EFFECTIVENESS OF APNEIC OXYGENATION IN PREVENTING DESATURATION DURING ENDOTRACHEAL INTUBATION IN EMERGENCY PATIENTS: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Endotracheal intubation in emergency settings is frequently associated with hypoxemia, which can lead to serious complications. Apneic oxygenation has been proposed as a simple technique to maintain oxygenation during the apneic phase of intubation; however, evidence in emergency settings remains limited.

Objectives: To evaluate the effectiveness of apneic oxygenation in preventing desaturation during endotracheal intubation in emergency patients.

Methods: This prospective observational study was conducted in the emergency department of a tertiary care hospital in North India from June 2020 to February 2021. A total of 42 adult patients requiring emergency intubation were included and divided into two groups based on the use of apneic oxygenation. Data on baseline characteristics, intubation parameters, and oxygenation outcomes were recorded. The primary outcome was the incidence of desaturation (SpO_2 <90%) during intubation. Statistical analysis was performed using SPSS version 22.0, with a p-value <0.05 considered statistically significant.

Results: Baseline characteristics were comparable between the two groups. The incidence of desaturation was significantly lower in the apneic oxygenation group compared to the non-apneic group (23.8% vs 52.4%, p = 0.048). The mean nadir oxygen saturation was significantly higher in patients receiving apneic oxygenation (88.6 ±5.2%) compared to those who did not (82.3 ±6.8%, p = 0.003). There were no significant differences in intubation characteristics or complication rates between the groups.

Conclusion: Apneic oxygenation is an effective and safe technique for reducing desaturation during emergency endotracheal intubation. Its routine use may improve patient safety and should be considered as part of standard airway management protocols.

Keywords: Apneic oxygenation; Endotracheal intubation; Emergency airway management; Hypoxemia; Desaturation; Prospective study

INTRODUCTION

Airway management is a critical component of emergency care, with endotracheal intubation being a life-saving intervention in critically ill patients. However, the procedure is associated with a significant risk of hypoxemia, particularly during the apneic phase between induction and successful tube placement. Desaturation during intubation has been linked to adverse outcomes, including cardiac arrhythmias, hemodynamic instability, and increased mortality [1]. This risk is especially pronounced in emergency settings, where patients often present with compromised physiological reserves, underlying respiratory pathology, or hemodynamic instability [2].

Preoxygenation has traditionally been employed to prolong the safe apnea time by denitrogenating the lungs and increasing oxygen reserves. Despite optimal preoxygenation, rapid desaturation may still occur in critically ill patients due to factors such as reduced functional residual capacity, increased oxygen consumption, and ventilation-perfusion mismatch [3]. Consequently, strategies to maintain oxygenation during the apneic phase have gained increasing attention in recent years.

Apneic oxygenation is one such technique that involves the administration of oxygen through nasal cannula during the apneic period of intubation. It is based on the physiological principle that oxygen continues to diffuse into the alveoli even in the absence of active ventilation, provided a gradient is maintained [4]. This phenomenon, often referred to as “aventilatory mass flow,” allows for continuous oxygenation and has been proposed as a simple and effective method to delay desaturation [5].

Several studies conducted in controlled settings, including operating rooms and intensive care units, have demonstrated the benefits of apneic oxygenation in prolonging safe apnea time and reducing the incidence of hypoxemia [6,7]. However, evidence from emergency departments, particularly in resource-constrained settings, remains limited. The emergency setting presents unique challenges such as time constraints, variable operator expertise, and heterogeneous patient populations, which may influence the effectiveness of apneic oxygenation [8].

In the Indian context, where emergency departments often cater to high patient volumes with limited resources, the applicability and effectiveness of apneic oxygenation require further evaluation. Few studies from low- and middle-income countries have explored its role in real-world emergency scenarios, and existing data show variable outcomes [9]. Additionally, differences in patient demographics, disease profiles, and healthcare infrastructure necessitate region-specific evidence to guide clinical practice.

Despite growing interest, there remains a lack of prospective observational data assessing the effectiveness of apneic oxygenation during emergency intubations in tertiary care settings in North India. Addressing this gap is essential to determine whether this low-cost intervention can be routinely implemented to improve patient safety and outcomes.

Therefore, the present study aims to evaluate the effectiveness of apneic oxygenation in preventing desaturation during endotracheal intubation in emergency patients in a tertiary care hospital setting. The specific objective is to compare the incidence and degree of oxygen desaturation during intubation among patients receiving apneic oxygenation.

METHODOLOGY

Study Design: This study was conducted as a prospective observational study, designed to evaluate the effectiveness of apneic oxygenation in preventing oxygen desaturation during endotracheal intubation in emergency patients.

Study Setting: The study was carried out in the emergency department of a tertiary care hospital in **North India**, catering to a high volume of critically ill patients requiring urgent airway management.

Study Duration: The study was conducted over a period of 9 months, from June 2020 to February 2021.

Study Population: The study population included adult patients presenting to the emergency department who required endotracheal intubation as part of their clinical management.

Inclusion Criteria

- Patients aged ≥18 years
- Patients requiring emergency endotracheal intubation
- Patients in whom pulse oximetry monitoring was feasible
- Patients for whom informed consent (from patient/attendant) was obtained

Exclusion Criteria

- Patients with cardiac arrest at presentation
- Patients with pre-existing severe hypoxemia (SpO_2 <85% despite oxygen support)
- Patients with upper airway obstruction precluding nasal oxygen administration
- Patients with facial trauma or contraindications to nasal cannula use
- Pregnant patients

Sample Size: The sample size was calculated based on previous studies reporting a reduction in desaturation rates with apneic oxygenation. Assuming an expected proportion difference of approximately 30%, with a confidence level of 95% and power of 80%, the minimum required sample size was estimated to be 38. Considering feasibility and possible data loss, a total of 42 patients were included in the study.

Sampling Technique: A consecutive sampling technique was used, wherein all eligible patients presenting during the study period and meeting inclusion criteria were enrolled until the desired sample size was achieved.

Data Collection Tools & Procedure: Data were collected using a pre-designed, semi-structured case record form. Baseline patient characteristics including age, sex, indication for intubation, and baseline oxygen saturation were recorded. All patients underwent standard preoxygenation prior to intubation. During the apneic phase, oxygen was administered via nasal cannula at a flow rate of 10–15 L/min in patients receiving apneic oxygenation, while others received standard care without nasal oxygen supplementation, as per clinician preference. Continuous pulse oximetry was used to monitor oxygen saturation. The lowest oxygen saturation (nadir SpO_2) during intubation, duration of intubation, number of attempts, and any complications were recorded. Data collection was performed by trained personnel to ensure accuracy and uniformity.

Study Variables: The independent variable in this study was the use of apneic oxygenation (present or absent). Dependent variables included incidence of desaturation (defined as SpO_2

<90%), nadir oxygen saturation during intubation, duration of intubation, and number of intubation attempts. Additional variables such as patient demographics and clinical indications were also recorded to assess potential confounders.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using Statistical Package for the Social Sciences (SPSS) version 22.0. Descriptive statistics were expressed as mean ± standard deviation for continuous variables and frequencies and percentages for categorical variables. The Chi-square test or Fisher's exact test was used to compare categorical variables, while the independent t-test was used for continuous variables. A *p-value of <0.05* was considered statistically significant.

Ethical Considerations: Written informed consent was obtained from patients or their legally authorized representatives prior to inclusion in the study. The study adhered to the ethical principles outlined in the Declaration of Helsinki. Confidentiality of patient data was maintained throughout the study, and no personal identifiers were disclosed.

RESULTS

A total of 42 patients were included in the study, with 21 patients in each group. The baseline demographic and clinical characteristics were comparable between the two groups, with no statistically significant differences in age, sex distribution, baseline oxygen saturation, or indications for intubation (Table 1).

Table 1: Baseline Demographic and Clinical Characteristics of Study Participants (n = 42)

Variable	Apneic Oxygenation (n = 21)	No Apneic Oxygenation (n = 21)	p-value
Age (years), mean ± SD	52.4 ± 14.2	49.8 ± 15.1	0.56
Male, n (%)	13 (61.9%)	12 (57.1%)	0.75
Baseline SpO_2 (%), mean ± SD	94.2 ± 3.1	93.8 ± 3.6	0.68
Indication – Respiratory failure, n (%)	10 (47.6%)	9 (42.9%)	0.76
Indication – Sepsis, n (%)	6 (28.6%)	7 (33.3%)	0.74
Indication – Trauma, n (%)	5 (23.8%)	5 (23.8%)	1.00

Intubation characteristics, including first-pass success rate, duration of intubation, and number of attempts, were similar between the two groups, with no statistically significant differences observed (Table 2).

Table 2: Intubation Characteristics

Variable	Apneic Oxygenation (n = 21)	No Apneic Oxygenation (n = 21)	p-value
First-pass success, n (%)	15 (71.4%)	13 (61.9%)	0.52
Duration of intubation (sec), mean ± SD	48.6 ± 12.4	52.3 ± 13.7	0.34
Multiple attempts (>1), n (%)	6 (28.6%)	8 (38.1%)	0.51

However, significant differences were noted in oxygenation outcomes. The incidence of desaturation (SpO_2 <90%) was significantly lower in the apneic oxygenation group compared to the non-apneic group (23.8% vs 52.4%, p = 0.048). Additionally, the mean nadir SpO_2 during intubation was significantly higher in patients receiving apneic oxygenation (88.6 ±5.2%) compared to those who did not (82.3 ±6.8%, p = 0.003) (Table 3). Although severe desaturation (SpO_2 <80%) was less frequent in the apneic oxygenation group, this difference did not reach statistical significance.

Table 3: Oxygenation Outcomes During Intubation

Variable	Apneic Oxygenation (n = 21)	No Apneic Oxygenation (n = 21)	p-value
Desaturation (SpO_2 <90%), n (%)	5 (23.8%)	11 (52.4%)	0.048*
Nadir SpO_2 (%), mean ± SD	88.6 ± 5.2	82.3 ± 6.8	0.003*

Severe desaturation (SpO_2 <80%), n (%)	2 (9.5%)	6 (28.6%)	0.12

*Statistically significant

The incidence of complications such as hypotension, arrhythmias, and esophageal intubation was comparable between the two groups, with no statistically significant differences (Table 4). Overall, apneic oxygenation was associated with improved oxygenation parameters during intubation without increasing procedural complications.

Table 4: Complications During Intubation

Complication	Apneic Oxygenation (n = 21)	No Apneic Oxygenation (n = 21)	p-value
Hypotension, n (%)	4 (19.0%)	5 (23.8%)	0.71
Cardiac arrhythmia, n (%)	1 (4.8%)	2 (9.5%)	0.55
Esophageal intubation, n (%)	1 (4.8%)	2 (9.5%)	0.55

DISCUSSION

The present prospective observational study evaluated the effectiveness of apneic oxygenation in preventing desaturation during endotracheal intubation in emergency patients. The key findings demonstrate that the use of apneic oxygenation was associated with a significantly lower incidence of desaturation (SpO_2 <90%) and a higher nadir oxygen saturation during intubation. Importantly, these benefits were achieved without a corresponding increase in procedural complications or adverse events.

Hypoxemia during emergency intubation remains a well-recognized challenge and has been consistently associated with poor clinical outcomes [1,3]. In our study, more than half of the patients in the non-apneic oxygenation group experienced desaturation, which aligns with previous reports highlighting the high incidence of peri-intubation hypoxemia in critically ill populations [2]. The significantly lower desaturation rate observed in the apneic oxygenation group supports the physiological basis of continuous oxygen diffusion during apnea, as originally described in early experimental studies [4].

Our findings are consistent with prior literature demonstrating the benefits of apneic oxygenation in maintaining oxygenation during airway management. Ramachandran et al. reported that apneic oxygenation significantly prolonged safe apnea time in obese patients undergoing elective procedures [6]. Similarly, Miguel-Montanes et al. demonstrated that high-flow nasal oxygen reduced the incidence of desaturation during intubation in critically ill patients [7]. Although these studies were conducted in controlled environments such as operating rooms and intensive care units, our results extend these findings to the emergency department setting, where patient variability and procedural urgency present additional challenges.

In contrast, the randomized controlled trial by Semler et al. did not demonstrate a significant reduction in desaturation with apneic oxygenation in critically ill patients [9]. The discrepancy between their findings and ours may be attributed to differences in study design, patient population, and oxygen delivery methods. The Semler study included a heterogeneous ICU population with more severe illness, which may have limited the effectiveness of apneic oxygenation. Additionally, variations in preoxygenation techniques and operator expertise could have influenced outcomes. Our study, being observational and conducted in a real-world emergency setting, reflects pragmatic clinical practice and may better capture the benefits of apneic oxygenation in routine use.

The absence of a significant difference in intubation characteristics such as first-pass success and duration of intubation suggests that apneic oxygenation does not interfere with procedural performance. This is an important consideration, as any intervention that complicates airway management may negate its potential benefits. Furthermore, the comparable complication rates between groups indicate that apneic oxygenation is a safe adjunct to standard airway management practices.

From a clinical perspective, the implementation of apneic oxygenation is simple, cost-effective, and requires minimal additional equipment, making it particularly suitable for resource-limited settings such as many emergency departments in India. Given the significant reduction in desaturation observed in our study, routine use of nasal oxygen during intubation could enhance patient safety and potentially reduce adverse outcomes associated with hypoxemia.

The strengths of this study include its prospective design, real-world emergency setting, and standardized data collection, which enhance the validity and applicability of the findings. However,

several limitations must be acknowledged. The relatively small sample size may limit the generalizability of the results and the ability to detect differences in less frequent outcomes such as severe desaturation and complications. The observational design introduces the possibility of selection bias, as the decision to use apneic oxygenation was based on clinician preference. Additionally, unmeasured confounders such as operator experience, patient positioning, and variability in preoxygenation techniques could have influenced the results.

Despite these limitations, the study provides valuable evidence supporting the effectiveness of apneic oxygenation in emergency airway management. Further large-scale, multicentric studies are warranted to validate these findings and establish standardized protocols for its use.

CONCLUSION

This prospective observational study demonstrates that apneic oxygenation is an effective and safe adjunct during endotracheal intubation in emergency patients. The use of apneic oxygenation was associated with a significant reduction in the incidence of desaturation and improved nadir oxygen saturation during the procedure, without increasing the risk of complications. These findings highlight its potential role in enhancing patient safety during airway management, particularly in critically ill individuals who are at high risk of rapid hypoxemia. Given its simplicity, low cost, and ease of implementation, apneic oxygenation can be readily incorporated into routine clinical practice in emergency departments, including resource-limited settings. Although the study findings are promising, larger multicentric studies are recommended to further validate the results and establish standardized guidelines. Integrating apneic oxygenation into airway management protocols may contribute to improved clinical outcomes and reduced peri-intubation morbidity.

DECLARATIONS

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