



Postoperative Intensive Care Requirements of Pediatric Surgery Patients

Pediatric Cerrahi Hastalarının Postoperatif Yoğun Bakım İhtiyacı

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Abstract

Introduction: To evaluate the duration of pediatric intensive care stay, hospitalization and the factors affecting mortality in patients who were operated by pediatric surgery and followed up in pediatric intensive care unit (PICU) in the postoperative period.

Methods: One hundred forty-three patients who were operated between September 2018 and January 2020 and hospitalized in the PICU for post-operative follow-up were included in the study.

Results: The median age of the 143 patients included in the study was 31.00 (1-205) months, and 76 (53.1%) were male. Ninety-six patients had no comorbidity, 47 patients had at least one comorbidity. The most frequent developed post-operative complications were sepsis (n=7) and intra-abdominal hypertension (n=7). The presence of sepsis extended the intensive care unit stay by 4.46 days, the need for inotropes by 3.61 days, the development of intra-abdominal hypertension by 3.33 days, and the presence of comorbidity by 0.86 days. The presence of sepsis extended the hospitalization period 28.04 days, the need for respiratory support 21.78 days, and the presence of malnutrition 14.42 days.

Conclusion: It would be more appropriate to follow-up patients, who are operated by pediatric surgery, especially those with comorbidity and malnutrition, who need intraoperative blood products or who have the risk of developing complications in the postoperative period in PICUs.

Keywords: Post-operative, intensive care, children

Öz

Giriş: Bu çalışmada çocuk cerrahisi tarafından opere edilen ve çocuk yoğun bakım ünitesinde (ÇYBÜ) takip edilen hastaların klinik özelliklerinin çocuk yoğun bakım yatış süresi, hastane yatış süresi ve mortaliteye olan etkileri değerlendirilmesi amaçlandı.

Yöntemler: Eylül 2018 ve Ocak 2020 arasında ÇYBÜ'de postoperatif takip edilen 143 hasta çalışmaya dahil edildi.

Bulgular: Çalışmaya dahil edilen 143 hastanın ortalama yaşı 31,00 (1-205) ay ve 76'sı (%53,1) erkek idi. Çalışmamızda 96 hastanın hiçbir komorbitesi olmayıp 47 hastanın en az 1 komorbitesi mevcuttu. Post-operatif en sık gelişen komplikasyonlar sepsis (n=7) ve intraabdominal hipertansiyondur (n=7). Postoperatif sadece bir (%0,7) hastada ölüm gerçekleşti. Çoğul lineer regresyon analizinde yoğun bakım yatış süresini sepsis varlığının 4,46 gün, inotrop ihtiyacı olmasının 3,61 gün, intra-abdominal hipertansiyon gelişmesinin 3,33 gün, komorbidite varlığının 0,86 gün uzattığı saptandı. Hastane yatış süresini; sepsis varlığının 28,04 gün, solunum desteği ihtiyacının 21,78 gün, malnütrisyon varlığının 14,42 gün uzattığı saptandı.

Sonuç: Çocuk cerrahi tarafından opere edilen, özellikle komorbidite ve malnütrisyonu olan, intraoperatif kan ürün desteği yapılan ve postoperatif komplikasyon gelişme riski olan hastalarının ÇYBÜ'lerinde takip edilmeleri uygundur.

Anahtar Kelimeler: Postoperatif, yoğun bakım, çocuk

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Introduction

Today, the frequency of perioperative mortality has decreased because of developments in the fields of anesthesia and intensive care, blood product support, and provision of parental nutrition.^{1,2} However, emergency operations, comorbidities, reoperation, sepsis, postoperative bleeding, a lack of experienced staff, and financial difficulties (specifically in low- and middle-income countries) can still cause an increase in morbidity and mortality.^{3,4} Early detection and intervention of complications occurring during the follow-up of postoperative pediatric patients, infection control, and adequate nutrition at the appropriate time are important.

Follow-up of postoperative pediatric surgery patients with a multidisciplinary approach including anesthesia, pediatric intensive care, and the pediatric surgery team will reduce perioperative morbidity and mortality. During the postoperative period, close follow-up of patients with a high risk of developing perioperative morbidity and mortality in the pediatric intensive care unit (PICU) can improve survival. However, when we investigated the literature, we found that the number of studies evaluating the factors affecting the duration of intensive care and hospital stay of patients followed up in the PICU in the postoperative period was limited.

This study was conducted retrospectively to investigate the duration of pediatric intensive care stay, hospitalization, and factors affecting mortality in patients who underwent pediatric surgery and were followed up in the PICU in the postoperative period.

Materials and Methods

This retrospective observational study was performed at a tertiary medical-surgical PICU. A total of 143 patients who underwent surgery at Çukurova University Faculty of Medicine, Department of Pediatric Surgery, between September 2018 and January 2020 and were hospitalized in the PICU for postoperative follow-up were included in the study. We do not have a written protocol on which patients will be followed in the PICU in the postoperative period; however, patients with comorbidities, unplanned operations, all those who underwent bronchoscopy for suspected foreign body aspiration, those with perioperative complications, and sometimes with the surgeon's foresight are followed up in pediatric intensive care. Approval was obtained from the Non-Invasive Clinical Research Ethics Committee of Çukurova University Faculty of Medicine (2019/94).

Sepsis was defined as a proven or clinically suspected infection along with systemic inflammatory response syndrome.⁵ Intra-abdominal pressure was measured using the gold standard

method, the trans-bladder technique. As previously described; sustained or repeated pathological elevation in intra-abdominal pressure >10 mmHg was accepted as intra-abdominal hypertension (IAH). The development of at least one organ failure or worsening of existing organ failure in addition to IAH was considered abdominal compartment syndrome.⁶ In our study, patients with weight-for-age (measured weight/median weight) measurements <90% were considered as malnutrition,⁷ and patients with body mass index >95p were considered obese.⁸

Demographic information of patients, primary cause of operation, comorbidity, PRISM-III score, blood product support during and after the operation, mechanical ventilation and inotrope need, intra-abdominal pressure measurements, length of the PICU, and hospital stay were recorded.

Statistical Analysis

Descriptive analyses were conducted to characterize the study cohort. Categorical measurements are summarized as numbers and percentages, whereas numerical measurements are summarized as median (minimum-maximum) values. We used the chi-square test or Fisher's Exact test, whichever was appropriate, to compare categorical variables. In the comparison of numerical measurements performed on the same individual at two different times, the t-test was used in dependent groups, and the Wilcoxon test was used when the differences did not show a normal distribution. The IBM SPSS Statistics Version 20.0 package program was used for statistical analysis of the data. The level of statistical significance was set as 0.05 in all tests. Multiple linear regression analysis was used for data analysis of the patients.

Results

The median age of the patients was 31.0 (1-205) months, 76 of them (53.1%) were male, and the median PRISM-III score was 2.0 (0-25).

The most frequent operations were abdominal surgery in 68 (47.6%) patients and bronchoscopy in 60 (42%) patients with suspicion of foreign body aspiration. In our study, 96 patients had no comorbidity, and 47 patients had at least one comorbidity. The most frequent comorbidities were neurological in 19 (13.2%) and cardiac in 12 (8.3%) patients. The primary diseases of the patients, the accompanying diseases, and the operations performed are given in Table 1 in detail. Thirty-two (22.4%) of the patients had malnutrition, and seven (4.9%) had obesity. An elective operation was performed on 136 (95.1%) of the patients, and an emergency operation was performed on 7 (4.9%) of them.

Nineteen (13.3%) patients received blood product support in the intraoperative period, and these supports were only

Table 1. Characteristics of the patients

	Mean ± SD Median (25p-75p)
Age (months)	55.0±54.7 31.00 (15-85)
Male n (%)	76 (53.1)
Malnutrition n (%)	32 (22.4)
Obesity	7 (4.9)
Primary diseases n (%)	
Respiratory	69 (48.3)
Gastrointestinal	36 (25.2)
Hemato/oncological	28 (19.6)
Genitourinary	5 (3.5)
Trauma	3 (2.1)
Infection	2 (1.4)
Comorbidity n (%)	
None	96 (67.1)
Neurological	19 (13.2)
Cardiac	12 (8.3)
Endocrinological	10 (6.9)
Respiratory	10 (6.9)
Genetics	9 (6.3)
Others	10 (7.1)
Elective surgery	136 (95.1)
Intraoperative blood product support	19 (13.3)
Postoperative blood product support	14 (9.8)
PRISM-III	3.8±4.64 2.0 (0-6)
Postoperative respiratory support	
None	46 (32.2)
Oxygen with a non-rebreather mask	82 (57.3)
Invasive ventilation	11 (7.7)
HFNC	4 (2.8)
Post-operative complications	
Sepsis	7 (4.9)
Intra-abdominal hypertension	7 (4.9)
Abdominal compartment syndrome	2 (1.4)
Length of PICU stay	2.1±2.3 1.0 (1-2)
Length of hospital stay	12.9±19.5 7.0 (3-16)
Death	1 (0.7)

HFNC: High-flow nasal cannula oxygen therapy, PICU: Pediatric intensive care unit, SD: Standard deviation

erythrocyte suspension (ES) or ES + fresh frozen plasma support. The PRISM-III score of patients who received intraoperative blood products was higher than that of patients who did not (7.4 vs. 3.3, respectively, $p=0.005$). Ten of these 19 patients needed blood product support during their PICU stay. Inotrope support was provided to three (2.1%) patients during the postoperative period. The most frequent postoperative complications were sepsis ($n=7$) and IAH ($n=7$). Three (42.8%) patients who developed sepsis were malnourished, and one (14.3%) was obese. IAH was present in 2 (28.6%) of 7 patients with sepsis and in only 5 (3.7%) of 136 patients without sepsis ($p=0.003$). In our study, a patient with neurometabolic disease who was

hospitalized for postoperative follow-up after tracheostomy and gastrostomy underwent emergency surgery because of gastrostomy leakage. This patient developed intra-abdominal sepsis and abdominal compartment syndrome during follow-up and died. No patient required intensive care again after being transferred to the pediatric surgery ward.

Factors affecting the duration of PICU and hospital stay were evaluated (Table 2). Patients who needed intraoperative blood products, respiratory support, and postoperative inotrope and who developed IAH and sepsis had a longer hospitalization period in pediatric intensive care ($p<0.05$). Multiple linear regression analysis was performed to determine the factors affecting the duration of PICU stay (Table 3). It was determined that sepsis extended the duration of intensive care by 4.46 days, the need for inotrope by 3.61 days, the development of IAH by 3.33 days, and the presence of comorbidity by 0.86 days. The duration of hospital stay was longer in patients with intraoperative blood product support, IAH, sepsis, comorbidity, lactate elevation, and those who needed respiratory support during postoperative follow-up. Multiple linear regression analysis demonstrated that the presence of sepsis prolonged the duration of hospital stay by 28.04 days, the need for respiratory support by 21.78 days, and the presence of malnutrition by 14.42 days (Table 4).

Discussion

In our study, postoperative complications during the PICU stay, factors affecting the length of the PICU and hospital stay, and mortality rates were evaluated. The length of the PICU and hospital stays were 2.1 and 12.9 days, respectively. In a retrospective study, Altintas et al.⁹ reported similar findings (2.0 and 13.0 days) to our study. The most common postoperative complications were sepsis and IAH. We found that comorbidity, postoperative need for inotrope, and IAH prolonged the duration of pediatric intensive care stay, and the presence of malnutrition and respiratory support prolonged the duration of hospital stay, whereas the presence of sepsis prolonged both PICU and hospital stays.

Postoperative sepsis remains a problem because it increases the risk of morbidity and mortality. Children with severe injury, comorbidity, and debilitating conditions are at risk of developing sepsis.⁵ Studies conducted in children have demonstrated that postoperative sepsis increases the duration of PICU and hospital stays.¹⁰⁻¹² In a multicenter study by Kronman et al.,¹² postoperative sepsis was reported to prolong hospital stays by 23.5 days. We also found that the development of sepsis in the postoperative period extended the duration of the PICU stay by 4.4 days and the duration of hospitalization by 28 days. In a large-scale retrospective study conducted with adults, it was reported that death occurred in

Table 2. Comparison of length of pediatric intensive care unit and hospital stay of the patients with regard to some factors

	Length of PICU stay Mean ± SD Median (25p-75p)	Length of hospital stay Mean ± SD Median (25p-75p)
Comorbidity		
Yes (n=47)	2.8±3.5 1 (1-3)	19.0±23.5 10 (4-26)
No (n=96)	1.7±1.4 1 (1-2)	10.0±16.5 5 (2-15)
p	0.056	0.006
Malnutrition		
Yes (n=32)	2.2±2.2 1 (1-2)	26.5±33.1 15 (8-27)
No (n=111)	2.1±2.4 1 (1-2)	9.1±10.6 5 (2-11)
p	0.956	<0.001
Obesity		
Yes (n=7)	1.7±1.5 1 (1-2)	11.7±6.9 11 (6-19)
No (n=136)	2.1±2.3 1 (1-2)	13.0±19.9 7 (2-16)
p	0.570	0.295
Emergency operation		
Yes (n=7)	7.6±6.6 5 (3-12)	29.8±22.9 25 (8-43)
No (n=136)	1.8±1.6 1 (1-2)	12.1±19.0 6 (2-15)
p	p<0.001	p=0.007
Intraoperative blood product support		
Yes (n=19)	3.9±4.3 3 (2-5)	19.2±15.5 16 (10-19)
No (n=124)	1.8±1.7 1 (1-2)	12.0±19.9 5 (2-13)
p	<0.001	<0.001
Postoperative respiratory support		
Yes (n=97)	2.4±2.7 1 (1-2.5)	15.1±22.5 8 (3-16)
No (n=46)	1.4±1.0 1 (1-1)	8.4±9.6 4 (2-15)
p	0.002	0.011
Intra-abdominal hypertension		
Yes (n=7)	6.7±6.2 5 (2-8)	22.1±10.2 19 (19-25)
No (n=136)	1.9±1.7 1 (1-2)	12.5±19.8 6 (2-15)
p	<0.001	0.004
Sepsis		
Yes (n=7)	8.3±6.2 7.0 (5-12)	47.1±35.1 37 (19-80)
No (n=136)	1.8±1.4 1.0 (1-2)	11.2±16.8 6 (5-15)
p	<0.001	<0.001

Table 2. Continued

	Length of PICU stay Mean ± SD Median (25p-75p)	Length of hospital stay Mean ± SD Median (25p-75p)
Inotropic support		
Yes (n=3)	9.3±9.3 5 (3-20)	24.7±15.9 16 (15-43)
No (n=140)	1.9±1.8 1 (1-2)	12.7±19.5 6 (2-16)
p	0.004	0.062
Lactate		
<2 mmol/L (n=56)	2.0±1.9 1 (1-2)	9.8±16.2 4.5 (2-10)
≥2 mmol/L (n=87)	2.2±2.6 1 (1-2)	15.0±21.2 8 (3-19)
p	0.379	0.011

PICU: Pediatric intensive care unit, SD: Standard deviation

Table 3. Impact of associated factors on the length of pediatric intensive care unit stay

Length of PICU stay (adjusted R ² =0.34)	p	Regression coefficient (Beta)	95% CI for beta	
			Lower	Upper
Sepsis	<0.001	4.46	3.07	5.86
Intra-abdominal hypertension	<0.001	3.33	2.05	4.61
Comorbidity	0.004	0.86	0.29	1.43
Inotrope support	0.001	3.61	1.56	5.67
Invariable	<0.001	1.35	1.02	1.68

PICU: Pediatric intensive care unit, CI: Confidence interval

Table 4. Impact of associated factors on the length of hospital stay

Length of hospital stay (adjusted R ² =0.34)	p	Regression coefficient (Beta)	95% CI for beta	
			Lower	Upper
Sepsis	<0.001	28.04	15.67	40.41
Malnutrition	<0.001	14.52	8.19	20.85
Respiratory support	<0.001	21.78	11.78	31.78
Invariable	<0.001	6.66	3.61	9.71

PICU: Pediatric intensive care unit, CI: Confidence interval

14.4% of patients who developed postoperative sepsis. Based on these data, a model was created to predict postoperative sepsis-associated mortality.¹³ There are no large-scale recent studies evaluating the development of postoperative sepsis and mortality in children. In our study, death occurred in 1 (14.2%) of 7 patients who developed postoperative sepsis. Prolonged intensive care unit and hospital stays and mortality due to postoperative sepsis were similar to those reported in previous studies.¹⁰⁻¹²

Although the prevalence of malnutrition in hospitalized children varies according to the development level of the countries, this rate varies between 6% and 31%.^{14,15} It has been

shown in many studies that the preoperative nutritional status of pediatric patients is related to postoperative morbidity and mortality as well as the duration of hospital stay.¹⁵⁻¹⁸ In a large-scale study evaluating non-cardiac pediatric surgery patients, it was reported that the extreme weight percentile (<5th, >95th) increased the incidence of postoperative complications.¹⁸ In our study, patients with malnutrition or obesity had a higher rate of sepsis than those who did not (of the patients who developed sepsis were 42.8% of malnourished and 14.2% were obese), and the hospitalization periods of these patients were longer.

IAH is another condition that should be followed up specifically in pediatric patients who have undergone abdominal surgery. Complications that may decrease abdominal wall compliance or an increase in postoperative intra-abdominal content can cause IAH. The association of IAH and abdominal compartment syndrome with organ failure and mortality has been demonstrated in previous studies.¹⁹⁻²¹ In a multicenter study conducted by Horoz et al.,²¹ it was reported that the frequency of IAH in patients who underwent abdominal surgery may increase up to 48%. In our study, IAH developed in seven (14.3%) of 49 patients who were followed up because of the risk of developing IAH in the postoperative period, and abdominal compartment syndrome developed in two (4.1%) of them. We believe that the frequency of IAH may vary depending on the type of operation performed, intraoperative or postoperative complications, and excessive fluid resuscitation.

It is expected that patients in the PICU with comorbidities will stay longer. In the study by Tobi and Amadasun,²² it was stated that comorbidities may be associated with prolonged intensive care stays. In our study, we found that the presence of comorbidity was associated with prolonged hospital stays rather than with pediatric intensive care stays.

It has been determined that emergency operations are associated with prolonged PICU and hospital stays. In the retrospective study of Talabi et al.,³ in which they analyzed 10-year perioperative mortality, it was found that emergency surgery increased the mortality rate by 90 times. In another study, the mortality rate was reported to be 12% in pediatric patients undergoing emergency surgery.²³ Considering the risk of developing complications in the follow-up of patients who have been urgently operated and need perioperative blood product support and comorbidity, it may be more appropriate to be followed up in PICUs in the postoperative period. In our study, one patient was urgently operated after gastrostomy operation because of gastrostomy leakage. Intra-abdominal sepsis and abdominal compartment syndrome occurred during follow-up.

Study Limitations

Our findings should be interpreted in light of some limitations. Because the study was conducted in a single center, it is not appropriate to generalize it to PICUs where different patient groups are followed. Surgical complications that occurred during the operation and could lead to a prolonged PICU stay were not recorded.

Conclusion

We believe that it would be more appropriate to follow-up patients who are operated on by pediatric surgery, especially those with comorbidity and malnutrition, who need intraoperative blood products, or who have the risk of developing complications in the postoperative period, in PICUs. In the postoperative follow-up of children, the clinician should be alert to the possibility of developing sepsis and IAH because both are associated with mortality and morbidity. According to our study, the presence of sepsis prolonged both PICU and hospital stays.

Ethics

Ethics Committee Approval: Approval was obtained from the Non-Invasive Clinical Research Ethics Committee of Çukurova University Faculty of Medicine (2019/94).

Informed Consent: Informed consent was obtained from the patients' parents for their anonymized information to be published in this article.

Authorship Contributions

Surgical and Medical Practices: Ş.S.K., Concept: Y.A., D.Y., F.E., Ş.S.K., Design: Y.A., D.Y., F.E., Ş.S.K., Data Collection or Processing: Ö.Ö.H., Analysis or Interpretation: A.Y., Y.A., Ö.Ö.H., D.Y., F.E., Literature Search: A.Y., Ö.Ö.H., Writing: A.Y., Ö.Ö.H.

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