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Retrospective Evaluation of Anesthesia Methods in Pediatric Orthopedic Surgery: A Single-Center Study of 1468 Patients

Mehmet Şirin Keleş[1], Nurettin Kurt[2], Nureddin Yüzkat[2], Celaleddin Soyalp[2], Mehmet Emin Keskin[2], Hacı Yusuf Güneş[2]

[1]*Department of Anesthesiology and Reanimation, Van Training and Research Hospital, Van, Türkiye*
[2]*Department of Anesthesiology and Reanimation, Van Yuzuncu Yil University Faculty of Medicine, Van, Türkiye*

Abstract

Introduction: This study aimed to evaluate the distribution of anesthesia methods and complication rates in pediatric patients aged 0–18 years who underwent orthopedic surgery at the Department of Anesthesiology and Reanimation, Van Yuzuncu Yil University Faculty of Medicine, between 2019 and 2021.

Materials and Methods: The study was designed as a retrospective, cross-sectional, and descriptive study. A total of 1468 pediatric patients aged 0–18 years classified as ASA I–II who underwent orthopedic surgery were included. Patient data including age, sex, type of surgery, anesthesia method applied, and anesthesia-related complications were recorded and analyzed.

Results: Of the 1468 patients included in the study, general anesthesia was administered to 70.8%, peripheral nerve blocks to 16%, and spinal anesthesia to 12.6%. A significant increase was observed in the rates of general and spinal anesthesia in 2021, while the rate of peripheral nerve blocks decreased. The most common complication was tachycardia, observed at a rate of 3.5% in 2019. Complication rates decreased significantly in subsequent years.

Conclusion: General anesthesia remains the most preferred method in pediatric orthopedic surgeries. However, regional anesthesia techniques are increasingly used and demonstrate safety. These findings suggest that regional techniques can be effectively and widely applied in pediatric populations with appropriate patient selection.

Key words: Pediatric anesthesia; pediatric orthopedic surgery; regional anesthesia; spinal anesthesia; general anesthesia

Introduction

Today, various anesthesia techniques are available, including general anesthesia (GA), epidural anesthesia (EA), spinal anesthesia (SA), combined spinal-epidural anesthesia (CSE), peripheral nerve blocks (PNB), and sedoanalgesia. Although regional anesthesia techniques are frequently preferred in adults, they have increasingly been applied in the pediatric age group in recent years. In particular, regional anesthesia techniques applied in extremity surgeries offer several advantages, such as early mobilization, shorter hospitalization, effective postoperative analgesia, reduced risk of thromboembolism and blood transfusion, and cost-effectiveness (1). The physiological, anatomical, and pharmacological characteristics of neonates, infants, and children differ significantly from those of adults. Knowing these differences is fundamental for safe, successful and effective anesthesia administration. Therefore, all of these differences should be considered when performing anesthesia in pediatric patients. The most current practice guidelines support the use of regional anesthesia across all pediatric age groups and recommend it as the preferred approach (2,3). In the literature review, studies on the anesthesia management of pediatric patients are limited. It was seen that some of the studies were aimed at very specific areas. Thus, there is a clear need for comprehensive studies that assess anesthesia techniques in the pediatric population in a multifaceted and detailed manner. In this retrospective study, we aimed to evaluate the anesthesia methods used in pediatric patients who underwent orthopedic surgery at Van Yuzuncu Yil University, Faculty of Medicine, between January 2019 and December 2021.

Materials and Methods

Before the study, approval was obtained from the Clinical Research Ethics Committee of Van Yuzuncu Yil University, Faculty of Medicine (Decision Number: 2022/03-02, dated 18.03.2022). In this study, data from 1468 pediatric patients aged 0–18 who underwent orthopedic surgery at Van Yuzuncu Yil University,

*Corresponding Author: Nurettin Kurt, Van Yuzuncu Yil University Faculty of Medicine, Department of Anesthesiology and Reanimation. 65080 Van, Turkey. **Email:** dr.nurettinkurt@gmail.com **Orcid:** Nurettin Kurt 0000-0001-7713-5120, Mehmet Şirin Keleş 0009-0000-9370-141X, Nureddin Yüzkat 0000-0002-8218-1217, Celaleddin Soyalp 0000-0002-2687-5329, Mehmet Emin Keskin 0000-0003-1915-175X, Hacı Yusuf Güneş 0000-0003-3594-0345

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Faculty of Medicine between January 2019 and December 2021 were retrospectively analyzed. Patient information was obtained from follow-up forms and the hospital information management system. Patient with complete data access and those who underwent surgery under general or regional anesthesia techniques were included the study. Patients with inaccessible or missing data, those who underwent local anesthesia or revision surgery were excluded. As a result of the data analysis, a total of 1468 patients aged between 0-18 years and who provided informed consent were included in the study sample. These patient data were reviewed and analyzed. Demographic data, comorbidities, American Society of Anesthesiology (ASA) scores, type of surgery and anesthesia, emergency or elective status of surgery, intraoperative blood transfusion needs and complications, postoperative intensive care requirements, morbidity, and mortality of the cases were analyzed. Additionally, detailed analyses of the distribution of preferred anesthesia methods by year were performed and the data were evaluated.

Statistical analysis: Mean, standard deviation, mean, minimum, maximum, frequency and proportion were used in the descriptive statistics of the data. The distribution of variables was measured using the Kolmogorov-Smirnov test. Kruskal-Wallis, Mann-U-Whitney test was used in independent quantitative data analysis. Fischer test is used when the conditions of chi-square and chi-square tests are not met in independent qualitative data analysis. SPSS 28.0 program was used in the analyses.

Results

A total of 1468 pediatric patients were operated by the Orthopedics and Traumatology clinic between 2019-2021. Of these, 629 patients (42.8%) were operated in 2019, 410 (28.0%) in 2020, and 429 (29.2%) in 2021. The sample included 830 males (56.5%) and 638 females (43.5%). Regarding age groups, 627 patients (42.7%) were aged 0–6 years, 482 (32.8%) were aged 6–14 years, and 359 (24.5%) were aged 14–18 years. Based on ASA classification, 1332 (90.7%) were ASA I, 105 (7.2%) ASA II, and 31 (2.1%) ASA III. In terms of comorbidities, 1358 (92.5%) of the cases had no comorbidities, while 110 (7.5%) had at least one comorbidity. There was no significant difference between the ages and genders of patients who underwent surgery in 2019-2020-2021. However, ASA scores and the presence of comorbidities were statistically higher in 2021 compared to other years ($p < 0.05$). Of the patients who underwent surgery, 465 (31.7%) were taken under emergency conditions and 1003 (68.3%) were taken under elective conditions. The distribution of emergency cases in 2019, 2020 and 2021 was 31.7% (208), 36.1% (148) and 25.4% (109), respectively. The rate of emergency surgery in 2021 was significantly lower than in 2019 and 2020 ($p < 0.05$). In 2019 and 2020, the rate of emergency surgery did not differ significantly (Table 1).

Table 1: Distribution of demographic data by year of surgery

		2019		2020		2021		P	
		n	%	n	%	n	%		
Number of cases		629	42.8	410	28.0	429	29.2		
Age	0-6	266	42.3	192	46.8	169	39.4	0.105	x^2
	6-14	220	35.0	119	29.0	143	33.3		
	14-18	143	22.7	99	24.1	117	27.3		
Gender	Male	364	57.9	243	59.3	223	52.0	0.070	x^2
	Female	265	42.1	167	40.7	206	48.0		
ASA score	I	576	91.6	382	93.2	374	87.2	*0.002*	x^2
	II	46	7.3	22	5.4	37	8.6		
	III	7	1.1	6	1.5	18	4.2		
Comorbidity	(+)	40	6.4	26	6.3	44	10.3	*0.029*	x^2
	(-)	589	93.6	384	93.7	385	89.7		
	None	589	93.6	384	93.7	385	89.7		
Number of comorbidities	1	32	5.1	18	4.4	32	7.5		
	2	7	1.1	8	2.0	10	2.3		
	3	1	0.2	0	0.0	2	0.5		
Emergency		208	31.7	148	36.1	109	25.4	0.002	x^2
Elective		421	66.9	262	63.9	320	74.6		

x2 Chi-square test

Table 2: Distribution of preferred anesthesia methods by year

Type of anesthesia	2019		2020		2021			
	n	%	n	%	n	%	p	
General anesthesia	399	63.4	273	66.6	314	73.2	*0.004*	X^2
Spinal anesthesia	32	5.1	13	3.2	41	9.6	*0.001*	X^2
Sedo-analgesia	25	4.0	12	2.9	6	1.4	0.051	X^2
Peripheral nerve block	45	7.2	35	8.5	29	6.8	0.583	X^2
Combined spinal-epidural	1	0.2	0	0.0	0	0.0	0.050	X^2
GA+ Caudal anesthesia	36	5.7	20	4.9	13	3.0	0.124	X^2
PNB+Sedasyon	69	11.0	44	10.7	13	3.0	*0.001*	X^2
Spinal anesthesia+sedation	16	2.5	10	2.4	7	1.6	0.589	X^2
Spinal anesthesia+PNB	1	0.2	0	0.0	3	0.7	0.050	X^2
Conversion from other methods to GA	5	0.8	3	0.7	3	0.7	0.983	X^2

^{K}Kruskal-wallis (Mann-Whitney u test) / X^2 Chi-square test, **GA:** General anesthesia, **PNB:**Peripheral nerve block

Table 3: Rates of orthopedic surgery types

Orthopedic surgery	n	%
Upper extremity bone/soft tissue surgery	555	37.8
Lower extremity bone/soft tissue surgery	442	30.1
Pelvic surgeries	286	19.5
Masses in the extremities	102	6.9
Other Surgeries	38	2.6
Extremity amputation	22	1.5
Hand Crush Injury	17	1.2
Multiple trauma	7	0.5

General anesthesia was administered to a total of 1040 (70.8%) of the cases taken on the specified dates, 986 (67.2%) underwent direct general anesthesia, 43 (2.9%) underwent sedo-analgesia, and 11 (0.7%) underwent intraoperative general anesthesia from other anesthesia methods. Regional anesthesia methods were preferred in 428 (29.2%) patients, and peripheral nerve blocks were the most frequently used regional anesthesia techniques. Peripheral nerve blocks were preferred in 261 (16%) patients, and 126 (48.3%) of them were performed with sedation. Spinal anesthesia was applied to 185 (12.6%) of the cases and 33 (17.8%) of them were supported with sedation. Combined spinal-epidural anesthesia technique was preferred in only 1 (0.1%) patient (Table 2).

The general anesthesia rate in 2021 was significantly higher than in 2019 and 2020 ($p < 0.05$). The general anesthesia rate did not differ significantly between 2020 and 2021. The spinal anesthesia rate in 2021 was significantly higher than in 2019 and 2020 ($p < 0.05$). The peripheral nerve block rate with sedation in 2021 was statistically lower than in 2019 and 2020 ($p < 0.05$) (Table 2). In pediatric cases between 2019 and 2021, 37.8% of surgeries were upper extremity bone/soft tissue, 30.1% were lower extremity bone/soft tissue, 19.5% were pelvic surgeries, 6.9% were masses in the extremities, 1.5% were extremity amputations, and 1.2% were crush injuries (Table 3). The mean surgery duration of the cases in 2019 were 70.9 ± 45.3 minutes and anesthesia duration was 90.3 ± 46.4 minutes, in 2020 the surgery duration was 72.3 ± 43.7 minutes and anesthesia duration was 91.9 ± 44.2 minutes, and in 2021 the surgery duration was 69.4 ± 43.5 minutes and anesthesia duration was 88.8 ± 44.2 minutes. When we look at all the surgery, it was determined that the shortest surgery lasted 10 minutes and the longest surgery lasted 360 minutes. While the average length of hospital stay was 4 days, it was observed that the hospital

Table 4: Anesthesia, surgery and hospitalization duration

		Year			
		2019	2020	2021	**p**
Duration of anesthesia (min)	Mean ± SD	90.3 ± 46.4	91.9 ± 44.2	88.8 ± 44.2	0.339[K]
	Median	90.0	90.0	60.0	
Duration of surgery (min)	Mean ± SD	70.9 ± 45.3	72.3 ± 43.7	69.4 ± 43.5	0.333[K]
	Median	70.0	70.0	40.0	
Hospitalization duration (day)	Mean ± SD	5.1 ± 4.6	5.2 ± 4.9	5.1 ± 3.8	0.052[K]
	Median	4.0	4.0	4.0	

K Kruskal-wallis (Mann-whitney u test) / X^2 Chi-square test, **SD:** Standard Deviation

Table 5: Complication and mortality rates by year

		Year							
		2019		**2020**		**2021**			
Complications		**n**	**%**	**n**	**%**	**n**	**%**	**p**	
Bradycardia		2	0.3	0	0.0	1	0.2	p>0.05	X^2
Tachycardia		22	3.5	1	0.2	0	0.0	*0.001*	X^2
Desaturation		3	0.5	0	0.0	2	0.5	p>0.05	X^2
Nausea-vomiting		8	1.3	1	0.2	1	0.2	0.059	X^2
Hypotension		2	0.3	2	0.5	3	0.7	p>0.05	X^2
Convulsion		1	0.2	1	0.2	0	0.0	p>0.05	X^2
First 24 Hour Mortality	(-)	629	100	410	100	429	100	1	X^2
	(+)	0	0	0	0	0	0		
First 30-Day Mortality	(-)	629	100	410	100	429	100	1	X^2
	(+)	0	0	0	0	0	0		

X^2 Chi-square test

stay of septic arthritis cases were more than 1 month. The anesthesia, surgery and hospitalization duration of the surgeries performed in 2019-2020-2021 did not show any statistically significant difference (Table 4). Intraoperatively, 36 (2.5%) patients received blood and blood product transfusion. Of these transfusions, 14 (1.0%) were performed in 2019, 8 (0.5%) in 2020, and 14 (1.0%) in 2021. Complications observed in the cases were tachycardia in 23 (1.6%), nausea-vomiting in 10 (0.7), hypotension in 7 (0.5%), desaturation in 5 (0.3%), bradycardia in 3 (0.2%), and convulsion in 2 (0.1%), respectively. The most common complication in 2019 was tachycardia with 3.5%, while it was hypotension with 0.5% in 2020-2021. The rate of tachycardia seen in 2020-2021 was significantly lower than in 2019 ($p < 0.05$). No significant difference was observed between the years in terms of bradycardia, desaturation, nausea-vomiting, hypotension, and convulsions. In terms of mortality, there were no cases with mortality in the 30-day period after surgery (Table 5). Postoperatively, 1456 patients (99.2%) were transferred to the regular ward, and 12 patients (0.8%) to the intensive care unit. In 2019, 6 (1.0 %) of 629 cases were admitted to the intensive care unit, in 2020, 5 (1.2%) of 410 cases, and in 2021, 1 (0.2%) of 429 cases. Blood and blood products were given to 36 (2.5%) of the orthopedic pediatric patients who underwent surgery between 2019 and 2021. Transfusion was performed in 14 of 629 cases in 2019, 8 of 410

Table 6: Distribution of patients' transfusion requirement and discharge status from the operating room by year

		2019		2020		2021			
Discharge from the operating room to		**n**	**%**	**n**	**%**	**n**	**%**	**p**	
Ward		623	99.0	405	98.8	428	99.8	0.25	X^2
Intensive care unit		6	1.0	5	1.2	1	0.2		
Intraoperatif transfusion requirement	(+)	14	2.2	8	2.0	14	3.3	0.418	X^2
	(-)	615	97.8	402	98.0	415	96.7		

K Kruskal-wallis (Mann-whitney u test) / **X^2** Chi-square test

cases in 2020, and 14 of 429 cases in 2021. There was no significant difference in the need for postoperative intensive care unit and blood-blood products requirements of the patients who underwent surgery in 2019-2020-2021 (Table 6).

Discussion

Surgical procedures are performed with different anesthesia methods. Each of the anesthesia methods applied has its own advantages and disadvantages. General anesthesia, for instance, provides rapid onset, which is especially valuable in emergency situations. It allows for controlled ventilation, offers sufficient muscle relaxation for optimal surgical conditions, and prevents the patient from experiencing the surgical environment. However, it also comes with disadvantages, including the potential for difficult airway management, pulmonary aspiration, early postoperative nausea-vomiting, and increased pain levels (4). While the most important advantages of regional applications are the absence of postoperative respiratory complications, easier pain control at the end of surgery, low cost and early discharge, they also have disadvantages such as postoperative head and back pain (5, 6). In pediatric patients, general anesthesia methods are mostly preferred. However, with the widespread use of ultrasound, it is observed that the rate of regional anesthesia techniques under sedoanalgesia has increased. Regional anesthesia techniques, especially central blocks, carry risks in children. It is recommended that they be performed very carefully by experienced anesthesiologists, considering the indication for surgery and the risk of complications. Peripheral nerve blocks, on the other hand, have a much lower incidence of side effects than central neuraxial blocks and should be the first choice (7). Especially when guided by ultrasound, regional techniques become even safer and more effective. It is possible to apply regional anesthesia methods effectively and safely with high success and low complication rates, especially in pediatric patients of all ages who will undergo orthopedic surgery under ultrasound guidance.

In the current study, the preferred anesthesia pediatric methods in 1468 patients who underwent surgery by the orthopedics and traumatology clinic were examined in detail. It is seen that it is one of the few studies in the literature in terms of the number of patients evaluated. Apart from the preferred anesthesia methods and demographic data, it is one of the rare studies in the literature that examines more than one variable at the same time, such as ASA, surgeries performed, surgery-anesthesia times, complications, mortality, blood transfusion and postoperative intensive care need. Furthermore, the distribution of these variables by year was examined and comparisons were also made within themselves. In our study, a total of 1468 pediatric patients were operated on by the Orthopedics and Traumatology clinic between 2019-2021. Of these cases, 830 (56.5%) were male and 638 (43.5%) were female. Based on ASA classification, 1332 (90.7%) were ASA I, 105 (7.2%) ASA II, and 31 (2.1%) ASA III. General anesthesia was applied to a total of 1040 (70.8%) patients, 986 (67.2%) of these cases were direct general anesthesia and 3.6% were intraoperatively converted from other anesthesia methods to general anesthesia. The most commonly preferred regional anesthesia method was peripheral nerve blocks with 261 (18.0%), and 126 (48.3%) of the peripheral nerve blocks were performed with sedation. Spinal anesthesia was used in 119 (8.1%) patients, and 36 (2.5%) of these cases were supported with sedation. Intraoperatively, 36 patients (2.5%) required blood-blood products transfusions. Postoperatively, 1456 patients (99.2%) were transferred to the ward, and 12 (0.8%) to the intensive care unit. Although general studies that analyze pediatric cases undergoing orthopedic surgery are not available in the literature, Akkoca et al. found that males were

injured 75% more in a study conducted on pediatric trauma patients only (8). Hosseinpour et al. also found that 77.4% of the injured were male in their study (9). In our study, the male gender rate was determined as 56.5% and female gender rate as 43.5%. We believe that our rates being lower than those in the literature is due to the inclusion of all orthopedic pediatric patients, not just trauma-related cases. In a study conducted by Başkan et al. on 967 pediatric patients, it was found that 86.0% of the patients were ASA-I, 13.1% were ASA-II, and 0.8% were ASA-III (10). Baydi et al. retrospectively examined 781 pediatric cases. In the study, 91.7% of the cases were ASA I, 6.27% were ASA II, and 2% were ASA III (11). In our study, 90.7% of the cases were ASA-I, 7.2% were ASA-II, and 2.1% were ASA-III. Although studies on pediatric orthopedic surgical anesthesia are limited in the literature, our ASA scores were similar to existing studies in the literature. In a study conducted by Aksoy et al. on 10636 adult patients undergoing orthopedic surgery, they stated that they preferred general anesthesia in 54.5% of the cases and regional anesthesia techniques in 45.3%. It is seen that spinal anesthesia is the most frequently preferred regional anesthesia method (12). Similarly, in a study conducted by Er et al. on 2814 adult patients undergoing orthopedic surgery, they preferred general anesthesia in 68.5% of the cases and regional anesthesia methods in 31.5%. In their study spinal anesthesia is the most frequently applied regional anesthesia technique (13). In contrast, in the current study, we see that general anesthesia (67.2%) is the most commonly preferred anesthesia method. However, peripheral nerve blocks (16.0%) were preferred more than spinal anesthesia as regional anesthesia methods. We think that this situation is due to the more effective and frequent use of ultrasound by clinicians. In addition, as a result of the limited postoperative analgesic drug availability in pediatric patients, the tendency towards peripheral nerve blocks has increased. We think that this increase in preference is due to the advantage of peripheral nerve blocks providing effective postoperative analgesia in addition to providing intraoperative anesthesia. Furthermore, complications associated with peripheral blocks are less likely in children when they are immobile—making sedation during block application particularly suitable. Therefore, it is recommended that blocks be applied under sedation in pediatric patients (14). In a retrospective study evaluating peripheral nerve blocks, 86% of the cases were performed under sedation (15). In this study conducted in our clinic, it was determined that blocks were applied under sedo-analgesia in 48.3% of the patients. In a study conducted by Yavaşçaoğlu et al. on 42,822 adult patients, it was reported that complications developed in 3.4% of the cases. While the complication rate was 3.1% in those who underwent general anesthesia, this rate remained at 0.25% in those who underwent regional block (16). The Pediatric Regional Anesthesia Network analyzed the risk of complications associated with regional anesthesia in children by examining data from more than 100,000 blocks performed in more than 20 children's hospitals. It was stated that no additional risk was observed in performing blocks under sedation-general anesthesia, and the most common complications were catheter-related failures. The data obtained from this study concluded that pediatric regional anesthesia showed a similar level of safety to adult practices (17). In the current study, complications developed in 3.3 % of patients, in the intraoperative period. These complications were generally mild, non-persistent, which were often slightly, uninterrupted and immediately recovered by intervention. The most common complications in cases were tachycardia, nausea-vomiting, hypotension and desaturation. Başkan et al. in the retrospective study conducted by 967 pediatric (0-16 years) patients, 3.3 % of patients were required blood-blood products transfusions (10). In the study conducted by Stey et al. on pediatric patients in 50 different centers, it was stated that only the erythrocyte transfusion rate needed in 1.5 %of the cases. In our study, we see that the proportion of patients in need of intraoperative transfusion is 2.5 %. In the literature, it was concluded that it would not be right to indicate that this ratio was high or low since there were no studies on transfusion rate in pediatric orthopedic surgery (18). Er et al. stated that postoperatively, 97.4 % of 2814 cases in all age groups undergoing orthopedics and traumatological surgery were transferred to the wards and 2.6 % of cases were transferred to the intensive care unit (13). In our study, 99.2 % of the cases were transferred to the surical wards in the postoperative period and only 0.8 % of the cases were transferred to the intensive care unit. Again in the literature, no study shows the rate of recruitment of pediatric orthopedic cases to postoperative intensive care unit.

Limitations of the study: Due to the retrospective nature of the study, some clinical parameters were evaluated in a limited way. In particular, postoperative pain level, block success

and patient satisfaction could not be evaluated. In addition, differences in surgical team and anesthesiologist preferences may have affected the choice of anesthesia method. However, we believe that this study is one of the largest retrospective pediatric anesthesia series in the literature.

Conclusion

The findings of this study demonstrate that general anesthesia remains the most commonly used method in pediatric orthopedic surgeries. However, the increasing use of regional anesthesia techniques, especially spinal anesthesia and peripheral nerve blocks, reveals that the trust and experience in these methods has increased in our clinical practice. Peripheral nerve blocks offer distinct advantages such as providing effective postoperative analgesia and maintaining a low complication rate, making them an increasingly favorable option for anesthesiologists. We believe that peripheral nerve blocks should be used more widely in pediatric orthopedic surgeries due to these advantages. Additionally, prospective, multicenter studies are needed to support these findings and promote the broader adoption of regional anesthesia in pediatric populations.

Ethical approval: Ethics committee permission was obtained from Van Yuzuncu Yil University, Faculty of Medicine Clinical Research Ethics Committee with the decision number 2022/03-02 on 18.03.2022.

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Author contributions: Concept: M.Ş.K., N.K., N.Y.Design : N.K., M.Ş.K., N.Y. Data Collection: M.Ş.K., N.K., M.E.K. Analysis and interpretation: M.Ş.K., N.K., N.Y., C.S.,H.Y.G. Writing manuscript: M.Ş.K., N.K., M.E.K., H.Y.G.

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