A COMPARATIVE ANALYSIS OF LAPAROSCOPIC APPENDECTOMY IN RELATION TO THE OPEN APPENDECTOMY IN CHILDREN
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UPOREDNA ANALIZA LAPAROSKOPске APENDEKTOMIJE U ODNOSE NA OTVORENU APENDEKTOMIJU KOD DECE
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ABSTRACT
Acute inflammation of the appendix in childhood usually requires an appendectomy. Surgical methods are open appendectomy (OA) and laparoscopic appendectomy (LA). Both have the same goal of removing the appendix.

Data collected from the medical records of children who underwent hospitalization and operation for acute appendicitis have been retrospectively analysed and statistically processed. The patients underwent surgery in 2010 at University Children’s Hospital in Belgrade, and the methods that were used were open appendectomy (OA) and laparoscopic appendectomy (LA). The analysed data refer to gender, age, length of hospital stay, surgery duration, use of pain management therapy, and antibiotic therapy; complications during surgery, complications after surgery, re-hospitalizations, and reoperations.

A total of 218 children underwent an appendectomy operation, of which 158 (72.5%) underwent OA and 60 (27.5%) underwent LA. The average age of patients who had OA was 11.44 years, and 10.87 years for those who underwent LA. The surgery duration was significantly longer for LA (45.3 vs. 42.1 minutes, \( p = 0.003 \)). The total number of postoperative complications was lower in LA (1 vs. 12), but there was no statistically significant difference. The number of hospital stay days was significantly lower in LA (3.48 vs. 5.45 days), with a high statistical difference, \( p = 0.00 \).

The advantages of LA compared with OA are shorter hospital stay, lower total number of intraoperative and postoperative complications, and fewer reoperations. The advantage of OA compared with LA is shorter surgery duration.

Keywords: appendicitis, appendectomy, laparoscopy, length of hospital stay, complications.

SAŽETAK
Akutna upala crvuljka u decem uzrastu najčešće zahteva izvođenje hirurške intervencije-apendektomije. Hirurške metode koje se koriste su otvorena apendektomija (OA) i laparoskopска apendektomija (LA), i obe imaju isti cilj, odstranjenje apendiksa.

Retrospektivno su analizirani i statistički obrađeni podaci pokušani iz istorija bolesti hospitalizovani i operisanih dece zbog akutne upale crvuljke. Bolesnici su operirani 2010. godine u Univerzitetskoj dečjoj klinici u Beogradu, metodama otvorene apendektomije (OA) i laparoskopske apendektomije (LA). Analizirani podaci se odnose na pol, godine starosti, dužinu bolničkog lečenja, trajanje hirurške intervencije, primenu terapije bola i antibiotika, komplekscije tokom operacije, komplikacije posle operacije, ponovne hospitalizacije i ponovne operacije.

Ukupno je operisano 218 dece od kojih je 158 (72.5%) operisano OA a 60 (27,5%) LA. Prosečna starost bolesnika operisanih OA je bila 11.44 godine, odnosno 10.87 godina onih kod kojih je primenjena LA. Vreme trajanje hirurške intervencije je značajno duže kod LA (45.3 vs. 42.1 minuta, \( p = 0.003 \)). Ukupan broj postoperativnih komplikacija je manji kod LA (1 vs. 12), ali ne postoji statistička značajna razlika. Broj dana bolničkog lečenja je znatno kraći kod LA (3.48 vs. 5.45 dana) i postoji visoka statistička razlika \( p = 0.00 \).

Prednost OA u odnosu na LA je kraća dužina bolničkog lečenja, manji ukupan broj intraoperativnih i postoperativnih komplikacija i manje reoperacije. Prednost OA u odnosu na LA je kraće vreme trajanja operacije.

Keywords: apendicitis, apendektomija, laparoskopska, dužina bolničkog lečenja, komplikacije.
INTRODUCTION

Acute inflammation of the appendix (appendicitis) is considered to be the most common disease in surgery that requires performing an emergency operation. The incidence of acute appendicitis is 1.1/1000 inhabitants per year in developed countries, and the risk that the population has the disease is 7.5% during a lifetime. It is equally common in both sexes, with the highest incidence between 10 and 19 years of age (1). It is diagnosed in emergency children’s clinics in approximately 8% of children who present with acute abdominal pain (2, 3). In 1894, McBurney was the first to apply the open appendectomy (OA) surgical method, which is currently successfully used (4). As a basic surgical technique, it has become an integral part of the catalogue of mastering surgical skills (5). In 1973, Gans successfully introduced laparoscopy in the paediatric population (6), which was an introduction to further development of this method. The first laparoscopic appendectomy (LA) was described by Kurt Semm, a German gynaecologist in 1983 (7). In contrast to the open method, LA became a new alternative in the late 1980s.

The aim of the present study was a comparison of LA with OA by length of hospital stay, surgery duration, intraoperative and postoperative complications, and re-hospitalizations.

MATERIALS AND METHODS

A retrospective comparative study was made. Data were gathered from 218 medical records of children under the age of 18 who were hospitalized for acute appendicitis and were surgically treated with OA and LA methods in 2010 in the abdominal and laparoscopic surgery ward of the Center for Pediatric Surgery at the University Children’s Hospital in Belgrade.

The following variables have been analysed: surgery type, gender, age of the child, hospital stay length, surgery duration, complications during the operation, postoperative complications, preoperative leukocyte count, body temperature, pain therapy, antibiotic use, re-hospitalization and reoperations.

Children who underwent an appendectomy in some other surgical interventions and patients who underwent an operation in other health institutions in Serbia and then were moved to the University Children’s Hospital in Belgrade because of postoperative complications have been excluded from the analysis.

Surgical techniques

An open appendectomy involves opening the abdominal cavity by cutting the lower right quadrant of the abdomen and removing the appendix. The additional use of retractors is necessary to make the operative field wider in order for the appendix to be accessed.

Laparoscopy involves visual inspection of the abdominal cavity by using optical instruments and is facilitated by insufflation of CO₂ medical gas. The instruments are brought into the abdominal cavity through three small holes on the stomach. The LA method allows full visualization of the operative field by looking at the screen.

Progress in the development of instruments and components, especially lights, optics, fibre optic transmission, gas insufflation, video equipment, in addition to the development of anaesthesia monitoring, have contributed to safe and more frequent applications of LA. Access to the abdominal cavity with minimal trauma makes LA a minimally invasive surgical technique (8). The clinical advantage of LA compared with OA has been shown in many studies (9, 10). From the beginning of its implementation, the method of laparoscopic appendectomy, as a minimally invasive technique, has been a topic among the professional public and has been a constant object of scrutiny, regarding surgery duration, complications, and length of hospital stay compared with the traditional open method of surgery. A large number of assays, studies of individual health care institutions, meta-analyses, randomized studies, and even national studies have given different opinions regarding the comparison of advantages and disadvantages of these two methods (9-17). Both methods are still used in children and adults. The surgery method is determined by the surgeon’s personal choice, equipment availability and clinical experience. The proponents of LA justify this method by stating that it reduces postoperative pain, shortens hospital treatment, and provides a faster return to daily activities. However, surgeons who prefer OA explain that the classical method is more justified because the duration of the operation is significantly shorter, the percentage of postoperative complications is lower, and the operation costs are lower.

Statistical analysis

The data obtained in the research have been analysed by descriptive and analytical statistics. Continuous data were expressed as the mean ± SD, and categorical data were expressed as percentages. Normality of the data distributions were tested with Kolmogorov Smirnov tests and graphical depictions (histogram, QQ plot, and a detrended QQ plot). Continuous variables were compared using Student’s t-test (normal distribution) or the Mann–Whitney U-test (non-normal distribution). A chi square test was appropriate for categorical variables. P-values ≤ 0.05 were considered to be statistically significant. The results are presented in tables and graphs. All statistical analyses were performed using SPSS® statistical software, version 15.0 (SPSS Inc., Chicago, IL, USA).

RESULTS

The research includes a total of 218 children who underwent acute appendicitis surgery at the University Chil-
The OA method was used in 158 (72.5%) cases, and LA was used in 60 (27.5%). The number of male children who underwent the OA method was 86 (54.4%), and the number of female children was 72 (45.6%); the number of male children who underwent the LA method was 23 (38.3%) compared with 37 (61.7%) females. The ratio of distribution according to gender and the applied surgery methods of OA and LA shows that there is no significant difference between gender ($X^2 = 3.886$, $df = 1$, $p = 0.49$) and that LA was more frequently performed in females. The age range of children in the OA group was from 4-17 years old, with an average age of 11.2 ± 3.5, while in the LA group, the age ranged from 5-18 years, with an average age of 12.1 ± 3.5 years; there was no statistically significant difference ($t = 0.488$, $df = 2$, $p = 0.61$) (Table 1).

According to the surgeons’ findings, the following types of inflammation were present during the operation: catarrhal, phlegmonous, gangrenous, perforated, and peritonitis. A total of 158 children underwent the OA method, of whom 45 children (28.5%) had the catarrhal type of inflammation, 49 (31%) had phlegmonous, 54 (34%) gangrenous, 7 (4.4%) perforated, and 3 (4.4%) peritonitis. From a total of 60 children who underwent the LA method, 38 (63.3%) had the catarrhal type of inflammation, 16 (26.7%) had phlegmonous, 3 (5%) had gangrenous; there was no perforate peritonitis or conversion (Table 2).

The average OA surgery duration was 42.12 ± 8.47 minutes, while in the group of children who underwent the LA method, the average surgery duration was 45.25 ± 6.20 minutes. The OA surgery duration is shorter than LA, and there is a statistically significant difference ($t$-test = -2.990, $df = 1$, $p = 0.03$) (Table 3).

The average duration of hospitalization was 5.45 and 3.48 days for OA and LA, respectively; there is a statistically significant difference, $p = 0.00$ (Table 3).

Bleeding and injuries of hollow organs were the intraoperative complications that were analysed. Bleeding during surgery occurred only in children who underwent OA, and it was observed in 3 of 158 children, i.e., 1.9%. From a total of 60 children who underwent the LA method, bleeding during surgery did not occur. There were no hollow organ injuries in either applied method. There is no statistically significant difference in the occurrence of intraoperative complications in relation to the type of operation ($X^2 = 0.180$, $df = 1$, $p = 0.672$) (Table 3).

The postoperative complications during hospitalization were: increased body temperature (BT) that lasted over 48 hours, abscess, ileus, bleeding, wound infection, peritonitis, and reoperation. In OA, 2 children, or 1.26%, had increased body temperature as a reactive response to tissue trauma, while one child had increased BT in LA, i.e., 1.6% (1/60). A total of 10 children who underwent OA surgery had increased body temperature associated with other postoperative complications (abscess, wound infection, and reoperation): 3 abscesses, i.e., 1.89% (3/158), 6 wound infections, i.e., 3.7% (6/158), and one reoperation, i.e., 0.63% (1/158). In LA, there were no postoperative complications (0/60). There was no statistically significant difference in relation to postoperative complications and surgery method ($X^2 = 7.150$, $df = 4$, $p = 0.128$). The frequency of re-hospitalization in the first 30 days after surgery did not differ significantly in children who underwent the OA method in comparison to LA ($X^2 = 0.000$, $df = 1$, $p = 0.95$) (Table 3).

### Table 1. Comparison of gender and age with the method of operation

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>OA $n=158$</th>
<th>LA $n=60$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>86 (54.4%)</td>
<td>23 (38.3%)</td>
<td>0.049</td>
</tr>
<tr>
<td>Female</td>
<td>72 (45.6%)</td>
<td>37 (61.7%)</td>
<td></td>
</tr>
<tr>
<td><strong>Age, years</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\text{min/ max}$</td>
<td>11.2±3.5</td>
<td>12.1±3.5</td>
<td>0.061</td>
</tr>
<tr>
<td>$\text{min/ max}$</td>
<td>(4-17)</td>
<td>(5-18)</td>
<td></td>
</tr>
<tr>
<td><em>Mean ± (SD).</em></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 2. Intraoperative findings

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>OA $n=158$</th>
<th>LA $n=60$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Catarrhal</strong></td>
<td>4 (28.5%)</td>
<td>38 (63.3%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Phlegmonous</strong></td>
<td>49 (31%)</td>
<td>16 (26.7%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Gangrenous</strong></td>
<td>54 (34%)</td>
<td>3 (5.0%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Perforated</strong></td>
<td>7 (4.4%)</td>
<td>0 (0%)</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td><strong>Peritonitis</strong></td>
<td>3 (1.9%)</td>
<td>0 (0%)</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

### Table 3. Surgery duration, length of hospital stay, intraoperative and postoperative complications and re-hospitalization

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>OA $n=158$</th>
<th>LA $n=60$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surgery duration</strong></td>
<td>42.1±8.5</td>
<td>45.3±6.2</td>
<td>0.03</td>
</tr>
<tr>
<td><strong>Length of hospital stay</strong></td>
<td>5.45±2.94</td>
<td>3.48±1.37</td>
<td>0.00</td>
</tr>
<tr>
<td><strong>Intraoperative complications</strong></td>
<td>3 (1.9%)</td>
<td>0 (0%)</td>
<td>0.67</td>
</tr>
<tr>
<td><strong>Postoperative complications</strong></td>
<td>12 (6.9%)</td>
<td>1 (1.7%)</td>
<td>0.12</td>
</tr>
<tr>
<td><strong>Re-hospitalization</strong></td>
<td>4 (2.5%)</td>
<td>1 (1.7%)</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*Mean ± (SD); *total; *up to 30 days due to complications

### Table 4. Leukocyte count, antibiotic treatment and pain reduction therapy

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>OA $n=158$</th>
<th>LA $n=60$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Le (x 109/L)</strong></td>
<td>13.4±8.56</td>
<td>11.6±4.7</td>
<td>0.02</td>
</tr>
<tr>
<td><strong>min/ max</strong></td>
<td>(4-27.9)</td>
<td>(4.9-28.9)</td>
<td></td>
</tr>
<tr>
<td><strong>Antibiotics</strong></td>
<td>158 (100%)</td>
<td>60 (100%)</td>
<td></td>
</tr>
<tr>
<td><strong>Pain reduction therapy</strong></td>
<td>100%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

*Le-leukocyte, mean ± (SD);
DISCUSSION

The results of our study related to the distribution by gender and age indicated no statistically significant difference, but the more common method used for appendicitis operations in girls was LA. There was also no statistical significance between surgery type and age, p=0.0061. A retrospective multicentre cohort study in southern California (18), which included 12 regional hospitals and 7,000 children who underwent LA and OA (where children were analysed by gender, age, and complications) showed no statistically significant differences by gender, but there was a significant difference regarding their age, p<0.001. The same study showed that in the ten-year period from 1997-2007, the number of LA operations increased on average in comparison to OA (22% vs. 70%). The percentage of postoperative complications (wound infections and intra-abdominal abscesses) was reduced, and duration of hospital stay was also reduced. The conclusion of this study indicates that the LA method for acute appendicitis treatment in children is always associated with a lower risk of postoperative complications and shorter hospital stay (18). The results of our study are consistent with this study. Postoperative complications such as soft tissue infections and ileus and intra-abdominal abscesses were less common in children who underwent LA in comparison to OA; it is worth noting that the use of LA in children reduces complications. Our study shows no statistically significant differences between the two applied methods in relation to the incidence of postoperative complications regardless of whether the complications were observed individually or collectively. An explanation for this finding can be the fact that a smaller number of children underwent the operation. No similar published data can be found in Serbian literature. The results of a meta-analysis (19), which included 23 comparative studies (retrospective, prospective, and randomized) and a total of 6,477 children who underwent surgery in the period from 1992-2004, showed that LA surgery is shorter, but there were no significant differences. A meta-analysis (20) of all 44 randomized control clinical studies published in English in the period from 1990-2009, which included both children and adults who underwent an operation with one of the mentioned methods (OA and LA), concluded that LA has the following advantages: shorter hospital stay, lower incidence of postoperative pain, better postoperative recovery, and lower complication rate. In this analysis, the average duration of surgery was 12.35 minutes longer for LA compared with OA, and the length of hospital stay was 0.6 days shorter. In summary, increasing use of LA is related to a better therapeutic effect, which recommends LA as a routine method of choice where there is professional staff and technical equipment availability. In our study, the LA operation duration was 3.5 minutes longer and hospitalization was two days shorter compared with OA (Table 3). The only study found in literature (21) that analyses the factors that influence the choice of operative technique draws a conclusion that the appendicitis severity, gender, operation duration, and surgeon experience are significant factors that affect the method choice and that complication rates and hospital stay length are significantly lower in LA. Both techniques have the same value, suggesting that a better selection of patients will provide better treatment. A conclusion of a large study (22) carried out by the University Department of Surgery in Munich that included 1,400 LA during the period from 1991 to 2005 suggests that LA can be introduced to university centres, especially for surgeons who perform fewer operations and where there is a liberal learning policy. Considering the fact that the percentage of complications and reoperations is low (2-4%), the LA method is an ideal laparoscopic training procedure for young surgeons (22). An increased leukocyte count is an integral part of clinical diagnosis confirmation in terms of inflammatory markers (leukocytes, C-reactive protein) as predictors of surgical procedure; they are the most obvious in phlegmonous and perforated appendicitis (23). In our study, the average number of Le in patients who underwent OA was 13.47 ± 8.56 (x 109/L) compared with patients who underwent LA, 11.6 ± 4.7 (x 109/L), which indicates that there is a statistically significant difference (p = 0.022). One American study showed that for LA, the length of hospital stay was only 0.9 ± 0.5 days (24); in contrast, our study had an average length of treatment of 3.48 ± 1.37 days in children who underwent LA. Summarizing the results, we concluded that our study concurs with the results of some other studies.

STUDY LIMITATIONS

This study included patients who underwent an operation in one paediatric hospital in Serbia. The clinical knowledge of surgeons (training for LA application) had a significant impact on the choice of surgical treatment method and its results. More frequent use of OA is associated with a lack of conditions regarding the equipment needed for LA, which does not allow for equal application of these methods based on the surgeon's choice.

CONCLUSION

Laparoscopic appendectomy is nearly three times less frequent than open appendectomy in University Children's Hospital in Belgrade. There is no significant difference in the applica-
tion of these two methods in relation to gender and age of the patients. The average length of hospitalization of children who underwent laparoscopic appendectomy was shorter compared with open appendectomy. There are no differences in the incidence of intraoperative and postoperative complications, or in the frequency of re-hospitalization. A disadvantage of LA is a longer surgery duration. Both methods are applied concurrently in surgery, while surgeons’ clinical experience is crucial for deciding which method will be applied, with restrictions regarding the availability of equipment and educated staff in the abdominal and laparoscopic surgery ward at the Center for Pediatric Surgery of the University Children’s Hospital in Belgrade.

Conflict of interest:
The authors report no conflicts of interest.

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