A Prospective Study Comparing Laparoscopic with Open Appendectomy in Children with Complicated Appendicitis

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Abstract

Background: Due to the difficulty of performing minimally invasive surgery in a region of distorted anatomy and significant inflammation, the decision to do laparoscopic appendectomy in pediatric patients with complicated appendicitis has been controversial. The main advantages of laparoscopic appendectomy in complicated appendicitis, according to several studies, are wound infection avoidance and shorter hospital stays. The study's goal is to investigate and compare various clinical outcomes in children with complicated appendicitis who were treated with laparoscopic appendectomy versus those treated with open appendectomy to determine the value of laparoscopic appendectomy in pediatric patients.

Methods: A prospective randomized controlled clinical trial was done at a single center in TAIF, Saudi Arabia. The study included children aged 14 years or less who were diagnosed with complicated appendicitis. All collected preoperative findings, investigations, type of surgery, operative findings and time, postoperative complications, antibiotic course, length of hospital stay, time to start oral intake, and histopathology report were analyzed.

Results: Operative time was significantly longer in the Laparoscopic Appendectomy (LA) group (73.1 min) than in the Open Appendectomy (OA) group (63.4min) (p=0.0344), while the total hospitalization duration was significantly shorter in the LA group (4.51days) in comparison with the OA group (5.94 days) (p=0.0001). In addition, a statistically significant difference was noted in the resumption of oral intake which was significantly faster in the LA vs OA group (2.1 days) vs (3.4 days) (p=0.0001). We observed that patients in the OA group had a higher rate of incidence of surgical site infection (SSI), which is statistically significant (p= 0.0389).

Conclusions: Our study shows that laparoscopic appendectomy in the expert hands for the management of complicated appendicitis in the pediatric population is considered safe and feasible and should be considered a first choice.

Keywords: Children, complicated appendicitis, open appendectomy, Laparoscopic Appendectomy.

Introduction

In the pediatric population, acute appendicitis (AA) is a prevalent condition that necessitates surgical intervention. Uncomplicated and complicated appendicitis (CA) are two different classifications of appendicitis. CA is detected in up to 30% of patients who have had surgery and is a highly resource-intensive condition [1].

Gangrenous appendicitis (GA), perforated appendicitis, suppurative appendicitis, and appendicitis with an abscess, or peri-appendicular masses are all types of CA that can be diagnosed histologically or intraoperatively [2].

Due to several advantages of minimally invasive surgery, such as a lesser percentage of surgical site infection (SSI), reduced occurrence of postoperative ileus, shorter length of hospital stays (LOS), and early return to normal activity, laparoscopic appendectomy (LA) has become increasingly popular over open appendectomy (OA) in the last 20 years. According to many meta-analyses, LA seems to be the preferred surgery for individuals with simple, uncomplicated appendicitis [3].

Compared to OA, the difficulty in dissecting and clearing peritoneal contamination, prolonged operating durations, a high likelihood of postoperative abdominal abscess and wound infections, and higher surgical costs make LA for CA appear controversial [4].

In comparison to the adult literature, the pediatric literature on the laparoscopic technique for CA seems to have conflicting results [5, 6].

This could be attributed to the difference in patients' clinical features, surgical practice, and disease severity between these studies [4].

More recent clinical trials have demonstrated that this technique is safe and feasible in CA, with a minimum incidence of infectious complications [7].

On the other hand, there are authors from other trials that used laparoscopy for CA management who reported an increased risk of infection, particularly intra-abdominal abscess (IAA) and superficial wound infection [8, 9, 10]. As a result, the use of laparoscopy for CA has remained a point of contention.

Therefore, the best technique for children with CA is still unclear, even though laparoscopy is increasingly being chosen over OA nowadays in managing these cases [11]. To assess the value of LA in the pediatric population, we conducted this study to investigate and compare various clinical outcomes in children with CA who were managed with LA against those who were managed with OA.

Methods

Between January 2020 and January 2022, a prospective randomized controlled clinical trial was done at the department of pediatric surgery at one center in TAIF, Saudi Arabia. The institutional ethical committee approved the proposal for the study.

The study included children aged equal to or less than 14-years who were diagnosed with CA either preoperatively (abscess/mass formation detected on abdominal ultrasonography or a contrast-enhanced computed tomography scan) or intraoperatively (presence of suppurative appendicitis, abscess, phlegmon, gangrenous or perforated appendicitis which is defined by the presence of a hole in the appendix or free fecolith in the abdomen). In our study, we excluded patients above the age of 14 years old and those with uncomplicated appendicitis.

All data such as preoperative presentation, clinical findings, investigations, surgical methods, intraoperative findings and time, postoperative complications (wound infection, intraperitoneal collection, ileus, and readmission within 6 weeks), antibiotic use, starting time of oral intake, hospital stay length, and histopathology report were collected and analyzed.

Postoperative complications were recorded for each patient during the hospital stay and at the follow-up. SSI is defined as the presence of any evidence of infection, such as redness, purulent discharge from the surgical incision that necessitates suture removal or antibiotic treatment, or any sign of wound dehiscence. IAA is defined as a purulent intra-abdominal fluid collection on radiograph with localized signs of infection. Infection within the peritoneal cavity without localized fluid collection was characterized as intraperitoneal infection. If the patient developed abdominal distension, nausea, and vomiting, he/she was considered as having a paralytic ileus, a condition in which the oral intake is restricted for a few days due to these symptoms.

Statistical analysis

The software SPSS was used to analyze the data (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp.). The mean and standard deviation of continuous variables were calculated and compared using the Student t-test. The chi-squared test was used to compare categorical variables that were reported as numbers and percentages. A P value of 0.05 was considered statistically significant.

Results

Throughout the period of the study, a total of 436 appendectomies were performed for acute appendicitis; 111 of them had CA.

Out of these children with CA, 53 patients underwent OA, and laparoscopy was attempted in the other 58 patients and was completed successfully in 47 patients, whereas 11 patients had been converted to open approach (conversion rate of 18.9%). As a result, these 11 patients were not included in the final analysis.

Table 1: Demographic data of patients

		Groups		Test	
		LA N = 47 (47%)	0A N = 53 (53 %)	X2/t	P value
Gender	Male	29 (61.7%)	28 (52.8%)	X2=0.479	0.488
	Female	18 (38.3%)	25 (47.2%)		
Age (years)	Mean ± SD	9.56±2.35	8.82±3.21	t =1.3009	0.196
BMI (kg/m^2)	Mean ± SD	22.1±3.5	22.33±4.1	t =0.2606	0.7949

X2: calculated by Chi-square test, t: calculated by Student T-test

Demographic data showed that there were 57 boys and 43 girls (ratio: 1.3:1). The mean age in the LA group was 9.56±2.35 years and 8.82±3.21 years in the OA group, with no significant difference between the two groups regarding the age (P = 0.488), as well as the BMI (kg/m2) [Table 1].

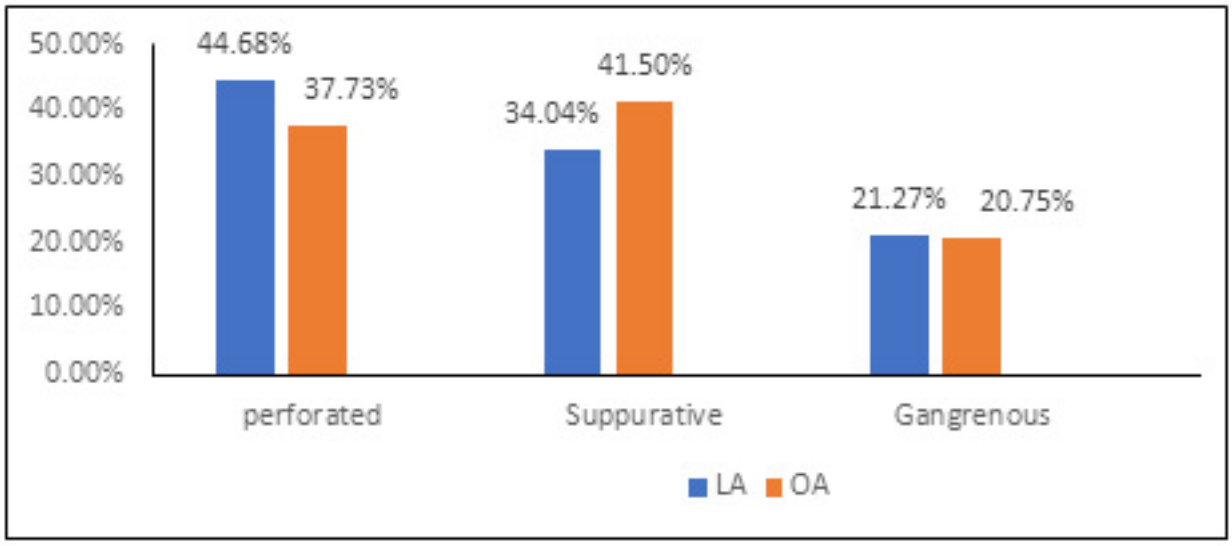
Table 2: Clinical characteristics of patients

		Groups		Test	
		LA N = 47 (47 %)	0A N = 53 (53 %)	t	P value
Symptoms duration (days)	Mean ± SD	3.11±0.9	3.29±0.5	1.2545	0.2127
Preoperative WBC (103/mm3)	Mean ± SD	16.2±2.6	15.7±3.7	0.7724	0.4417
Preoperative CRP (mg/dL)	Mean ± SD	23.7±9.4	24.9±9.3	0.7922	0.4302

WBC white blood cell, CRP C-reactive protein, t: calculated by Student T-test

The mean duration of complaints in the preoperative period was 3.11±0.9 days in the LA group and 3.29±0.5 days in the OA group. The mean white blood cells count was 16.2±2.6 in the LA group and 15.7±3.7 in the OA group, while C-reactive protein was 23.7±9.4 in the LA group and 24.9±9.3 in the OA group. There were no statistically significant differences between the two groups [Table 2].

Figure 1: Operative Findings of patients



According to the operative findings, there were 21 (44.68 %) patients with a perforated appendix, 16 (34.04%) with suppurative appendicitis, and 10 (21,27%) with gangrenous appendicitis in the LA group, while in the OA group, there were 20 (37.73%) patients with a perforated appendix, 22 (41.50%) with suppurative appendicitis, and 11 (20.75%) with gangrenous appendicitis. There are no statistically significant differences between the two groups (x2= 0.6618, P= 0 .718291) [Figure 1].

Table 3: Intraoperative and postoperative course details

		Groups		Test	
		LA N = 47 (47 %)	0A N = 53 (53 %)	X2/t	p
Operative time (min)	Mean ± SD	73.1±25.02	63.4±20.15	t = 2.1453	0.0344*
Hospital stays (days)	Mean ± SD	4.51±1.62	5.94±1.92	t = 3.9973	0.0001*
Resumption of fluid intake (days)	Mean ± SD	2.1±0.52	3.4±0.85	t = 9.0828	0.0001*
Duration of antibiotic use (days)	Mean ± SD	4.13±2.5	4.61±1.9	t = 1.1106	0.2695

X2: calculated by Chi-square test, t: calculated by Student T-test, * significant

Operative time was significantly longer in the LA group; the mean was 73.1±25.02 min in the LA group vs. 63.4±20.15 min in the OA group (p=0.0344).

The total duration of hospitalization was significantly shorter in the LA group (4.51±1.62 days) in comparison with the OA group (mean 5.94±1.92 days) (p=0.0001).

In addition, a statistically significant difference was noted among the two groups in the resumption of oral intake which was significantly faster in the LA vs OA group (2.1±0.52 days) vs (3.4±0.85 days) (p=0.0001).

On the other hand, there is no statistically significant difference between the two groups in terms of the duration of intravenous antibiotics given, (4.13±2.5) vs (4.61±1.9) LA vs OA groups respectively [Table 3]. Fortunately, none of the participants in the study died.

Table 4: Postoperative complications

	Groups		Test	
	LA N = 47 (47 %)	0A N = 53 (53 %)	X2/t	p
Surgical site infection	4 (8.5%)	14 (26.4%)	4.265	0.0389*
Intra-abdominal abscess	4 (8.5%)	5 (9.4 %)	0.026	0.8721
Paralytic ileus	6 (12.7 %)	5 (9.4%)	0.045	0.8326
Need for readmission	3 (6.3%)	6 (11.3 %)	0.261	0.6093
Delayed complications	0 (0%)	2 (3.7%)	0.397	0.5289

X2: calculated by Chi-square test, t: calculated by Student T-test, * significant

The incidence of SSI was higher in the OA group, which is statistically significant (p= 0.0389), with 4 cases in the LA group (8.5%) vs. 14 cases in the OA group (26.4). The infected wound was opened for all patients in both groups to obtain adequate drainage.

Conversely, our study showed no significant difference (p=0.8721) between the LA and OA groups regarding the occurrence of postoperative IAA, 4 cases (8.5%) vs. 5 cases (9.4 %) respectively, as well as no significant difference in postoperative paralytic ileus incidence in both groups, 6 (12.7%) after LA vs 5 (9.4%) after OA (p=0.8326). Also there was no statistically significant difference (p=0.6093) in the need for readmission, 3 in the LA (6.3%) and 6 in the OA (11.3 %).

Finally, regarding delayed complications, we had 2 cases (3.7%) with adhesive Intestinal obstruction (IO) that occurred only in the OA group which is not statistically significant (p=0.5289). Those cases were treated conservatively.

Discussion

Minimal-access surgical techniques are used in a wide range of medical disciplines. When compared to open operations, laparoscopic surgeries have better outcomes due to increased laparoscopic experience, improved surgical techniques, and technological advancements [12].

In the case of appendicitis, laparoscopy provides various advantages, including a minor wound, rapid healing, reduced risk of postoperative wound infection, and a short hospital stay [13].

The decision to do LA in pediatric patients with CA has been controversial due to the difficulty of performing minimally invasive surgery in an area of distorted anatomy and severe inflammation. Dissecting and visualizing the appendix, performing and determining the appropriateness of peritoneal wash, and preventing infection spread to the surrounding abdominal compartments are all difficult tasks, and more demanding if a laparoscopic approach is used [3].

The usefulness of the laparoscopic technique in the treatment of complicated appendicitis has been thoroughly researched.

Several research studies have demonstrated that the main advantages of LA for complicated appendicitis are wound infection prevention and reduced hospital stay time [14, 15]. In older research, however, operative time and postoperative complications linked with LA have been noted as potential disadvantages of this surgical method [16, 17].

Clinical presentation of appendicitis in children can be quite severe, with complicated appendicitis accounting for a significant portion of the cases. Children under the age of six have particular anatomic and pathophysiologic characteristics that make them more likely to develop severe appendicitis, and Marzuillo et al. found that children under the age of six have a diagnostic delay [6].

In our study, there was no statistically significant difference between the two groups concerning age, sex, duration ofthe symptoms, total leukocyte counts, and CRP level.

Apart from this, we observed a significant difference in operating time between the two groups, which is longer in LA than for OA (LA=73.1±25.02 min vs. OA=63.4±20.15 min), due to the need for meticulous dissection of the appendix from the surrounding organs during the laparoscopic procedure. This result is very similar to the results from Seqsaqa et al. (LA= 85.17 ± 27.02, OA= 61.33 ± 20.08) [18] and Taguchi et al. (84.6 ± 34.57, 63.5 ± 20.76) [19].

This result contrasts with the observation reported previously by Sreekantamurthy et al. (LA= 55.83±4.81 min, OA= 67.16±4.27 minutes) [20], Khirallah et al. (LA = 56.41 min, OA =63.42 minutes) [21], that showed LA took less time than OA, whereas a study by Menezes et al. demonstrated that the operative time for CA is similar in both groups with increased experience [22].

Clearly, we believe that the surgeons' technical skills, experience, and cases flow have a significant impact on operative time.

It should be noted that one of the most important factors impacting directly on the cost is the duration of hospitalization. Our findings show that the duration of hospitalization is shorter in the LA group. The mean postoperative hospital stay was 4.51±1.62 days in the LA group and 5.94±1.92 days in the OA group. Similarly, Sreekantamurthy et al [20] and Khirallah et al. [21] showed that the length of hospital stay was significantly reduced in cases operated laparoscopically. We believe that these results may be related to the advantages of laparoscopic surgery, which include reduced postoperative pain and early mobilization leading to early discharge.

In our study, we started oral intake once bowel sounds were heard, and they were noted faster in the LA group, which is similar to the observation reported previously by Low et al. and Li et al [23,24].

Dissimilarily, the study done by Murali et al. showed no significant difference between the two groups [4].

In our study, the course of intravenous antibiotics started with one dose pre-operatively and continued for 2-3 days postoperatively in the case of CA. As a result, we assume that there was no significant difference between both groups in the duration of intravenous antibiotics, while, the study done by Sreekantamurthy showed a lesser course in the LA group (4.2 days Vs 5.8 days in OA group) as the oral antibiotics were started as soon as the patient tolerated oral intake and there was less demand for intravenous antibiotics [20].

We noted that the incidence of postoperative SSI in the OA group was found to be significantly higher than the LA group, which corresponds with previous studies by Murali et al., Low et al., and Zhang et al. [4, 23, 15]. This is most likely due to the wound being directly exposed to the infected contents during open surgery, which was reduced with laparoscopic surgery, as indicated by the use of a retrieval bag to shield the appendix extraction during LA.
Undoubtedly, the intra-abdominal collection is a common postoperative complication that can delay patients' recovery. It may extend the length of stay in the hospital and the course of the intravenous antibiotics and, in serious cases, may require re-admission and additional interventions.

It is possible that LA for perforated appendicitis will reduce the incidence of IAA, as laparoscopy provides the benefit of exploring the entire abdomen and getting rid of the contaminated peritoneal cavity in generalized peritonitis as described by Ikeda et al. [25].

Despite that, the incidence of postoperative IAA in our study shows no statistical difference between the two groups. Similarly, Seqsaqa et al. [18] and Vahdad et al [26] showed that there were no significant differences between the two techniques in the development of the postoperative intraperitoneal collection.

Inconsistent with the findings of our research, several research studies by Zhang et al. and Markar et al. [15,5] discovered a higher rate of postoperative IAA in the LA group, while others such as Tsai et al. and Khirallah et al. found a lower incidence of IAA in the LA group [27,22].

However, there are some suggestions to reduce the risk of the intra-abdominal abscess, to standardize the operative procedure of LA; improve clinical practices and training for the surgical residents and surgeons to reduce the impact of learning curves; to reduce the abdominal pressure during the operation; to drain the fluid accumulated in the abdomen completely; to avoid the same body posture for a long time; to optimize intervention timing and operative technique including plentiful irrigation for all abdominal quadrants; to extract the appendiceal faecolith whole without breaking it; to effectively use antibiotics treatment.

We had approximately the same number in both groups in our study that developed post-operative ileus. Studies by Murali et al [4] and Low et al. [23] supported this finding. In cases of simple appendicitis, the main reason for prolonged ileus in OA is due to bowel handling, which is minimized in LA, while there are other factors impacting ileus in the cases with CA including the degree of peritoneal contamination and the presence of postoperative IAA.
There were 9 cases of readmission in the current study; 3 of them occurred after LA (6.3%) while the other 6 cases occurred after OA (11.3%), with no significant difference between the two groups. They were all due to intraperitoneal fluid collection and were treated conservatively with ultrasound-guided drainage and antibiotics.

Overall, patients who underwent LA had better clinical outcomes than those who underwent OA as laparoscopic appendectomy has many benefits such as rapid recovery, less hospitalization, as well as less wound infection, with no proof of rising postoperative infection, ileus, or readmission.

Conclusions

With available expertise, our study shows that LA is safe, doable, and efficient in the management of CA in the pediatric population. Therefore, we propose that the surgeon with improvements in techniques and devices should consider laparoscopy as the first-line procedure in managing patients with CA.

Ethical approval
The study was approved by the Institutional Ethics Committee

Abbreviations

AA; acute appendicitis.
CA; complicated appendicitis
IAA; intra-abdominal abscess.
IO; intestinal obstruction.
LA; laparoscopic appendectomy.
Los; length of stay.
OA; open appendectomy.
OT; operative time.
TTOI; time taken to oral intake.
TLC; Total leukocyte count.
CRP; C reactive protein.
vs; Versus.

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