ORIGINAL ARTICLE

Phnx Med J. July 2022, Volume 4 No 2
DOI: 10.38175/phnx.1064132

Anesthesia and Postoperative Outcome in Pediatric Cranial Surgery: A Retrospective Single Center Study

Pediatrik Kraniyal Cerrahide Anestezi ve Postoperatif Sonuçların Değerlendirilmesi: Retrospektif Tek Merkezli Çalışma

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ABSTRACT

Objective: *Perioperative patient monitoring and follow-up is very important to minimize morbidity and mortality in pediatric neurosurgical interventions.*

In this study, it was aimed to evaluate the perioperative anesthesia management by examining the findings of the pediatric patients who underwent cranial surgery along with to examine the effects of hemorrhagic surgical procedures, which play an active role in morbidity, both intraoperatively and postoperatively, including hospitalization in intensive care unit.

Material and Method: *Follow-up files of 303 pediatric patients between the ages of 0-18, who were taken to cranial operation, between 2015-2018 years evaluated as retrospectively.*

Results: *A total of 303 children 199 (65.7%) ≤1 year old, 104 (34.3%) >1 year old who underwent pediatric neurosurgery were included in our study. It was determined that the most frequently performed operation was shunting due to hydrocephalus and craniosynostosis. In subanalysis, in craniosynostosis operations performed frequently in infants aged ≤1, it was observed that bleeding amount was as much as subdural and epidural hematoma operations performed in children >1 year old (181ml and 196 ml, p =0.444, respectively). There was no difference between groups in intensive care unit admission.*

Conclusıons: *We think that in pediatric neurosurgery patients' perioperative anesthesia management, it is important to closely monitor the vital signs of patients, to record complications and blood transfusions in detail. We believe that due to the more aggressive duration of hypotensive processes, more attention should be paid to morbidity and mortality, especially in cases of craniosynostosis.*

Keywords:
Craniosynostosis
Hydrocephalus
Neurosurgery
Pediatric anesthesia
Perioperative anesthesia management

ÖZET

Amaç: *Pediyatrik nöroşirurjik cerrahi girişimlerde morbidite ve mortaliteyi en aza indirgemek için perioperatif hasta monitörizasyonu oldukça önemlidir. Bu çalışmada, kraniyal cerrahi uygulanan çocuk hastaların verileri incelenerek perioperatif anestezi yönetiminin değerlendirilmesi beraberinde morbiditede etkin rol oynayan hemorajik cerrahi prosedürlerin hem intraoperatif hem de yoğun bakım ünitesinde yatış sürecini de içeren postoperatif dönemdeki etkilerinin incelenmesi amaçlandı.*

Gereç ve Yöntem: *2015-2018 yılları arasında kraniyal cerrahi nedeni ile operasyona alınmış 0-18 yaş arası, toplam 303 çocuk hastanın verileri retrospektif olarak değerlendirildi.*

Bulgular: *Çalışmamıza, pediyatrik kraniyal cerrahi geçirmiş 199'u (%65,7) ≤1 yaş, 104'ü (%34,3) >1 yaşında olmak üzere toplam 303 çocuk dahil edildi. En sık hidrosefali nedeniyle şant ve kraniyosinostoz operasyonlarının olduğu belirlendi. Alt analizde ≤1 yaş bebeklerde sık uygulanan kraniyosinostoz ameliyatlarında kanama miktarının >1 yaş çocuklarda yapılan subdural ve epidural hematom ameliyatlarında ki kadar fazla olduğu görüldü (sırasıyla 181ml ve 196ml, p=0,444). Yoğun bakıma yatışta gruplar arasında fark yoktu.*

Sonuç: *Pediyatrik beyin cerrahisi hastalarının perioperatif anestezi yönetiminde hastaların vital bulgularının yakından izlenmesi, komplikasyonların ve kan transfüzyonlarının detaylı olarak kayıt altına alınmasının önemli olduğunu düşünüyoruz. Hipotansif süreçlerin daha agresif seyir göstermesi nedeniyle, özellikle kraniyosinostoz vakalarında morbidite ve mortalitenin önlenmesi açısından daha fazla dikkat edilmesi gerektiğine inanıyoruz.*

Anahtar Kelimeler:
Kraniyosinostoz
Hidrosefali
Kraniyal cerrahi
Pediyatrik anestezi
Perioperatif anestezi yönetimi

INTRODUCTION

Recent advances in pediatric neurosurgery have shown that the prognosis improves dramatically in infants and children affected by central nervous system (CNS) lesions (1). Age-related differences in surgical lesions, anatomy and physiological responses to surgery are clinically important differences between pediatric patients and adults (2). Keeping the little baby's homeostasis up to the demands of the surgery and surgeon is a difficult task for a neuroanesthesiologist (3). Perioperative management

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Cite as: Yalçın N, Ay N, Sandal B, Derbent A, Salihoğlu Z. Anesthesia and Postoperative Outcome in Pediatric Cranial Surgery: A Retrospective Single Center Study. Phnx Med J. 2022;4(2):61-66.
Received: 27.01.2022 **Accepted:** 14.04.2022

of pediatric patients planned for cranial surgery poses many difficulties for anesthesiologists. Anesthesiologists should be aware of the unique challenges of anesthesia management in pediatric neurosurgery patients, such as difficulty in positions during operation due to difficult airway and abnormal skull shape, sudden and massive blood loss, venous air embolism, apnea, airway obstruction, and ocular injuries (4). Hydrocephalus is defined by the increase in the volume of cerebrospinal fluid in the CNS, and > 380,000 is characterized by new cases every year. Cerebral shunt operation is the main treatment method of hydrocephalus (5). The ventriculoperitoneal shunt (VPS) is prone to complications such as mechanical failures (occlusion of the valve or catheter, catheter rupture or migration), excessive drainage and infection. Risk factors in the literature such as ethnic origin, etiology of hydrocephalus, prematurity, age under 1, male gender, spina bifida, epilepsy and degree of ventricular dilation may increase the risk of shunt revision in patients with hydrocephalus (6). The approach to children with craniosynostosis is multidisciplinary and has improved significantly over the past fifty years. Treatment is primarily surgical and anesthesia management is often further complicated by syndrome-specific problems (7). The cranial reconstruction method is a major surgical procedure and is associated with prolonged operative duration, prolonged duration of hospital stay, major blood loss, high blood transfusion rates, and the need for postoperative intensive care unit (ICU) admission after surgery (8). Another characteristic cranial surgery group is traumatic brain injury in infants and children. It remains one of the main causes of long-term disability and mortality worldwide (9). Presence of pediatric neurosurgical intensive care has reduced mortality in cases of severe pediatric traumatic brain injury (10). In addition to the follow-up in intraoperative and postoperative periods, preoperative and intraoperative evaluation together with good communication is of great importance in minimizing perioperative morbidity and mortality. Recent advances in neurosurgery, neuromonitoring, and pediatric neurology intensive care have dramatically improved the outcome in children undergoing CNS surgery (11).

This study aims to evaluate perioperative anesthesia administration by examining preoperative, intraoperative, recovery and postoperative period findings of pediatric patients undergoing cranial surgery. While examining the effects of surgical procedures performed in different age groups on perioperative anesthesia management, it is also aimed to evaluate the prognostic parameters in operations with high bleeding risk.

MATERIAL AND METHOD

The study was started after the approval of the local ethics committee (Kanuni Sultan Süleyman Training and Research Hospital / KAEK / 2018.7.08-08 / 08/2018). The follow-up files of 303 pediatric patients between the ages of 0-18, who underwent cranial surgery (hydrocephalus, craniosynostosis, collapse fractures, subdural, epidural hemorrhages, brain tumors, etc.), emergency surgery or elective surgery between 2015 and 2018, were evaluated retrospectively. The aim of this study was to retrospectively evaluate the intraoperative, postoperative data, accompanying recovery and ICU follow-up findings of pediatric cases undergoing cranial surgery under general anesthesia. Perioperative anesthesia management and mortality are planned to be examined. In a sub-analysis, it is planned to examine the factors affecting outcome in surgical procedures where massive blood loss is expected. The demographic data, American Society of Anesthesiologists (ASA) scores, intracranial pathologies, durations of surgery, intraoperative and postoperative complications (desaturation, embolism, EtCO2 reduction, bradycardia, hypertension and hypotension), amount of intraoperative bleeding, erythrocyte suspension and fresh frozen plasma replacement amounts intraoperatively and post-operatively, antagonization of the muscle relaxant in the postoperative period, the patient's need for extubation or intubated recovery or transfer to the ICU, the need for post-operative ICU admission, the duration of mechanical ventilation, length of stay in the ICU of the patients were recorded.

Statistical analysis

SPSS 25.0 (IBM Corporation, Armonk, New York, United States) and PAST 3 (Hammer, Ø., Harper, D.A.T., Ryan, P.D. 2001. Paleontological Statistics) programs were used to analyze the variables. The compatibility of univariate data to normal distribution was evaluated by the Lilliefors-corrected Kolmogorov-Smirnov test and the Shapiro-Wilk test, with variance homogeneity evaluated by the Levene test. The Mardia (Dornik and Hansen omnibus) test was used for analysis of the normal distribution of multivariate data and homogeneity of variance was evaluated by the Box's M test. The Mann-Whitney U test was used together with the Monte Carlo results in the comparison of two independent groups according to the quantitative data. The Wilcoxon signed-Rank test was used to compare two repetitive measurements of dependent quantitative variables using Monte Carlo simulation results. The Pearson Chi-Square test was used with the Fisher exact results, the Fisher-Freeman-Halton test with the exact and Monte Carlo results, with the Monte Carlo Simulation technique used in the comparison of categorical variables. Column ratios were compared with each other and expressed according to the Benjamini-Hochberg corrected p-value results. In the sub-analysis of the study, group parameters were evaluated using the Mann-Whitney U Test (age, weight, amount of intraoperative bleeding), Independent t-Test (operation time), Chi-Square Test (ICU admission, re-operation). The quantitative variables were shown as Median (Min/Max.), and categorical variables as n (%) in the tables. The variables were examined at 95% confidence level and the p-value was accepted as significant when less than 0.05.

RESULTS

A total of 303 children, 199 (65.7%) ≤1 year and 104 (34.3%) >1 year, who underwent pediatric neurosurgery, were included in the present study. Of the children, 171 were girls and 132 were boys, while there was no significant difference between the age groups in terms of gender ($p>0.05$). ASA scores were determined to be higher in children >1 year compared to children ≤1 year ($p<0.001$). (Table I). The mean duration of surgery of the patients was determined to be 60 minutes and the

Table 1: Comparison of children undergoing pediatric cranial surgery

	Total n (%)	≤1 Yaş (n=199) n (%)	>1 Yaş (n=104) n (%)	p
Gender				
Female	171 (56.4)	112 (56.3)	59 (56.7)	0.999[1a]
Male	132 (43.6)	87 (43.7)	45 (43.3)	
ASA Score				
I	45 (14.9)	14 (7.0)	31 (29.8)[A]	<0.001[1b]
II	205 (67.7)	144 (72.4)[B]	61 (58.7)	
III	53 (17.5)	41 (20.6)[B]	12 (11.5)	
Desaturation (yes)	15 (5.0)	9 (4.5)	6 (5.8)	0.781[1a]
Bradycardia (yes)	40 (13.2)	31 (15.6)	9 (8.7)	0.108[1a]
Hypertension (yes)	8 (2.6)	0 (0.0)	8 (7.7)	<0.001[2]
Hypotension (yes)	39 (12.9)	27 (13.6)	12 (11.5)	0.719[1a]
Re-operation (yes)	115 (38.0)	75 (37.7)	40 (38.5)	0.901[1a]
Postoperative FFP use	18 (5.9)	10 (5.0)	8 (7.7)	0.443[1a]
Postoperative mechanic ventilation (yes)	54 (17.8)	34 (17.1)	20 (19.2)	0.752[1a]
Reversal of neuromuscular blockade				
None	45 (14.9)	28 (14.1)	17 (16.3)	<0.001[1b]
Atropin-Neostigmin	163 (54.0)	139 (70.2) [B]	24 (23.1)	
Sugamaddex	94 (31.1)	31 (15.7)	63 (60.6) [A]	
	Median (Min. / Max)	Median (Min. / Max)	Median (Min. / Max)	
Duration of operation (min.)	60(10/ 300)	60 (10 / 300)	80 (20 / 220)	0.011[3]
Intraoperative blood loss (ml.)	20 (5 / 600)	15 (5 / 350)	80 (5 / 600)	<0.001[3]

Pearson Chi-Square Test (1a Exact, 1b Monte Carlo), Fisher Exact test (Exact); Post Hoc Test: Benjamini Hochberg correction, Mann Whitney U Test b (Monte Carlo), A ≤1 Significant according to age group, B >1 Significant according to age group, Min., Minimum; Max., Maximum; min., minutes, ASA; American Society of Anesthesiologists, FFP;Fresh Frozen Plasma

duration of surgery and intraoperative bleeding amount were higher in children >1 year (p<0.05). When the patients were evaluated in terms of their intraoperative amount of bleeding, it was seen that the mean amount of bleeding, 80 ml, in patients >1 year increased significantly compared to children ≤1 year (p<0.001) (Table I). It was determined that a maximum of 3 units of erythrocyte suspension and 2 units of fresh frozen plasma replacement were performed intraoperatively. A total of 93 children underwent postoperative erythrocyte suspension and 18 children underwent fresh frozen plasma replacement. While there was a need for the reversal of neuromuscular blockade with atropine and neostigmine combination in 163 children, it was seen that this procedure was applied more frequently in children ≤1 year than in children >1 year (p<0.001) (Table 1). However, when the children were evaluated in terms of intraoperative monitorization findings, it was seen that intraarterial tension was high in 8 children >1 year, while this was not the case in children ≤1 year. Besides, there was no significant difference between the groups in terms of intraoperative desaturation, hypotension and bradycardia (p>0.05) (Table 1). Mechanical ventilatory requirement was detected in 54 cases in total. There was no significant difference between 1 ≤ age and > 1year old children (34 and 20 respectively p = 0.752) (Table 1). It was seen that 115 of the children included in the study were re operated. There was no significant difference between the two groups in terms of the need for re operation (p>0.05) (Table I).

It was seen that the most common operations were shunting due to hydrocephalus and craniosynostosis. However, the most common re operation procedures were shunt revisions due to hydrocephalus and external ventricular drainage operations. When the etiological reasons for the operations were evaluated, it was found that 145 (48.3% reoperation) operations in children ≤1 year and 44 (59.1% reoperation) operations in children >1 year were performed due to hydrocephalus. Craniosynostosis was performed on 31 (2 re-operations) children ≤1 year and only 5 (3 re-operations) children >1 year. All operations due to epidural (13) and intracerebral hemorrhage (1) were performed on children >1 year of age. It was found that 7 of the children, who were operated for subdural hematoma were ≤1 year and 10 were >1 year-old. It was found that in children who were operated for brain tumors, 2 were performed in ≤1 year-old and 7 in children > 1 year old. In terms of postoperative ICU needs, a total of 122 pediatric cases, 2 of which were external centers, were sent to ICU. In the analysis in which craniosynostosis and subdural-epidural hematomas were evaluated mutually, the mean age was 9 months and 86 months (p<0.01), respectively, the mean weight was 8.2 kg and 27.2 kg (p<0.05), respectively,

Table 2: Comparison of children with craniosynostosis (Group: I) and Subdural-Epidural Hematoma (Group: II)

	Group I (n=36)	Group: II (n=26)	p value
Age (months)	9 ± 4.4	86 ± 72.1	<0.01
Operation time (min)	156 ± 54.2	103 ± 43.7	<0.01
Intraoperative bleeding amount (ml)	181 ± 72	196 ± 136	0.444
Intraoperative hypotension	30.6%	4.8%	0.002
Intraoperative bradycardia	9.7%	4.8%	0.722
Intraoperative hypertension	0%	6.5%	0.027
Amount of ES delivered intraoperatively (cc)	177± 103	148± 202	0.046
Postoperative intensive care need	58.8%	33.9%	0.494
Re-operation	8.1%	1.6%	0.387

Mann-Whitney U Test, Independent t- Test, Chi-Square Test, p <0.05 was evaluated at the level of significance. ES; Erythrocyte suspension, min; minute

and the operation times were 156 and 103 minutes (p<0.01) respectively. When the groups were compared in terms of the amount of intraoperative bleeding, no significant difference was observed, the mean value was 181 ml and 196 ml, respectively (p=0.444). When compared with the amount of erythrocyte suspension administered intraoperatively, 177 ml and 148 ml, respectively (p <0.046) were considered statistically significant. In terms of intraoperative hypotension frequency, the relationship between craniosynostosis (52.8%) and subdural-epidural hematoma (11.5%) groups was considered statistically significant (p=0.002). The comparison between the groups for postoperative ICU admission was 83.3% and 84.6% (p= 0.494) respectively, there was no significant difference between the groups (Table 2).

No intraoperative death was observed in the patients included in this study. Postoperative mortality occurred in 10 (3.3%) of the 303 patients. Of these patients, 5 died after hydrocephalus surgery and/or revision, 2 died after craniosynostosis surgery and the remaining 3 died after subdural and epidural hematoma surgery. In the course of mortality, craniosynostosis had early postoperative mortality with death developing in the first ninth hour after bleeding in the postoperative period. In hydrocephalus, shunt revision and hematoma cases, postoperative late mortality was encountered after intensive care conditions that could last from 1 month to 3 months.

DISCUSSION

Management of pediatric neurosurgical patients is difficult for neurosurgeons and anesthesiologists. The need for emergency procedures, severe comorbidities (such as prematurity) and communication difficulties in the age group, in addition to other complications such as sedation and intravenous access may significantly increase morbidity and mortality in these patients (12).

Surgical intervention involves the most common pediatric neurosurgical procedure ventriculoperitoneal shunting (13). In the present study, where the perioperative anesthesia management and monitoring of patients in the 0-18 age group, who underwent neurosurgical intervention in the last three years in our clinic was evaluated, it was determined that the most common surgical indications were hydrocephalus-dependent shunting and craniosynostosis. However, the most common re-operations were shunt revisions and external ventricular drainage operations due to hydrocephalus. These findings are considered to be consistent with the literature (3).

Craniosynostosis correction, hydrocephalus, and ventriculoperitoneal shunting, and brain tumor resection are the three most common surgical procedures in children with high complication rates. In the study by Drake et al., where 1082 pediatric neurosurgical procedures were evaluated, it was emphasized that the most common complications occurred after hydrocephaly-dependent shunts (38.4%) and brain tumor surgeries (17.5%) (14). In the present study, 48.3% of the children ≤1 year, who underwent hydrocephaly-dependent shunting required re-operation, while this rate increased to 59.1% in children >1 year- old. This is an inevitable surgical complication expected from perioperative anesthesia management (15). Craniosynostosis is a skull development disorder that occurs as a result of early fusion of one or more cranial sutures and occurs in approximately 1 in every 2000 live births (16). Surgical procedures for craniosynostosis are various and complex and carry a great risk for the development of significant complications in intraoperative and postoperative periods. In craniosynostosis patients, the main requirement in their operations is to cope with the inevitable and often significant blood loss that occurs during the procedures (17,18). In a study by Howe et al. conducted on 127 infants aged < 24 months, who underwent craniosynostosis surgery in Australia, it was emphasized that perioperative blood loss may exceed the total blood volume of pediatric patients (19). The difficulty in predicting blood loss due to small blood volume requires accurate timing and the appropriate amount of blood transfusion, depending on the clinician's experience. Meyer et al. reported that perioperative blood loss in 115 children undergoing craniosynostosis surgery reached 66-91% of the estimated blood volume, and that blood transfusions should be adjusted according to the extent of the surgical method. In the same study, the fact that over transfusion occurred in 32% of the children, suggested that the volume management of these patients was quite difficult (20). Kearney et al. argued that blood transfusion is almost inevitable in craniosynostosis surgery, but that blood transfusion is generally unnecessary in the postoperative period (21). In the study of Stricker et al.

in the craniofacial surgeries of infants and children, they stated that long surgical times were associated with greater blood volume losses and the possibility of at least one metabolic acidosis episode (22). Habaz et al. mentioned that besides the long-term effects of general anesthesia on neurological development in the pediatric population, significant blood loss is observed with increased exposure to anesthesia. In their study, they stated that there was an average of 18 ml/kg blood loss in their operations in the cranial vault reconstruction group and 98% blood transfusion was achieved (23). In the craniosynostosis cases of our study, similar to that of Habaz et al., we found that an average of 22 ml/kg blood loss, an average of 21.5 ml/kg erythrocyte suspension (ES) infusion and 94% blood transfusion occurred in operations lasting 156 minutes on average. We believe that the transfusion rates performed due to the hypovolemic process increase our need for ICU by causing intraoperative as well as postoperative complications. In Bonfield et al.'s retrospective study, only 6.14% of 114 cases of craniosynostosis were admitted directly to the ICU and among the reasons for admission were: preoperative increased intracranial pressure, lack of beds in the ward, older patients with large reconstruction areas, or significant medical comorbidity has existed (24). In a retrospective cohort study of 107 craniosynostosis patients by Seruya et al., they observed that only 4.7% of the patients required ICU treatment in the presence of a significantly higher incidence of comorbidities such as intraoperative blood loss and postoperative blood transfusion (25). In the review of Goobie et al., in which a total of 225 craniosynostosis cases over 10 years were examined, the need for postoperative ICU was determined as 36%, in the study, the patient's weight below 10 kg, infusion of ES over 60 ml/kg and intraoperative complications were mentioned as risk factors for the need for ICU (26). In our study, we believe that the rate of need for postoperative ICU increased due to the fact that the patient's weight was 8 kg on average, 21.5 ml/kg (177 ml) ES infusion was administered on average, and intraoperative complications such as hypotensive process at a high rate of 52.8% were encountered. While Goobie et al. reported that the length of stay in the ICU was only 1 day in 70% of the cases, the average length of stay was two days in our craniosynostosis case.

In our study, the frequency in cases of craniosynostosis under 1 year of age, the presence of comorbidity features such as intraoperative blood loss and hypotensive process, as well as the fact that our hospital is not a branch hospital in terms of neurosurgery and pediatrics, considering patient safety, we see that ICU transfer is more intense than the literature, at a rate of 83.3%. We think that the fact that the rate of intubated patients is 19.4% in the transfer to the postoperative ICU and that the higher rate of postoperative ICU transfer is detected, also plays a role in the desire to perform postoperative patient care in more reliable environments in terms of monitoring and follow-up.

Miller et al. reported that the incidence of intraoperative hypotension during emergency decompressive craniotomy in children was as high as 52%, especially in children under the age of 3 years with a higher rate, and intraoperative blood loss was the most independent risk factor in these operations (27). On the other hand Khan et al., reported that the presence of persistent intracranial hypertension is associated with mortality exceeding 80% in some series and that intraoperative blood loss exceeding 300 ml is an important predictor of poor prognosis in traumatic brain injuries (28). In Fenton et al.'s study on preventable pediatric intensive care unit (PICU) admission in 16,209 pediatric patients, most of the patients were admitted to the PICU with head trauma. More specifically, they found that 83% of the preventable admission group was head trauma, and 72% of this number was referred as an isolated injury (29).

In our study, we planned to examine two different groups which craniosynostosis and subdural-epidural hematomas as a sub-analysis among the three-year pediatric cranial surgery cases due to the high probability of intraoperative bleeding and their similarities. While the incidence of intraoperative hypotension was higher in the craniosynostosis group (52.8%), intraoperative hypertension was detected only in the subdural-epidural hematoma group with a rate of 15.4%. Contrary to Miller et al., hypotension was observed at a rate of 11.5% in the subdural-epidural hematoma group. We think that the lower rate may be affected by the fact that our age range is above 7 years on average for the group. Due to possible poor prognostic factors such as bleeding, hypotension and hypertension, the proportion of patients intubated at postoperative ICU transfer was 46.2% in the subdural-epidural hematoma group. ICU admission was found to be 84.6%, similar to the studies of Fenton et al.

In the present study, operative durations, postoperative intensive care needs, perioperative vital signs follow-up, and mechanical ventilator monitoring parameters were evaluated. It was determined that operative durations were longer in children >1 year and their vital instabilities were similar to those of infants ≤1 year during the follow-up period. Mechanical ventilator follow-up findings and postoperative blood product replacement conditions were also similar in both groups.

The present study has significant limitations. Firstly, the fact that the study was retrospective and based on files and electronic data were considered an important limitation. In addition, the fact that the age distribution in the study was wide and the number of patients included in the study was less than similar studies because this was a single-center study was considered to be another important limitation. However, it is considered that the present study has an important contribution to make in terms of facilitating the follow-up of pediatric neurosurgery interventions and evaluation of patient characteristics in our hospital. Close monitoring of patients' perioperative vital signs and detailed recording of blood products can be considered a strong aspect of the study.

CONCLUSION

Close monitoring of vital signs of pediatric neurosurgery patients and detailed recording of advanced complications and blood transfusions are thought to be important in perioperative anesthesia management. In particular, it was observed that prolonged operation time increased the amount of intraoperative bleeding. In patients with craniosynostosis, subdural and epidural hematoma, often accompanied by massive bleeding, the need for ICU increased in the postoperative period due to frequent intraoperative hemodynamic complications.

We believe that it is necessary to be more careful in terms of morbidity and mortality, especially in cases of craniosynostosis, which are more common in children aged 1≤ years, due to massive bleeding than cranial operations in children> 1 year old, and the hypotensive process is more aggressive. It is considered that prospective and multicenter studies are needed on this subject.

Conflict of Interest: No conflict of interest was declared by the authors

Ethics: Approved by Medical Ethics Review Committee of Kanuni Sultan Süleyman Training and Research Hospital / KAEK / 2018.7.08-08 / 08/2018).

Funding: There is no financial support of any person or institution in this research.

Approval of final manuscript: All authors

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