

## Surgery Type as an Independent Predictor of Prolonged PACU Stay After General Anesthesia

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### ABSTRACT

**Background:** Prolonged post-anesthesia care unit (PACU) stay is a critical indicator of postoperative efficiency and hospital resource utilization. Delayed recovery may compromise patient flow, increase the risk of complications, and strain perioperative systems.

**Objective:** To determine independent predictors of prolonged PACU stay following general anesthesia, with particular focus on the role of surgery type.

**Methods:** This cross-sectional study was conducted from January to June 2025 at a government-owned secondary referral hospital in West Java, Indonesia. The PACU manages adult patients undergoing elective and emergency surgeries under general anesthesia, but does not routinely admit pediatric, post-cardiac surgery, or burn patients. A total of 96 adult patients were included. Variables analyzed were age, American Society of Anesthesiologists (ASA) physical status, anesthesia technique, surgery type, surgical duration, pain intensity, comorbidities, and transfer timing. Prolonged PACU stay was defined as  $\geq 30$  minutes. Data were analyzed using chi-square tests and multivariate logistic regression.

**Result:** Prolonged PACU stay occurred in 37.5% of patients. Age ( $p=0.011$ ), ASA physical status ( $p=0.012$ ), anesthesia technique ( $p=0.035$ ), and surgery type ( $p=0.001$ ) were significantly associated with prolonged stay. After adjustment, surgery type remained the strongest independent predictor ( $p=0.004$ ; OR=2.524; 95% CI: 1.355–4.700). Major procedures demonstrated substantially higher prolonged recovery rates (60%) compared with minor surgeries (21.8%). Other variables were not statistically significant.

**Conclusion:** Surgery type independently predicts prolonged PACU stay, with major procedures markedly increasing recovery duration. These findings emphasize the need for risk-stratified perioperative planning and strategic PACU resource optimization.

**Keywords:** ASA physical status; general anesthesia; PACU length of stay; postoperative recovery; surgery type

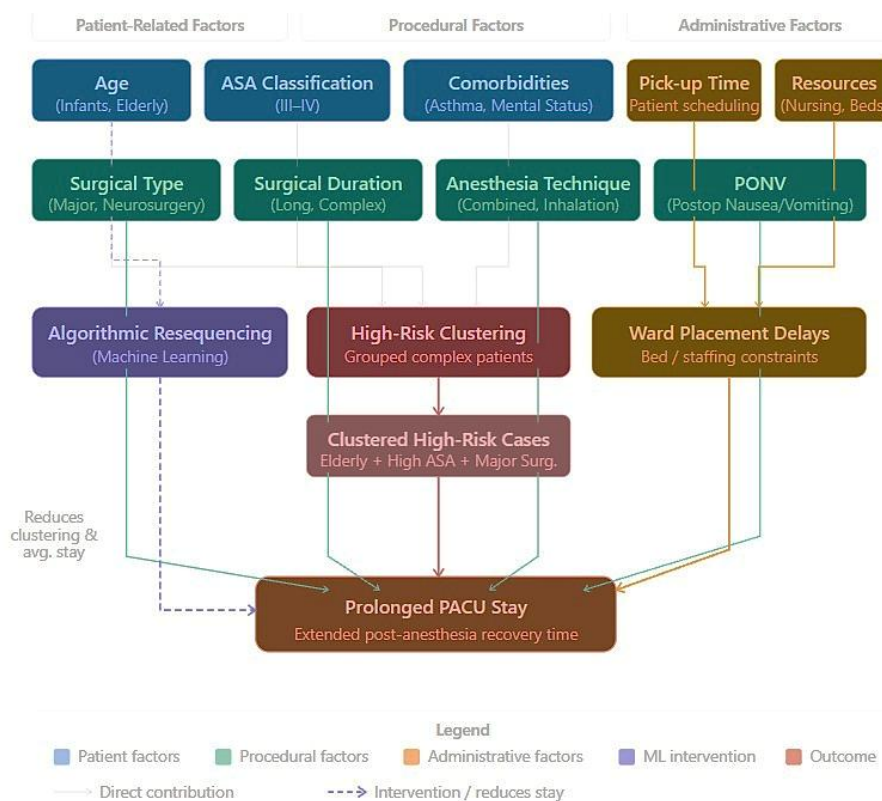
**INTRODUCTION**

The post-anesthesia care unit (PACU) represents a critical transition phase in the perioperative pathway, where patients recover from anesthesia and achieve physiological stability prior to ward transfer.<sup>1</sup> With more than 230 million surgical procedures performed each year globally and general anesthesia widely utilized, optimizing PACU efficiency has become increasingly important.<sup>2</sup> Prolonged PACU stay may disrupt patient flow, increase complication risk, and strain hospital resources.<sup>3,4</sup>

PACU length of stay is influenced by multiple perioperative factors, including patient characteristics, anesthetic management, surgical complexity, and institutional practices. Previous studies have identified advanced age, higher American Society of Anesthesiologists (ASA) physical status, postoperative

pain, comorbidities, and prolonged surgical duration as contributors to extended recovery. However, findings remain inconsistent, particularly regarding the relative impact of surgery type compared with other perioperative determinants.<sup>5,6,7</sup>

Emerging evidence suggests that surgical complexity may substantially influence postoperative recovery trajectories through mechanisms such as hemodynamic instability, inflammatory response, and increased analgesic requirements.<sup>8,9</sup> Nevertheless, the independent contribution of surgery type remains unclear across different healthcare settings, especially in middle-income countries. Therefore, this study aimed to identify predictors of prolonged PACU stay following general anesthesia, with particular emphasis on the role of surgery type.<sup>10, 11</sup>



**Figure 1.** Risk factors for prolonged PACU stay - hierarchical model

## METHOD

This cross-sectional analytical study was conducted from January to June 2025 at a government-owned secondary referral hospital in West Java, Indonesia. The PACU manages adult patients undergoing elective and emergency surgeries under general anesthesia and does not routinely admit pediatric, post-cardiac surgery, or burn patients.

The population in this study consisted of all patients undergoing surgical procedures with the use of general anesthesia. The sampling technique employed was non-probability sampling using a purposive sampling method, based on predetermined inclusion and exclusion criteria.

The inclusion criteria comprised patients who underwent a single general anesthesia technique consistently throughout the surgical procedure, whether intravenous, inhalational, or a combination technique, without any change in method during the operation. The exclusion criteria included patients with incomplete medical records, emergency procedures requiring immediate transfer to the intensive care unit (ICU), and cases involving changes in anesthetic technique during surgery. The sample size was calculated using the Cochran formula, as the study analyzed data in the form of proportions. With a 95% confidence level ( $Z = 1.96$ ), an estimated population proportion ( $p$ ) of 0.5, and a margin of error ( $e$ ) of 10% (0.1), the calculation required sample size was 96 patients.

Data collection utilized validated observation sheets developed through expert judgment validation. Primary outcome measurement involved direct observation using standardized timing protocols, with PACU stay duration

calculated from patient handover to PACU until achievement of discharge criteria: Aldrete Score  $\geq 8$  for general anesthesia in adults and Steward Score  $\geq 5$  for pediatric anesthesia. Patient pickup time was measured from nursing staff notification to actual PACU departure.

Secondary data extraction from medical records included demographic information (age, gender), physical status classification with ASA, comorbid conditions, surgical duration, surgery type classification, and anesthesia technique documentation. Pain assessment utilized the Numeric Rating Scale (0-10) with categorization as follows: no pain (0), mild pain (1-3), moderate pain (4-6), and severe pain (7-10).

PACU length of stay was dichotomized as normal ( $< 30$  minutes) versus prolonged ( $\geq 30$  minutes) based on established clinical benchmarks and institutional protocols.<sup>6</sup>

ASA Physical Status: Classification followed American Society of Anesthesiologists guidelines, with emergency procedures designated by "E" suffix.

Procedures were categorized using standardized surgical complexity criteria: (1) Minor surgery: Superficial procedures with minimal physiological impact (e.g., skin lesion excision, minor orthopedic procedures); (2) Intermediate surgery: Moderate complexity procedures involving single body systems (e.g., appendectomy, cholecystectomy), (3) Major surgery: Complex procedures with significant physiological impact (e.g., abdominal, thoracic, neurosurgical procedures).

Categorical variables were summarized as frequencies and percentages. Bivariate associations between independent variables and prolonged PACU stay were analyzed using chi-square tests. Variables with  $p < 0.05$  in bivariate analysis or with strong clinical relevance were entered into the multivariate logistic regression model to control for confounding effects.

Multivariate logistic regression identified independent predictors of prolonged PACU stay, with results presented as odds ratios (OR) with 95% confidence intervals (CI). Model fit was assessed using the Hosmer-Lemeshow goodness-of-fit test. Statistical analysis was performed using SPSS version 26.0, with a significance level set at  $p < 0.05$ .

Ethical approval was obtained from the Institutional Ethics Committee (No. 029/09.KEPK/UBK/III/2025).

## RESULTS

A total of 96 patients were included in this study. Based on PACU length of stay, 60 patients (62.5%) had a normal stay ( $< 30$  minutes), while 36 patients (37.5%) experienced prolonged stay ( $\geq 30$  minutes).

The distribution of demographic and clinical characteristics: adults aged 19–59 years represented the largest age group (38.5%), followed by elderly patients aged  $\geq 60$  years (28.1%). Most patients were classified as ASA I (57.3%). Mild pain was reported in 70.8% of patients. The majority of procedures lasted less than one hour (77.1%), and 24% of patients had comorbidities. Minor surgery was performed in 57.3% of cases, and combined anesthesia technique was used in 89.6% of patients. More than half of the patients (56.3%) were transferred within 15 minutes after notification.

The association between independent variables and prolonged PACU stay was analyzed using the chi-square test (Table 1).

Age group was significantly associated with PACU length of stay ( $p = 0.011$ ). The highest proportion of prolonged stay was observed in infants/toddlers (75.0%) and elderly patients (55.6%).

ASA classification demonstrated a statistically significant association with PACU stay duration ( $p = 0.012$ ). Prolonged stay occurred more frequently in ASA III patients (80.0%) compared to ASA II (46.4%) and ASA I (27.3%).

Pain intensity was not significantly associated with PACU length of stay ( $p = 0.071$ ). No statistically significant association was observed between surgical duration and PACU stay ( $p = 0.336$ ).

Comorbid conditions were not significantly associated with prolonged PACU stay ( $p = 0.056$ ). Type of surgery showed a statistically significant association with PACU length of stay ( $p = 0.001$ ). Prolonged stay occurred in 21.8% of minor procedures, 57.7% of intermediate procedures, and 60.0% of major procedures.

Anesthesia technique was significantly associated with PACU stay duration ( $p = 0.035$ ). No significant association was found between PACU transfer and PACU length of stay ( $p = 0.915$ ).

Variables that demonstrated statistical significance in the bivariate analysis (age, ASA physical status, type of surgery, and anesthesia technique) were included in multivariate logistic regression analysis (Table 2).

Type of surgery remained significantly associated with prolonged PACU stay ( $p = 0.004$ ; OR = 2.524; 95% CI: 1.355–4.700). Age ( $p = 0.814$ ), ASA physical

status ( $p = 0.716$ ), and anesthesia technique ( $p = 0.998$ ) were not independently associated with prolonged PACU stay after adjustment.

**Table 1.** Distribution of patient characteristics by PACU length of stay (n = 96)

Variable	Normal (<30 min) n (%)	Prolonged ( $\geq 30$ min) n (%)	p-value
<b>Age</b>			
0-59 months	2 (25.0%)	6 (75.0%)	0.011
5-9 years	8 (80.0%)	2 (20.0%)	
10-18 years	10 (71.4%)	4 (28.6%)	
19-59 years	28 (75.7%)	9 (24.3%)	
$\geq 60$ years	12 (44.4%)	15 (55.6%)	
<b>Physical Status (ASA)</b>			
ASA I	40 (72.7%)	15 (27.3%)	0.012
ASA II	15 (53.6%)	13 (46.4%)	
ASA III	1 (20.0%)	4 (80.0%)	
ASA I-E	4 (80.0%)	1 (20.0%)	
ASA II-E	0 (0%)	3 (100%)	
<b>Pain Intensity</b>			
No Pain (0)	5 (55.6%)	4 (44.4%)	0.071
Mild (1-3)	46 (67.6%)	22 (32.4%)	
Moderate (4-6)	6 (37.5%)	10 (62.5%)	
Severe (7-10)	3 (100%)	0 (0%)	
<b>Surgical Duration</b>			
<1 hour	49 (66.2%)	25 (33.8%)	0.336
1-2 hours	8 (47.1%)	9 (52.9%)	
>2 hours	3 (60.0%)	2 (40.0%)	
<b>Comorbidities</b>			
No	50 (68.5%)	23 (31.5%)	0.056
Yes	10 (43.5%)	13 (56.5%)	
<b>Type of Surgery</b>			
Minor	43 (78.2%)	12 (21.8%)	0.001
Intermediate	11 (42.3%)	15 (57.7%)	
Major	6 (40.0%)	9 (60.0%)	
<b>Anesthesia Technique</b>			
Combined	50 (58.1%)	36 (41.9%)	0.035
TIVA	8 (100%)	0 (0%)	
Inhalational	2 (100%)	0 (0%)	
<b>PACU Transfer</b>			
<15 minutes	33 (61.1%)	21 (38.9%)	0.915
$\geq 15$ minutes	27 (64.3%)	15 (35.7%)	

**Table 2.** Multivariate analysis

Characteristics	B	P value	OR	95% CI	
				Lower	Upper
Age	-0.047	0.814	0.954	0.643	1.414
Physical status ASA	0.049	0.716	1.050	0.806	1.369
Type of Surgery	0.926	0.004	2.524	1.355	4.700
General Anesthesia Technique	19.01	0.998	1815027.82	0.000	
Constant	-58.90	0.998	0.000		

## DISCUSSION

Based on the multivariate analysis (Table 2), type of surgery was the only independent predictor of prolonged PACU stay ( $p = 0.004$ ; OR = 2.524; 95% CI: 1.355–4.700). Patients undergoing intermediate or major surgery had significantly higher odds of prolonged PACU stay compared with those undergoing minor procedures. This finding is consistent with previous studies demonstrating that surgical complexity influences postoperative recovery patterns and PACU utilization.<sup>9,10,12</sup>

In the bivariate analysis (Table 1), age was significantly associated with prolonged PACU stay ( $p = 0.011$ ). Infants/toddlers and elderly patients demonstrated higher proportions of prolonged stays compared to other age groups. Similar associations between age extremes and delayed postoperative recovery have been reported in prior studies.<sup>6,7,13</sup> Age-related pharmacokinetic and pharmacodynamic variability, reduced physiologic reserve, and increased vulnerability to respiratory or cardiovascular instability may contribute to delayed recovery in these populations. However, age was not statistically significant in the multivariate model (Table 2), suggesting that its effect may be influenced by other perioperative factors included in the adjusted analysis.

ASA physical status also showed a significant association with PACU duration in the bivariate analysis ( $p = 0.012$ ), with higher ASA classes demonstrating increased proportions of prolonged stays (Table 1). Previous literature has similarly identified ASA classification as a predictor of postoperative recovery outcomes.<sup>14,15,16</sup> Nevertheless, ASA status did not remain significant after multivariate adjustment (Table 2).

The borderline significance of comorbidities ( $p = 0.056$ ) suggests potential clinical relevance despite statistical non-significance. Prior investigations have demonstrated that multimorbidity increases postoperative monitoring requirements and complication risk.<sup>14,16</sup> The absence of statistical significance in this study may reflect limited sample size, heterogeneity in comorbidity severity, or insufficient stratification of specific high-risk conditions.

Anesthesia technique was significantly associated with PACU stay in the bivariate analysis ( $p = 0.035$ ), with lower proportions of prolonged stay observed in patients receiving TIVA compared with combined techniques (Table 1). Comparable findings have been reported in studies evaluating recovery profiles between intravenous and inhalational techniques, particularly regarding emergence time, postoperative nausea

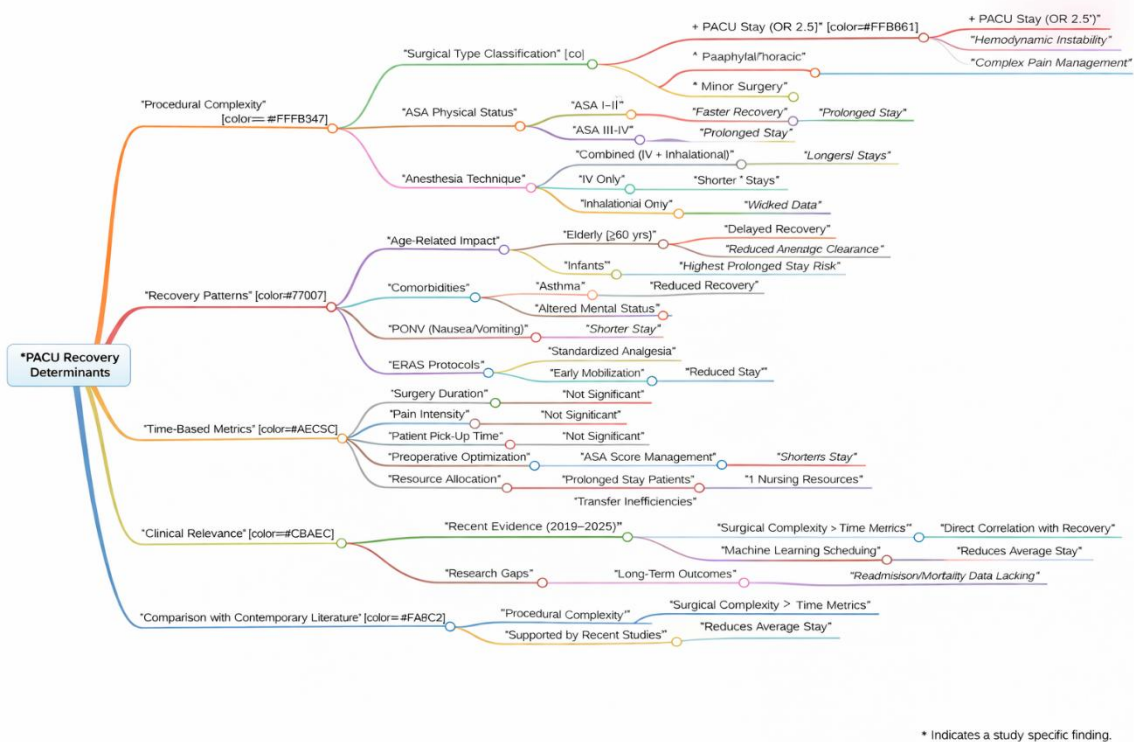
and vomiting, and early recovery metrics.<sup>17,18</sup> Nevertheless, anesthesia technique was not independently associated with prolonged PACU stay in the multivariate model (Table 2), indicating that surgical characteristics may exert a stronger influence on overall recovery duration than anesthetic modality alone.

Pain intensity, surgical duration, comorbidities, and PACU transfer were not significantly associated with PACU length of stay (Table 1). While previous research has reported associations between pain, postoperative nausea and vomiting, and PACU recovery time,

such relationships were not statistically demonstrated in this study.<sup>19</sup>

The overall rate of prolonged PACU stay in this study was 37.5%. Variations in reported PACU duration across studies may reflect differences in patient populations, surgical case mix, discharge criteria, and institutional protocols.<sup>5,20</sup>

The identification of surgery type as the dominant predictor provides actionable intelligence for healthcare administrators and clinical leaders. Preoperative risk stratification based on surgical complexity can inform staffing decisions, bed allocation, and patient flow optimization strategies.<sup>21,22,23</sup>



Picture 2. Conceptual model of PACU recovery determinants

The present findings indicate that although several variables were associated with prolonged PACU stay in univariate analysis, only type of surgery remained significant after adjustment. This suggests that surgical complexity may play a primary role in determining PACU recovery duration within this study population.

Several limitations should be considered. The cross-sectional design limits causal inference, and the single-center setting may affect external validity. The sample size in certain subgroups was relatively small, potentially affecting statistical precision. In addition, the dichotomization of PACU stay at 30 minutes may reduce sensitivity to detect more subtle variations in recovery duration.

Further research with larger multicenter populations and standardized PACU outcome definitions is needed to clarify the relative contributions of perioperative factors to prolonged PACU stay.

### CONCLUSION

Type of surgery was the only independent predictor of prolonged PACU stay after general anesthesia, with intermediate and major procedures increasing the risk of delayed recovery by 2.5-fold. Although age, ASA physical status, and anesthesia technique were associated with prolonged PACU stay in bivariate analysis, they were not independently significant after adjustment. No significant associations were observed between pain intensity, surgical duration, or comorbidities and prolonged PACU stay. Further multicenter studies with larger sample sizes are needed to confirm these findings and to better clarify determinants of prolonged PACU recovery.

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