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Comparison of clinical results of open and laparoscopic appendectomy in the treatment of acute and chronic appendicitis in pediatric patients

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Abstract

Background: Approximately 7-10% of the total population develops appendicitis during their lifetime, so that appendectomy is the most often performed abdominal surgery. For over a century, the golden standard in the treatment of patients with acute appendicitis was an open appendectomy. However, today many polemics among researchers are guided by whether, in pediatric population, the laparoscopic approach is superior to an open appendectomy.

Methods: A retrospective, clinical, comparative study was carried out covering 293 patients with an appendectomy in the period from November 2015 to April 2018 at the Clinical Center of the University of Sarajevo. Patients were divided according to the treatment method in a group of patients with open appendectomy and a group of patients treated by laparoscopic and compared with demographic and clinical data and outcomes of treatment.

Results: The average time of anesthesia was 10 minutes longer in the group of patients who received laparoscopic appendectomy compared to the open appendectomy ($p = 0.0086$). The average length of hospitalization was 2 days shorter in the laparoscopic group of patients ($p < 0.0001$). Laparoscopically operated patients had a shorter application of parenteral analgesia compared to the patients with the open appendectomy ($p = 0.0061$). In patients with laparoscopic appendectomy the period of drainage was shorter ($p < 0.0001$).

Conclusion: Laparoscopic appendectomy proved to be an effective method and is increasingly represented in the treatment of acute appendicitis of children. Children undergoing laparoscopic treatment are significantly shorter in the hospital, have a lower level of postoperative pain, a shorter period of drainage, however, longer application of anesthesia compared to children who have been operated with an open approach.

Keywords: Appendectomy, laparoscopic, treatment outcome.

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Introduction

Appendicitis is the most common surgical abdominal pathology.[1] Approximately 7-10% of the total population develops appendicitis during the lifetime with the highest incidence in the second and third life decade.[2] Consequently, it is easy to conclude that appendectomy is the most frequent abdominal surgery performed.[3]

For over a century, the gold standard in the treatment of patients with acute appendicitis was an open appendectomy.[4] However, today many polemics among researchers are exist by whether, in pediatric population, laparoscopic approach is superior to open appendectomy. There are a number of retrospective studies, randomized studies and meta-analysis which give preference to laparoscopic appendectomy, due to significantly shorter hospitalization length, lower intensity of postoperative pain, faster return to daytime activities, fewer complications, shorter duration of parenteral and oral analgesia, minimal scarring.[5-10,22,23] On the other hand, there are authors who point out that the clinical benefits of laparoscopy are negligible, that the incidence of intra-abdominal abscess is more frequent, and that the laparoscopic procedure is technically and economically more demanding.[11,13] All this is probably the reason why laparoscopic appendectomy has not yet become a standard procedure in pediatric surgery.

The aim of the study is to retrospectively Comparison of the outcome of treatment of acute and chronic appendicitis between a group of patients treated with laparoscopic appendectomy and a group of patients treated with open appendectomy who were operated at the Clinic for Children's Surgery KCUS in the period from November 2015 to April 2018.

Methods

A retrospective, clinical, comparative study was conducted. Data from the history of diseases of patients hospitalized at the Clinic for Children's Surgery of the Clinical Center of the University of Sarajevo have been used, which includes a medical documentation, laboratory tests, a pathohistological finding, anesthesia card, temperature and nurse list. The study included 293 patients who underwent an appendectomy due to a suspicion of acute or chronic appendicitis in the period from November 2015 to April 2018. Out of the total number of patients included in the study, 205 patients were treated with open appendectomy and 88 laparoscopic. The treatment was dependent on the operator's tendency.

Patients were divided into two groups according to the treatment method: a group of patients with open appendectomy and a group of patients treated with laparoscopic route. The following parameters were analyzed and compared between two groups: demographic data (age, sex); preoperative inflammatory parameters (leukocytes, CRP); Clinical data (duration of symptoms, body temperature, vomiting, local findings); Treatment outcome (length of hospitalization, anesthesia, duration of parenteral analgesia, period of drainage); Complications (frequency and type, frequency of reoperation).

The results of the study are presented in tabular or graphs by the number of cases and the percentage for categorical variables, that is, the median and interquartile range (IR) for quantitative variables. Differences in the mean values of the quantitative variables between the tested groups were tested by Mann-Whitney U test. Comparison of different categorical variables was carried out using the Fisher Exact Test. The results of all tests were considered statistically significant with $p < 0.05$. The analysis was carried out using the GraphPad Prism v7.04 statistical package.

Results

305 patients were diagnosed as acute or chronic appendicitis, recorded from November 2015 to April 2018, 293 patients were included in the study. Nine patients were excluded because the data were insufficient, while 3 patients were excluded because they had a concomitant pathology that would potentially influence the clinical outcome of treatment. 205 patients

were treated with open apendectomy and 88 by laparoscopic approach (Diagram 1). An analysis of the parameters of the whole study was done and a comparison was made between these two groups of patients.

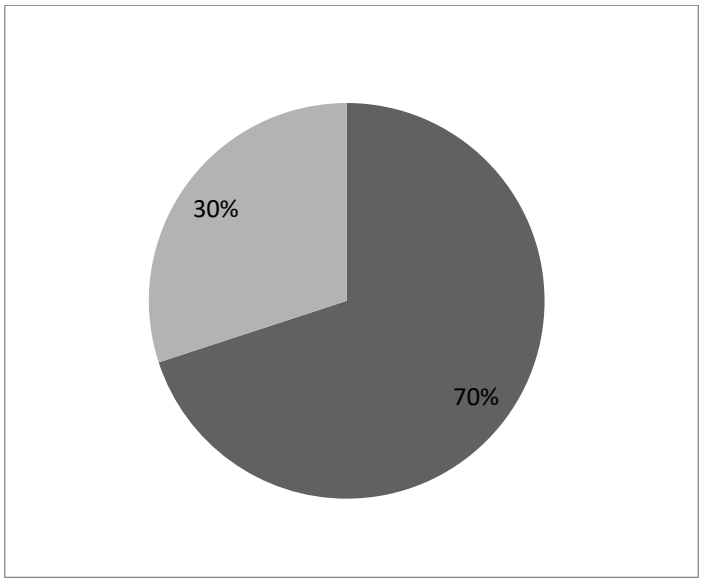

Diagram 1. Ratio of laparoscopic and open apendectomy at the Clinic for Children's Surgery of KCUS, in the period November 2015 - April 2018. (30 % laparoscopy – 70% open)

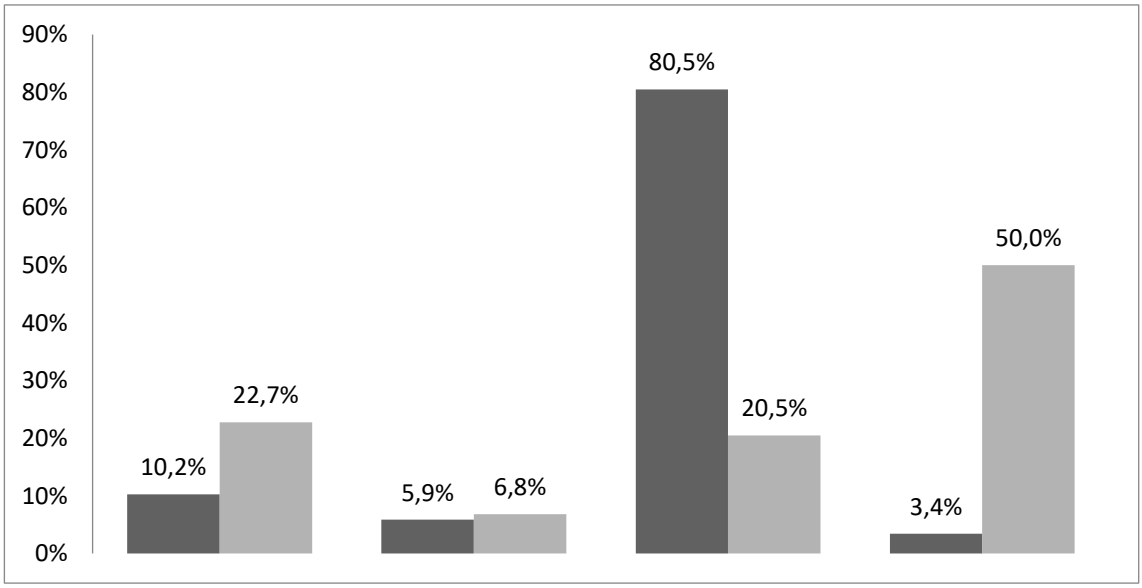

Diagram 2. Distribution of appendicitis according to patohistology examination.

In each of the 293 patients involved in the study, the pathohistological analysis showed a positive finding of apendicitis. Of the total number there were 242 (82.6%) with acute appendicitis and 51 (17.4%) with chronic. In the group of patients with open apendectomy, 198 (96.6%) of acute and 7 (3.4%) chronic appendicitis were diagnosed, and in the laparoscopic group there was an equal number of acute and chronic appendicitis and amounted to 44 (50%). Distribution of apendicitis according to the stage established pathohistologically to acute phlegmonous, gangrenous and perforated, and chronic apendicitis is shown in Diagram 2.

Table 1. Demographic, laboratory and clinical data from patients in both examined groups.

	Open appendectomy n=205	**Laparoscopic appendectomy** n=88	p[a]
Demographic data			
Age (years) (Medijana, IR)	11 (8-14)	12 (9,25-16)	p<0,05**
Sex (n, %)			
M	123 (60)	46 (52,3)	0,246*
F	82 (40)	42 (47,7)	
Preoperative inflammatory parameters			
White blad cells (x10^9/l) (Medijana, IR)	14,8 (11,3-20,6)	12,4 (8-17,8)	p<0,05**
CRP (mg/dl) (Medijana, IR)	26,45 (8,9-75,5)	10,4 (1,2-32,8)	p<0,05**
Clinical data			
Duration of symptoms (hours) (Medijana, IR)	24 (12-48)	24 (12-24)	0,433**
Physical temperature (° C) (Medijana, IR)	37 (37-38)	37 (37-37)	0,667**
Vomiting (n, %)			
Yes	138(67,3)	49(55,7)	
No	66(32,2)	37(42)	0,107*
Unknown	1(0,5)	2(2,3)	
Local illness (n, %)			
Yes	205(100)	87(98,8)	0,300*
No	0(0)	1(1,2)	
Migration of pain in the lower right quadrant of the abdomen (n, %)			
Yes	189(92,2)	75 (85,2)	
No	16(7,8)	11(12,5)	0,189*
Unknown	0(0)	2(2,3)	

a - p-value of Fisher Exact Test * or Mann-Whitney Test **; shaded fields indicate a statistically significant p-value

Table 1 shows the obtained values of demographic, laboratory and clinical parameters for open and laparoscopic patient groups and p-values obtained by comparing these two groups of patients. The results shown in Table 1 will be described below.

The average age at the time of hospitalization was 11 years for a group of patients treated with open apendectomy, ranging from 8 to 14 years, and 12 years for a group of patients treated with laparoscopic appendectomy, ranging from 9.25 to 16 years, which represents statistically significant difference ($p < 0.05$).

Out of 205 open-label patients, 123 (60%) were male and 82 (40%) females, while in the second group 46 (52.3%) were male and 42 (47.7%) females.

Statistical analysis of the preoperative values of leukocytes and CRP in a group of patients treated with open apendectomy and laparoscopic appendectomy showed a statistically significant difference in both parameters ($p < 0.05$). In the first group of patients, the median leukocyte value was 14.8 x 109 / l, ranging from 11.3 to 20.6 x 109 / l, and the median value of CRP was 26.45 mg / dl, with a range from 8.9 to 75.5. In the laparoscopic group of patients, the median leukocyte value was 12.4 x 109 / l, ranging from 8 to 17.8 x 109 / l, and the median value of CRP was 10.4 mg / dl, with a range of 1, 2 to 32.8.

If clinical data are viewed, none of them showed a statistically significant difference between the two groups of patients. The median duration of the symptoms was 24 hours for both groups of patients, while in the group of patients treated with open access ranged from 12 to 48 hours, and in the laparoscopic group from 12 to 24 hours. The median values of body temperature in two groups of patients were also identical, and it was 37 ° C, with a range of 37 to 38 for a group of patients operated by the classical route, and 37 to 37 for those who were operated by a laparoscopic route. In the group of patients treated by open procedure 138 (67.3%) patient had vomiting, while in the second group there were 49 (55.7%) of patients who vomited. All patients from the group treated openly were painfully during physical examination, while in the laparoscopic group it was not only for one patient. Pain migrated in the lower right quadrant of the abdomen in 189 (92.2%) patients from the first group, and in 75 (85.2%) of the second group.

Analyzing the outcome of treatment between the two investigated groups, a statistically significant difference in the duration of anesthesia, the length of hospitalization, the duration of parenteral analgesia and the period of drainage were found ($p < 0.05$). The frequency of reoperations and complications did not show statistically significant differences.

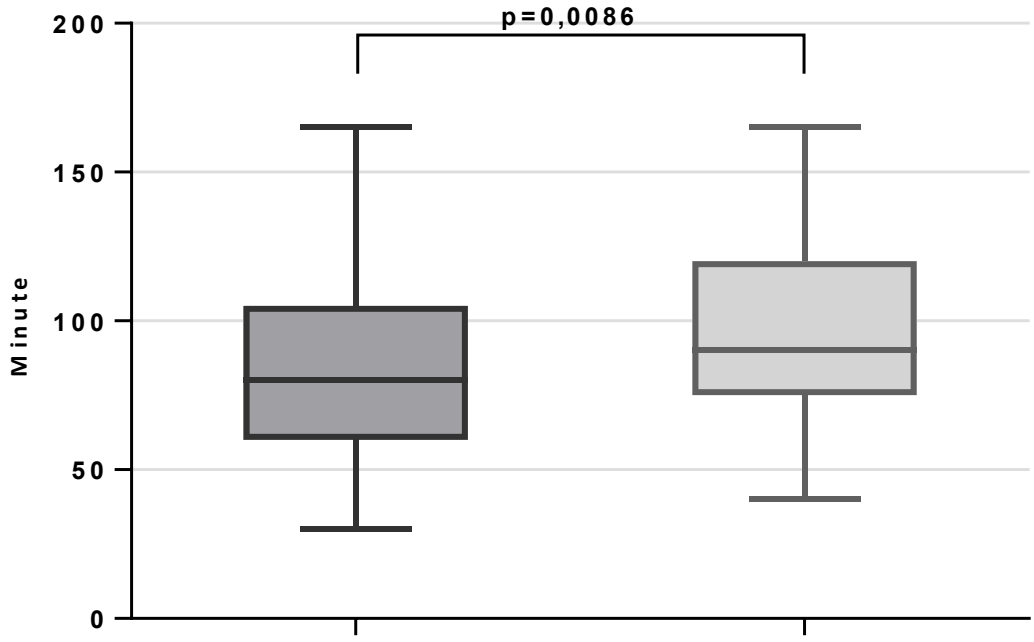

Diagram 3. Comparison of the duration of anesthesia between the two investigated groups expressed in minutes.

The median duration of general anesthesia for the group of open-label patients was 80 minutes (IR: 60-105), while for the laparoscopic group of patients it was 90 minutes (IR: 75-120). From this it can be seen that the average time of anesthesia is 10 minutes longer in the group of patients who received laparoscopic appendectomy compared to open apendectomy with the level of statistical significance p = 0.0086.

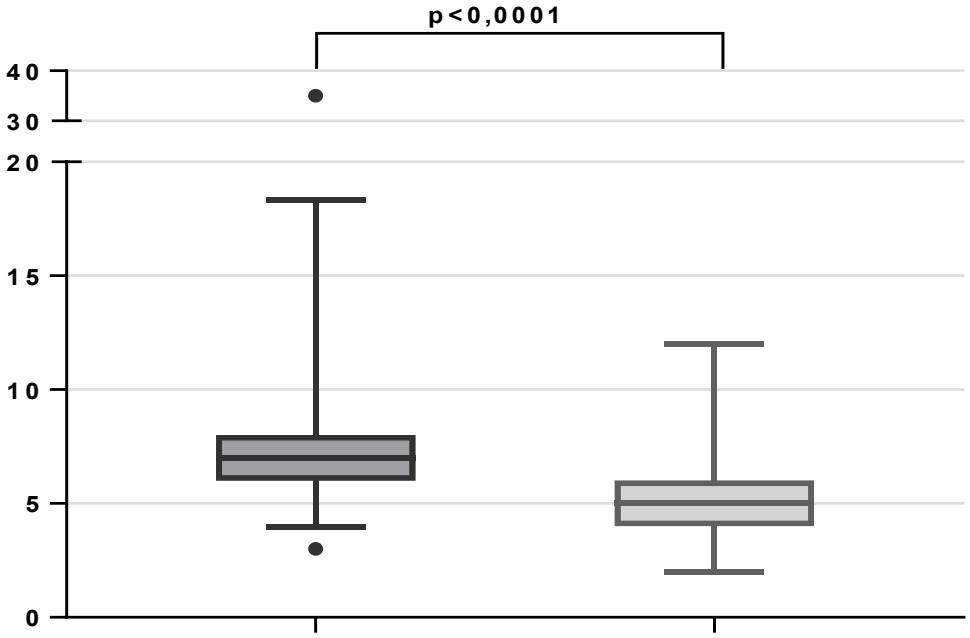

Diagram 4. Comparison of the length of hospitalization between the two investigated groups expressed in days (lower and upper whiskers show the first and 99th percentile, circulating outlier values).

The median length of hospitalization for the group of patients with open apendectomy was 7 days (IR: 6-8), while for the group treated with laparoscopy 5 days (IR: 4-6). The average length of hospitalization was shorter in the laparoscopic group of patients in relation to patients with open apendectomy at the level of statistical significance p <0.0001, which is clearly shown in Diagram 4.

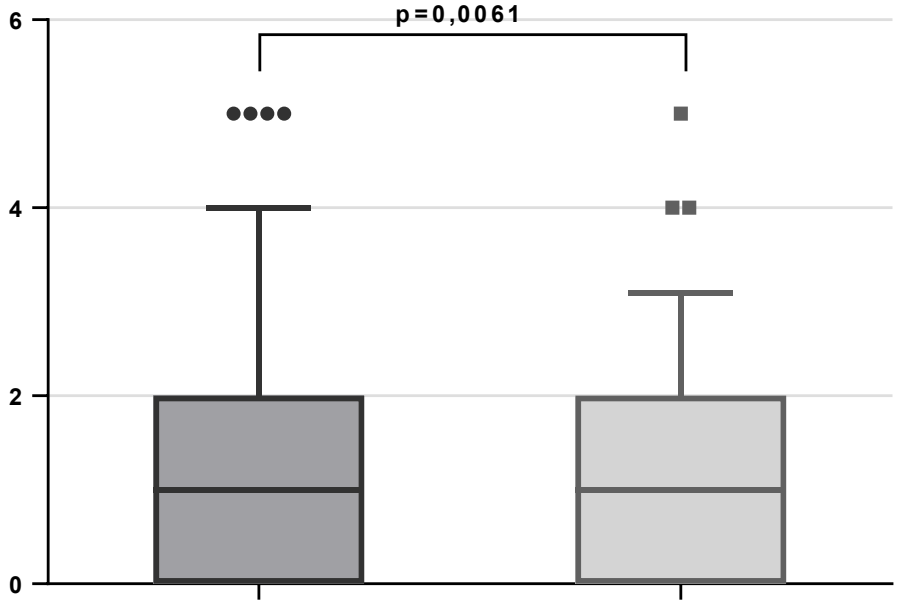

Diagram 5. Comparison of the duration of parenteral analgesia between the two groups examined in days (lower and upper whiskers show 5th and 95th percentile, circles and cubes of outlier values).

Median duration of parenteral analgesia was the same for both groups of patients and was 1 day (IR: 0-2). However, statistical analysis showed that laparoscopically operated patients were parenteral analgesia shorter application compared to open-label patients at the level of statistical significance p = 0.0061 (Diagram 5).

Table 2. Comparison of the outcome of treatment between the two examined groups.

	Open appendectomy n=205	**Laparoscopic appendectomy** n=88	p[a]
Outcome of treatment			
Drainage Period (days) (Medijana, IR)	0 (0-3)	0 (0-0)	p<0,05**
Complications (n, %)			
Minor	12 (5,8)	7 (7,9)	0,6051*
Major	10 (4,8)	3 (3,4)	0,7608*
Reoperation (n, %)			
Da	2 (1)	2 (2,2)	0,5861*
Ne	203 (99)	86 (97,8)	

[a] - p-value of Fisher Exact Test * or Mann-Whitney test **; shaded fields indicate a statistically significant p-value

Table 2 shows the remaining parameters that evaluate the outcome of treatment for groups of patients operated open and laparoscopic and the p-value obtained by comparing these two groups of patients.

The median period of drainage for both groups of patients was 0 days. Nevertheless, in patients with laparoscopic appendectomy (IR: 0-0), the period of drainage was shorter compared to the group of patients operated with open procedure (IR: 0-3) with a high level of statistical significance p <0.0001.

Postoperative complications are divided into minor and major and comparable between the two groups of patients. In the group of patients with open apendectomy there were 12 (5.8%) minor and 10 (4.8%) major complications, while in the laparoscopically operated patients there were 7 (7.9%) minor and 3 (3, 4%) major complications. There was no statistically significant difference in the comparison of minor (p = 0,6051) and major (p = 0,7608) complications.

Due to some of the complications 2 (1%) patients from the laparoscopic group were re-operated, and 2 (2,2%) from the group with open apendectomy, which does not represent a statistically significant difference (p = 0,5861).

Vomiting had 4 (1.9%) patients, diarrhea 3 (1.4%) of the patient, and the wound was secreted in 5 (2.4%) patients, while vomiting in the laparoscopic group was also 4 (4.5%) of the patient, diarrhea had 1 (1.1%) patient, and secretion of the wound 2 (2.2%) of the patient. Of the major complications, after an open appendectomy, one (0.5%) patient with wound infection, one (0.5%) with operative incision bleeding, and one (0.4%) patient with purulent peritonitis, and 3 (1.4%) of the patient with intra-abdominal abscess, 2 (0.9%) with a caecal fistula and 2 (0.1%) with pleural effusion.

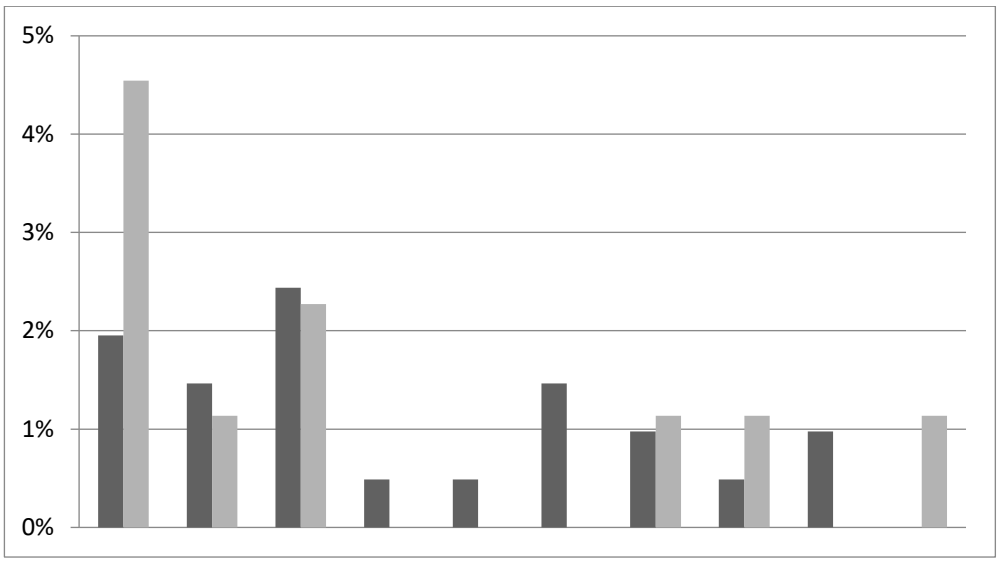

Diagram 6. Distribution of postoperative complications between the two investigated groups.

In the group of patients who were surgically laparoscopic, there were 3 major complications, 1 (1.1%) patients with fistula, 1 with peritonitis (1.1%), and 1 with stump appendicitis. The percentage distribution of these complications is shown in Figure 6. However, the analysis of the incidence of certain postoperative complications did not show a statistically significant difference between the examined groups (vomiting p = 0.2470, diarrhea, wound healing, wound infection, incision bleeding, fistula, pleural effusion p> 0.9999; apsces p = 0.5566; peritonitis p = 5112; stump appendicitis p = 0.3003).

Discussion

Apendectomy is the most commonly performed abdominal surgery in both adult and pediatric population.[3] Perforation is a typical complication in children. Perforated appendicitis has 55-80% of children under 6 years of age.[9] Open appendectomy for a long time was a gold standard in the treatment of apendicitis and for almost a century has remained practically unchanged. However, the development of minimally invasive surgery has encouraged the application of laparoscopy and in the treatment of apendicitis, and in the last twenty years laparoscopy has been popularized. However, the question arises whether the laparoscopic approach is superior to open and uncomplicated and perforated apendicitis. This is the theme of the debate of many children's surgeons around the world.

Analyzing pediatric literature on apendectomy, it has been observed that in the period from 1997 to 2010, most patients with acute appendicitis were operated with an open approach. Out of a total of 123,628 children and adolescents (0-18 years) analyzed in 21 studies, 65.9% were exposed to open apendectomy and only 34.1% were laparoscopic. However, if we only take into account the data for the last 5-6 years, we can notice a change; In fact, after 2006, laparoscopy, as the operative treatment of appendicitis in the pediatric population, assumes dominance over an open approach.[14,15]

Our study included 293 patients, 205 were operated open and 88 laparoscopic. Retrospectively analyzed treatment outcomes and compared between two groups of patients. The results showed that in patients treated with laparoscopic appendectomy, the length of hospitalization was considerably shorter, the duration of parenteral analgesia, and the period of drainage, in contrast to the anesthetic time that was longer in comparation to the group of patients treated classically. The period of antibiotic administration, frequency of reoperations and the frequency of complications did not show statistically significant differences.

Anesthesia time is a parameter that does not have the same value for the results as the length of the operation, but the latter could not be isolated from the available documentation. In our study, the anesthetic time was 10 minutes longer in the group of patients with laparoscopic appendectomy (90 minutes) compared to open apendectomy (80 minutes). Similar

results were obtained in the prospective study Lintula et al., where the average anesthesia time was 11 minutes longer in the laparoscopic group of patients.[16] In a study conducted by Katkhouda et al. this difference is even more noticeable, where anesthesia in laparoscopically operated patients lasted an average of 30 minutes longer.[12] The prolonged duration of anesthesia indirectly suggests a longer duration of laparoscopic procedure, as indicated by the results of numerous meta-analyzes.[6,7,9,17,18] As a reason for this, the authors often cite an insufficient operator experience in performing laparoscopic appendectomy.[6,17] Therefore, we think that the difference in time would be overcome if laparoscopy would become a routine procedure. This study is supported by the results of a study conducted by Buljubašić and Yau et al., where the average time of surgery was shorter for 15 minutes in the group of patients with laparoscopic appendectomy, which is explained by the good experience of the operator in laparoscopic surgery and consequently with a higher speed of work.[19]

Hospitalization length is an important parameter since it directly affects both the cost of treatment and the psychological trauma of the child as a result of staying in the hospital. The average length of hospitalization was shorter for 2 days in the laparoscopic group of patients compared to patients treated with open apendectomy with a high level of statistical significance. Markar et al. also found that the length of hospitalization was shorter in the laparoscopic group of patients, whether it was complicated or uncomplicated appendicitis.[11] Similar results can be found in other meta-analyzes, which is not surprising since postoperative pain is reduced in minimally invasive surgery, which allows early mobilization and faster return to daily activities.[6,7,9,17] However, in the last published meta-analysis of the authors Dai and Shuai, a significant difference in length of hospitalization was found in adults but not in the pediatric population.[18] The discrepancy in the results of the meta-analysis of various authors is probably due to the difference in social standards, the health insurance system and general health policy.[17,20]

The duration of parenteral analgesia is the parameter by which the severity of postoperative pain[17] is quantitatively estimated, which is expected to be lower in laparoscopically treated patients given the lower invasiveness of the procedure. Consequently, this group of patients would require a shorter duration of analgesia, as shown by the results of our study. The same was noted by Wei et al.[7], as well as other authors in their studies.[8,9,21] Tsai et al. and Ohtani et al. did not find a statistically significant difference in the duration of parenteral analgesia.[6,22] Assessment of postoperative pain can be complicated due to its subjectivity, so some authors in their studies serve a visual analogue pain scale (VAS). While some studies did not record a lower pain score in laparoscopic patients[23,25], Sauerland et al. found in their review article that included 67 studies that the VAS score after laparoscopy was lowered by 8 mm on a 100 mm scale.[10]

There are not many studies that have taken into consideration the period of drainage, although this is one of the factors associated with postoperative recovery. In a study conducted by Yu et al. the drainage period was significantly shorter after laparoscopic appendectomy, which coincides with the results of our study.[26] Eskandaros et al. explained that this is due to the fact that laparoscopy provides the possibility of exploring a large part of the abdominal cavity with facilitated lavage and suction of the purulent content.[27]

Postoperative complications represent the best parameter for assessing the safety of a procedure.[18] In our study, the complications are divided into minor and major. Percentually more minor complications occurred after laparoscopic appendectomy (7.9%) compared to open (5.8%), however, the number of major complications was dominated by a group of patients treated openly (4.8% vs 3.4%). These differences are not statistically significant. Dai and Shuai reported in their meta-analysis that the incidence of postoperative complications between the two groups is significantly different in adult patients, but not in children, which is in line with our results.[18] Ohtani et al. also obtained similar results,[6] and in a study by Markar et al. there was no statistically significant difference between groups in cases of uncomplicated appendicitis, but it is complicated, in favor of laparoscopic appendectomy (15.3% versus 29.3%).[11]

Complications after apendectomy, which most authors distinguish as the most important are infection of the wound, intra-abdominal abscess, postoperative ileus.[7,9] Infection of the wound is the most common complication and has a strong influence on the period of convalescence and quality of life. In a cohort study conducted by Biondi et al. 43.4% of wound infections were reported in the group of patients treated with open apendectomy, and only 13.8% in the laparoscopic group. The difference is statistically significant.[2] Similar results were found in most other studies taken into consideration[6,7,9,11,17], with the exception of the meta-analysis of Dai and Shuai, where a significant difference was found in adults but not in children.[18] It is assumed that the reason for a smaller number of infections in the laparoscopic approach is the removal of appendix using an endo-sack or a trocar so that the inflamed appendix does not come into contact with the surgical incision.[9] As a second reason, a greater incision is indicated in open apendectomy, which is particularly pronounced in obese patients.[18] In our study, only one infection of the wound was reported after open apendectomy, and none after laparoscopy. However, data were available to us only for those complications that occurred during the hospitalization period or those that required rehospitalization. This had the greatest impact on the data on wound infection, since most of them were treated conservatively.

Intraabdominal abscess (IAA) is one of the most serious complications after apendectomy.[9] In our study, three IAAs were recorded, and all reported after an open apendectomy. However, the difference is not statistically significant. In almost all studies taken into consideration between laparoscopic and classically performed patients, a similar incidence of IAA was found.[6,7,9,17,18] In a study by Markar et al. In the case of uncomplicated appendicitis, there was also no significant difference in the comparison of the two groups, however, it is in complicated apendicitis where laparoscopic appendectomy is associated with a significantly higher incidence of IAA in children (3.69 versus 2.59%).[11] There are a number of previously published studies that have shown increased IAA formation after perforated appendicitis after laparoscopic appendectomy, both in children and adults.[28,30] Gupta et al. as a reason for this, indicated the contamination of the peritoneal cavity as a result of aggressive manipulation with infective apendix in laparoscopy.[31] Another explanation is that induction of pneumoperitoneum causes mechanical diffusion of the bacteria into the peritoneal cavity.[11] Katkhouda et al. announced that the introduction of standardized surgical techniques would reduce the incidence of IAA following laparoscopic appendectomy.[32] However, in our study, no IAA was found after laparoscopy.

Postoperative ileus as a complication is not recorded in the results of our study. The results of other studies have emphasized that laparoscopic approach results in a reduced incidence of postoperative ileus, where the cause of minor adhesion after laparoscopy is due to less manipulation with bowel vertebrae and earlier mobilization.[7,9,17]

Of the remaining complications, it would be useful to point out that stump apendicitis has occurred in one patient treated with laparoscopic appendectomy. This is one of the few complications that implies recurrent inflammation of the residual apendix after it is only partially removed during apendectomy.[33] Although, according to theory, the possibility of the formation of stump apendicitis is greater after laparoscopic appendectomy, 66% of reported cases occurred after open access.[4] Esposito et al. in their meta-analysis, they found 7 studies with reoperative data, but none of them showed a significant reduction in reoperation after laparoscopic appendectomy compared to open.[9] In our study, the difference between groups is also not significant.

Finally, it should be emphasized that each surgeon should develop his own operational approach, taking into account the clinical situation, patient benefits, his own surgical skills (and team skills), and the specific organizational background in which he is working.[35] This study may be a guidance to surgeons when selecting an operational approach, as well as to encourage further research on the same or similar topic.

Conclusion

The length of hospitalization in patients treated with laparoscopic appendectomy is significantly shorter compared to patients treated with open apendectomy. Anesthesia time in patients treated with laparoscopic appendectomy is significantly longer in relation to patients treated with open apendectomy. Level of postoperative pain, i.e. the period of analgesic administration in patients treated with laparoscopic appendectomy is significantly lower in relation to patients treated with open apendectomy. The period of drainage in patients treated with laparoscopic appendectomy is significantly shorter compared to patients treated with open apendectomy. The number of postoperative complications, including wound infections, in patients treated with laparoscopic appendectomy does not differ significantly from those treated with open apendectomy.

Author contributions

KK conceived of the study and participated in its design and coordination as well as helped to draft the manuscript; also read and approved the final manuscript.

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Conflict of interest

All authors declare that they have no conflict of interest.

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