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Research Article

Application of pediatric minimally invasive surgery and its advantages compared to open surgery - analysis of patients operated on at the Children's Surgery Clinic KCUS in the period 2012-2022

D.Dizdarević [1], K.Karavdić [2]*

[1]Medical Faculty University of Sarajevo, Bosnia and Herzegovina

[2]Cilinic for Pediatric Surgery, Clinic Center of University Sarajevo, Bosnia and Herzegovina

***Corresponding Author**: K.Karavdić, 36514 Monarch Canyon Road Coarsegold, CA 93614 University of California Santa Barbara.

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Abstract

Introduction: The use of pediatric minimally invasive surgery and its advantages over open surgery speak of a modern way of surgical treatment using advanced technologies to avoid the need for large incisions used in the traditional approach. The goal is to reduce pain, the frequency of complications and speed up the patient's recovery.

Methods: Clinical observational research, eleven-year, retrospective, cross-sectional study, conducted in the department of the Clinic of Paediatric surgery KCUS. The study included 1348 kids who met the inclusion criteria.

Results: According to the research conducted at the Children's Surgery Clinic from 2012 to 2022, the statistical analysis according to the type of surgery shows that there is a statistically significant difference. Minimally invasive surgery has an advantage over open surgery in the pediatric age for diseases that could be treated with both the minimally invasive method and the open method.

Conclusion: Based on the research in this thesis, the conclusions are as follows: the comparison according to the type of surgery shows a difference in the sense that fewer patients were operated laparoscopically compared to the open procedure, the comparison of age groups according to the type of surgery shows a statistical difference in the sense that patients from infancy until childhood, patients were more often operated on through an open procedure, and patients in early adolescence were more often operated on laparoscopically, a comparison of the average age according to the type of surgical procedures shows that patients who were operated on laparoscopically were older compared to patients who were operated on with an open procedure, a comparison of the length of antibiotic therapy after the surgical procedure according to surgical procedures shows that patients operated on by an open procedure had a longer duration of antibiotic administration in days compared to patients operated on laparoscopically and a comparison of the length of hospitalization according to surgical procedures shows that patients operated on by an open procedure had a longer average duration of hospitalization compared to patients operated on laparoscopically.

Keywords: organization, human capital, intangible asset, model, specification

Introduction

After the success of minimally invasive surgical techniques in adults, application in pediatric patients was the next logical step.(1) However, the use of these techniques in young children spread slowly, because surgical instruments had to be miniaturized, the learning curve was relatively long, and they had to develop safe and reliable anesthetic procedures to ensure good tolerance to pneumoperitoneum.(2) Today, it is essential that every pediatric surgeon must have adequate training in minimally invasive surgery because it has numerous advantages for the patient.(3) Minimally invasive pediatric surgery has evolved rapidly over the past 30 years, from fetuses to overweight 17-year-old adolescents.(4)

The laparoscopic approach offers several advantages over the open procedure: it potentially reduces surgical stress and the changes that can accompany it, in addition, there is less need for postoperative analgesia, a reduction in postoperative respiratory and wound complications, a shorter postoperative recovery, including the stay in the intensive care unit , quick return to normal diet and reduced overall hospital stay.(5) Numerous intra-abdominal operations in children can be performed open or laparoscopically. (6) Meta-analyses for specific procedures such as laparoscopic appendectomy in healthy children result in less postoperative pain and shorter hospitalization compared to open.(7) With the introduction of laparoscopic techniques, especially cholecystectomy in adults, in the 1980s, a virtual revolution in surgery took place, leading to tremendous progress in minimal access surgery (MAS) of increasing complexity.(8)

Objectives Of The Work

1. To present an analysis of the total number of patients operated on at the Children's Surgery Clinic of KCUS in the period 2012-2022.
2. To present an analysis of the age of patients operated on at the Children's Surgery Clinic of KCUS in the period 2012-2022.
3. To present an analysis of the gender distribution in the total sample of patients operated on at the Children's Surgery Clinic of KCUS in the period 2012-2022.
4. To present a statistical analysis of the duration of antibiotic therapy in days of patients operated on at the Children's Surgery Clinic of KCUS in the period 2012-2022.
5. To present an analysis of the duration of hospitalization in days of patients operated on at the Clinic for Children's Surgery of the KCUS in the period 2012-2022.
6. To present an analysis of the types of surgical procedures performed on patients operated on at the Children's Surgery Clinic of KCUS in the period 2012-2022.
7. To present a comparison of variables according to the type of surgical procedures of patients operated on at the Clinic for Children's Surgery of KCUS in the period 2012-2022.
8. To present a comparison of age groups according to the type of surgical procedures of patients operated on at the Clinic for Children's Surgery of KCUS in the period 2012-2022.
9. To present a comparison of the average age according to the type of surgical procedures of patients operated on at the Clinic for Children's Surgery of KCUS in the period 2012-2022.
10. To present a comparison of the length of antibiotic therapy after surgery for patients operated on at the Children's Surgery Clinic of the Croatian Medical Center in the period 2012-2022.
11. To present a comparison of the length of hospitalization according to the operative procedures of patients operated on at the Clinic for Children's Surgery of KCUS in the period 2012-2022.
12. To present a correlational analysis of the influence of period, age and gender on the duration of antibiotic therapy and hospitalization of patients operated on at the Children's Surgery Clinic of KCUS in the period 2012-2022.

1. Research type:Clinical observational research, eleven-year, retrospective, cross-section study.

Material and methods:

The research (data collection) was conducted in the period from 1.1.2012. until 31.12.2022. in the department of the Clinic for Children's Surgery of the Clinical Center of the University of Sarajevo. The research included children who were hospitalized in the departments of the Clinic for Children's Surgery in the period from January 1, 2012. until 31.12. in 2022. Out of the total number of hospitalized children, which was 9013 children, 1348 children who met the criteria for inclusion in the study were included in the research. The criteria for the inclusion of children in the research were: diagnoses that can be performed laparoscopically and through an open procedure such as: Appendicitis complicata and noncomplicata, abdomen acutum, cholelithiasis, hernia, diverticulitis, ileus, invaginatio, malrotatio, peritonitis, testis non palpable, varicocoele , volvulus. The exclusion criteria are: diagnoses that did not meet the criteria are all those that are not performed laparoscopically or through an open procedure. A table was created through which data from medical histories and discharge letters were collected, and statistical data processing was performed based on them. Example of a table in the "Results" section of the thesis.

In the first part of the table, general data such as initials and date of birth will be taken. The following data will be collected: gender, length of antibiotic therapy in days, length of hospitalization in days, patient diagnosis and type of surgery (laparoscopy or open) for statistical analysis.Diagnoses that met the research criteria are: Appendicitis complicata and noncomplicata, abdomen acutum, cholelithiasis, hernia, diverticulitis, ileus, invaginatio, malrotatio, peritonitis, testis non palpable, varicocoele, volvulus. In order to be included in the research, the patient had to meet the criteria. For the purposes of statistical data processing, patients were repeatedly grouped according to the categories that were statistically processed.

Statistical methods:

The data were processed using the Excel program. The total number of tables that were used was x, and the number of graphs was x.The results of the analysis are presented tabularly and graphically through the number of cases, percentages, arithmetic mean with standard deviation and range of values.Distribution testing was performed using chi-square and Kolmogorov-Smirnov tests, and non-parametric tests were used accordingly.Testing of differences between variables in relation to the type of surgery was performed using the Mann-Whitney test and the chi-square test, while testing the dependence of the outcome variables on sociodemographic characteristics was performed using the Spearman rank correlation coefficient.The results of all the mentioned tests were considered statistically significant at the confidence level of 95% or with values of $p<0.05$.The analysis was carried out using the statistical package IBM Statistics SPSS v 23.0.

Results:

The research included a total of 1379 patients who were operated on in the period from January 1, 2012. until 31.12.2022. years.

		N	%
Period	01.01.2012. - 31.12.2012.	142	10,3
	01.01.2013. - 31.12.2013.	140	10,2
	01.01.2014. - 31.12.2014.	121	8,8
	01.01.2015. - 31.12.2015.	126	9,1
	01.01.2016. - 31.12.2016.	90	6,5
	01.01.2017. - 31.12.2017.	99	7,2
	01.01.2018. - 31.12.2018.	169	12,3

	01.01.2019. - 31.12.2019.	156	11,3
	01.01.2020. - 31.12.2020.	102	7,4
	01.01.2021. - 31.12.2021.	112	8,1
	01.01.2022. - 31.12.2022.	122	8,8
	Total	1379	100,0
χ2=48,136; p=0,0001			

Table 1: Patients who were operated on in the period 2012-2022

Analysis of the total number of patients who were operated on in the period 2012-2022. shows that there is a statistically significant deviation from the expected distribution ($p<0.05$) in the sense that the largest number of patients recorded during 2018 was 169 or 12.3%, followed by the frequency of 2019 with 156 or 11.3% and 2012 with 142 or 10.3% of patients, while the lowest number of patients operated on in 2020 was 102 or 7.4%, in 2017 99 or 7.2% and in 2016 90 or 6.5%.

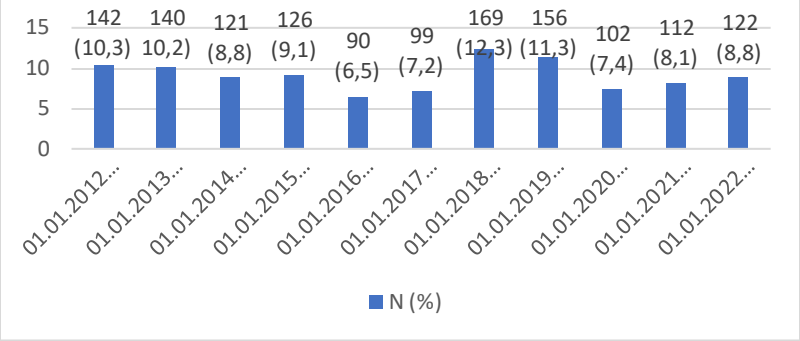

Diagram 1. Patients who were operated on in the period 2012-2022

			N	%
	Age	Group Infants (0-2 years)	88	6,5
		Early childhood (3-5 years)	117	8,6
		Childhood (6-11 years)	555	40,7
		Early adolescence (12-18 years)	602	44,2
	In total		1362	100,0
	χ2=69,900; p=0,0001			
	X̄		10,40	
	SD		4,34	
	Minimum		0,08	
	Maximum		17,00	
Z=0,088; p=0,0001				

Table 2. Age distribution of the patients

The analysis of the age of the patients was performed in all ways, and in both cases it shows a statistically significant deviation from the normal or expected distribution ($p<0.05$). The average age of the patients was 10.4±4.34 years, with the youngest patient at the age of 1 month and the oldest at the age of 17 years. According to age groups, the largest number of patients who were operated on were in the age group "Early adolescence (12-18 years) in 602 or 44.2% of cases, then "Childhood (6-11 years)" in 555 or 40.7%, "Early childhood (3-5 years)" in 117 or 8.6%, and the least in the age group "Infants (0-2 years)#" in 88 or 6.5% of cases.

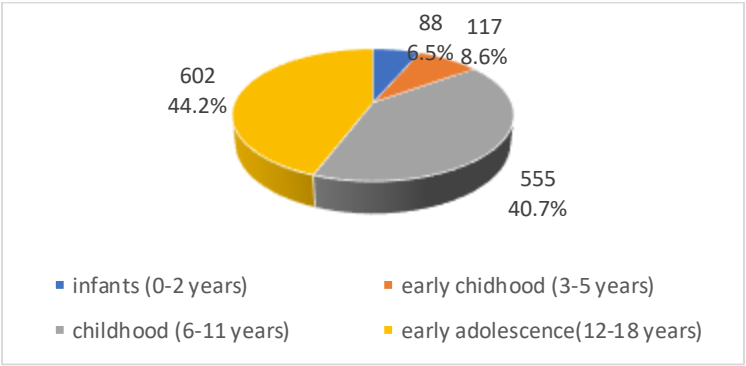

Diagram 2. Age distribution of the patientspatient

		N	%
Sex	Male	876	63,5

	Female	503	36,5
	In total	1379	100,0
χ2=100,891; p=0,0001			

Table 3. Gender distribution of patients

The analysis of gender distribution in the total sample shows that there were statistically significant (p<0.05) more boys - 876 or 63.5% compared to girls - 503 or 36.5%.

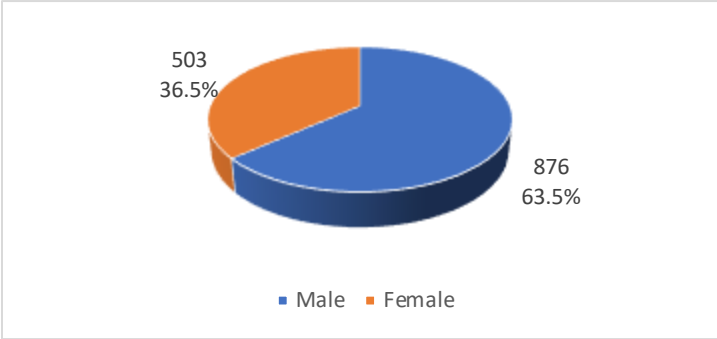

Diagram 3. Gender distribution of patients

Length of antibiotic therapy (days)	N	**Valid**	1074
		No answer	305
	$\bar{X}$		6,72
	SD		1,66
	Minimum		3
	Maximum		18
Z=0,281; p=0,0001			

Table 4. Duration of antibiotic therapy

There are data for 1074 patients for this question. Statistical analysis of the duration of antibiotic therapy in days shows that there is a statistically significant deviation from the uniform distribution (p<0.05). The average duration of antibiotic therapy was 6.72±1.66 days, with the shortest duration of antibiotic therapy being 3 days and the longest being 18 days.

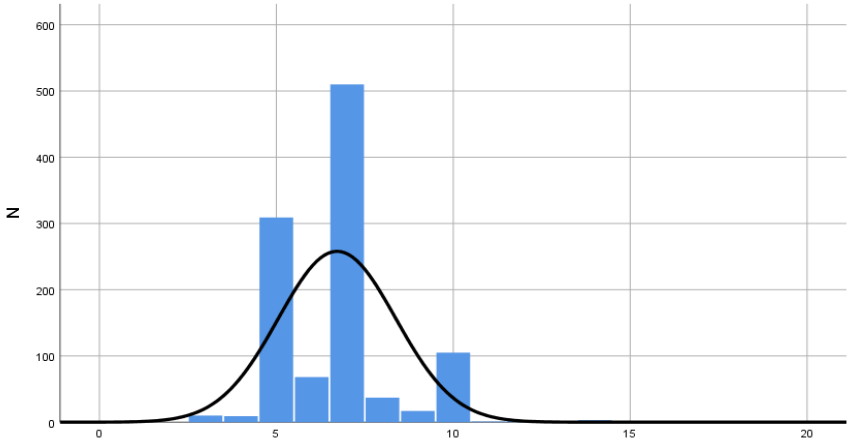

Diagram 4. Duration of antibiotic therapy (days)

Length of hospitalisation (days)	N	**Valid**	1379
		No answer	0
	$\bar{X}$		9,57
	SD		16,18
	Minimum		1
	Maximum		215
		Z=0,320; p=0,0001	

Table 5. Length of hospitalization

Analysis of the length of hospitalization in days shows a statistically significant deviation from the uniform distribution (p<0.05). The average duration of hospitalization was 9.57±16.18 days, with the shortest duration of hospitalization of one day and the longest of 215 days or 7 months.

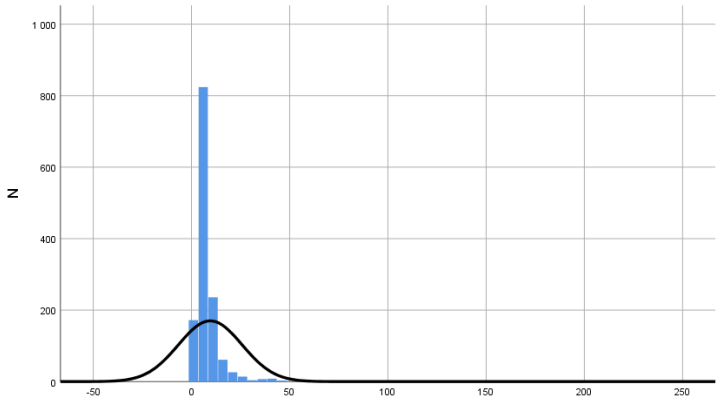

Diagram 5. Length of hospitalisation (days)

		N	%
Type of surgery	Laparascopio	284	20,6
	Open surgery	1095	79,4
	In total	1379	100,0
χ2=76,955; p=0,0001			

Table 6. Type of surgery

The analysis of the types of operative interventions shows a statistically significant deviation from the expected distribution ($p<0.05$). Thus, a significantly higher number of surgical procedures was performed by open surgery in 1095 or 79.4% compared to laparoscopic surgery in 284 or 20.6% of cases.

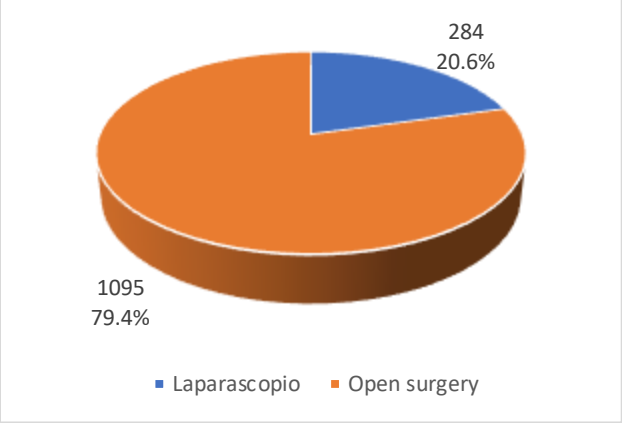

Diagram 6. Types of surgery

			Type of surgery		In total
			Laparascopio	Otvoreni zahvat	
Diagnosis	Appendicitis complicata	N	84	563	647
		%	29,6	52,9	48,0
	Appendicitis noncomplicata	N	144	281	425
		%	50,7	26,4	31,5
	Abdomen acutum	N	1	63	64
		%	0,4	5,9	4,7
	Cholesystitis chronica	N	7	0	7
		%	2,5	0,0	0,5
	Cholelithiasis	N	24	2	26
		%	8,5	0,2	1,9
	Diverticulitis Meckeli intestini ilei	N	0	8	8
		%	0,0	0,8	0,6
	Hernia diaphragmalis	N	2	10	12
		%	0,7	0,9	0,9
	Hernia hiatalis	N	0	2	2
		%	0,0	0,2	0,1
	Hernia ventralis	N	0	4	4

		%	0,0	0,4	0,3
	Ileus e athesione	N	2	19	21
		%	0,7	1,8	1,6
	Ileus e obstructione	N	0	2	2
		%	0,0	0,2	0,1
	Ileus e strangulatione	N	0	6	6
		%	0,0	0,6	0,4
	Invaginatio ileocaecolica	N	4	41	45
		%	1,4	3,9	3,3
	Malrotatio intestini	N	0	4	4
		%	0,0	0,4	0,3
	Peritonitis primaria purulenta	N	1	2	3
		%	0,4	0,2	0,2
	Peritonitis serofibrosa diffusa	N	0	2	2
		%	0,0	0,2	0,1
	Peritonitis seropurulenta diffusa	N	0	1	1
		%	0,0	0,1	0,1
	Testis non palpable	N	4	1	5
		%	1,4	0,1	0,4
	Varicocoele	N	11	48	59
		%	3,9	4,5	4,4
	Volvulus intestini tenui	N	0	4	4
		%	0,0	0,4	0,3
	Volvulus malrotatio	N	0	1	1
		%	0,0	0,1	0,1
In total		N	284	1064	1348
		%	100,0	100,0	100,0

The analysis of referral diagnoses shows that patients were most often referred under the diagnoses of Appendicitis complicata in 647 or 48.0% of cases, followed by Appendicitis noncomplicata in 425 or 331.5% and Abdomen acutum in 64 or 4.7%, and the least frequently under the diagnoses of Volvulus malrotatio in one case or 0.1% of the total sample. The comparison according to the type of surgery shows a statistically significant difference ($p<0.05$) in the sense that 144 or 50.7% of patients with a diagnosis of appendicitis noncomplicated were operated laparoscopically and 563 or 52.9% of patients with a diagnosis of appendicitis complicated were operated on by open surgery.

			Type of surgery		**In total**
			Laparascopio	Open surgery	
Sex	Male	N	163	713	876
		%	57,4	65,1	63,5
	Female	N	121	382	503
		%	42,6	34,9	36,5
In total		N	284	1095	1379
		%	100,0	100,0	100,0
$\chi 2=5,800$; p=0,019					

Table 8. Type of surgery and sex distribution

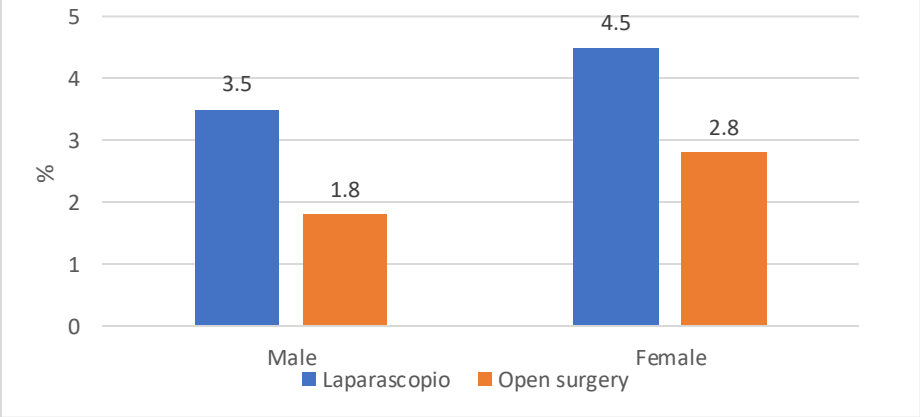

Diagram 7. Type of surgery and sex distribution

			Type of surgery		In total
			Laparascopio	Open surgery	
Age	Group Infants (0-2 years)	N	7	81	88
		%	2,5	7,5	6,5
	Early childhood (3-5 years)	N	14	103	117
		%	5,0	9,5	8,6
	Childhood (6-11 years)	N	89	466	555
		%	31,6	43,1	40,7
	Early adolescence (12-18 years)	N	172	430	602
		%	61,0	39,8	44,2
In total		N	282	1080	1362
		%	100,0	100,0	100,0
χ2=44,216; p=0,0001					

Table 9. Type of surgery and age distribution

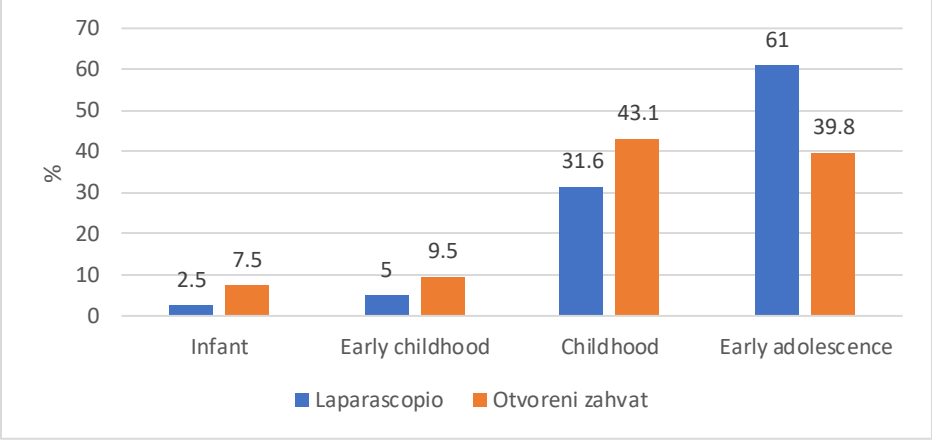

Diagram 8. Type of surgery and age distribution

The comparison of age groups according to the type of operation shows a statistically significant difference ($p<0.05$) in the sense that patients from infancy to childhood (0-11 years) were more often operated on using an open procedure, while patients in early adolescence (12-18 years) more often operated laparoscopically.

		N	$\bar{X}$	SD	Minimum	Maximum
Age (years)	Laparascopio	282	11,97	3,79	0,17	17,00
	Open surgery	1080	9,99	4,38	0,08	17,00
	In total	1362	10,39	4,34	0,08	17,00
Mann-WhytneyZ=-6,966;p=0,0001						

A comparison of the average age according to the type of surgery shows that patients operated laparoscopically were statistically significantly older with an average age of 11.97±3.79 years compared to patients operated on by an open procedure with an average age of 9.99±4.38 years.

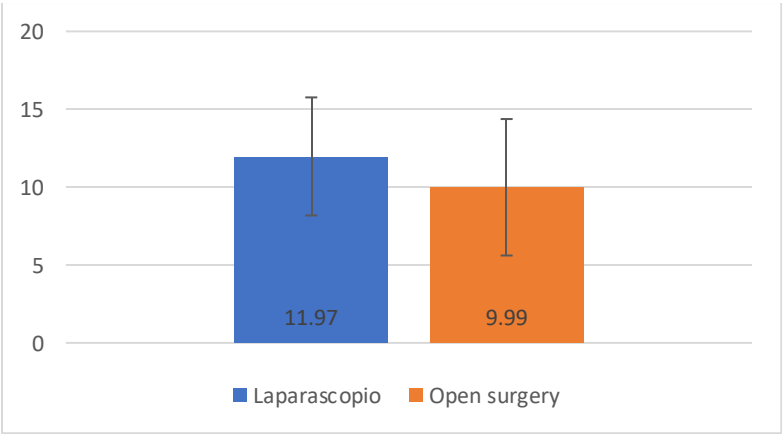

Diagram 9. A comparison of the average age according to the type of surgery

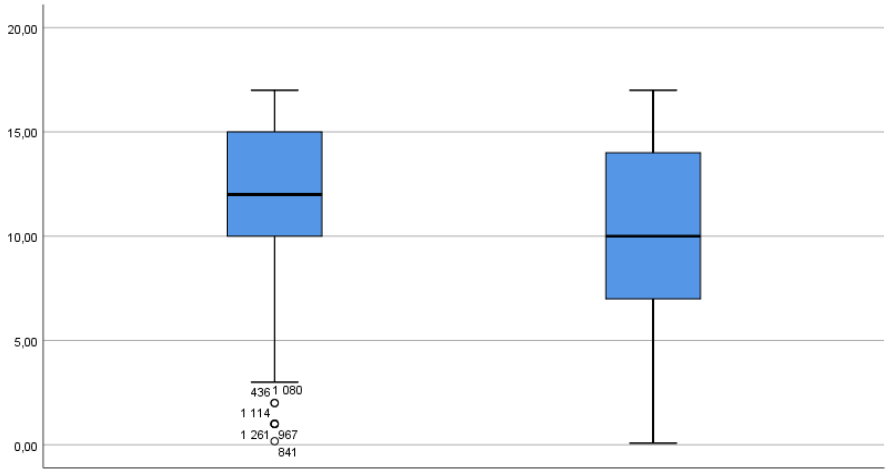

Diagram 10. A comparison of the average age according to the type of surgery

		N	$\bar{X}$	SD	Minimum	Maximum
Lenght of antibiotic therapy (days)	Laparascopio	143	5,94	1,34	3	10
	Open surgery	931	6,83	1,67	3	18
	In total	1074	6,72	1,66	3	18
Mann-WhytneyZ=-6,188;p=0,0001						

Table 10: Length of antibiotic therapy after surgery according to surgical procedures

A comparison of the length of antibiotic therapy after surgery according to surgical procedures shows that patients operated on by an open procedure had a longer antibiotic administration time of 6.83±1.67 days compared to patients operated laparoscopically with an average antibiotic administration time of 5.95±1.34 days. Statistical analysis according to the type of operation shows that there is a statistically significant difference ($p<0.05$).

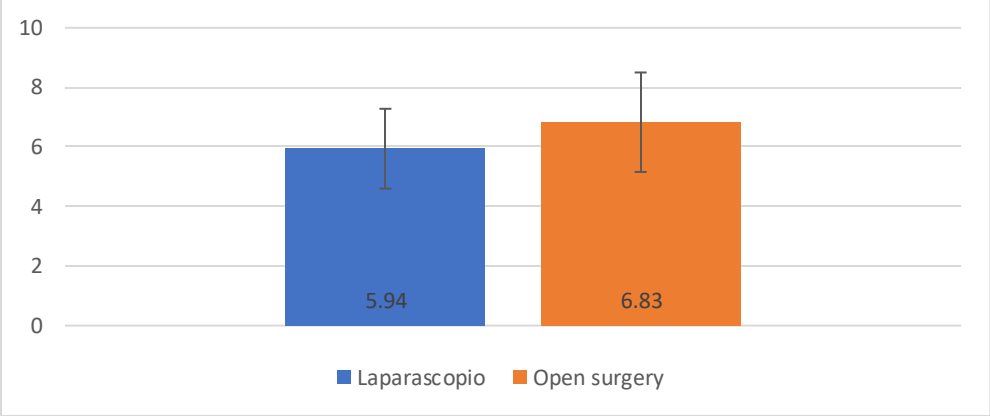

Diagram 10: Lenght of antibiotic therapy (days)

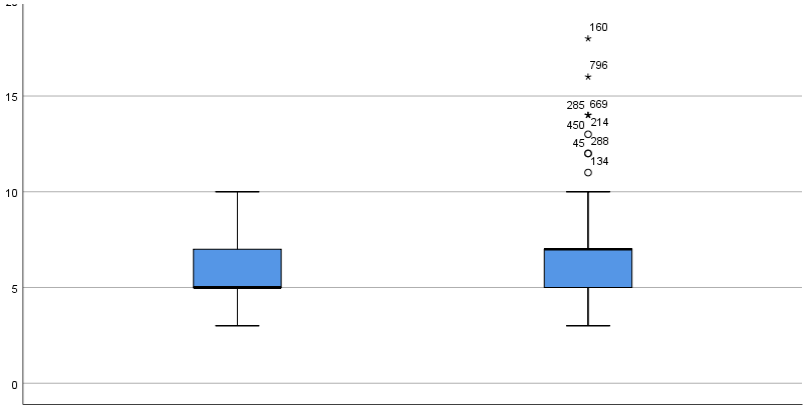

Diagram 11: Lenght of antibiotic therapy (days) according the type of surgery

		N	$\bar{X}$	SD	Minimum	Maximum
Lenght of horpitalization	Laparascopio	284	6,25	13,57	1	215
	Open surgery	1095	10,43	16,69	1	189
	In total	1379	9,57	16,18	1	215
Mann-WhytneyZ=-12,196;p=0,0001						

Table 11: Length of hospitalization according to surgical procedures

A comparison of the length of hospitalization according to surgical procedures shows that patients operated on by an open procedure had a longer average duration of hospitalization of 10.43±16.69 days compared to patients operated on laparoscopically with an average duration of hospitalization of 6.52±13.57 days. Statistical analysis according to the type of operation shows that there is a statistically significant difference ($p<0.05$).

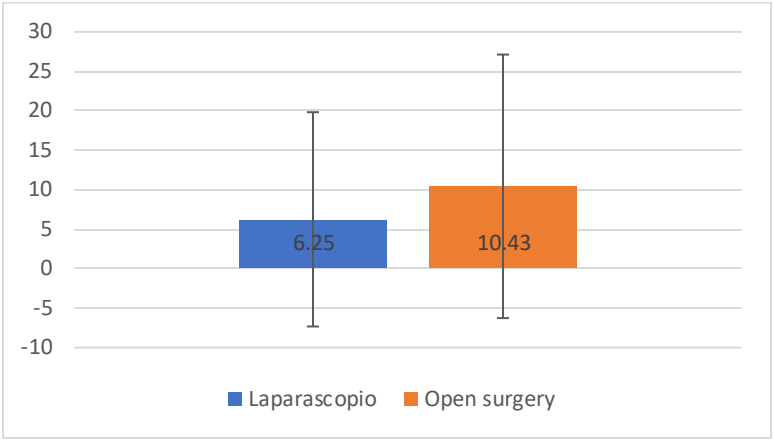

Diagram 12: Lenght of hospitalization according to surgical procedures

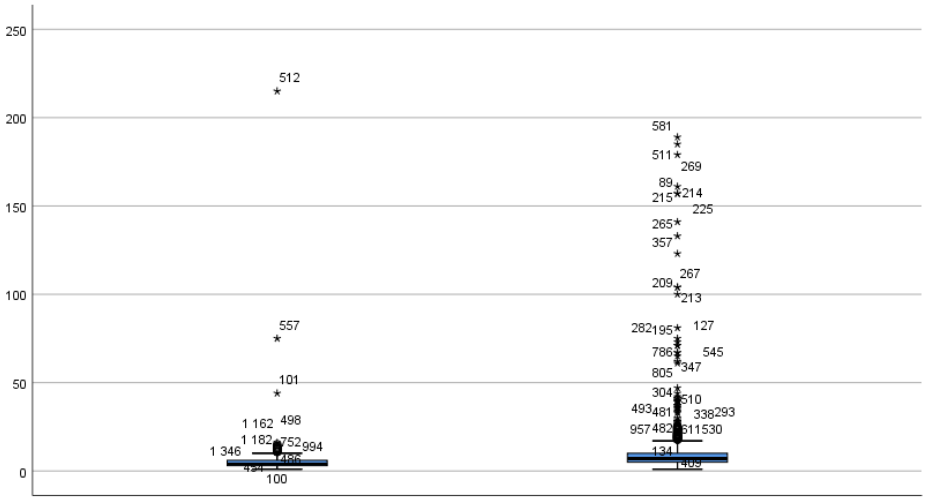

Diagram 13: Lenght of hospitalization according to surgical procedures

			Duration of antibiotic therapy (days)	Length of hospitalization
Spearman ro	Period	ro	-,411**	-,540**
		p	,000	,000
		N	1074	1379
	Age (years)	ro	-,088**	-,083**
		p	,004	,002
		N	1061	1362
	Sex	ro	-,024	,019
		p	,439	,481
		N	1074	1379
****. Correlation significant at the level (p<0,01)**				
***. Correlation significant at the level (p<0,05)**				

Table 12. Correlation analysis of the influence of period, age and gender on the duration of antibiotic therapy and hospitalization

Gender does not show a statistically significant influence on the duration of antibiotic therapy, nor on the duration of hospitalization (p>0.05). Period and age show a statistically significant negative correlation with the duration of antibiotic therapy and hospitalization (p<0.05) in the sense that there is a trend of shortening these periods from 2012 to 2022, and also that older patients had a shorter duration of administration antibiotic therapy and duration of hospitalization.

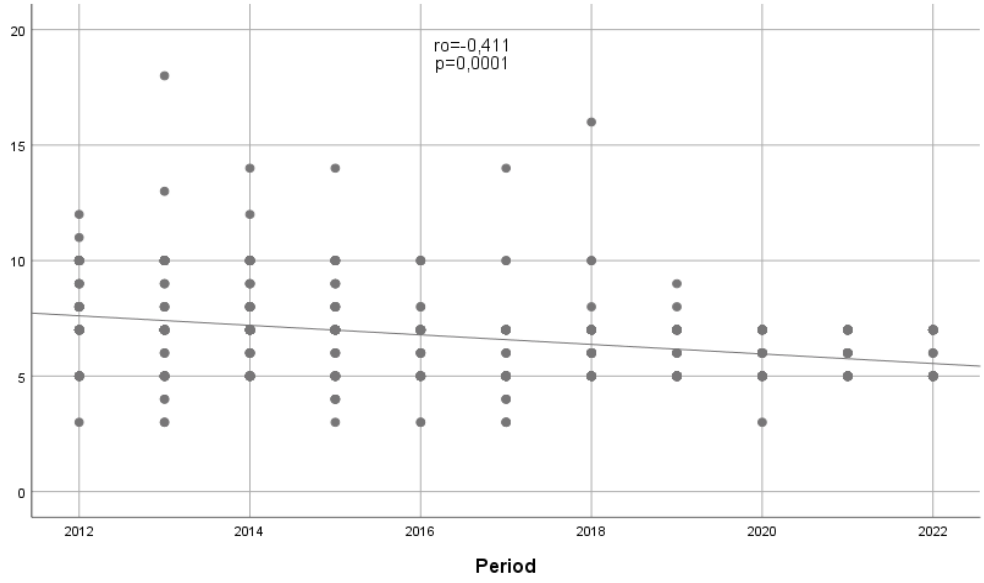

Diagram 14. Correlation analysis of the influence of period, age and gender on the duration of antibiotic therapy and hospitalization

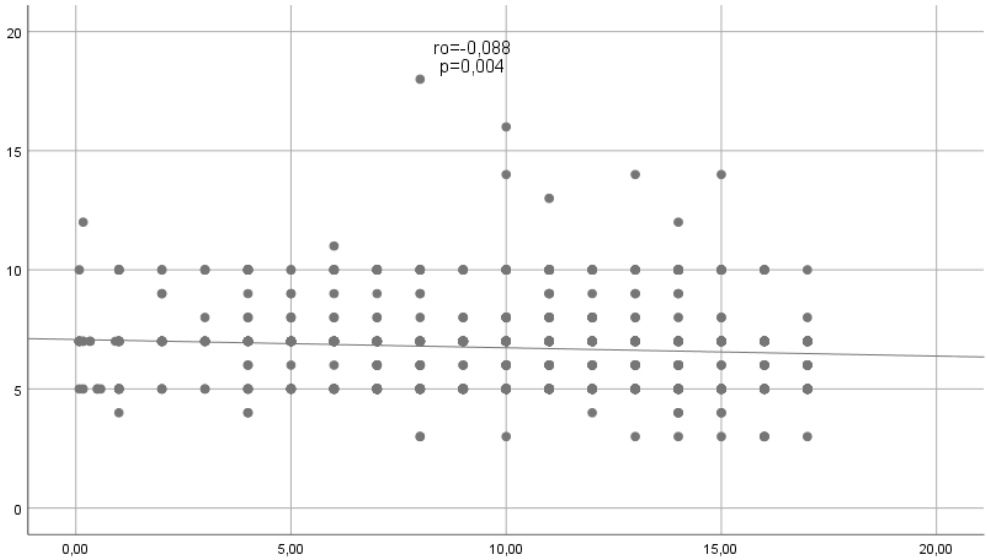

Diagram 15. Correlation analysis of the influence of period, age and gender on the duration of antibiotic therapy and hospitalization

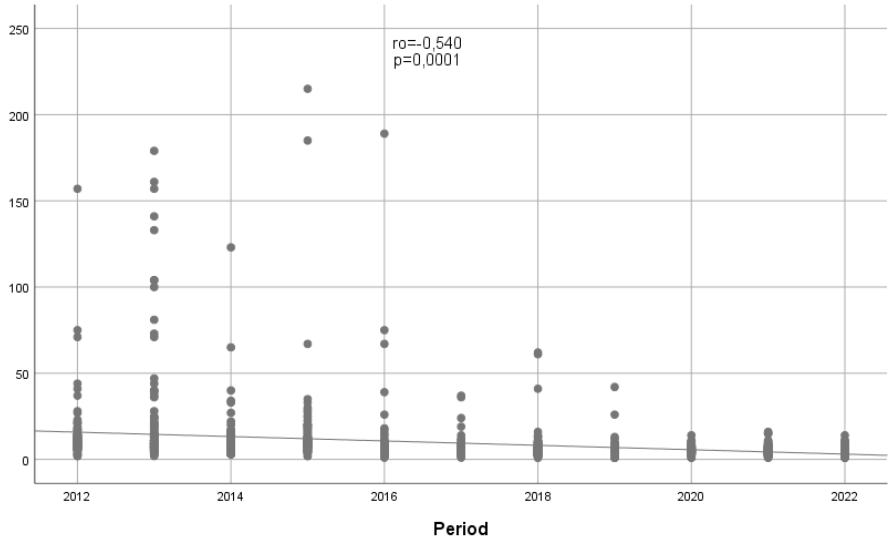

Diagram 16: Correlation analysis of the influence of period, age and gender on the duration of antibiotic therapy and hospitalization

Discussion

The results of the analysis are presented tabularly and graphically through the number of cases, percentages, arithmetic mean with standard deviation and range of values. Distribution testing was performed using chi-square and Kolmogorov-Smirnov tests, and non-parametric tests were used accordingly. Testing of differences between variables in relation to the type of surgery was performed using the Mann-Whitney test and the chi-square test, while testing the dependence of the outcome variables on sociodemographic characteristics was performed using the Spearman rank correlation coefficient. The results of all the mentioned tests were considered statistically significant at the confidence level of 95% or with values of $p<0.05$.The analysis was carried out using the statistical package IBM Statistics SPSS v 23.0.

We conducted an eleven-year, retrospective, clinical study based on the collection of data from the medical history of 9013 hospitalized children. The study included 1348 patients who met the criteria for inclusion in the study. The obtained values in the results will be compared with other research below.

According to research conducted by Ulrich Guller and others in 2004,(9) the discharge notes of 43,757 patients were used for analysis. 7618 patients (17.4%) underwent laparoscopic and 36139 patients (82.6%) underwent open appendectomy. According to the research carried out at the Children's Surgery Clinic of KCUS during 2012-2022, the comparison according to the types of surgical procedures shows a statistically significant difference ($p<0.05$) in the sense that 144 or 50.7% of patients with the diagnosis noncomplicated appendicitis was operated laparoscopically, and 563 or 52.9% of patients diagnosed with appendicitis complicated were operated on by open surgery. Overall, data were similar among 393 institutional and 11,399 NTDB patients who underwent laparoscopic surgery (n = 88, 22%; n = 1663, 16%) in a 2019 study by Parker T. Evans et al.(10) or open (n = 305, 78%; n = 9736, 85%) surgery for abdominal trauma.(11) In both registries, laparoscopy was more often used in younger (institutional $p = 0.026$; NTDB $p < 0.001$) women ($p = 0.019$; $p < 0.001$) with less serious injuries ($p < 0.001$) and blunt injuries ($p = 0.03$). $p < 0.001$).(12) According to the research carried out at the Children's Surgery Clinic of KCUS during 2012-2022, the comparison of age groups according to the type of operation shows a statistically significant difference ($p<0.05$) in the sense that patients from infancy to childhood (0-11 years) were more often operated using an open procedure, while patients in early adolescence (12-18 years) were more often operated laparoscopically. According to research conducted by Elissa K. Butler et al.,(13) in 2020, of 720 patients, 504 underwent laparotomy, 132 underwent laparoscopy, and 84 underwent laparoscopy converted to laparotomy. Median age was 10 (IQR: 7-15) years and median ISS was 9 (IQR: 5-14). According to the research carried out at the Children's Surgery Clinic of KCUS during 2012-2022, the comparison of the average age according to the type of surgery shows that the patients operated laparoscopically were statistically significantly older with an average age of 11.97±3.79 years. compared to patients operated on by an open procedure with an average age of 9.99±4.38 years.

According to the research conducted by Xiaolin Wang et al., in 2009,(14) no significant difference was found in the duration of antibiotic use between the 2 groups (5.8 +/- 1.8 days for LA vs. 6.3 +/- 2.3 days for OA ; $t = -1.37$; $P = .174$). According to the research conducted at the Children's Surgery Clinic of KCUS during 2012-2022, a comparison of the length of antibiotic therapy after surgery according to surgical procedures shows that patients operated on with an open procedure had a longer duration of antibiotic use of 6.83±1, 67 days compared to patients operated laparoscopically with an average antibiotic administration time of 5.95±1.34 days. According to research conducted by Xiaohang Li et al.,(15) in 2010, hospital stay after laparoscopy was shorter by 0.60 days (95% CI: -0.85 to -0.36, $p < 0.00001$) compared to laparotomy. According to the research carried out at the Children's Surgery Clinic of KCUS during 2012-2022, a comparison of the length of hospitalization according to surgical procedures shows that patients operated on by an open procedure had a longer average duration of hospitalization of 10.43±16.69 days compared to patients operated laparoscopically with an average duration of hospitalization of 6.52±13.57 days.Statistical analysis according to the type of operation shows that there is a statistically significant difference ($p<0.05$).

Conclusions

According to the results of foreign research and the results of our research, the comparison according to the type of surgery shows a statistically significant difference in the sense that fewer patients were operated laparoscopically compared to open surgery. A comparison of the average age according to the type of surgery shows that patients who underwent laparoscopic surgery were statistically significantly older than patients who underwent open surgery. A comparison of the length of antibiotic therapy after the surgical procedure according to the surgical procedures shows that the patients operated with an open procedure had a longer duration of antibiotic administration in days compared to the patients operated laparoscopically. A comparison of the length of hospitalization according to surgical procedures shows that patients operated by an open procedure had a

longer average duration of hospitalization compared to patients operated laparoscopically.

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