International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008

https://theinternationalmedicine.com/

Original Researcher Article DOI: 10.61336/im/26-06-63

# A COMPARATIVE STUDY OF TWO DIFFERENT METHODS OF PREOXYGENATION BEFORE INDUCTION OF GA IN DIFFICULT INTUBATION.

**Dr. Kratika Purwar[1*], Dr. Puru Agarwal[2], Dr. Sarita Gohiya[3].**

[1]3rd Year PG Resident, Department of Anaesthesiology, Sri Aurobindo Medical College and Postgraduate Institute, Indore (M.P.).

[2]3rd Year PG Resident, Department of Anaesthesiology, Sri Aurobindo Medical College and Postgraduate Institute, Indore (M.P.).

[3]Professor & Head of Department, Department of Anaesthesiology, Sri Aurobindo Medical College and Postgraduate Institute, Indore (M.P.).

**Correspondence:**
***Dr. Kratika Purwar.***
*3rd Year PG Resident, Department of Anaesthesiology, Sri Aurobindo Medical College and Postgraduate Institute, Indore (M.P.).*

**Received:** 05-05-2026
**Revised:** 13-05-2026
**Accepted:** 01-06-2026
**Published:** 11-06-2026

## Abstract

***Background:*** Preoxygenation is an essential step before induction of general anaesthesia because it increases oxygen reserves and prolongs the duration of safe apnea during airway management. Adequate preoxygenation reduces the risk of hypoxemia, particularly in patients with anticipated difficult airway. Various techniques have been described to achieve optimal preoxygenation, including tidal volume breathing for several minutes and rapid vital capacity breathing within a shorter time. The present study aimed to assess and compare two different methods of preoxygenation before induction of general anaesthesia in patients with difficult intubation. ***Methods:*** This analytical cross-sectional study was conducted at Sri Aurobindo Medical College and PG Institute, Indore, after institutional ethics committee approval. Sixty patients aged 20–60 years undergoing surgery under general anaesthesia with anticipated difficult airway were included. Patients were randomly divided into two groups of 30 each. Group A received preoxygenation using tidal volume breathing for three minutes, while Group B received eight vital capacity breaths within one minute. Arterial blood gas parameters including pH, $PaO_2$, $PaCO_2$, and $HCO_3$ were measured before and after preoxygenation. Oxygen saturation and time to desaturation to 90% were also recorded. ***Results:*** Post-preoxygenation arterial oxygen levels were significantly higher in the vital capacity breathing group compared with the tidal breathing group (352.2 ± 38.9 mmHg vs 318.6 ± 34.7 mmHg; p=0.01). The time required for oxygen saturation to fall to 90% was also longer in the vital capacity breathing group (249 ± 32 seconds vs 212 ± 29 seconds; p=0.01). No significant differences were observed in $PaCO_2$, pH, or bicarbonate levels between the groups. ***Conclusion:*** Vital capacity breathing provided higher arterial oxygen levels and prolonged the duration of safe apnea compared with tidal volume breathing. This method may therefore offer a greater margin of safety during induction of general anaesthesia in patients with anticipated difficult intubation.

**Keywords:** Preoxygenation; difficult airway; tidal breathing; vital capacity breathing; general anaesthesia; oxygen desaturation.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC-BY) license (http://creativecommons.org/licenses/by/4.0/).

## INTRODUCTION

Preoxygenation is a fundamental step performed prior to induction of general anaesthesia to improve patient safety during endotracheal intubation. The technique involves administering 100% oxygen to replace the nitrogen present in the lungs, thereby increasing oxygen reserves within the functional residual capacity. By raising the fraction of inspired oxygen ($FiO_2$) close to 1.0 before induction, end-tidal oxygen concentration ($EtO_2$) can exceed 90%, which indicates adequate denitrogenation of the lungs and effective preoxygenation [1,2]. This physiological preparation significantly prolongs the duration of safe apnea, defined as the time interval before arterial oxygen saturation decreases below 90% after cessation of breathing [3,4].

Adequate preoxygenation plays an important role in airway management because induction of anaesthesia and administration of neuromuscular blocking agents temporarily abolish spontaneous ventilation. During this period, patients depend entirely on oxygen reserves stored in the lungs and blood. Effective preoxygenation therefore increases the margin of safety by delaying oxygen desaturation and providing clinicians additional time to secure the airway. This becomes particularly critical in difficult airway situations and in emergencies described as “cannot intubate, cannot oxygenate” (CICO) scenarios [5–7]. Consequently, current airway management guidelines recommend routine preoxygenation prior to tracheal intubation to minimize the risk of hypoxemia during induction of anaesthesia [8].

Several techniques have been proposed to achieve adequate preoxygenation. The choice of method often depends on patient-related factors such as age, body mass index, ASA physical status, airway anatomy, and the clinical setting, including operating rooms, intensive care units, or emergency departments [9–11]. Among the commonly used approaches are tidal volume breathing with 100% oxygen for three to five minutes and vital capacity breathing performed over a shorter duration using deep breaths [12]. Both techniques aim to maximize alveolar oxygen concentration and reduce nitrogen content in the lungs.

Despite routine use of preoxygenation, hypoxemia during induction of anaesthesia remains a frequent clinical concern. Certain patient populations, including obese individuals, pregnant women, elderly patients, and those with pulmonary disease, may experience rapid oxygen desaturation due to reduced functional residual capacity and increased oxygen consumption [6]. In addition to conventional techniques, adjunctive methods such as non-invasive positive pressure ventilation (NIPPV), positive end-expiratory pressure (PEEP), and high-flow nasal oxygen delivery systems like Transnasal Humidified Rapid-Insufflation Ventilatory Exchange (THRIVE) have been explored to improve oxygenation and delay desaturation during airway management [12–14]. However, conventional mask-based techniques remain the most widely used in many clinical settings.

Therefore, comparing commonly used methods such as tidal volume breathing and vital capacity breathing may help determine which technique provides better oxygenation and a longer duration of safe apnea in patients with anticipated difficult intubation.

## MATERIALS AND METHODS

After obtaining approval from the Institutional Ethics Committee of Sri Aurobindo Medical College and PG Institute, Indore, the study was carried out in the Department of Anaesthesiology between June 2024 and November 2025. Written informed consent was obtained from all participants after explaining the purpose and procedure of the study. A total of 60 patients scheduled for elective surgical procedures under general anaesthesia with anticipated difficult intubation were enrolled. Using computer-generated randomization, patients were allocated into two groups of 30 each.

### Inclusion Criteria

Patients were included if they fulfilled the following criteria:

- Age between 20 and 60 years
- ASA physical status I or II
- Mallampati grade III or IV
- Mouth opening less than three fingers
- Restricted neck extension

### Exclusion Criteria

Patients were excluded if they had:

- Refused to participate in the study
- Hypersensitivity to drugs used in general anaesthesia
- Ischemic heart disease
- Chronic obstructive pulmonary disease
- Obesity with BMI >30 kg/m²

### Study Groups

Patients were divided into two groups according to the technique of preoxygenation.

- Group A: Preoxygenation using tidal volume breathing for three minutes through a face mask delivering 100% oxygen.
- Group B: Preoxygenation using eight vital capacity breaths within one minute through a face mask delivering 100% oxygen.

### Study Procedure

Patients were kept fasting according to standard preoperative guidelines. After arrival in the operating room, standard monitoring including ECG, pulse oximetry, and non-invasive blood pressure monitoring was applied. Baseline parameters including heart rate, blood pressure, and oxygen saturation were recorded. A large bore intravenous cannula was secured and patients were preloaded with 10 ml/kg of intravenous lactated Ringer's solution. An arterial blood gas sample was obtained prior to preoxygenation. Patients were then preoxygenated according to their assigned group using a face mask delivering 100% oxygen. Parameters such as $FiO_2$, end-tidal $CO_2$ ($EtCO_2$), and inspired $CO_2$ ($FiCO_2$) were monitored during the preoxygenation period. After induction of general anaesthesia and endotracheal intubation, another arterial blood gas sample was obtained immediately. Parameters recorded included pH, $PaO_2$, $PaCO_2$, and bicarbonate ($HCO_3$). The time required for oxygen saturation to decrease to 90% was also recorded to evaluate the effectiveness of the preoxygenation technique.

**Outcome Measures**

The outcomes assessed included arterial oxygen tension ($PaO_2$), oxygen saturation ($SpO_2$), and arterial blood gas parameters including pH, $PaCO_2$, and $HCO_3$. In addition, the duration of safe apnea was evaluated by measuring the time required for oxygen saturation to decrease to 90%.

**Statistical Analysis**

Data were entered into Microsoft Excel and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, and categorical variables were expressed as frequency and percentage. Comparisons between groups were performed using the independent t-test, and a p-value <0.05 was considered statistically significant.

## RESULTS

A total of 60 patients were enrolled in the study and were divided equally into two groups of 30 each. Group A underwent preoxygenation using tidal volume breathing for three minutes, while Group B received eight vital capacity breaths within one minute. Baseline demographic characteristics including age and gender were comparable between the two groups, with no statistically significant difference ($p > 0.05$), confirming homogeneity of the study population.

**Table 1. Comparison of Demographic Characteristics**

| Parameter | Group A (n = 30) | Group B (n = 30) | p-value |
|---|---|---|---|
| Age (years, Mean ± SD) | 39.6 ± 10.2 | 40.4 ± 9.8 | 0.72 (NS) |
| Sex (M/F) | 17/13 | 16/14 | 0.79 (NS) |

NS = non-significant ($p > 0.05$)

Hemodynamic parameters including pulse rate, systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) were recorded before and after preoxygenation. The mean values were comparable between the two groups and did not show statistically significant differences ($p > 0.05$), indicating that both preoxygenation techniques maintained stable hemodynamic conditions.

**Table 2. Comparison of Hemodynamic Parameters Before and After Preoxygenation**

| Parameter | Group A | | Group B | | p-value |
|---|---|---|---|---|---|
| | Before | After | Before | After | |
| Pulse (beats/min) | 82.6 ± 7.3 | 80.9 ± 6.8 | 83.4 ± 6.9 | 81.1 ± 6.4 | 0.48 (NS) |
| SBP (mmHg) | 124.5 ± 8.4 | 122.8 ± 7.6 | 125.1 ± 7.9 | 123.6 ± 7.4 | 0.62 (NS) |
| DBP (mmHg) | 78.2 ± 6.1 | 76.5 ± 5.8 | 77.9 ± 6.4 | 75.8 ± 5.9 | 0.55 (NS) |
| MAP (mmHg) | 93.6 ± 6.8 | 92.1 ± 6.3 | 93.9 ± 6.5 | 92.4 ± 6.2 | 0.67 (NS) |

*p-value calculated by comparing **post-preoxygenation values between Group A and Group B** using independent t-test.; NS = non-significant ($p > 0.05$)

The change in hemodynamic parameters (Δ = After − Before) was calculated for each group. No statistically significant difference was observed between the two groups, indicating that both techniques maintained stable hemodynamic conditions. [Table 3]

**Table 3. Change in Hemodynamic Parameters After Preoxygenation**

| Parameter | Group A Δ (Mean ± SD) | Group B Δ (Mean ± SD) | p-value |
|---|---|---|---|
| Pulse (beats/min) | −1.7 ± 2.4 | −2.3 ± 2.6 | 0.41 |
| SBP (mmHg) | −1.7 ± 3.2 | −1.5 ± 3.0 | 0.78 |
| DBP (mmHg) | −1.7 ± 2.5 | −2.1 ± 2.7 | 0.55 |
| MAP (mmHg) | −1.5 ± 2.9 | −1.5 ± 3.1 | 0.98 |

Δ = Change from baseline (After − Before); NS = Non-significant ($p > 0.05$)

Arterial blood gas parameters were analyzed before and after preoxygenation in both groups. The post-preoxygenation $PaO_2$ values were significantly higher in Group B compared with Group A ($p = 0.01$). However, pH, $PaCO_2$, and $HCO_3$ values did not show statistically significant differences between the groups. [Table 4]

**Table 4. Comparison of Arterial Blood Gas Parameters**

| Parameter | Group A | | Group B | | p-value |
|---|---|---|---|---|---|
| | Before | After | Before | After | |
| pH | 7.39 ± 0.03 | 7.40 ± 0.03 | 7.39 ± 0.02 | 7.41 ± 0.02 | 0.34 (NS) |
| $PaCO_2$ (mmHg) | 40.2 ± 3.7 | 39.1 ± 3.6 | 40.0 ± 3.5 | 38.5 ± 3.4 | 0.48 (NS) |
| $PaO_2$ (mmHg) | 94.3 ± 8.5 | 318.6 ± 34.7 | 95.1 ± 8.2 | 352.2 ± 38.9 | **0.01 (S)** |
| $HCO_3$ (mEq/L) | 24.4 ± 2.0 | 24.5 ± 1.9 | 24.3 ± 1.8 | 24.7 ± 2.0 | 0.63 (NS) |

*p-value calculated by comparing post-preoxygenation values between Group A and Group B using independent t-test; S = Significant ($p < 0.05$)

The change in ABG values was calculated to assess the effect of the preoxygenation technique. A significantly greater increase in $PaO_2$ was observed in Group B compared with Group A, indicating more effective oxygenation with the vital capacity breathing technique. [Table 5]

**Table 5. Change in Arterial Blood Gas Parameters After Preoxygenation**

| Parameter | Group A Δ (Mean ± SD) | Group B Δ (Mean ± SD) | p-value |
|---|---|---|---|
| pH | +0.01 ± 0.02 | +0.02 ± 0.02 | 0.32 (NS) |
| $PaCO_2$ (mmHg) | −1.1 ± 2.5 | −1.5 ± 2.7 | 0.43 (NS) |
| $PaO_2$ (mmHg) | +224.3 ± 36.2 | +257.1 ± 40.4 | **0.01 (S)** |
| $HCO_3$ (mEq/L) | +0.1 ± 1.3 | +0.4 ± 1.5 | 0.61 (NS) |

Δ = Change from baseline (After − Before); S = Significant ($p < 0.05$)

Oxygen saturation increased in both groups following preoxygenation. However, patients in Group B demonstrated slightly higher $SpO_2$ levels and a significantly longer time before desaturation to 90%, indicating a longer duration of safe apnea compared with Group A.

**Table 4. Comparison of Oxygen Saturation and Duration of Safe Apnea**

| Parameter | Group A | Group B | p-value |
|---|---|---|---|
| Baseline $SpO_2$ (%) | 98.1 ± 0.7 | 98.3 ± 0.6 | 0.39 (NS) |
| Post-preoxygenation $SpO_2$ (%) | 99.2 ± 0.4 | 99.5 ± 0.3 | **0.02* (S)** |
| Time to desaturation to 90% (sec) | 212 ± 29 | 249 ± 32 | **0.01* (NS)** |

S = Significant ($p < 0.05$)

Overall, vital capacity breathing produced higher arterial oxygen levels and a longer duration before desaturation, suggesting a greater margin of safety during induction of general anaesthesia.

## DISCUSSION

Preoxygenation is a critical component of airway management before induction of general anaesthesia as it increases oxygen reserves in the lungs and prolongs the duration of safe apnea during airway manipulation. This is particularly important in patients with anticipated difficult intubation, where prolonged attempts at airway control may increase the risk of hypoxemia.

In the present study, baseline demographic characteristics including age and gender were comparable between the two groups, indicating that the observed differences in outcomes were primarily attributable to the preoxygenation technique used. The results demonstrated that the vital capacity breathing technique produced significantly higher $PaO_2$ levels compared with tidal volume breathing. This suggests that rapid deep breathing may facilitate faster denitrogenation of the lungs and enhance oxygen reserves prior to induction of anaesthesia.

These findings are consistent with the study conducted by Taha et al. (2009), who evaluated the efficacy of eight deep breaths within 60 seconds for preoxygenation and reported that this technique achieved adequate oxygenation when high oxygen flow rates were used [15]. Similarly, Nimmagadda et al. (2001) compared tidal volume breathing with deep breathing techniques and found that although tidal breathing for 3–5 minutes achieved maximal preoxygenation, deep breathing techniques could provide effective oxygenation when time was limited [16].

Kang et al. (2010) also reported that three-minute tidal volume breathing provided reliable protection against hypoxemia during apnea and achieved adequate denitrogenation of the lungs before induction of anaesthesia [17]. In the present study, oxygen saturation after preoxygenation was slightly higher in the vital capacity breathing group, although both techniques resulted in high oxygen saturation levels. Similar observations were reported by Arora et al. (2018), who noted that tidal breathing with appropriate oxygen flow rates could achieve optimal preoxygenation within approximately three minutes, although variations in breathing patterns and oxygen delivery systems could influence the efficiency of preoxygenation [18].

Another important observation in the present study was that the time required for oxygen saturation to decrease to 90% was significantly longer in the vital capacity breathing group, indicating a longer safe apnea duration. Effective denitrogenation increases oxygen stores within the lungs and delays arterial desaturation during apnea. A recent comparative analysis also reported that the eight deep-breath technique may provide superior preoxygenation compared with conventional tidal breathing, particularly in situations requiring rapid airway management [19]. Nevertheless, tidal volume breathing remains the most widely recommended technique in routine anaesthetic practice because of its simplicity and reliability, and several reviews have suggested that breathing 100% oxygen for approximately three minutes generally achieves adequate denitrogenation in most patients [20].

The present study had certain limitations. The sample size was relatively small and the study was conducted at a single tertiary care center, which may limit the generalizability of the findings. Additionally, factors such as mask fit, patient cooperation, and variations in respiratory effort could have influenced the effectiveness of preoxygenation.

## CONCLUSION

Effective preoxygenation is essential to ensure patient safety during induction of general anaesthesia, particularly in individuals with anticipated difficult airway. The present study demonstrated that both tidal volume breathing for three minutes and eight vital capacity breaths within one minute provided adequate preoxygenation. However, the vital capacity breathing technique resulted in higher arterial oxygen tension and a longer duration before oxygen desaturation, indicating a greater margin of safety during apnea. These findings suggest that rapid vital capacity breathing can achieve efficient lung denitrogenation and improved oxygen reserves within a shorter time. Therefore, vital capacity breathing may serve as a practical and effective alternative to conventional tidal breathing, especially in situations requiring rapid and reliable preoxygenation.

## REFERENCES

1. Wawersik J. History of anesthesia in Germany. Journal of Clinical Anesthesia. 2019 May 1;3(3):235-44.
2. Chin KJ, El-Boghdadly K. Mechanisms of action of the erector spinae plane (ESP) block: a narrative review. Canadian Journal of Anesthesia / Journal canadien d'anesthésie. 2021 Mar;68(3):387-408.
3. McDonnell JG, O'Donnell BD, Farrell T, Gough N, Tuite D, Power C, Laffey JG. Transversus abdominis plane block: a cadaveric and radiological evaluation. Regional Anesthesia & Pain Medicine. 2007 Sep;32(5):399-404.
4. Buttner B, Mansur A, Bauer M, Hinz J, Bergmann I. Unilateral spinal anesthesia: literature review and recommendations. Der Anaesthesist. 2016 Nov 1;65(11):847-65.
5. Apaydin Y, Erk G, Sacan O, Tiryaki C, Taspinar V. Characteristics of unilateral spinal anesthesia at different speeds of intrathecal injection. Journal of Anesthesia. 2011 Jun;25(3):380-5.
6. Borghi B, Wulf H. Advantages of unilateral spinal anaesthesia. Anaesthesiologie, Intensivmedizin, Notfallmedizin, Schmerztherapie. 2010 Mar 15;45(3):182-7.
7. Borghi B, Stagni F, Bugamelli S, Paini MB, Nepoti ML, Montebugnoli M, Casati A. Unilateral spinal block for outpatient knee arthroscopy: a dose-finding study. Journal of Clinical Anesthesia. 2003 Aug 1;15(5):351-6.
8. Khaw KS, Kee WDN, Lee SW. Hypotension during spinal anaesthesia for caesarean section: implications, detection, prevention and treatment. Fetal and Maternal Medicine Review. 2006;17:1-27.
9. Obasuyi BI et al. A comparison of the haemodynamic effects of lateral and sitting positions. Obstetric Anesthesia. 2013;22(2):124.
10. Rucklidge MWM et al. A comparison of the lateral, Oxford and sitting positions for performing combined spinal-epidural anaesthesia for elective caesarean section. Anaesthesia. 2005;60(6):53.
11. Kinsella SM, Harvey NL. A comparison of the pelvic angle using lateral tilt table or a pelvic wedge at elective caesarian section. Anaesthesia. 2012;67(12):1327-31.
12. Inglis A, Daniel M, McGrady E. Maternal position during induction of spinal anaesthesia for caesarean section: a comparison of right lateral and sitting positions. Anaesthesia. 1995;50(4):363-65.
13. Tan ED, Gunaydin B. Comparison of maternal and neonatal effects of combined spinal epidural anaesthesia either in sitting or lateral position during elective caesarean section. Turkish Journal of Anaesthesiology and Reanimation. 2014;42:23-32.
14. Hocking G, Wildsmith JAW. Intrathecal drug spread. British Journal of Anaesthesia. 2014;93(4):568-578
15. Taha SK, El-Khatib MF, Baraka AS. Preoxygenation by eight deep breaths within 60 seconds: randomized clinical study. Journal of Clinical Anesthesia. 2009.
16. Nimmagadda U, Salem MR, Crystal GJ. Preoxygenation with tidal volume and deep breathing techniques: the impact of duration of breathing and fresh gas flow. Anesthesia & Analgesia. 2001.

17. Kang H, et al. Effects of preoxygenation using three-minute tidal volume breathing technique. Korean Journal of Anesthesiology. 2010.
18. Arora S, et al. Efficacy of preoxygenation using tidal volume breathing with different breathing systems. Brazilian Journal of Anesthesiology. 2018.
19. T CS, R P, Kapart L. A randomised control study comparing the efficacy of 2 techniques of preoxygenation - tidal volume breathing for one minute and 8 deep breaths in one minute [Internet]. Indian J Clin Anaesth. 2019 [cited 2026 Mar 11];6(1):71-76.
20. Azam Danish M. Preoxygenation and Anesthesia: A Detailed Review. Cureus. 2021 Feb 9;13(2):e13240.