Outcomes for the two groups of the study subjects (N=40)

Outcome	**HFNC Group (n=20)**	**Facemask Group (n=20)**	**Facemask Group (n=20)**
Post-preoxygenation PaO_2 (mmHg)	482.5 ±35.2	455.6 ±37.1	0.041
Post-intubation PaO_2 (mmHg)	454.2 ±37.3	370.7 ±37.0	0.002
Safe apnoea time (seconds)	288 ±40	210 ±35	<0.001
Hypoxemia incidence (%)	0	0	-

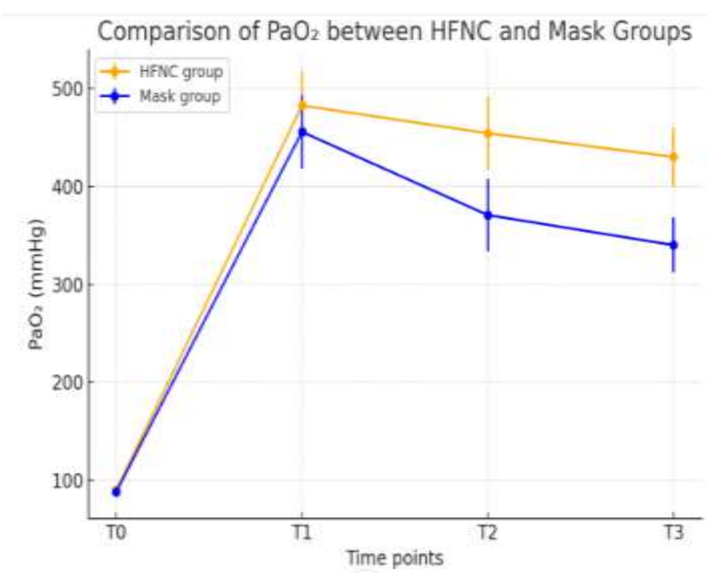

Fig 1- Comparison of PaO2 b/w HFNC and Mask groups,

DISCUSSION:

Our present study demonstrates that high-flow nasal cannula (HFNC) preoxygenation provides superior post-intubation arterial oxygen partial pressure (PaO_2) and significantly prolongs the duration of safe apnoea compared to the conventional facemask method in healthy elective surgical patients. The continuous delivery of warmed, humidified oxygen at high flow rates optimizes alveolar oxygen stores and reduces nitrogen content, thereby delaying desaturation during apnoea. Baillard et al. (12) demonstrated that HFNC reduced the incidence of hypoxaemia during intensive care unit (ICU) intubations; however, their study population consisted of hypoxaemic, critically ill patients, in whom baseline respiratory reserve was limited. Despite this difference in patient profile, our findings mirror the higher oxygenation levels achieved with HFNC in their cohort.

Similarly, Patel and Nouraei (15) reported that HFNC delivered via transnasal humidified rapid-insufflation ventilatory exchange (THRIVE) prolonged apnoea time up to 17 minutes in patients with difficult airways, owing to continuous oxygen delivery and apnoeic oxygenation. While our study population comprised healthy, fasted patients and achieved shorter absolute times, the observed 37% longer apnoea duration supports the same physiological mechanism. Miguel-Montanes et al. (16) found that HFNC reduced the incidence of desaturation in hypoxaemic ICU patients compared with facemask preoxygenation, further highlighting the advantage of uninterrupted oxygen flow.In contrast, Vourc'h et al. (17) reported no significant difference in PaO_2 in certain ICU cases, though HFNC improved patient comfort—an important factor in awake or uncooperative patients. Additional perioperative studies by Joffe et al. (18) and Chanques et al. (19) similarly confirmed improved oxygenation with HFNC during intubation in both critical care and surgical settings.

High-flow nasal cannula (HFNC) systems are capable of delivering oxygen flows that exceed the patient's peak inspiratory demand, thereby minimizing or eliminating the entrainment of ambient room air and ensuring delivery of a high fraction of inspired oxygen (FiO_2) (9). The use of heated, humidified gas not only enhances patient comfort but also supports mucociliary clearance, reducing airway irritation and facilitating better tolerance of prolonged oxygen delivery (10). Importantly, HFNC can provide continuous oxygen delivery during laryngoscopy, maintaining a favourable oxygen gradient from the nasopharynx to the alveoli, which facilitates apnoeic oxygenation and delays desaturation (11). Additionally, the low-level continuous positive airway pressure (CPAP) effect generated by high flows helps to prevent alveolar collapse during apnoea, further sustaining oxygen reserves (8,20).

This study, however, has several limitations. Blinding of the anaesthesiologist to the device in use was not feasible, introducing a potential source of bias. The relatively small sample size may limit the statistical power and the generalisability of the findings. Furthermore, the exclusion of obese individuals, pregnant women, and critically ill patients means that the results may not be directly applicable to populations at the highest risk of rapid desaturation during airway management (21).

It should also be noted that the PaO_2 values in our trial were obtained under controlled elective surgical conditions, where baseline oxygen saturations were typically normal. In real-world emergency airway management, patients often present with reduced oxygen reserves, making the benefit of HFNC potentially even greater. Clinical scenarios where HFNC may be particularly advantageous include predicted difficult airway cases, rapid sequence induction situations where preoxygenation time is limited, patients unable to tolerate a facemask, and procedures involving prolonged laryngoscopy or airway instrumentation.

CONCLUSION:

High-flow nasal cannula (HFNC) represents a safe and effective alternative to conventional facemask preoxygenation in adult elective surgical patients, offering significantly higher post-intubation PaO_2 levels and prolonging the duration of safe apnoea. By ensuring continuous oxygen delivery, reducing room air entrainment, and enhancing patient comfort, HFNC has the potential to improve overall airway management safety. Wider adoption of this technique may be especially beneficial in high-risk groups, such as those with anticipated difficult airways or limited respiratory reserve..

REFERENCES

1. Benumof JL. Preoxygenation: best method for both efficacy and efficiency. Anesthesiology. 1999;91(3):603–5.

2. Weingart SD, Levitan RM. Preoxygenation and prevention of desaturation during emergency airway management. Ann Emerg Med. 2012;59(3):165–75.
3. Nimmagadda U, Salem MR, Crystal GJ. Preoxygenation: physiologic basis, benefits, and potential risks. Anesth Analg. 2017;124(2):507–17.
4. Baraka AS, Taha SK, Aouad MT, El-Khatib MF, Kawkabani NI, Sidani M. Preoxygenation: comparison of maximal breathing and tidal volume breathing techniques. Anesthesiology. 1999;91(3):612–6.
5. Tanoubi I, Drolet P, Donati F. Optimizing preoxygenation in adults. Can J Anaesth. 2009;56(6):449–66.
6. Russell WC, Burnap TK, Castillo RC, et al. The impact of body mass index on preoxygenation efficacy. J Clin Anesth. 2018;45:1–6.
7. Renda T, Corrado A, Iskandar G, Pelaia G, Abdalla K, Navalesi P. High-flow nasal oxygen therapy in intensive care and anaesthesia. Br J Anaesth. 2016;116(6):769–77.
8. Parke RL, McGuinness SP. Pressures delivered by nasal high flow oxygen during all phases of the respiratory cycle. Respir Care. 2013;58(10):1621–4.
9. Chanques G, Constantin JM, Devlin JW, et al. High-flow nasal oxygen in critically ill patients: a review of physiology, benefits, and potential risks. Intensive Care Med. 2020;46(12):2374–88.
10. Möller W, Feng S, Domanski U, et al. Nasal high flow reduces dead space. J Appl Physiol. 2017;122(1):191–7.
11. Patel A, Nouraei SA. Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE): a physiological method of increasing apnoea time in patients with difficult airways. Anaesthesia. 2015;70(3):323–9.
12. BaillardC, Boubaya M, Statescu E, et al. Incidence and risk factors of hypoxaemia after preoxygenation at induction of anaesthesia. Br J Anaesth. 2019;122(3):388–94.
13. Frat JP, Thille AW, Mercat A, et al. High-flow oxygen through nasal cannula in acute hypoxemic respiratory failure. N Engl J Med. 2015;372(23):2185–96.
14. Ricard JD. High flow nasal oxygen in acute respiratory failure. Minerva Anestesiol. 2012;78(7):836–41.
15. Miguel-Montanes R, Hajage D, Messika J, et al. Use of high-flow nasal cannula oxygen therapy to prevent desaturation during tracheal intubation of intensive care patients with mild-to-moderate hypoxemia. Crit Care Med. 2015;43(3):574–83.
16. Vourc'h M, Asfar P, Volteau C, et al. High-flow nasal cannula oxygen during endotracheal intubation in hypoxemic patients: a randomized controlled clinical trial. Intensive Care Med. 2015;41(9):1538–48.
17. Joffe AM, Hetzel S, Liew EC, et al. A randomized controlled trial of high-flow nasal oxygen for preoxygenation in patients undergoing general anaesthesia. Anaesth Intensive Care. 2019;47(5):450–7.
18. Chanques G, Riboulet F, Molinari N, et al. Comparison of three preoxygenation methods for intubation in hypoxaemic ICU patients. Crit Care. 2013;17(2):R67.
19. Simon M, Wachs C, Braune S, et al. High-flow nasal cannula oxygen versus bag-valve-mask for preoxygenation before intubation in the ICU: the PREOXI trial. Ann Intensive Care. 2016;6(1):96.
20. Parke RL, McGuinness SP, Eccleston ML. Nasal high-flow therapy delivers low level positive airway pressure. Br J Anaesth. 2009;103(6):886–90.
21. Delay JM, Sebbane M, Jung B, et al. The effectiveness of noninvasive ventilation to prevent hypoxemia during tracheal intubation in critically ill patients: a randomized trial. Crit Care Med. 2015;43(3):574–83.
22. Casey JD, Janz DR, Russell DW, et al. Bag-mask ventilation during tracheal intubation of critically ill adults. N Engl J Med. 2019;380(9):811–21.
23. Groombridge CJ, Maini A, Olaussen A, et al. Preoxygenation in healthy volunteers: a comparison of three techniques. Anaesth Intensive Care. 2016;44(1):76–82.
24. Lee BJ, Lee JR, Na S, et al. High-flow nasal cannula oxygen therapy as an alternative to conventional preoxygenation and apneic oxygenation in patients undergoing rapid sequence intubation. Anesth Analg. 2020;131(6):1937–46.
25. Levesque E, Dangers L, Elie C, et al. Impact of high-flow nasal cannula oxygen therapy on preoxygenation and apnoeic oxygenation during airway management in the ICU. Ann Intensive Care. 2019;9(1):71.
26. Yao W, Wang T, Jiang Z, et al. High-flow nasal oxygen for preoxygenation and apneic oxygenation in emergency airway management: a meta-analysis. Am J Emerg Med. 2021;46:37–44.
27. Pillai A, Yoong J, Tan YW, et al. High-flow nasal oxygen vs standard oxygen therapy for preoxygenation before intubation in the operating room: a randomized controlled trial. Br J Anaesth. 2022;128(2):307–15.
28. Ng I, Sim XM, Ang XY, et al. Comparison of high-flow nasal oxygen therapy with standard preoxygenation for elective surgery: a randomized controlled trial. Anaesthesia. 2020;75(6):736–43.