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Retrospective review of laparoscopic versus open surgery in the treatment of appendiceal abscess in pediatric patients

Laparoscopic versus open surgery for appendiceal abscess

Ping Li, MD[a], Yan Han, MD[b], Yang Yang, MD[c], Hongjie Guo, MD[c], Fabao Hao, MD[c], Yan Tang, BN[c,*], Chunbao Guo, MD, PhD[c,d,*]

Abstract

Laparoscopic appendectomy (LA) has become well accepted, but the role of LA for appendicitis upon presentation with an abscess remains undefined. This study was to assess the postoperative recovery and complications following LA in pediatric patients with appendiceal abscess in comparison with open appendectomy (OA).

We conducted a retrospective review of patients presented with appendiceal abscess between 2005 and 2016. Propensity score matching (PSM) was conducted to adjust for any potential selection bias for the surgical approaches. In 108 matched patients, operative outcomes and surgical complications were evaluated based on LA or OA.

The patients with LA experienced prompt postoperative gastrointestinal function recovery, like first bowel movement (risk ratio [RR], 0.52; 95% confidence interval [CI], 0.44–0.69; $P < .001$), so spend the lower mean length of hospitalization (RR, 0.53; 95% CI, 0.41–0.76; $P < .001$) in comparison with patients with OA. Furthermore, the immunologic and inflammatory variable white blood cell (WBC) (RR, 0.56; 95% CI, 0.46–0.73; $P < .001$) and C-reactive protein (CRP) (RR, 0.58; 95% CI, 0.43–0.86; $P = .011$) on postoperative days (POD) 5 was reduced in patients undergone LA compared with that of OA. A lower overall postoperative complication rate, including surgical wound infection (odds ratio [OR], 0.38; 95% CI, 0.18–0.81; $P = .008$) and incision dehiscence (OR, 0.06; 95% CI, 0.01–0.45; $P < .001$) was noted in patients with LA compared with OA.

LA was feasible and effective for appendicitis upon presentation with an abscess and associated with beneficial clinical effects, such as postoperative gastrointestinal function recovery and reduced postoperative complications. LA should be seriously considered as the first line procedure of choice.

Abbreviations: CRP = C-reactive protein, LA = laparoscopic appendectomy, LOS = length of hospital stay, OA = open appendectomy, PCT = procalcitonin, POD = postoperative days, WBC = white blood cell.

Keywords: appendiceal abscess, gastrointestinal function, laparoscopy, postoperative complications

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[a] Department of Ultrasound, The Affiliated Hospital of Medical College, Qingdao University, Qingdao, [b] Department of Neonatal, [c] Department of Pediatric General Surgery and Liver Transplantation, [d] Ministry of Education Key Laboratory of Child Development and Disorders, Children's Hospital of Chongqing Medical University, Chongqing, P.R. China.

[*] Correspondence: Yan Tang, Department of Pediatric General Surgery and Liver Transplantation, Children's Hospital of Chongqing Medical University, 136 Zhongshan 2nd Rd. Chongqing, 400014, P.R. China (e-mail: 3256525@qq.com); Chunbao Guo, Department of Pediatric General Surgery and Liver Transplantation, Children's Hospital of Chongqing Medical University, 136 Zhongshan 2nd Rd. Chongqing, 400014, P.R. China (e-mails: guochunbao@cqmu.edu.cn & guochunbao@foxmail.com).

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1. Introduction

Although open appendectomy (OA) has been the gold standard for treatment of acute appendicitis for more than a century, the management of appendiceal abscess is controversial.[1–3] Open surgery for periappendiceal abscess is technically challenging, and may be fraught with postoperative complications. On the other hand, persistent symptoms, recurrent abscesses, and numerous home healthcare visits may complicate drainage procedures followed by interval appendectomy.[4,5] To date, there is no standard management strategy among various surgeons. Recently, studies comparing immediate surgery and nonsurgical approach have been published. The nonsurgical approach was recommended by several systematic reviews and meta-analysis, as it was associated with lower complication rate and lower morbidity rate,[6,7] whereas, in children, one prospective nonrandomized study 6 showed that early surgical intervention was beneficial over nonoperative management.[8] Other studies did not find significant differences between the 2 approaches.

Surgical complications are the major concern for immediately operating, with wound complications occurring in up to 17% of patients; furthermore, surgical exploration may lead to ileocecal resection or right hemicolectomy.[9] Laparoscopic surgery has gained acceptance in many centers worldwide. It proved, by several studies and meta-analysis,[10–12] to be a feasible and safe procedure, with numerous clinical advantages, such as shorter postoperative ileus, lower incidence of wound infection, less postoperative pain, reduced hospital stay, and faster return to normal work activities. Because laparoscopic appendectomy (LA) was associated with reduced risk of surgical complications, it may provide a better alternative for acute management of appendiceal abscess than interval appendectomy and immediate open surgery. But in the specific age group of younger children, there are no reports that compare laparoscopic surgery with open surgery and the incidence of postoperative complications.

The purpose of our study was to compare the clinical outcomes, including hospital stay, operating time, postoperative complications, time to oral intake, and to resume normal activity in laparoscopic surgery versus open management in these patients.

2. Methods

2.1. Patient population

This study is a retrospective review of the medical records of consecutive pediatric patients (less than 14 years old) admitted to our institutions from 2007 to August 2016. The study protocol was approved by the Institutional Review Board of the Chongqing Medical University and performed in accordance with the ethical standards prescribed by the Helsinki Declaration. Patients were eligible for entry into the study upon meeting the following inclusion criteria: presenting a well-defined appendiceal abscess or pan-peritonitis by CT or ultrasound imaging at the time of initial presentation. Exclusion criteria included patients undergoing antimicrobial therapy for more than 72 hours; patients with severe chronic disease, which substantially increased the risk for operative mortality; and patients with previous major intra-abdominal surgery, which may have caused intra-abdominal adhesions.

In our institution, conservative treatment (such as percutaneous drainage and intravenous antibiotics) was initially carried when the duration of clinical symptoms exceeded 3 days. Otherwise, emergency surgical interventions, including laparoscopic or open approach, were considered if fever (temperature over 38.0°C) and obstruction (abdominal distention, vomiting) were presented. The decision about the type of operation was made according to the preference and experience of the surgical team on duty. OA was performed via conventional methods. Dissection, vessel ligation, and irrigation were conducted through a midline or pararectal incision. LA was performed with the 3-trocar approach (2 of 5 mm, 1 of 10 mm). The mesoappendix was dissected using an energy device, and the appendix was ligated with titanic or biological clamps then cut away. To avoid contamination, the appendix was removed in an endoscopic bag through the umbilical wound. A total of 889 patients met the inclusion criteria. For each patient, the collected clinical data, including demographic data, duration of symptoms, white blood cell (WBC) value upon admission, histopathology reports, surgical procedure descriptions, postoperative hospital stay, postoperative complications, and previous abdominal surgeries, were recorded. Before the operation and on days 1, and 5 after surgery, the following parameters were assessed in all patients: CRP, procalcitonin (PCT), albumin and prealbumin, and liver and kidney function tests. Duration of surgery, operating time, intraoperative blood loss, transfusion rate, and necessity for re-operation were also recorded.

2.2. Outcome evaluation

The main outcome measure was postoperative length of hospital stay (LOS, the number of days from the day of operation until the date of discharge). Secondary outcome measures included the recovery of bowel movement, restoration of physical activity, changes in the WBC count and CRP level after surgery, complication rates, complication types within 60 days after surgery, and recurrent abscesses within 60 days after surgery. Gastrointestinal symptoms were assessed and recorded daily for the first 5 days postoperatively, including first bowel movement (gas and feces) after operation, abdominal bloating, abdominal cramps, diarrhea (defined as more than 3 bowel movements per day), and vomiting. In the first 5 days, more than 1 episode of nausea or vomiting was defined as early ileus. Late ileus was defined as nausea or vomiting after the first 5 days. Prolonged ileus was defined as a sustained nonmechanical obstruction lasting more than 5 days after the operation and confirmed by simple abdominal radiography. Infectious complications were confirmed with microbiological analyses and positive cultures, and included pneumonia (radiographic confirmation) and abdominal, urinary, or systemic (fever [oral temperature >38.5°C]) infection. Wound complications consisted of wound dehiscence, erythema, swelling, and pus. Major complications were defined as the need for repeat laparotomy or percutaneous drainage of intra-abdominal deep fluid collections by interventional radiology procedures or the occurrence of complications requiring patient transfer to the intensive care unit.

2.3. Propensity scores and matching

A 1:1 propensity score matching (PSM) analysis was accomplished using nearest-neighbor analysis to minimize the effect of potential confounders on selection bias related to LA or OA. The selected variables entered into the propensity model included demographic data information, laboratory values, and duration of symptom. Propensity scores were estimated at the time of first evaluation before surgery (cohort entry date) with a multivariable logistic regression model using SPSS 20.0 (IBM, Armonk, NY) or R software 3.1.2 (The R Foundation for Statistical Computing) and the MatchIt package. Matching without replacement was performed based on the estimated propensity score of each patient with no replacement, and a 0.1 caliper width. At last, our propensity score model matched 108 patients with LA to 108 patients with OA. The characteristics of both the LA and OA patients were compared before and after PSM.

2.4. Statistical analysis

After PSM, the statistical comparisons were conducted using SPSS 20.0 (IBM, Armonk, NY). Student *t* test was used to compare normally distributed continuous variables, reported as means ± SDs, and the Mann-Whitney *U* test, to compare abnormally distributed variables. The difference between discrete variables, expressed with frequencies (percentages), was analyzed by a chi-square test or Fisher exact test. The potential relative risks for postoperative variables were assessed by univariate analysis using cross-tabulation (odds ratio [OR]) or multivariate logistic regression analysis (risk ratio [RR]) with 2-tailed 95% confidence interval (CI), and a *P* value less than .05 was regarded statistically significant.

3. Results

3.1. Patient characteristics

As shown in the Table 1, the baseline characteristics of the patients were comparable. Among the 398 pediatric patients

Table 1

Baseline characteristics of eligible patients and surgical parameters.

Treatment	Total population			Propensity matched population		
	LA (149)	OA (249)	*P* values	LA (108)	OA (108)	*P* values
Age, y	6.1±2.8	4.2±1.7	.034	5.6±1.8	5.4±2.0	.33
Duration of clinical symptoms, d, mean±SD	4.3±2.6	5.9±3.6	.021	4.9±2.2	5.1±2.9	.45
Clinical symptoms, N (%)						
Abdominal pain	136 (91.3)	229 (92.0)	.47	97 (90.1)	99 (92.3)	.41
Vomiting	76 (51.0)	135 (54.3)	.30	55 (51.3)	56 (52.2)	.50
Fever	91 (61.1)	157 (63.1)	.39	66 (61.1)	67 (62.3)	.50
Male: female	83:66	151:98	.38	58:50	57:51	.25
Mean body weight, kg	20.6±6.8	17.2±4.9	.12	20.4±4.7	19.7±4.4	.37
Abscess 2 cm or more, N (%)	73 (49)	132 (53)	.25	53 (49.1)	55 (51.2)	.45
WBC, 10^9/L	16.7±3.2	17.2±3.6	.14	15.9±3.5	16.2±3.3	.45
PCT, ng/mL (normal value: 0–0.5)	6.8±2.7	6.5±2.6	.094	6.8±2.6	6.7±2.4	.54
CRP, mg/L (normal value: 0–8)	21.5±5.3	20.8±4.6	.11	21.1±3.8	20.9±3.4	.35
Albumin, g/L (normal range, 35–50)	35.6±4.5	35.3±4.7	.53	35.5±4.8	35.4±4.9	.74
Prealbumin, mg/dL (normal range, 20–40)	24.6±3.8	23.8±3.7	.38	23.1±3.5	22.9±3.2	.87

CRP = C-reactive protein, LA = laparoscopic appendectomy, OA = open appendectomy, PCT = procalcitonin, SD = standard deviation, WBC = white blood cell.

eligible for analysis, 149 (37.4%) received laparoscopy surgery. The baseline features of the pediatric patients according to conservative or laparoscopy surgery are shown in Table 1. Six patients, converted from LA to open surgery, were transferred from the LA group to OA group. Before PSM, baseline features were similar, with the exception of age, and duration of clinical symptoms, suggesting that, in this observational study, there were systematic differences in baseline characteristics between the patients with laparoscopy (n=149) and open surgery (n=249). There were no significant differences in the demographic features of patients between the 2 groups, including gender distribution, initial mean body weight, etc, and laboratory test, like WBC, PCT, and CRP. Under PSM, the absolute standardized mean differences reduced the values to the range from 0.01 to 0.10, indicating that the continuous and categorical variables were very similar and comparable between the patients with conservative and laparoscopy surgery (Table 2). A total of 108 patients with LA were matched to 108 patients with OA. Several variables, including age and duration of clinical symptoms, became comparable after PSM (Table 1).

3.2. Gastrointestinal function

Intestinal function characteristics are assessed by first flatus, first bowel movement and postoperative feeding time. In the propensity matched cohort, the first bowel movements occurred 1.8±0.5 and 2.3±1.1 days after surgery in the patients with laparoscopic and with open surgery, respectively (RR, 0.52; 95% CI, 0.44–0.69; $P<.001$), so the feeding within postoperative days (POD) 3 rate (RR, 0.65; 95% CI, 0.43–0.96, $P=.071$) and first flatus (RR, 0.72; 95% CI, 0.51–0.97, $P=.092$) is higher in the patients with LA than with OA, although no significant difference was stained. After PSM, the incidences of abdominal cramps ($P=.31$) and abdominal distention ($P=.18$) within 5 PODs in patients with LA were similar with patients with OA. Diarrhea within 5 PODs was reduced in patients with LA compared with

Table 2

Outcome characteristics in the matched population (multivariate logistic regression).

Treatment	LA (108)	OA (108)	*P* values	RR (95% CI)
First bowel movement, days, mean±SD	1.8±0.5	2.3±1.1	<.001	0.52 (0.44–0.69)
Feeding within POD 3, N (%)	89 (82.4)	75 (69.4)	.019	2.06 (1.08–3.92)
First flatus, days, mean±SD	2.1±0.7	2.6±1.2	.092	0.72 (0.51–0.97)
Abdominal cramps, N (%)	35 (32.4)	43 (39.8)	.19	0.75 (0.43–1.30)
Abdominal distension, N (%)	26 (24.1)	31 (28.7)	.27	0.79 (0.43–1.45)
Vomiting, N (%)	13 (12.0)	16 (14.8)	.35	0.79 (0.36–1.73)
Diarrhea, N (%)	45 (41.7)	51 (47.2)	.25	0.80 (0.47–1.37)
Early ileus, N (%)	31 (28.7)	43 (39.8)	.057	0.61 (0.35–1.07)
Mean duration of parenteral nutrition, days, mean±SD	1.8±0.6	2.1±0.8	.29	0.75 (0.39–1.12)
Postoperative LOS, days, mean±SD	6.3±1.2	7.4±1.5	<.001	0.53 (0.41–0.76)
WBC, 10^9/L, on POD 5	8.2±2.5	9.7±3.1	<.001	0.56 (0.46–0.73)
PCT, ng/mL (normal value: 0–0.5) on POD 5	0.8±0.3	1.2±0.6	.092	0.61 (0.49–0.87)
CRP, mg/L (normal value: 0–8) on POD 5	7.4±3.6	9.5±4.6	.011	0.58 (0.43–0.86)
Bacterial cultures, N (%)	91 (84.3)	96 (88.9)	.21	0.67 (0.30–1.48)
Duration of IV antibiotics, days, mean±SD	6.8±1.3	7.9±2.1	.042	0.54 (0.45–0.72)
Use of drains, N (%)	76 (70.4)	82 (75.9)	.22	0.75 (0.41–1.38)
Operative time, min	43.9±28.4	46.1±23.6	.16	0.79 (0.55–1.42)
Operative blood loss, mL	13.6±5.2	18.9±7.8	.35	0.82 (0.69–1.78)

CI = confidence interval, CRP = C-reactive protein, IV = intravenous, LA = laparoscopic appendectomy, LOS = length of hospital stay, OA = open appendectomy, PCT = procalcitonin, POD = postoperative days, RR = risk ratio, SD = standard deviation, WBC = white blood cell.

Table 3

Postoperative complications in the matched population (chi-square test).

Treatment	LA (108)	OA (108)	*P* values	OR (95% CI)
Total complications (at least 1 complication), N (%)	26 (24.1)	37 (34.3)	.067	0.61 (0.34–1.10)
Total number of complications	58 (53.7)	69 (63.9)	.083	0.66 (0.38–1.13)
Surgical wound infection, N (%)	11 (10.2)	25 (23.1)	.008	0.38 (0.18–0.81)
Peritonitis or recurrent abscess, N (%)	6 (5.6)	4 (3.7)	.37	—
Sepsis, N (%)	3 (2.8)	5 (4.6)	.36	—
Pneumonia, N (%)	9 (8.3)	11 (10.2)	.41	—
Incision dehiscence, N (%)	1 (0.9)	15 (13.9)	<.001	0.06 (0.01–0.45)
Late ileus, N (%)	15 (13.9)	27 (25.0)	.029	0.48 (0.24–0.97)
Readmissions	7 (6.5)	9 (8.3)	.39	

CI= confidence interval, LA = laparoscopic appendectomy, OA = open appendectomy, OR = odds ratio.

patients with OA, but this difference was not statistically significant ($P=.19$). Early ileus occurred in 31 of 108 patients with laparoscopic treatment versus 43 of 108 patients without open treatment ($P=.17$). There were no differences in the incidence of diarrhea or serum electrolyte abnormalities between the 2 groups.

The mean postoperative LOS was 6.3 ± 1.2 days in patients receiving LA, which was significantly less than the mean length of stay (7.4 ± 1.5 days) in patients with OA (RR, 0.53; 95% CI, 0.41–0.76, $P<.001$) (Table 2). Significant differences were found in inflammation variables between the 2 groups at POD 5 (WBC [RR, 0.56; 95% CI, 0.46–0.73, $P<.001$] and CRP [RR, 0.58; 95% CI, 0.43–0.86, $P=.011$], Table 2). Analysis of liver and kidney function did not demonstrate any alterations related to PGE1 treatment (data not shown). The operative magnitude was evaluated by measurement of operative time, estimated blood loss, and total units of blood transfused within the 24-hour perioperative period and were no different in the 2 groups.

3.3. Postoperative complications

According to established criteria, postoperative salient complication features are summarized in Table 3. Postoperative early gastrointestinal complications were generally mild and recoverable. Fewer total postoperative complications were noted in patients undergone LA than in patients with OA (RR, 0.61; 95% CI, 0.34–1.10, $P=.067$). In particular, a reduction in postoperative surgical wound infection (OR, 0.38; 95% CI, 0.18–0.81; $P=.008$) and incision dehiscence (OR, 1.16; 95% CI, 1.08–1.25; $P<.001$) was noted in patients receiving LA compared with patients receiving OA (Table 3). Fifteen of 108 patients (13.9%) with LA developed late ileus, which was significantly less than the 27 of 108 patients (25.0%) with OA (OR, 0.48; CI, 0.24–0.97, $P=.029$). Only 7 patients with LA reported readmissions versus 9 patients with OA ($P=.39$). The patients due to recurrent appendiceal abscess had to be reoperated and due to late ileus were managed conservatively.

4. Discussion

The present retrospective research addressed the issue whether LA effectively improves various measures of postoperative recovery and reduces the incidence of postoperative complications in pediatric patients in comparison with conventional open approach with pediatric appendiceal abscess. It is in favor of the laparoscopic surgery with regard to postoperative recovery and pooled complication rate, especially high rate of surgical site infections (16.4%) and ileus/bowel obstruction (8%), which was associated with the length of postoperative hospital stay. Although we still found a high percentage of patients developing a post-treatment abscess in the 2 approaches (20% and 25%, respectively), laparoscopic surgery still outperformed open surgery by requiring less additional interventions.

The critical factor, that directly influences the well-being of the patient and economical concern, reduced is LOS, which resulted from earlier resumption of oral intake, postoperative complications, and so quicker return to activity.[13] Distinguishing features of the laparoscopically treated group of children over the conventional open approach include the aforementioned advantages, which have been indicated by recent meta-analysis, which indicated that patients undergoing LA return earlier to work or normal daily activities.[14,15] Our analysis involved closely monitored measures, with continuous intestinal function monitoring and frequent nursing assessments, which could be taken in our hospital setting. Therefore, any clinically significant intestinal complaints would likely be captured in the involved patients. We found that hospital stay was significantly shorter in patients with LA ($P=.015$) with a remarkable concomitant beneficial earlier postoperative intestinal function recovery, including bowel movements, which led to earlier feeding and discharge from hospital. Although the targeted patients were different, our findings are in agreement with several studies that demonstrated a significantly short hospital stay for the laparoscopic approach.[16–18] The conceivable explanation for these findings might come from a minor abdominal trauma and reduced manipulation of the ileum and the cecum by a skilled surgeon during LA, and less pain due to the smaller extension of the incision.

In clinical practice, despite the obvious advantages described, the open approach appears to be still widely used due to concerns about possible longer operative time, higher costs, and in some institutes, the unavailability of instruments and skilled surgeon for LA. Generally, a longer duration of the operation is owing to the lack of experience of surgeons, like setup of instruments, insufflation, and making ports under vision.[19,20] However, in this study, although it was not found to be statistically significant, total operative time in our series was in favor of LA group with a difference of 2.9 min. In the case of complicated appendicitis, the safe dissection was technically challenging and time consuming, which was associated with severe inflammatory reaction and dense adhesions, even more challenging and higher rate of switch to open surgery for the longer duration of symptoms. Also, bowel resection during LA must be taken into consideration, which may predispose patients to more severe postoperative complications. Our group has a large experience of the laparoscopically treated group of children for complicated appendicitis. For the past 5 years, we have preferred laparoscopically treated group of children for appendicitis, regardless of acute or perforated appendicitis. Our rate of conversion to open surgery is only 3%; this finding represents the experience of the laparoscopic procedure in our institute. Furthermore, the training in laparoscopic techniques was spread worldwide, contributing to the significant reduction in difference of operative time.

The current study confirmed a significant lower incidence of postoperative complications following the laparoscopically treated group of children. We reported a lower rate of postoperative complications, with 24.5% and 6.7% for OA and LA, respectively. This result is consistent with the conclusion in a recent meta-analysis,[21] although which focuses on appendicitis for adult. Wound infection is common in complicated appendicitis, although it may not represent a life-threatening complication but has a strong impact on the recovery time and quality of life in the early postoperative period. The reduction of wound infection rate represents a significant advantage of LA.[2] Although the exact mechanism is difficult to determine in this clinical setting, the lower rate of wound infection in laparoscopic group may be explained by the smaller size of the laparoscopic incisions and extraction of specimen with an Endobag, which reduces the probability of infection. Because this approach obviates the wound issues often incurred from the open operation, it is important that surgeons can perform the majority of these operations laparoscopically despite the abscess.

The occurrence of an intra-abdominal abscess following appendectomy is a serious and life-threatening complication event. We observed peritonitis or recurrent abscess formation in 6 patients in laparoscopically treated group of children (5.6%) and in 4 patient in the group of children treated by open surgery (3.7%) (P=.37). A meta-analysis of randomized controlled trials (RCT), published,[11] shows an increased risk of intra-abdominal abscess after LA. But our findings are consistent with other studies and the most recent RCT that showed a low incidence of intra-abdominal infections, with no significant difference between the laparoscopic and the open approach. The intra-abdominal abscess have been suggested to be related with an improper manipulation, such as an excessive irrigation fluids residual in the abdominal cavity, which could lead to significant contamination or an aggressive handling of infected appendix, especially in case of ruptured appendix; furthermore, mechanical spread of bacteria could be promoted by carbon dioxide insufflation. However, in our study, the intra-abdominal abscess rate of LA was no significantly difference with that following OA. In our opinion, this finding might be due to the increased laparoscopic skills as previously suggested by some authors.[22,23] Also, antibiotics were given timely before and after LA in my patients.

This study was limited by its retrospective, single-center design, and the decision to initiate LA or OA was not made randomly. Selection of cases for LA might be biased by factors as age at presentation or duration of symptoms and the operator preference. We were inclined to perform LA in some patient prone to shorter duration of symptoms with slight inflammatory reaction. To limit the influence of confounding variables on the actual effects of LA, we performed PSM analysis to generate similar baseline factors regarding LA or OA. Following the PSM, this discrepancy was comparable, as indicated by the standardized mean differences and P value. However, we could not completely avoid variables that may affect this comparison.

In summary, clinical evidence from the present study supported the clinical benefits of LA in terms of postoperative intestinal recovery, complications, and LOS for pediatric patients with appendiceal abscess, although it was still controversial whether laparoscopic surgery in unexperienced hands was associated with benefits in specific patient populations, particularly with respect to lesion location and severe inflammatory reaction. We acknowledged that the utility of this result may not be generalizable to all pediatric surgeons and should be framed according to the laparoscopic skills and the resources within their institution.

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