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Association between postoperative pain severity and oxygen saturation: a retrospective cross-sectional study in surgical patients

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ABSTRACT

Postoperative pain is a common clinical problem that may compromise physiological stability and delay recovery, potentially reducing oxygenation, increasing infection risk, and prolonging hospitalization. This study aimed to examine the correlation between postoperative pain intensity and oxygen saturation levels. This study employed a quantitative correlational analytic design with a cross-sectional approach using retrospective medical record data. Data were collected at a single time point, with both postoperative pain intensity and oxygen saturation (SpO_2) measured simultaneously at approximately 12 hours after surgery when patients were clinically stable in the postoperative ward. A total of 208 eligible patients were included using total sampling. Data were analyzed descriptively and using the Chi-square test, with statistical significance set at $p < 0.05$. The results showed that 74% of patients experienced severe pain and 26% mild pain, while 49.5% presented with reduced oxygen saturation. A statistically significant association was identified between pain intensity and oxygen saturation ($p < 0.001$). Patients with low oxygen saturation were 25.5 times more likely to report severe pain (OR = 25.505; 95% CI: 6.379–101.979). In conclusion, postoperative pain intensity is significantly associated with oxygen saturation levels. These findings support the integration of subjective pain assessment with objective physiological monitoring, and future prospective studies are recommended to clarify causal relationships.

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1. INTRODUCTION

Postoperative pain is a common clinical problem that can adversely affect respiratory function and oxygenation in surgical patients. Physiologically, uncontrolled pain may interfere with normal breathing patterns by limiting chest wall movement and promoting shallow respiration. This condition can lead to hypoventilation, which reduces alveolar ventilation and increases the risk of atelectasis. As a consequence, impaired gas exchange may occur, ultimately resulting in decreased oxygen saturation (hypoxemia) [1]-[3]. These mechanisms indicate that postoperative pain is not only a subjective experience but also a clinically relevant factor that may influence respiratory stability and oxygenation status.

Each year, approximately 300 million surgical procedures are performed worldwide, and postoperative pain remains one of the most common and challenging complications despite advances in perioperative care [4]-[6]. Around 80% of surgical patients report moderate to severe pain following surgery, which is associated with adverse outcomes such as prolonged hospitalization, increased disability, and higher healthcare costs [7]-[12]. In addition, inadequate pain management may contribute to respiratory complications, psychological distress, thromboembolic events, and progression to chronic pain [13]-[15]. Despite its high prevalence and clinical impact, postoperative pain is often assessed primarily as a subjective symptom, although it may have important physiological consequences.

Pain is a multidimensional experience influenced by physiological and psychological factors; therefore, accurate assessment is essential in postoperative care. It has been recognized as the "fifth vital sign," reflecting its importance in clinical monitoring and treatment decisions [16]-[18]. In addition to subjective assessment, physiological parameters such as oxygen saturation (SpO_2) may provide complementary information regarding patient condition. Oxygen saturation reflects arterial oxygenation and is generally considered clinically adequate at levels ≥95% [19]-[21]. Monitoring this parameter is particularly important during the postoperative period, when hypoxemia may occur due to reduced lung expansion, impaired chest wall movement secondary to pain, residual anesthetic effects, or ventilation–perfusion mismatch [1]-[3]. Although oxygen therapy is commonly used to prevent desaturation, excessive supplementation may also lead to adverse respiratory and cardiovascular effects [22]-[24]. Previous studies investigating the relationship between pain and oxygenation have reported inconsistent findings, making the clinical significance of this association difficult to interpret. Pasek *et al.* [25] demonstrated that hyperbaric oxygen therapy reduced pain intensity in patients with diabetic foot ulcers; however, the study focused on a chronic wound population and evaluated the therapeutic effects of oxygen administration rather than the relationship between naturally occurring postoperative pain and oxygen saturation. In a postoperative setting, Pranata and Ekaprasetia [26] reported a significant association between oxygen saturation and pain intensity, suggesting that oxygenation status may be related to pain responses. Conversely, Larenas *et al.* [27] found no significant correlation between oxygen saturation and pain perception among postoperative patients. These contrasting findings may reflect differences in patient populations, clinical settings, and measurement approaches, limiting the generalizability of existing evidence. Furthermore, although Suzuki [1] emphasized the importance of oxygen saturation monitoring and individualized oxygen therapy during postoperative care, the direct relationship between postoperative pain intensity and oxygen saturation remains insufficiently understood. Therefore, current evidence does not yet provide a consistent understanding of whether pain intensity is associated with oxygenation status in postoperative patients, highlighting the need for further investigation in different clinical settings.

Preliminary clinical data from a private hospital in East Java recorded 780 surgical cases in 2022, with varying reports of postoperative pain and fluctuating oxygen saturation levels. Despite the routine assessment of both variables in postoperative care, their association has not been systematically evaluated in this clinical setting. Existing literature provides inconclusive evidence regarding the relationship between postoperative pain intensity and oxygen saturation, and differences in study populations and methodologies further limit direct comparison across studies [1], [25]-[27]. Consequently, an important knowledge gap remains regarding whether postoperative pain intensity is associated with oxygenation status in routine postoperative patients. Therefore, this study aimed to examine the correlation between postoperative pain intensity and oxygen saturation levels among postoperative patients using retrospective clinical data. By addressing this gap, the study seeks to contribute additional evidence to support the integration of subjective pain assessment with objective physiological monitoring in postoperative care.

2. METHOD

This study employed a quantitative correlational analytic design using a cross-sectional approach to examine the relationship between postoperative pain intensity and oxygen saturation levels. This study employed a quantitative correlational analytic design using a cross-sectional approach to examine the relationship between postoperative pain intensity and oxygen saturation levels. Data were collected retrospectively from medical records of postoperative patients who underwent surgery between July and September 2022 in the postoperative care unit of a private hospital in East Java, Indonesia. The hospital provides inpatient and outpatient surgical services and routinely documents postoperative pain scores and pulse oximetry measurements as part of standard clinical monitoring. Pain intensity and oxygen saturation were recorded concurrently as part of routine postoperative assessment at a single observation point. The study population consisted of postoperative patients who underwent surgery under local, general, or spinal anesthesia during the study period. Inclusion criteria were patients who were fully conscious and clinically stable at the time of postoperative assessment and whose medical records contained complete documentation of pain scores and oxygen saturation values. Exclusion criteria included patients who experienced clinical

instability during assessment or were referred to another facility before evaluation was completed. The study population consisted of 519 postoperative patients who underwent surgery during the study period. A total sampling technique was applied to maximize the use of available clinical data. Medical records were screened according to the predefined inclusion and exclusion criteria, and 208 records met all eligibility requirements and contained complete documentation of postoperative pain intensity and oxygen saturation measurements. Therefore, all eligible records were included in the final analysis. The use of total sampling was intended to ensure that the study reflected the characteristics of the available postoperative population and to minimize potential sampling bias. The final sample size was determined by the number of eligible medical records available during the study period rather than by sample size estimation, which is a common approach in retrospective record-based studies employing total sampling.

Data were extracted from electronic and paper-based medical records using a standardized data collection form by trained research staff. The independent variable was postoperative pain intensity, while the dependent variable was oxygen saturation level. Additional demographic and clinical variables included age, sex, type of surgery, type of anesthesia, comorbidities, and hemoglobin level. Pain intensity was assessed using the numeric rating scale (NRS), ranging from 0 (no pain) to 10 (worst pain imaginable). For analysis, NRS scores of 1–4 were categorized as mild pain and scores of 5–9 as severe pain. This categorization was applied to enhance clinical interpretability and to align with routine documentation practices in the study setting, where simplified pain groupings are commonly used to guide postoperative management. Oxygen saturation (SpO_2) was measured using pulse oximetry and categorized as normal (98–100%) or reduced (95–97%) based on recorded values. This categorization was aligned with clinical monitoring practices in the study setting, where oxygen saturation levels ≥95% are generally considered adequate for peripheral oxygenation, while values below optimal saturation may indicate early impairment in oxygenation status [19]-[21]. The selected categorization range was intended to distinguish patients with relatively optimal oxygenation from those with borderline reductions that may still be clinically relevant in the postoperative period. However, the use of categorical groupings for both pain intensity and oxygen saturation may reduce analytical sensitivity and limit the ability to detect more subtle variations in these variables. All pulse oximeters were routinely calibrated by hospital technicians to ensure measurement accuracy.

To address potential confounding, additional variables including age, sex, type of surgery, type of anesthesia, comorbidities, and hemoglobin level were descriptively analyzed to characterize the study population. Stratified analysis was conducted to observe patterns of distribution across these variables, and their potential influence on the relationship between pain intensity and oxygen saturation was considered during interpretation of the findings. Data were processed through editing, coding, entry, and cleaning before analysis using SPSS version 25.0. Descriptive statistics were used to summarize categorical variables as frequencies and percentages. The association between postoperative pain intensity and oxygen saturation was analyzed using the Chi-square test, with statistical significance set at $p < 0.05$. Missing data were handled through listwise deletion.

Ethical approval for the study was obtained from the Hospital Institutional Review Board (IRB) in East Java, Indonesia. All procedures adhered to ethical principles for research involving human data. Patient confidentiality was maintained by anonymizing all records and restricting data access to authorized research personnel only.

3. RESULTS

A total of 208 postoperative patient medical records met the inclusion criteria and were included in the analysis. The distribution of respondent characteristics is presented in Table 1. Table 1 shows that the largest age group was 26–45 years (37.0%), with a predominance of female patients (63.0%). Nearly half of the respondents had a normal BMI (49.0%), and most procedures were performed under general anesthesia (54.3%) with a duration of 31–60 minutes (61.5%). The majority of patients had no documented comorbidities (85.6%) and had hemoglobin levels above 12 g/dL (71.2%). These findings indicate that the study population was predominantly composed of patients without major documented clinical risk factors, while still demonstrating sufficient variation in demographic and perioperative characteristics to allow exploration of differences in postoperative pain and oxygen saturation patterns.

The distribution of postoperative pain intensity and oxygen saturation levels is presented in Table 2. As shown in Table 2, severe postoperative pain was reported in the majority of patients (74.0%), whereas oxygen saturation levels were distributed almost equally between the normal (50.5%) and abnormal (49.5%) categories. The difference in distribution between pain intensity and oxygen saturation suggests that elevated pain intensity was common across the study population, while oxygenation status varied considerably among patients. This variability indicates that the occurrence of severe pain alone did not uniformly correspond with

reduced oxygen saturation, highlighting the importance of examining the relationship between these variables through inferential analysis rather than relying solely on descriptive distributions. To enhance data visualization, the relationship between pain intensity and oxygen saturation is illustrated in the following bar chart in Figure 1.

Table 1. Distribution of respondent characteristics

Characteristic	Category	Frequency (n)	Percentage (%)
Age (years)	<25	68	32.7
	26-45	77	37.0
	>46	63	30.3
Gender	Male	77	37.0
	Female	131	63.0
BMI	Underweight	33	15.9
	Normal	102	49.0
	Overweight	56	26.9
	Obese	17	8.2
Type of anesthesia	General (GA)	113	54.3
	Regional (RA)	94	45.2
	Local (LA)	1	0.5
Duration of surgery	<30 minutes	68	32.7
	31-60 minutes	128	61.5
	61-90 minutes	11	5.3
	91-120 minutes	1	0.5
Comorbidities	Present	30	14.4
	Absent	178	85.6
Medical history	Present	0	0.0
	Absent	208	100.0
Hemoglobin (g/dL)	>12	148	71.2
	<12	60	28.8

Table 2. Distribution of pain intensity and oxygen saturation

Variable	Category	Frequency (n)	Percentage (%)
Pain intensity	Severe pain	154	74.0
	Mild pain	54	26.0
Oxygen saturation	Normal	105	50.5
	Abnormal	103	49.5
Total		208	100.0

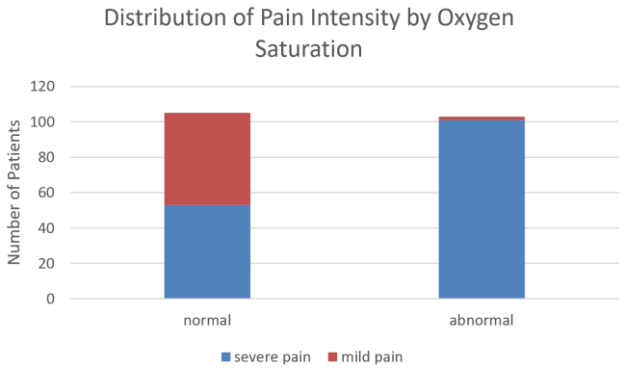

Figure 1. Distribution of pain intensity by oxygen saturation

The association between postoperative pain intensity and oxygen saturation is summarized in Table 3. Table 3 demonstrates a statistically significant association between postoperative pain intensity and oxygen saturation ($p < 0.001$). Among patients with abnormal oxygen saturation, 98.1% experienced severe pain, whereas only 1.9% reported mild pain. In contrast, patients with normal oxygen saturation showed a substantially more balanced distribution between severe pain (50.5%) and mild pain (49.5%). This marked difference in distribution suggests that severe pain was disproportionately represented among patients with abnormal oxygen saturation. The estimated odds ratio (OR = 25.505; 95% CI: 6.379–101.979) further indicates a strong association, with patients experiencing severe postoperative pain demonstrating

substantially higher odds of abnormal oxygen saturation compared with those reporting mild pain. Although the confidence interval was relatively wide, its lower bound remained well above unity, supporting the consistency of the observed association within the study sample.

From a clinical perspective, these findings indicate that reduced oxygen saturation was more frequently observed among patients with severe postoperative pain. From an observational perspective, reduced oxygen saturation was more frequently identified among patients reporting severe postoperative pain than among those reporting mild pain. The strength of the association observed in the present analysis indicates that pain intensity and oxygen saturation were not independently distributed within the study population. These findings highlight a clinically relevant pattern that warrants further consideration in postoperative patient monitoring. Although the statistical analysis indicates a strong association (OR = 25.505; 95% CI: 6.379–101.979), the findings should be interpreted as a relationship rather than causation.

Additional descriptive observations indicated that 28.8% of patients had hemoglobin levels below 12 g/dL, 14.4% had documented comorbidities, and 5.8% underwent procedures lasting longer than 60 minutes. General anesthesia accounted for the largest proportion of cases (54.3%). Although these variables were not included in inferential testing, they demonstrate the presence of clinical heterogeneity within the study population and provide important context for interpreting the observed relationship between postoperative pain intensity and oxygen saturation. No missing data or inconsistencies were identified during data extraction and analysis, allowing all 208 eligible medical records to be included in the final dataset.

Table 1. Correlation between pain intensity and oxygen saturation

Oxygen saturation	Severe pain (n/%)	Mild pain (n/%)	Total (n/%)	p-value	OR	95% CI
Normal	53 (50.5%)	52 (49.5%)	105 (100%)			
Abnormal	101 (98.1%)	2 (1.9%)	103 (100%)	0.000	25.505	6.379-101.979
Total	154 (74.0%)	54 (26.0%)	208 (100%)			

4. DISCUSSION

The significant association observed between postoperative pain intensity and oxygen saturation should be interpreted within the context of postoperative physiological responses rather than as evidence of a direct causal relationship. Postoperative pain is known to influence respiratory behavior by discouraging deep breathing, coughing, and effective chest expansion, which may contribute to less efficient ventilation and reduced oxygenation in some patients. Therefore, the observed association may reflect the interaction between pain-related respiratory adaptations and oxygenation status during postoperative recovery rather than an isolated effect of pain alone. Contemporary perioperative research has similarly emphasized that inadequate pain control may contribute to postoperative respiratory complications through mechanisms that affect ventilation and gas exchange [28].

The present findings are generally consistent with the study conducted by Pranata and Ekaprasetia [26], which reported a significant relationship between oxygen saturation and postoperative pain intensity. However, the current findings differ from those reported by Larenas *et al.* [27], who found no significant association between oxygen saturation and pain perception among postoperative patients. These contrasting findings may reflect differences in patient characteristics, clinical settings, perioperative management, timing of measurements, and outcome classification methods. Pain perception is inherently subjective and may vary substantially across populations, whereas oxygen saturation can be influenced by multiple perioperative factors beyond pain alone. Broader perioperative research further emphasizes the importance of oxygen saturation as a clinical marker in postoperative care, with postoperative hypoxemia being associated with prolonged recovery and other adverse outcomes, although direct associations with pain intensity were not the primary focus of those studies [29]. In addition, recent clinical practice guidelines highlight the importance of comprehensive pain assessment and multimodal management, suggesting that integrating physiological indicators such as SpO_2 with pain evaluation may support more informed postoperative decision-making and patient management [30].

From a clinical perspective, the findings highlight the importance of interpreting pain assessment and physiological monitoring as complementary components of postoperative evaluation. Although abnormal oxygen saturation was not observed in all patients experiencing severe pain, the strong association identified in this study suggests that patients reporting higher pain intensity may warrant closer observation of their respiratory status. Integrating subjective pain assessment with objective physiological parameters such as oxygen saturation may assist clinicians in identifying patients who could benefit from more individualized postoperative monitoring and supportive care.

Despite these findings, several methodological considerations related to the retrospective design should be carefully acknowledged. The use of medical records as the primary data source introduces the possibility of documentation bias, as the accuracy of recorded pain scores and SpO_2 values depends on routine clinical documentation practices rather than standardized research protocols. Variability in the timing of measurement, although conducted within routine postoperative monitoring, may also influence recorded values and introduce measurement variability across patients.

Potential selection bias should also be considered when interpreting the findings. Although a total sampling approach was applied, inclusion was limited to patients with complete medical records who met all eligibility criteria. Consequently, patients with incomplete documentation or those who could not be fully evaluated were not represented in the final dataset. While this approach was necessary to ensure data completeness and analytical consistency, it may limit the extent to which the findings represent all postoperative patients treated during the study period.

Information bias may also have influenced the observed association. Pain intensity was derived from routine clinical documentation using the numeric rating scale (NRS), and the recorded score may not fully capture temporal fluctuations in pain experienced during the postoperative period. Likewise, oxygen saturation values represented single documented measurements rather than continuous monitoring data. As a result, transient changes in either pain intensity or oxygenation status may not have been reflected in the medical records, potentially affecting the precision of the observed association.

The categorization of oxygen saturation also warrants careful consideration. In this study, oxygen saturation values of 98–100% were classified as normal, whereas values of 95–97% were categorized as abnormal to distinguish patients with relatively optimal oxygenation from those with borderline reductions. Although this approach was intended to enhance clinical sensitivity in the postoperative setting, it is more stringent than the conventional clinical threshold in which oxygen saturation values $\geq$ 95% are generally considered acceptable. Consequently, the applied classification may have increased the proportion of patients categorized as having abnormal oxygen saturation and could have influenced the magnitude of the observed association. Therefore, the findings should be interpreted within the context of the selected classification approach.

Furthermore, the retrospective cross-sectional nature of the study restricts the ability to account for all potential confounding variables. Although demographic and clinical characteristics such as age, type of surgery, anesthesia, comorbidities, and hemoglobin levels were described, these variables were not included in multivariable analysis, which may result in residual confounding. The use of bivariate analysis in this study further limits the ability to adjust for these confounding variables. For example, differences in perioperative management or patient condition at the time of measurement could influence both pain intensity and oxygen saturation, thereby affecting the observed association. Important clinical variables such as intraoperative analgesic administration, supplemental oxygen use, and specific comorbid conditions were not controlled in the analysis and may have influenced the observed association.

Taken together, the findings provide evidence of a statistically significant association between postoperative pain intensity and oxygen saturation within the study population. However, the retrospective cross-sectional design, potential selection and information biases, and the absence of multivariable adjustment necessitate cautious interpretation of the results. The observed association should therefore be viewed as an indicator of a clinically relevant relationship rather than proof of causality. Future prospective studies incorporating standardized measurement procedures and multivariable analytical models are needed to further clarify the nature and underlying mechanisms of this association.

5. CONCLUSION

This study demonstrated a significant association between postoperative pain intensity and oxygen saturation levels among surgical patients, indicating that pain assessment and oxygenation status may represent closely related aspects of postoperative recovery. Although the retrospective cross-sectional design does not permit causal inference, the findings contribute to the growing body of evidence supporting the integration of subjective and objective indicators in postoperative patient evaluation. From a clinical perspective, the study highlights the value of incorporating routine oxygen saturation monitoring alongside pain assessment as part of comprehensive postoperative care. Such an approach may assist healthcare providers in identifying patients who require closer observation and more individualized management during the recovery period. The findings also underscore the importance of considering physiological parameters when evaluating postoperative pain, rather than relying exclusively on patient-reported symptoms. In terms of patient safety, the observed association suggests that patients experiencing severe postoperative pain may warrant increased attention to their respiratory status. Early recognition of concurrent pain and oxygenation abnormalities may support timely clinical intervention and contribute to safer postoperative monitoring practices. Future prospective studies employing standardized measurement protocols and multivariable

analytical approaches are needed to further clarify the relationship between postoperative pain and oxygenation and to evaluate its implications across different surgical populations.

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AUTHOR CONTRIBUTIONS STATEMENT

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Ircham Saifudin	✓				✓					✓			✓	
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Annes Rindy Permana	✓	✓	✓	✓	✓	✓	✓		✓	✓				
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Sindu Sintara	✓				✓				✓					

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

The datasets generated and analyzed during the current study are available from the corresponding author upon reasonable request, in accordance with institutional policies and ethical considerations.

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