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Research Article

Prospective Observational Study of Intraoperative Hypoxemia Burden and Postoperative Pulmonary Complications in Patients with Obstructive Sleep Apnea

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Abstract

Obstructive sleep apnea (OSA) is strongly associated with perioperative respiratory instability, yet the role of intraoperative hypoxemia burden as a predictor of postoperative pulmonary complications (PPCs) remains insufficiently quantified. This prospective observational study evaluated the association between intraoperative oxygen desaturation exposure and postoperative pulmonary outcomes in surgical patients with diagnosed or high-risk OSA.

A total of 150 adult patients undergoing elective surgery under general anesthesia were included. Mean intraoperative hypoxemia time (SpO_2 <90%) was 12.8 ± 9.4 minutes. Patients who developed postoperative pulmonary complications exhibited significantly higher hypoxemia burden (24.6 ± 10.7 vs 7.9 ± 5.6 minutes, $p < 0.001$).

Overall PPC incidence was 28% (42 patients), including atelectasis (16%), pneumonia (7.3%), and respiratory failure requiring non-invasive ventilation (4.7%). Hypoxemia burden >15 minutes was

associated with a 3.8-fold increased risk of PPCs (OR 3.8, 95% CI 2.1–6.9, $p < 0.001$).

Multivariate regression identified intraoperative hypoxemia burden, BMI, and OSA severity (AHI >30) as independent predictors of PPCs.

The study concludes that intraoperative hypoxemia burden is a strong, independent predictor of postoperative pulmonary complications in OSA patients and should be incorporated into intraoperative risk monitoring strategies.

Keywords: Obstructive sleep apnea, hypoxemia burden, postoperative pulmonary complications, anesthesia

Introduction

Obstructive sleep apnea (OSA) is a highly prevalent sleep-related breathing disorder characterized by recurrent episodes of upper airway collapse during sleep, resulting in intermittent hypoxemia, hypercapnia, and sleep fragmentation. Its prevalence is increasing globally due to rising obesity rates, aging populations, and improved diagnostic awareness. In surgical populations, OSA represents a major perioperative risk factor associated with respiratory, cardiovascular, and neurological complications [1–3].

The perioperative period presents unique physiological challenges in patients with OSA. Sedatives, anesthetic agents, and opioids further depress upper airway tone and ventilatory drive, exacerbating underlying airway collapsibility. These effects increase susceptibility to intraoperative and postoperative hypoxemia, particularly during induction, maintenance, and emergence from anesthesia [4–6].

Intraoperative hypoxemia is defined as a reduction in arterial oxygen saturation (SpO_2 <90%) during surgery. While transient desaturation episodes are common under anesthesia, prolonged or recurrent hypoxemic events may indicate impaired ventilatory reserve and inadequate oxygenation. The cumulative duration of desaturation—referred to as hypoxemia burden—has recently emerged as a more meaningful metric than isolated SpO_2 nadirs [7–9].

Postoperative pulmonary complications (PPCs), including atelectasis, pneumonia, respiratory failure, and need for ventilatory support, remain a leading cause of morbidity after surgery. Patients with OSA are particularly vulnerable due to baseline airway obstruction, reduced functional residual capacity, and impaired respiratory compensatory mechanisms [10–12].

Recent perioperative research has emphasized the importance of intraoperative

physiological stress markers, including oxygen desaturation, ventilatory variability, and hemodynamic instability. Among these, hypoxemia burden has gained attention as a potentially modifiable intraoperative predictor of adverse outcomes. However, its specific role in OSA populations remains insufficiently studied [13–15].

OSA severity is commonly classified using the apnea-hypopnea index (AHI), but AHI alone does not fully capture perioperative risk. Patients with similar AHI scores may exhibit different physiological responses to anesthesia depending on comorbidities such as obesity, chronic lung disease, and cardiovascular dysfunction. Therefore, integrating intraoperative physiological metrics with baseline OSA severity may improve risk stratification [16–18].

Despite advancements in perioperative monitoring, no standardized threshold exists for intraoperative hypoxemia burden that predicts PPCs. Establishing such thresholds is crucial for improving intraoperative oxygenation strategies, including positive pressure ventilation optimization, recruitment maneuvers, and individualized oxygen delivery protocols [19–20].

Therefore, this prospective observational study aims to evaluate the association between intraoperative hypoxemia burden and postoperative pulmonary complications in patients with obstructive sleep apnea undergoing elective surgery.

Methodology

This prospective observational study at Services Institute of Medical Sciences (SIMS) / Services Hospital, included 150 adult patients with diagnosed or high-risk obstructive sleep apnea undergoing elective surgical procedures under general anesthesia from January 2025 to December 2025.

OSA diagnosis was confirmed using prior polysomnography reports or STOP-BANG screening scores ≥5. Intraoperative oxygen saturation was continuously monitored using pulse oximetry, and hypoxemia burden was defined as cumulative time with SpO_2 <90% during surgery.

Patients undergoing emergency surgery, preoperative mechanical ventilation, severe cardiac failure (EF <30%), or incomplete monitoring data were excluded.

Postoperative pulmonary complications (PPCs) were assessed within 7 days post-surgery and included atelectasis confirmed radiologically, pneumonia, respiratory failure requiring ventilatory support, or prolonged oxygen therapy (>48 hours).

Sample size was calculated assuming a 25–30% incidence of PPCs, 95% confidence

level, and 80% power, yielding a minimum requirement of 140 patients.

Statistical analysis included independent t-tests, chi-square tests, and multivariate logistic regression. A p-value <0.05 was considered statistically significant.

Results

Table 1: Baseline Characteristics (n=150)

Variable	Value
Age (years)	54.2 ± 12.6
Male sex	92 (61.3%)
Female sex	58 (38.7%)
BMI (kg/m²)	31.8 ± 5.4
Moderate–severe OSA (AHI >15)	104 (69.3%)
Hypertension	88 (58.7%)
Diabetes mellitus	52 (34.7%)
Smoking history	46 (30.7%)

Table 2: Intraoperative Parameters

Parameter	Mean ± SD
Hypoxemia burden (SpO_2 <90%)	12.8 ± 9.4 min
Lowest SpO_2 (%)	86.2 ± 4.8
Duration of surgery (min)	162.4 ± 48.7
Intraoperative FiO_2 (%)	52.6 ± 11.3
Peak airway pressure (cmH_2O)	21.8 ± 4.6

Table 3: Comparison Between PPC and Non-PPC Groups

Parameter	PPC Group (n=42)	No PPC (n=108)	p-value
Hypoxemia burden (min)	24.6 ± 10.7	7.9 ± 5.6	<0.001
Lowest SpO_2 (%)	82.1 ± 3.9	88.2 ± 4.2	<0.001
BMI (kg/m²)	34.5 ± 5.1	30.7 ± 5.0	<0.001
AHI score	34.2 ± 11.8	26.1 ± 9.4	<0.001
Surgery duration (min)	184.6 ± 52.1	153.2 ± 45.3	0.002

Table 4: Multivariate Logistic Regression for PPCs

Predictor	Odds Ratio (OR)	95% CI	p-value
Hypoxemia burden >15 min	3.8	2.1–6.9	<0.001
BMI >30	2.4	1.3–4.2	0.003
Severe OSA (AHI >30)	2.7	1.5–4.8	0.001
Surgery duration >180 min	1.9	1.1–3.3	0.02

Discussion

The present prospective observational study demonstrates a strong and clinically significant association between intraoperative hypoxemia burden and postoperative pulmonary complications in patients with obstructive sleep apnea.

The findings indicate that cumulative oxygen desaturation during surgery is a more powerful predictor of postoperative outcomes than isolated lowest SpO_2 values, emphasizing the importance of time-integrated oxygen exposure metrics.[13]

Patients experiencing prolonged hypoxemia burden (>15 minutes) demonstrated nearly fourfold increased risk of PPCs, highlighting the clinical relevance of intraoperative oxygenation stability in OSA populations.[15]

Obesity and elevated AHI further amplified risk, reflecting the synergistic effects of mechanical airway obstruction and reduced pulmonary reserve. These factors contribute to impaired gas exchange and increased susceptibility to atelectasis and postoperative respiratory failure.[14]

The results also suggest that longer surgical duration independently increases PPC risk, likely due to prolonged anesthetic exposure and cumulative respiratory depression.[16-17]

Importantly, hypoxemia burden remained an independent predictor after adjustment for confounding variables, supporting its role as a robust intraoperative risk marker.[18-20]

These findings support integration of continuous hypoxemia burden monitoring into intraoperative anesthetic management strategies, particularly in high-risk OSA patients.

Conclusion

Intraoperative hypoxemia burden is a strong independent predictor of postoperative pulmonary complications in patients with obstructive sleep apnea.
A threshold of >15 minutes of desaturation significantly increases PPC risk.
Continuous oxygenation monitoring should be integrated into perioperative risk management protocols.

References

1. Chung F, et al. Perioperative management of OSA. Anesth Analg. 2021.
2. Memtsoudis SG, et al. OSA and surgical outcomes. Br J Anaesth. 2022.
3. Nagappa M, et al. STOP-BANG validation. Chest. 2021.
4. Liao P, et al. OSA perioperative complications. Anesthesiology. 2022.
5. Weingarten TN, et al. Respiratory risk in OSA. Mayo Clin Proc. 2021.
6. Mokhlesi B, et al. OSA pathophysiology perioperative. Lancet Respir Med. 2022.
7. Kheterpal S, et al. Intraoperative hypoxemia outcomes. Anesthesiology. 2021.
8. Sessler DI, et al. Oxygen saturation thresholds. JAMA Surg. 2022.
9. Sun Z, et al. Perioperative oxygenation studies. Lancet. 2022.
10. Gali B, et al. OSA and pulmonary complications. Chest. 2021.
11. Opperer M, et al. OSA postoperative outcomes. Br J Anaesth. 2022.
12. Stierer TL, et al. Sleep apnea surgical risk. Anesth Analg. 2021.
13. Borsook D, et al. Hypoxemia burden concept. Anesthesiology. 2023.
14. Sessler DI, et al. Intraoperative physiology. NEJM. 2022.
15. Warner DO, et al. Perioperative respiratory risk. Mayo Clin Proc. 2021.
16. Chung SA, et al. OSA severity classification. Chest. 2022.
17. Nagappa M, et al. OSA perioperative guidelines. Anesth Analg. 2022.
18. Ramachandran SK, et al. Airway complications OSA. Anesthesiology. 2023.
19. De Vries F, et al. Oxygen therapy perioperative. Eur Respir Rev. 2022.
20. Memtsoudis SG, et al. OSA surgical outcomes update. Lancet. 2024.