Medical Scope Journal 2026;8(2):261-267
DOI: https://doi.org/10.35790/msj.v8i2.64554
URL Homepage: https://ejournal.unsrat.ac.id/index.php/msj

Correlation between Surgical Procedure, Type of Surgery, Duration of Surgery, and Intraoperative Complications with the Usage of PICU

Andy Rangan,[1] Harsali Lampus,[2] Candy,[2] Fima L. F. G. Langi

[1]Department of Surgery, Faculty of Medicine, Universitas Sam Ratulangi, Manado, Indonesia
[2]Division of Pediatric Surgery, Department of Surgery, Faculty of Medicine, Universitas Sam Ratulangi – Prof. Dr. R. D. Kandou General Hospital, Manado, Indonesia
[3]Faculty of Public Health, Universitas Sam Ratulangi, Manado, Indonesia
Email: andyrangan@gmail.com
Received: December 19, 2025; Accepted: March 27, 2026; Published online: March 30, 2026

Abstract: Pediatric postoperative intensive care remains a topic of debate due to the high demand and limited availability of PICU beds. This study aimed to bridge that gap by identifying types of procedure (major or minor), emergency or elective surgery, type of duration and complication contributing to PICU admissions, thereby enhancing perioperative care quality and resource allocation. This was a prospective cohort study conducted at Prof. Dr. R. D. Kandou General Hospital Manado between August 2022 and December 2023 using pediatric patients undergoing surgery. Data were extracted from medical records, analyzed and evaluated using descriptive statistics, chi-square tests, and logistic regression. A p-value of <0.05 was considered statistically significant. The results showed that among 455 pediatric postoperative cases, 14% required PICU care. Emergency surgeries (57%), major procedures (87%), prolonged surgery (67%), intraoperative complications (7%), and preoperative PICU recommendations (42%) were associated with more PICU admissions. The significant key predictors were emergency surgery (p<0.001), intraoperative complications (p=0.005), and preoperative PICU recommendations (p<0.001). In conclusion, emergency surgeries, major procedures, prolonged surgery, and intraoperative complications are key determinants of PICU admissions in pediatric patients. Preoperative PICU recommendations were the strongest predictor of postoperative intensive care needs, followed by intraoperation complication and emergency operation. These highlight the need for improved preoperative assessment, perioperative risk stratification, and structured postoperative care planning to optimize PICU resource allocation and reduce unplanned admissions.
Keywords: pediatric surgery; PICU admission; postoperative care; emergency surgery; risk factors; perioperative management

INTRODUCTION

Intensive care for pediatric post-operative patients remains a controversy due to the limited availability of intensive care unit (ICU) rooms or beds, while the demand for these facilities is high, especially for post-surgical patients. In the adult surgical population, unplanned admission to the ICU within 24 hours after a procedure has been proven to be a valid measure of patient safety. Consequently, preoperative, perioperative, and postoperative risk factors associated with unplanned ICU admission have been increasingly described in adult literature. Identifying these risk factors is crucial to anticipate preventable complications and to improve postoperative management and resource allocation for this vulnerable patient population.[1,2]

Kurowski and Sims[3] discovered that most unplanned ICU admissions were secondary to airway issues (47%), followed by respiratory problems (29%). This finding was later reinforced by Gibson et al., who found that airway and respiratory issues accounted for 56% and 25% of unplanned postoperative ICU admissions, respectively.[4] Da Silva et al[5] identified airway abnormalities (defined as adenotonsillar hypertrophy, cleft palate, or choanal atresia) and intraoperative hypoxia (defined as SpO2 <90%) as statistically significant comorbidities associated with unplanned ICU admission.

Based on the limited number of studies, it is evident that airway and respiratory complications place the pediatric population at increased risk for unplanned ICU admissions. Furthermore, much of the previous literature has focused on specialized pediatric hospitals treating highly selected patient populations. A broader and more diverse analysis of unplanned postoperative ICU admissions is necessary to address risk factors that have yet to be identified in the current literature.[2,6] This retrospective study analyzed the unplanned postoperative ICU admissions and further characterized the risk factors associated with these admissions in pediatric surgical patients. The data from a heterogeneous cohort of pediatric patients (aged <18 years) who underwent various types of surgeries were analyzed. Specifically, the study aimed to identify the relationship between the type of surgery, duration of surgery, surgical procedures, and intraoperative complications with Pediatric Intensive Care Unit (PICU) utilization. By identifying these risk factors, the authors hope to gain insights into ways to improve perioperative anesthesia quality, surgical care, and better allocate PICU resources.

METHODS

This prospective cohort study was conducted at Prof Dr. R.D Kandou General Hospital in Manado from August 2022 to December 2023. The study included pediatric patients with age more than 28 days and less than 18 years old who underwent surgical procedures. Eligible participants included paediatric patients undergoing surgical procedures during the study period. Patients with incomplete medical records, patients or guardians who do not consent to this study or patients who died during surgery.

Patient demographics, PICU admission postoperatively, procedure type (major or minor), urgency (elective or emergency), duration of surgery (≤2.5 hours or exceeded 2.5 hours), intraoperative complications and preoperative PICU recommendations were extracted from the medical record. Medical records were reviewed for demographic data, surgical details such as the type of operation, urgency, were there any intraoperative complications, duration of surgery and whether the patient was admitted to PICU. The consistency of assessment methods was ensured across all patients. Efforts were made to minimize selection bias by including all eligible patients during the study period. Sample size was determined based on prior literature and expected PICU admission rates. Based on prior studies, a minimum of 46 patients were required to detect significant associations with a confidence level of 95%.

Descriptive statistics summarized patient characteristics. Chi-square tests were used to compare categorical variables. Logistic regression analysis identified independent predictors of PICU admission, with p-values <0.05 considered statistically significant.

RESULTS

During the study period of August 2022 to December 2023, a total of 455 paediatric postoperative cases were analyzed (Table 1); 63 (14%) requiring PICU admission, while 392 (86%) patients received postoperative care in a regular ward (Table 2). The median age was 4.5 years (IQR: 2-8 years). Every single participant participated in this study.

Table 1. Data of demographics

Variables	n (%)	Med (Q_1;Q_3)
Age	—	6.0 (2.0; 12.0)
Gender		
Male	290 (64)	—
Female	165 (36)	—
Surgery procedure		
Minor	231 (51)	—
Major	231 (49)	—
Surgery urgency		
Elective	323(71)	—
Emergency	132 (29)	—
Surgery duration		
≤2.5 hours	351 (77)	—
≥2.5 hours	104 (23)	—
Intraoperation Complication	4 (1)	—
Preoperative PICU recommendations		
Not recommended	416 (92)	—
Recommended	38 (8)	—
Post-operative care		
Regular ward	329 (86)	—
PICU	63 (14)	—

Note: Med Median, Q_1 Quantile I, Q_3 Quantile III, PICU *pediatric intensive care unit*

The gender distribution consisted of 290 males (64%) and 165 females (36%). Regarding surgical characteristics, 231 patients (51%) underwent minor procedures**,** while 231 patients (49%) underwent major procedures**.** 323 cases (71%) were elective surgeries**,** and 132 cases (29%) were emergency procedures**.** The majority of surgeries **(**351 cases, 77%**)** lasted ≤2.5 hours, whereas 104 cases (23%) exceeded 2.5 hours**.**

Among the total sample, four cases (1%) experienced intraoperative complications. Preoperative PICU recommendations were recorded for 38 patients (8%)**,** while 416 patients (92%) were not initially recommended for PICU care. From the 63 PICU admissions, emergency procedures were responsible for 57% of cases. There were 87% of PICU patients underwent major procedures, compared to 43% in the regular ward. Intraoperative complications were significantly associated with PICU admission, with 7% of PICU patients experiencing such events, compared to 0% in the regular ward (Table 2). A grouped bar chart outlining the comparison of number of patients in the regular ward and PICU (Figure 1).

The study identified several significant predictors of PICU admission in pediatric surgical patients. Emergency surgeries were found to substantially increase the likelihood of PICU admission, with an adjusted relative risk (RR) of 3.71 (95% CI 2.01–6.86; $p<0.001$). This suggests that patients undergoing emergency surgical procedures face a higher risk of complications and postoperative instability, necessitating intensive care monitoring. Additionally, major surgical procedures were more frequently associated with PICU admission compared to minor procedures; however, in the adjusted analysis, this association was not statistically significant (Adjusted RR 2.05; $p=0.084$) (Table 3).

Table 2. Variable distribution according to post-operation placement

Variables	Regular (n = 392)		PICU (*n* = 63)		*p*[a]
	n (%)	Med (Q_1,Q_3)	n (%)	Med (Q_1,Q_3)	
Age	—	7,0 (2,0; 12,0)	—	2,0 (0,0; 10,5)	0,003
Gender					
Male	256 (65)	—	34 (54)	—	0.110
Female	136 (35)	—	29 (46)	—	
Surgery procedure					
Minor	223 (57)	—	8 (13)	—	<0.001
Major	169 (43)	—	55 (87)	—	
Surgery urgency					
Elective	296 (76)	—	27 (43)	—	<0.001
Emergency	96 (24)	—	36 (57)	—	
Intraoperation complication	0 (0)	—	4 (7)	—	<0.001
Pre-operative PICU recommendation					
Not recommended	380 (97)	—	36 (58)	—	<0.001
Recommended	12 (3)	—	26 (42)	—	

Note: Med median, Q_1 Quantile I, Q_3 Quantile III, PICU *pediatric intensive care unit.* [a] Mann-Whitney test for numeric variables, chi-square or Fisher's Exact for categoric variables

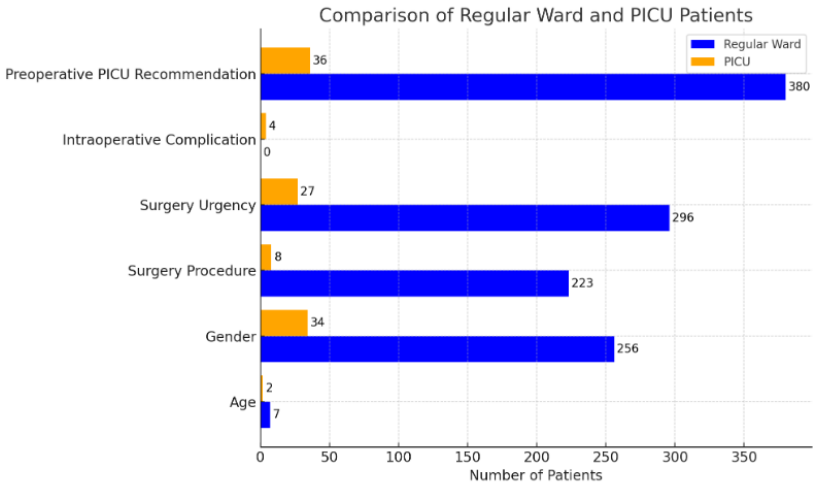

Figure 1. Comparison of regular ward and PICU patients

The presence of intraoperative complications was one of the strongest predictors of PICU admission, with an adjusted RR of 6.70 (95% CI 1.80–24.90; p=0.005). Intraoperative complications, such as severe hemorrhage, respiratory distress, and hemodynamic instability, increased the need for intensive monitoring and immediate postoperative interventions (Table 3).

Furthermore, preoperative PICU recommendations were found to be the most significant predictor of PICU admission, with an adjusted RR of 17.20 (95% CI 7.48–39.57; p<0.001). This indicates that patients identified as high-risk during preoperative evaluations were more likely to require intensive postoperative care. These findings emphasize the importance of thorough preoperative assessments to anticipate PICU resource needs and enhance patient safety (Table 3).

DISCUSSION

PICU is needed for intensive care for pediatric patients, providing 24 hours intensive observation and gave access to a team of multi-discipline medical team.[7-9] In patients with major operation, around 20-45% needed PICU. This percentage depends on surgery complexity, patient's comorbid and risk of post-operative complications.[10-11]

Table 3. Regression analysis report in PICU admission to post-operative care

Predictors	Univariate		Multivariate	
	RR (95% CI)	p	aRR (95%CI)	p
Age	0.94 (0.90; 0.99)	0.016	–	
Gender	1.50 (0.91; 2.46)	0.109	–	
Surgery procedures				
Major vs Minor	7.09 (3.38; 14.88)	<0.001	2.05 (0.91; 4.65)	0.084
Type of operations				
Emergency vs elective	3.26 (1.98; 5.37)	<0.001	3.71 (2.01; 6.86)	<0.001
Intraoperative complications	7.86 (2.86; 21.66)	<0.001	6.70 (1.80; 24.90)	0.005
Pre-operative PICU recommendations	7.91 (4.77; 13.09)	<0.001	17.20 (7.48; 39.57)	<0.001

Note*:* CI *confidence interval,* RR *relative risk,* a RR *adjusted relative risk*, PICU *pediatric intensive care unit*

Indication to be admitted to PICU depends on the needed for mechanical ventilation, hemodynamic observation, disorder of acid-base, pain management, cardiovascular support, neurological diseases, complex surgery or long duration of surgery, the need for inotropic drugs and complication post-surgery.[12]

The study findings showed that the type of surgery, duration, and intraoperative complications significantly influence PICU admissions. Major surgeries and emergency procedures were strongly associated with the need for intensive postoperative care, which aligns with existing literature. Pediatric patients have limited physiological reserves, making them more vulnerable to perioperative stress, particularly in infants and neonates.[13] This study also found that surgeries lasting more than 2.5 hours increased the likelihood of PICU admission. Prolonged exposure to anesthesia has been linked to complications such as hypothermia and excessive fluid loss, in addition to a higher probability of surgical complications. Short et al. found that extended surgery times correlate with increased postoperative morbidity, particularly in pediatric patients, supporting the findings of this study.[13]

Although intraoperative complications were relatively rare (1%)**,** they were influential factor in determining PICU admission. Severe complications, including massive hemorrhage, organ injury, and anesthesia-related issues**,** contribute significantly to increased ICU admissions. This is consistent with Da Silva et al,[5] who identified that airway complications and intraoperative hypoxia significantly increased the likelihood of intensive postoperative care in pediatric surgery.[2,5] Emergency surgical procedures were found to have a higher likelihood of postoperative PICU admission compared to elective procedures. This can be explained by the urgency of intervention in emergency cases, which often leads to inadequate preoperative optimization and a higher risk of intraoperative complications. Another studies had similarly concluded that emergency surgeries led to higher complication rates and a greater likelihood of requiring intensive care support postoperatively.[1,4,19]

Preoperative recommendations for PICU admission were the strongest predictor in this study. Patients who were assessed preoperatively as high-risk had a 17.2 times greater likelihood of requiring PICU care (Adjusted RR 17.2; 95% CI 7.48-39.57; p<0.001). This underscores the importance of structured preoperative evaluations in identifying patients who will require intensive monitoring and intervention, allowing for better resource allocation and improved perioperative management**.**[13-16] This study was conducted at a single institution, limiting its generalisability. Additionally, retrospective data collection for some variables may introduce documentation bias. A larger, multi-center study is recommended for external validation of these findings. Future research should adopt a prospective approach to allow better control over variables affecting outcomes and develop a clinical protocol for early identification of high-risk patients requiring PICU care. Subsequent studies could also include additional variables such as preoperative patient condition, nutritional status, comorbidities, and surgical team quality, which

may also contribute to the need for intensive postoperative care. These would help surgical and anesthesiology teams to implement preventive measures and optimize perioperative care which will ultimately recue complication rates and unexpected PICU admissions.[17-19]

CONCLUSION

Surgical procedure type, urgency of surgery, duration of surgery, and the presence of intraoperative complications are associated with an increased risk of PICU admission in pediatric surgical patients postoperatively. Emergency surgeries, intraoperative complications, and preoperative PICU recommendations were significant predictors of PICU admissions in pediatric patients. The strongest predictor was preoperative PICU recommendations, emphasizing the importance of risk stratification before surgery. To reduce unplanned PICU admissions, preoperative optimization, surgical planning, and intraoperative risk mitigation strategies should be prioritized. Future research should focus on multi-center validation and prospective trials to confirm these findings.

Conflict of Interest

The authors affirm no conflict of interest in this study.

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