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ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Postoperative recovery assessment after appendectomy in children – laparoscopic versus open technique

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SUMMARY

Introduction/Objective Surgery is a "gold standard" in treating the acute appendicitis in pediatric patients. The aim of the study was to determine the effect of open and laparoscopic appendectomy on postoperative recovery, return to everyday activities, and the quality of life in patients operated on for acute appendicitis.

Methods This prospective study was performed at the Institute for Children and Youth Healthcare of Vojvodina, over a period of 10 months. This study was approved by the Ethics Committee of the Institute. All patients treated for acute appendicitis by surgery were divided into two basic groups – open or laparoscopic appendectomy – and into three subgroups, depending on the degree of appendicitis. We analyzed the length of surgery, oral intake, establishing peristalsis, hospital stay, return to everyday activities, and the quality of life after surgery.

Results Laparoscopic technique was performed in 60 patients (48%), and the open method in 65 patients (52%). In 66.7% of laparoscopically treated patients, peristalsis occurred earlier ($p < 0.001$), length of hospital stay was shorter (5.95 ± 1.21 days) ($Z = -3.054$; $p = 0.002$), the total score of daily activities showed a statistically significantly better score ($Z = -7.667$; $p = 0.000$), and they achieved a high level of quality of life significantly earlier ($t = 2.773$; $p = 0.007$).

Conclusion The advantages of minimally invasive surgery in the treatment of acute appendicitis in children are reflected in the faster re-establishment of everyday functioning, faster recovery, and a good quality of life.

Keywords: appendicitis; minimally invasive surgery; return to everyday activities; quality of life; children

INTRODUCTION

Acute appendicitis is one of the most common abdominal emergencies in pediatric population. The lifetime risk of developing appendicitis is 6–8%, with a peak incidence in the teenage years [1]. The cause of appendicitis is an obstruction of the appendix, either from inflammation of the wall or a fecalith. Typical symptoms of appendicitis are acute abdominal pain, fever, nausea and vomiting. Appendicitis in pediatric patients is less likely to present in a classic manner than commonly thought [2]. Considering the stage of inflammation, appendicitis can be classified as noncomplicated and complicated. Complicated appendicitis is defined as gangrenous or perforated appendicitis, suppurative appendicitis, or appendicitis with an abscess formation, periappendicular mass, or fecal peritonitis [3]. In children, complicated appendicitis is relatively common, and the rate of perforated appendicitis varies with age, the presence of obesity, socioeconomic status, and healthcare access. High rate of postoperative morbidity in complicated cases in children require prompt and precise diagnosis, as well as adequate treatment [4].

Surgical treatment is a "gold standard" in treating this condition. Surgeons still use the open surgical technique described back in the 18th century. Rising popularity of minimally-invasive surgery in other surgical fields implemented this technique in pediatric surgeon's everyday practice. First laparoscopic appendectomy was performed by Kurt Semm in 1981 [5]. Eight years later, Thom Lobe performed this technique in a child [6]. Compared to the open technique, laparoscopic appendectomy, like any minimally invasive technique, causes less tissue trauma, which is associated with less postoperative pain, shorter hospital stay, faster recovery, and better cosmetic result.

There has been an increased interest in the conservative management of appendicitis over the last 20 years [7, 8]. Conservative (non-operative) management for carefully selected children with acute appendicitis has been described. In patients with initial appendicitis, non-operative treatment, with the use of antibiotics, could be applied, with healing in most of them. The use of antibiotics in these patients may be sufficient for cure, if there are no sure indications for surgery, such as the presence of peritonitis or signs of perforation [9, 10, 11].

Although laparoscopic appendectomy gained popularity among many surgeons, the advantage of laparoscopic appendectomy is still the subject of research [3].

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The aim of the study was to determine the effect of both methods, the open technique and laparoscopic appendectomy, on early postoperative recovery, return to everyday activities, and the quality of life in pediatric patients operated on for acute appendicitis.

METHODS

This prospective study was performed at the Clinic for Pediatric Surgery, Institute of Children and Youth Healthcare of Vojvodina, over a period of 10 months. This study was approved by the Ethics Committee of the Institute. We analyzed all patients treated for the acute appendicitis by surgery during this period. All patients with acute appendicitis, American Society of Anesthesiologists (ASA) classification (general state) I–III, whose parents had given written consent, were included in research. Patients who were classified as ASA IV and V, and without written consent, were excluded.

All patients operated on for acute appendicitis were divided into two basic groups, in relation to the surgical technique: open or laparoscopic appendectomy. Conversion, intraoperative change of laparoscopic to open access was performed due to a complex operative finding. It is important to emphasize that the decision to make a conversion is due to a proper intraoperative surgeon judgment which provides the best possible outcome for the child.

Then, all the patients operated on were divided into three subgroups, depending on the degree of appendicitis (negative, uncomplicated, and complicated appendicitis). Appendicitis with perforation or with abscess was classified as complicated appendicitis, and those remaining were classified as uncomplicated. Intraoperative assessment of the degree of appendix was performed by a surgeon macroscopically, after which all surgical specimens were transferred to the histopathology department for histopathological analysis. Age, sex, and ASA classification score were analyzed preoperatively. Type of surgery, the degree of appendicitis, and the length of surgery were analyzed during surgery. Oral intake, establishing peristalsis, length of hospitalization, restitution of daily activities using Activity Assessment Scale (AAS) modified for children, and the quality of life of patients after surgery, were analyzed after surgery.

AAS is a measure of functional activity designed as part of the postoperative period analysis. This scale measures a wide degree of activity, and in the form of a questionnaire, it is easily and quickly filled out by the patient. AAS modified for children was used to measure activity every postoperative day, during the first five days, a month, three, and six months after surgery. The patient's ability to perform activities was measured through nine categories, from behavior in hospital bed to the ability to go to school and engage in sports activities after dismissing. All items have response categories ranging 1–5. The response categories for the activities are as follows: (1) no difficulty, (2) little difficulty, (3) difficult, (4) very difficult, (5) unable to do so.

We especially observed the quality of life of patients after surgery on the basis of the child's health condition, limitations in performing daily activities, physical pain, the child's satisfaction, and anxiety. We used the modified questionnaire SF 10 for children during the period of six months after surgery.

Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics, Version 20.0 (IBM Corp., Armonk, NY, USA). Descriptive statistical methods were used. The significance of the differences between the two groups was determined using the t-test of independence or the Mann–Whitney U-test, depending on the normality of the distribution determined by the Shapiro–Wilk test. Significance between categorical variables was determined using the χ^2 test. One-factor analysis of variance (ANOVA) with repeated measurements was used to determine the difference between the quality of life after the first, third, and sixth months. Statistically significant correlations between days of hospitalization with daily activities were determined by Pearson's correlation analysis and linear regression model. The influence of age and sex on the type of surgery and the degree of inflammation as potential predictors of performing daily activity in the observed time periods was analyzed by multiple regression analysis. For daily activities in the examined time intervals, the area under the curve was determined by the receiver operating characteristic (ROC) curve analysis. Values of $p < 0.05$ were considered statistically significant.

RESULTS

Over a period of 10 months, we operated on 125 patients, aged 2–18 years, due to acute appendicitis. Laparoscopic technique was performed on 60 patients (48%), and the open method on 65 (52%). Conversion (operative technique changed from laparoscopic to open method) was made in four patients, and they were included into the open group. There were no statistically significant differences between the treatment groups with respect to mean age, sex distribution, preoperative risk assessment, the degree of appendix inflammation. In both treatment groups, most subjects belong to ASA I category, and only one child belongs to ASA III (Table 1). The mean operative time was 65 minutes (range 25–185 minutes) when laparoscopy was used. Open technique required statistically significantly shorter period of time (mean 49.38 minutes, range 25–130 minutes; $p < 0.001$). In the majority of laparoscopically treated patients (66.7%), peristalsis occurred on the first postoperative day, whereas in 78.5% of the patients who were classically operated on it was registered one day later, which made a significant difference ($p < 0.001$). Oral feeding was initiated earlier in patients operated on laparoscopically (in 85% on the first postoperative day) compared to those operated on using open technique (on the second postoperative day in 84.6%) ($\chi^2 = 82.763$; df = 4; $p = 0.000$).

Length of hospital stay in children operated on by laparoscopy was 5.95 ± 1.21 days and by open technique it was

Table 1. Demographics data

Demographics	Laparoscopic (n = 60)	Open (n = 65)	Total (N = 125)	Significance
Sex ratio (M/F)	37/23	39/26	76/49[&]	0.859[‡]
Age (yr) (Mean ± SD)	12.17 ± 3.55	11.09 ± 3.69		0.100[†]
Degree of inflammation				
negative appendix n (%)	5 (8.3)	3 (4.6)	8 (6.4)	0.480[#]
uncomplicated n (%)	25 (41.7)	30 (46.2)	55 (44.0)	0.500[‡]
complicated n (%)	30 (50)	32 (49.2)	62 (49.6)	0.799[‡]
American Society of Anesthesiologists classification				
I n (%)	37 (61.6)	50 (76.9)	87 (69.6)	0.163[‡]
II n (%)	22 (36.7)	14 (21.5)	36 (28.8)	0.182[‡]
III n (%)	1 (1.7)	1 (1.5)	2 (1.6)	-

[&]χ^2 test (χ^2 = 6.950; df = 1; p = 0.008);
[†]t-test between groups;
[‡]χ^2 test between groups;
[#]Fisher exact test between groups

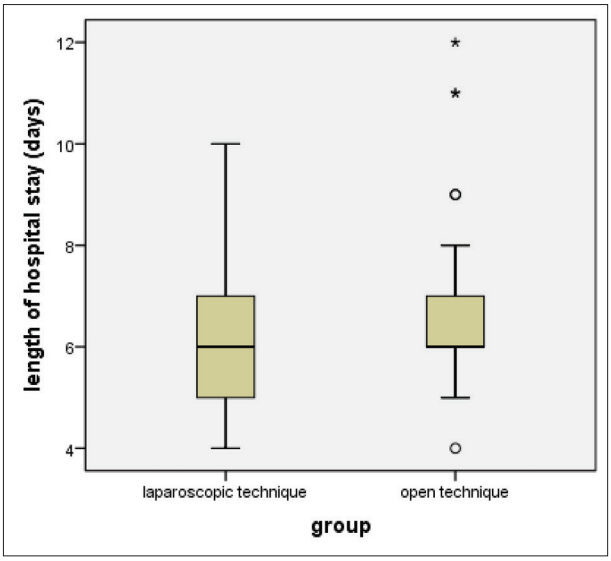


Figure 1. Distribution of length of hospitalization in days in relation to the method of surgery

6.63 ± 1.04 days, which is significantly longer (Z = -3.054; p = 0.002) (Figure 1).

AAS modified for pediatric population was used for measuring period of time needed for recovering to everyday activities. These results were compared for the first, third, seventh postoperative day, as well as for one, three, and six months after surgery. It is noticed that daily activities are established faster after minimally invasive surgery in each observed time period. The difference was statistically relevant on the first (Z = -7.783; p = 0.000) and third postoperative day (Z = -3.955; p = 0.000). The total score of daily activities showed a statistically significantly better overall score for the group of laparoscopic appendectomies (Z = -7.667; p = 0.000) (Figure 2).

We analyzed the influence of special categories such as the technique of surgery, the degree of inflammation of the appendix, sex, and age on everyday activities.

From the partial influences on the performance of everyday activities after the first and third postoperative day, the method of operation and the degree of inflammation have a statistically significant influence. From the seventh day to six months after the operation, only the technique of operation held a statistically significant (p < 0.05) effect (Table 2). Results of the Mann–Whitney U-test showed significantly better overall record of daily activities for a group of laparoscopic appendectomy (Z = -7.667; p = 0.000).

Table 2. Influence of sex, method of operation, degree of inflammation, and age of the patients on daily activities in the examined times

Parameter	Beta	Significance	R
1st day			0.715
Sex	0.107	0.100	
Group	-0.698	**< 0.001**	
Degree of inflammation	-0.125	**0.048**	
Age	0.015	0.818	
3rd day			0.430
Sex	0.028	0.735	
Group	-0.350	**< 0.001**	
Degree of inflammation	-0.239	**0.005**	
Age	-0.083	0.324	
7th day – 6th month			0.286
Sex	0.087	0.340	
Group	-0.188	**0.038**	
Degree of inflammation	-0.171	0.061	
Age	-0.089	0.323	

Values in bold are statistically significant

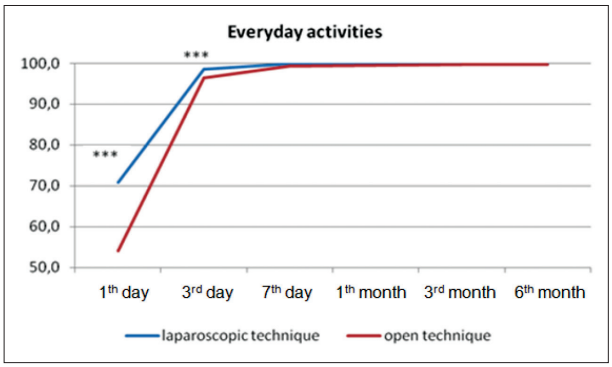


Figure 2. Total score of daily activities in the examined times for the examined groups

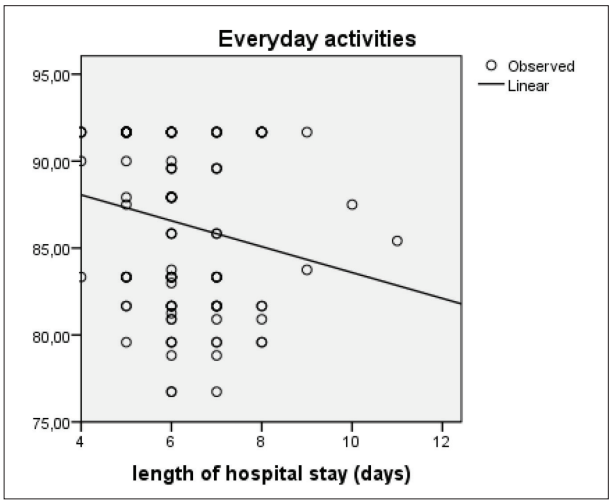


Figure 3. Influence of hospital length on performing daily activitiesto the method of surgery

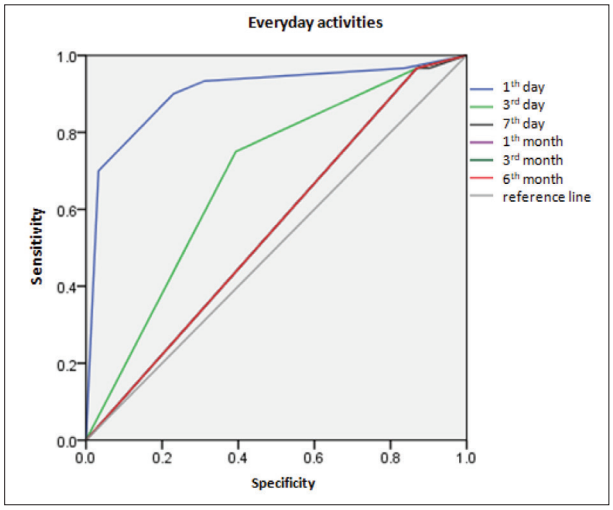


Figure 4. Receiver operating characteristic curve analysis of performing everyday activities by days

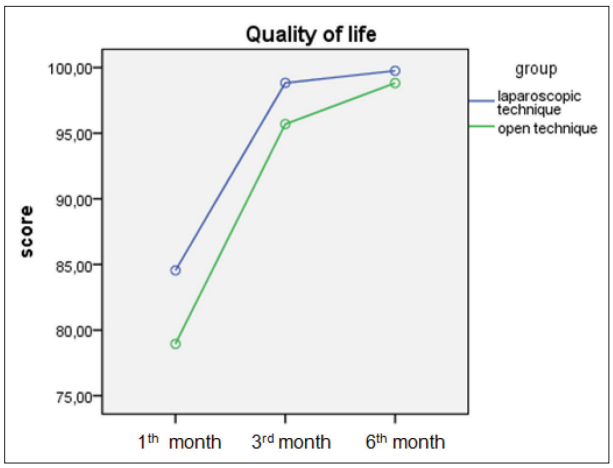


Figure 5. Quality of life at one month, three months, and six months after surgery in laparoscopic and open technique groups

The influence of the length of hospitalization on daily activities is shown in Figure 3, where a significant negative correlation was observed between daily activities ($r = -0.190$; $p = 037$) and the length of hospitalization.

ROC analysis results suggested that randomly chosen child operated on by laparoscopy performed better in everyday activities than a child operated on using open technique in 88.8% of cases on the first and in 68% of cases on the third postoperative day (area under the ROC curve – AUC = 0.888; $p = 0.000$; 95% CI = 0.825–0.951 and AUC = 0.680; $p = 0.000$; 95% CI = 0.586–0.778, respectively). There was no significant separation in other time intervals examined (Figure 4).

In all examined indicators of the quality of life, children of the laparoscopic group had a higher score. Statistically significant ($p < 0.01$) is the fact that they complained less about pain and were more satisfied. Children with acute appendicitis operated on by laparoscopy achieved a high level of the quality of life significantly earlier ($t = 2.773$; $p = 0.007$). The quality of life increased gradually over the time ($F = 7.404$; $p = 0.007$), with significantly better results in the laparoscopy group after the first and third month (Figure 5).

Over 95% of parents reported their children's quality of life as excellent six months after the surgery in all the patients. There was no difference in the quality of life between children in these two groups.

DISCUSSION

The advantages of laparoscopic surgery in relation to open surgery are described in many papers in terms of postoperative recovery, reduced pain, significantly better aesthetic result, and a total number of complications [12, 13, 14]. However, many studies have described that the length of the operation, and even the cost of treatment, are higher with the laparoscopic technique compared to the open one [15, 16]. In our study, the mean operative time was 65 minutes (range 25–185 minutes) when laparoscopy was used. The open technique required statistically significantly shorter period of time (mean 49.38 minutes, range 25–130 minutes; $p < 0.001$). Recent studies have indicated that the operative time for laparoscopic appendectomies in uncomplicated appendicitis is even shorter compared to the open technique. One study showed that the average operative time for laparoscopic appendectomies today is 41 minutes in the trainee group *vs.* 39 in the surgeons group [16]. Another meta-analysis shows that increased experience of surgeons and nursing staff indeed decreased the operating time [17].

Analyzing immediate postoperative recovery in our study, in majority of the laparoscopically treated patients (66.7%), peristalsis occurred faster, oral feeding was initiated earlier. These results, which indicate a statistically significant difference between the two groups of patients, definitely confirm the advantage of the laparoscopic approach in resolving acute appendicitis. Seqsaqa et al. [13] compared the results of open and laparoscopic appendectomy in complicated appendicitis. Patients could tolerate oral intake after 2.37 ± 0.85 days in the open appendectomy group *vs.* 1.9 ± 0.71 days in the laparoscopic appendectomy group, which was significantly faster with laparoscopic appendectomy ($p = 0.025$). Meta-analysis of Neogi et al. [3] showed that the laparoscopy group has a statistically significant shorter time taken to oral intake as compared to open appendectomy, with almost no statistical heterogeneity.

The length of hospital stay in children operated on by laparoscopy was significantly shorter. Patients of both treatment groups with complicated appendix had a statistically significantly longer hospital stay than children with negative and uncomplicated appendix. According to results of some recent studies, the length of hospitalization after laparoscopic appendectomy is significantly shorter compared to open appendectomy, which is explained by faster postoperative mobilization of the patient and recovery. In this way, costs of treatment are reduced and the return of patients to daily life activities is accelerated [3, 13]. Most authors agree that the length of hospital stay is shorter for patients operated on with laparoscopy. Median hospital stay for laparoscopic appendectomy varies among authors. Some report a median stay of three days in cases of simple

appendicitis and 5.2 days in cases of peritonitis. In other studies, it varies 2.06–4.1 days [3].

Restoring daily functioning is an important measure of patient satisfaction. The AAS is a measure of functional activity designed as part of the postoperative period analysis. This scale measures a wide range of activities in the form of a questionnaire that is easily filled out by the patient [18, 19]. This instrument was constructed to analyze the results of a multicenter study after open and laparoscopic operations for inguinal hernias [18]. McCarthy et al. [20] classified physical activities at 13 levels of physical activity, and scoring was done according to the degree of difficulty in performing them.

The questionnaire created for the purposes of this study is a modified form of the AAS questionnaire, with the necessary adaptation to children's age. Physical activities were classified to four or five levels according to the difficulty in performing them. Then, we analyzed them on the first, third, seventh postoperative day, one month, three months, and six months after the operation. In our study, it was very clearly observed that a significantly higher number of patients from the laparoscopy group did not have or had minimal difficulties in getting up, sitting, and walking compared to the group of open appendectomies. At the end of the observed period, the results of the analysis were equalized. It can be concluded on the basis of the mentioned analysis that faster recovery of children after laparoscopic appendectomy was confirmed, in relation to the therapeutic group of open appendectomies.

The effects of treatment on the functioning of patients and on their quality of life have been the subject of much research for decades [21, 22, 23]. When the postoperative course was analyzed through the prism of the quality of life of patients, the questionnaire SF-10, which was modified for the needs of our study, was especially emphasized in clinical practice. This questionnaire was completed by parents and contains 10 questions to assess physical and psychosocial categories.

Within this analysis, limitations in performing daily activities, the presence of pain, child satisfaction, and anxiety after surgery were assessed. In our study, a statistically significantly better quality of life is clearly seen in the group of children laparoscopically operated on, especially in the first three months after surgery, which is another confirmation of faster recovery and return to daily activities after laparoscopic appendectomies.

The quality of life increased gradually over the time in all the patients, but in the first and the third month after surgery it was significantly better in the group of patients operated on with the minimally invasive approach.

CONCLUSION

It is already known that laparoscopic appendectomy, like any minimally invasive technique, causes less tissue trauma, which is associated with less postoperative pain, shorter hospital stay, and better cosmetic result. The advantage of minimally invasive surgery in the treatment of acute appendicitis in children is reflected in the faster re-establishment of everyday functioning and, therefore, a faster overall recovery, resuming normal activities, and a good quality of life.

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Процена постоперативног опоравка након апендектомије код деце – лапароскопска у поређењу са класичном техником

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САЖЕТАК

Увод/Циљ Хируршко лечење представља „златни стандард" у третману акутног апендицитиса код педијатријских болесника.

Циљ студије је да се утврди ефекат отворене и лапароскопске технике на постоперативни опоравак, повратак свакодневним активностима и квалитет живота болесника оперисаних због акутног апендицитиса.

Методе Ова проспективна студија рађена је на Институту за здравствену заштиту деце и омладине Војводине током десет месеци. Студију је одобрио Етички одбор Института. Сви болесници хируршки лечени због акутног апендицитиса подељени су у две основне групе у односу на хируршку технику: отворена или лапароскопска апендектомија и у три подгрупе, у зависности од степена упале апендикса. Анализирали смо дужину операције, започињање оралног уноса, успостављање перисталтике, дужину хоспитализације, повратак свакодневним активностима и квалитет живота после операције.

Резултати Лапароскопска техника изведена је код 60 болесника (48%), а отворена метода код 65 (52%). Код већине лапароскопски оперисаних болесника (66,7%) перисталтика је успостављена раније ($p < 0,001$), хоспитализација је била краћа (5,95 ± 1,21 дана) ($Z = -3,054$; $p = 0,002$), укупни скор дневних активности показао је статистички значајно бољу укупну вредност ($Z = -7,667$; $p = 0,000$) и постигнут је висок ниво квалитета живота знатно раније ($t = 2,773$; $p = 0,007$).

Закључак Предност минимално инвазивне хирургије у лечењу акутног апендицитиса код деце огледа се у бржем поновном успостављању свакодневног функционисања, бржем опоравку и добром квалитету живота.

Кључне речи: апендицитис; минимално инвазивна хирургија; повратак свакодневним активностима; квалитет живота; деца