

COMPARATIVE OUTCOMES OF LAPAROSCOPIC AND OPEN APPENDECTOMY IN CHILDREN WITH COMPLICATED APPENDICITIS: A PROSPECTIVE OBSERVATIONAL STUDY

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ABSTRACT

Background: Acute appendicitis is one of the most common surgical emergencies in children, with complicated forms presenting significant management challenges. While laparoscopic appendectomy (LA) has become the gold standard for simple appendicitis, its role in complicated pediatric appendicitis remains debated. The objective is to compare the clinical outcomes of laparoscopic versus open appendectomy (OA) in children with complicated appendicitis, focusing on surgical site infection, postoperative pain, hospital stay duration, operative time, postoperative ileus, and intra-abdominal abscess formation. **Materials and Methods:** This prospective comparative observational study was conducted at the Department of Paediatric Surgery, SAT Hospital, Government Medical College, Thiruvananthapuram, Kerala, India, from June 2018 to May 2019. Thirty-two children with intraoperatively confirmed complicated appendicitis (gangrenous or perforated) were enrolled after obtaining informed consent. Patients were categorized into LA (n=16) and OA (n=16) groups based on the surgical approach employed. Baseline demographic, clinical, laboratory, and radiological data were prospectively recorded. Postoperative outcomes, including surgical site infection, pain severity (Visual Analogue Scale), hospital stay duration, operative time, postoperative ileus, and intra-abdominal abscess, were assessed and compared using appropriate statistical tests. **Result:** Both groups were comparable in baseline characteristics. Surgical site infection occurred significantly more frequently in the OA group (50%) compared to the LA group (6.3%, $p=0.006$). Severe postoperative pain was reported in 37.5% of OA patients versus 6.3% of LA patients ($p=0.043$). An extended hospital stay (11-15 days) was required in 31.3% of OA cases compared to 6.3% of LA cases. Intra-abdominal abscess developed in 12.5% of OA patients, whereas none of the LA patients developed this complication. Postoperative ileus rates were similar between groups (18.8% OA vs 12.5% LA, $p=0.426$). Operative time was slightly longer in the LA group, with 12.5% of procedures exceeding 90 minutes, compared with none in the OA group ($p=0.144$). **Conclusion:** Laparoscopic appendectomy is a safe and effective approach for managing complicated appendicitis in children. It offers significant advantages over open appendectomy, including reduced surgical site infections, decreased postoperative pain, shorter hospital stays, and lower rates of intra-abdominal abscess formation. The marginally longer operative time does not adversely affect overall patient outcomes. LA should be considered the preferred surgical approach for pediatric patients with complicated appendicitis.

INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies worldwide and is particularly

prevalent in the pediatric population.^[1,2] Children are at a higher risk of developing complicated appendicitis, characterized by gangrene or perforation, which is associated with increased

postoperative morbidity and prolonged hospitalization. Surgical intervention remains the definitive treatment for acute appendicitis. Traditionally, open appendectomy (OA), performed through a right lower quadrant incision, has been the standard treatment since the late nineteenth century and has demonstrated excellent safety and effectiveness.^[3,4] With the introduction of minimally invasive surgery, laparoscopic appendectomy (LA) has gained widespread acceptance and is now considered the preferred approach for uncomplicated appendicitis in both adults and children.^[3,4]

The advantages of laparoscopic surgery include reduced postoperative pain, shorter hospital stay, faster recovery, and improved cosmetic outcomes.^[5] However, its role in complicated pediatric appendicitis remains controversial. Concerns have been raised regarding higher operative costs, longer operative times, and the potential risk of postoperative intra-abdominal abscess (IAA) formation.^[6,7] Although several studies have evaluated the outcomes of LA and OA in complicated appendicitis, the available evidence remains inconclusive because many are retrospective, involve small sample sizes, or use heterogeneous patient populations and outcome measures.^[8] Consequently, there is no clear consensus regarding the optimal surgical approach for children with complicated appendicitis.

Complicated appendicitis in children is associated with a higher incidence of postoperative complications such as surgical site infection, prolonged ileus, intra-abdominal abscess, and extended hospital stay. Therefore, identifying the most effective surgical approach is important for improving patient outcomes and reducing healthcare burden. In view of the existing uncertainty and limited high-quality evidence, this study was undertaken to compare the outcomes of laparoscopic and open appendectomy in pediatric patients with complicated appendicitis. The study evaluated key parameters, including surgical site infection, postoperative pain, duration of hospital stay, operative time, postoperative ileus, and intra-abdominal abscess formation, to provide evidence to guide surgical decision-making in this patient population.

MATERIALS AND METHODS

This prospective comparative observational study was conducted in the Department of Paediatric Surgery, SAT Hospital, Government Medical College, Thiruvananthapuram, Kerala, India, between 1 June 2018 and 31 May 2019 after obtaining approval from the Institutional Ethics Committee. Patients aged 1–18 years presenting with clinical and radiological features suggestive of acute appendicitis were screened for inclusion. Patients with intraoperative confirmation of complicated appendicitis, defined as gangrenous or

perforated appendicitis, were enrolled after obtaining written informed consent from parents or legal guardians. Patients with associated intra-abdominal pathology, incomplete clinical records, inadequate follow-up, or those whose parents declined consent were excluded. Patients requiring conversion from laparoscopic to open surgery were excluded from the comparative analysis. A total of 32 patients met the eligibility criteria and were included in the study, with 16 undergoing laparoscopic appendectomy (LA) and 16 undergoing open appendectomy (OA). The surgical approach was not randomized; instead, it was chosen based on surgeon preference, availability of laparoscopic facilities, patient-specific factors, and prevailing institutional practices.

Baseline demographic and clinical data were prospectively collected using a standardised data-collection proforma. Information recorded included age, sex, weight, duration of symptoms, presenting complaints, and relevant physical examination findings. Routine preoperative laboratory investigations, including complete blood count, renal function tests, serum electrolytes, and, when available, C-reactive protein levels, were documented. All patients underwent preoperative abdominal ultrasonography, and findings such as appendiceal diameter, appendicolith, and periappendiceal fluid collection were recorded. Surgical procedures were performed by experienced pediatric surgeons proficient in both open and laparoscopic techniques. Following surgery, all patients received standardized postoperative care according to institutional protocols, including broad-spectrum intravenous antibiotics targeting gram-negative and anaerobic organisms, intravenous fluid therapy, analgesia, and gradual advancement of oral feeding based on recovery of bowel function and clinical status.

Postoperative outcomes were prospectively assessed and compared between the two groups. Surgical site infection (SSI) was defined according to the Centres for Disease Control and Prevention criteria as an infection within 30 days of surgery that requires antibiotic therapy or wound drainage. Postoperative pain was assessed using the Visual Analogue Scale (VAS) at predefined intervals and categorised as mild (1–3), moderate (4–6), or severe (7–10), with the highest recorded score used in the analysis. Operative duration was measured from skin incision to skin closure, and hospital stay from surgery to discharge. Postoperative ileus was defined as failure to pass flatus or stool beyond 48 hours after surgery, with abdominal distension, nausea, or vomiting. Intra-abdominal abscess was assessed by ultrasonography on the fifth postoperative day or earlier when clinically indicated. Data were analyzed using SPSS version 20. Continuous variables were expressed as mean $\pm$ standard deviation and compared using the independent-samples t-test, while categorical variables were analyzed using the Chi-square test or Fisher's exact

test as appropriate. A two-tailed p-value of <0.05 was considered statistically significant.

RESULTS

A total of 32 pediatric patients with intraoperatively confirmed complicated appendicitis were enrolled in this study over the 12-month study period. The patients were equally distributed between the two surgical approaches, with 16 patients undergoing open appendectomy (OA group) and 16 patients undergoing laparoscopic appendectomy (LA group). The baseline demographic and clinical characteristics of the study population are presented in Table 1.

The age distribution was similar between the two groups. In the OA group, 1 patient (6.3%) was in the 1-5-year age range, 10 patients (62.5%) were in the 6-10-year age range, and 5 patients (31.3%) were older than 10 years. In the LA group, 1 patient (6.3%) was in the 1-5-year age range, 14 patients (87.5%) were in the 6-10-year age range, and 1 patient (6.3%) was older than 10 years. The majority of patients in both groups were in the 6-10 year age category, which is consistent with the known epidemiology of acute appendicitis in children. The difference in age distribution between groups was not statistically significant ($p=0.189$).

Male patients predominated in the OA group, accounting for 10 patients (62.5%), while female patients comprised 6 patients (37.5%). In contrast, the LA group showed a female predominance, with 9 female patients (56.3%) and 7 male patients (43.8%). This difference in gender distribution between the two groups was not statistically significant ($p=0.288$).

Abdominal pain was the universal presenting complaint, reported in all 32 patients (100%) in both groups. This finding is consistent with the cardinal symptom of acute appendicitis. Nausea and vomiting were commonly associated symptoms, observed in 12 patients (75%) in the OA group and 10 patients (62.5%) in the LA group, with no significant difference between groups ($p=0.446$). Fever was present in 10 patients (62.5%) in the OA group and 11 patients (68.8%) in the LA group, again showing no significant difference ($p=0.71$). On clinical examination, right iliac fossa tenderness was elicited in all patients (100%) in both groups, representing a key diagnostic finding. Abdominal guarding, indicating peritoneal irritation, was noted in 13 patients (81.3%) in the OA group and 12 patients (75%) in the LA group, with no significant difference between groups ($p=0.669$).

The mean total leukocyte count was $13,621.9 \pm 276.3$ cells/mm³ in the OA group and $12,525 \pm 222.1$ cells/mm³ in the LA group, both indicating leukocytosis consistent with acute inflammation. A differential leukocyte count showing a left shift (indicating increased immature neutrophils) was present in 13 patients (81.3%) in both groups, suggesting significant bacterial infection.

Ultrasonographic examination revealed abnormal findings in 10 patients (71.4%) in the OA group and 11 patients (78.6%) in the LA group, with normal findings in 4 patients (28.6%) and 3 patients (21.4%), respectively. The difference in ultrasonographic findings between groups was not statistically significant ($p=0.663$).

The duration of surgery showed a trend toward longer operative times in the LA group, although this difference did not reach statistical significance ($p=0.144$). All 16 procedures (100%) in the OA group were completed within 61-90 minutes. In the LA group, 14 procedures (87.5%) were completed within 61-90 minutes, while 2 procedures (12.5%) required 91-120 minutes. This finding reflects the technical complexity of laparoscopic surgery in the setting of complicated appendicitis, where extensive inflammation, adhesions, and contamination may increase operative time.

The comparative postoperative outcomes between the two surgical approaches are presented in Table 2. Pain assessment revealed significant differences between the two groups. In the OA group, postoperative pain was categorized as mild in 1 patient (6.3%), moderate in 9 patients (56.3%), and severe in 6 patients (37.5%). In contrast, the LA group showed a more favourable pain profile, with mild pain in 5 patients (31.3%), moderate pain in 10 patients (62.5%), and severe pain in only 1 patient (6.3%). The difference in pain severity distribution between groups was statistically significant ($p=0.043$), indicating that laparoscopic appendectomy was associated with significantly less severe postoperative pain compared to open appendectomy.

Wound infection represented one of the most striking differences between the two surgical approaches. In the OA group, surgical site infection occurred in 8 patients (50%), while in the LA group, only 1 patient (6.3%) developed wound infection. This difference was highly statistically significant ($p=0.006$), demonstrating a substantial reduction in infectious complications with the laparoscopic approach. The high infection rate in the OA group reflects the challenges of managing contaminated wounds in complicated appendicitis, where direct contact between the inflamed appendix and the surgical wound increases the risk of bacterial contamination. The incidence of postoperative ileus was relatively low in both groups. In the OA group, 3 patients (18.8%) developed postoperative ileus, while in the LA group, 2 patients (12.5%) experienced this complication. The difference between groups was not statistically significant ($p=0.426$), suggesting that both surgical approaches have similar effects on postoperative bowel function recovery. Intra-abdominal abscess formation, a feared complication of complicated appendicitis, showed a notable difference between groups. In the OA group, 2 patients (12.5%) developed intra-abdominal abscesses detected on postoperative ultrasonography, whereas none (0%) in the LA

group did. Although this difference did not reach statistical significance ($p=0.144$), likely due to the small sample size and low event rate, the trend favours the laparoscopic approach.

Hospital stay duration showed a favourable trend toward shorter stays in the LA group. In the OA group, no patients were discharged within 1-5 days; 11 patients (68.8%) required 6-10 days of hospitalization; and 5 patients (31.3%) required extended hospitalization of 11-15 days. In the LA

group, 1 patient (6.3%) was discharged within 1-5 days, 14 patients (87.5%) required 6-10 days, and only 1 patient (6.3%) required 11-15 days of hospitalization. While the overall difference did not reach statistical significance ($p=0.134$), the substantially lower proportion of patients requiring extended hospitalization in the LA group (6.3% vs 31.3%) represents a clinically meaningful difference with important implications for healthcare resource utilization and patient quality of life.

Table 1: Baseline characteristics of the study population and clinical findings

Variables	Open N (%)	Lap N (%)	p-value
Age			0.189
1-5	1 (6.3)	1 (6.3)	
6-10	10 (62.5)	14 (87.5)	
>10	5 (31.3)	1 (6.3)	
Gender			0.288
Male	10 (62.5)	7 (43.8)	
Female	6 (37.5)	9 (56.3)	
Presenting complaints			
Abdominal pain	16 (100)	16 (100)	NA
Nausea/vomiting	12 (75)	10 (62.5)	0.446
Fever	10 (62.5)	11 (68.8)	0.71
Clinical Examination			
Tenderness	16 (100)	16 (100)	NA
Guarding	13 (81.3)	12 (75)	0.669
WBC count (Mean $\pm$ SD)	13621.9 $\pm$ 276.3	12525 $\pm$ 222.1	
Shift to left			NA
Present	13 (81.3)	13 (81.3)	
Absent	3 (18.8)	3 (18.8)	
Ultrasound findings			0.663
Normal	4 (28.6)	3 (21.4)	
Abnormal	10 (71.4)	11 (78.6)	

Table 2: Comparison of duration of surgical approaches and postoperative outcomes

Variables	Open N (%)	Lap N (%)	p-value
Duration of surgery (minutes)			0.144
61-90	16 (100)	14 (87.5)	
91-120	0	2 (12.5)	
Postoperative pain			0.043
Mild	1 (6.3)	5 (31.3)	
Moderate	9 (56.3)	10 (62.5)	
Severe	6 (37.5)	1 (6.3)	
Wound Infection			0.006
Present	8 (50)	1 (6.3)	
Absent	8 (50)	15 (93.8)	
Postoperative ileus			0.426
Present	3 (18.8)	2 (12.5)	
Absent	13 (81.3)	14 (87.5)	
Intra-abdominal abscess			0.144
Present	2 (12.5)	0	
Absent	14 (87.5)	16 (100)	
Duration of stay (days)			0.134
1-5	0	1 (6.3)	
6-10	11 (68.8)	14 (87.5)	
11-15	5 (31.3)	1 (6.3)	

DISCUSSION

This prospective observational study compared the outcomes of laparoscopic appendectomy (LA) and open appendectomy (OA) in children with complicated appendicitis. The findings demonstrate important advantages of the laparoscopic approach, particularly in reducing surgical site infections and postoperative pain, while showing favourable trends

in hospital stay, postoperative ileus, and intra-abdominal abscess formation.

The most notable finding was the significantly lower rate of surgical site infection (SSI) in the laparoscopic group compared with the open group (6.3% vs 50%, $p=0.006$). This eightfold reduction is consistent with findings from multiple meta-analyses and large clinical series reporting lower wound infection rates following laparoscopic appendectomy.^[9-11] The likely explanation is the

reduced contamination of the surgical wound during specimen retrieval. In laparoscopic surgery, the inflamed appendix is removed through a trocar port, minimizing direct contact between infected tissue and the wound. In contrast, open appendectomy requires extraction through the incision, increasing the likelihood of wound contamination. The high SSI rate observed in the OA group is consistent with previous reports involving perforated and gangrenous appendicitis, where heavy bacterial contamination and purulent collections increase the risk of postoperative wound infection. Clinically, reducing SSI is highly relevant as it decreases patient discomfort, need for prolonged antibiotics, wound care requirements, and overall healthcare costs.

Postoperative pain was also significantly lower in the laparoscopic group, with severe pain occurring in only 6.3% of patients compared with 37.5% in the open group ($p=0.043$). This finding is consistent with numerous randomized trials and meta-analyses that report lower pain scores and reduced analgesic requirements after laparoscopic surgery.^[12,13] The smaller incisions used in laparoscopy result in less tissue trauma, reduced muscle disruption, and a lower inflammatory response. Conversely, open appendectomy involves greater manipulation and retraction of the abdominal wall muscles, contributing to increased postoperative pain. Effective pain control has important clinical implications beyond patient comfort, facilitating earlier mobilization, improved respiratory function, faster recovery of bowel activity, and reduced opioid consumption. These benefits are particularly important in children, in whom postoperative pain can significantly affect recovery.

Operative time was slightly longer in the laparoscopic group, with 12.5% of procedures lasting more than 90 minutes compared with none in the open group, although the difference was not statistically significant ($p=0.144$). Similar findings have been reported in previous studies evaluating complicated appendicitis.^[14,15] Longer operative times in laparoscopy may be related to port placement, creation of pneumoperitoneum, meticulous dissection of inflamed tissues, and extensive peritoneal lavage. However, the absolute increase in operative duration was modest, and most procedures were completed within a reasonable timeframe. Furthermore, operative time generally decreases with increasing surgical experience and advancement along the learning curve.^[10] Therefore, the slightly prolonged operative duration should be interpreted in the context of the significant postoperative benefits associated with laparoscopic surgery.

A favourable trend toward shorter hospitalization was observed in the laparoscopic group, with fewer patients requiring prolonged hospital stays of 11–15 days (6.3% vs 31.3%). Although the difference did not reach statistical significance ($p=0.134$), likely because of the small sample size, the clinical

relevance remains important. Reduced postoperative pain, lower infection rates, earlier mobilization, and faster return of bowel function contribute to earlier fulfillment of discharge criteria. Similar findings have been reported in systematic reviews and cohort studies, which consistently demonstrate shorter hospital stays following laparoscopic appendectomy.^[10,11,15] Reduced hospitalization not only decreases healthcare expenditure but also minimizes disruption to family life and allows children to return more quickly to normal activities and schooling.

The incidence of postoperative ileus was lower in the laparoscopic group (12.5% vs 18.8%), although the difference was not statistically significant ($p=0.426$). This trend is consistent with previous studies suggesting a modest reduction in postoperative ileus following laparoscopic surgery.^[12,15] Reduced bowel handling, a less pronounced inflammatory response, and lower opioid requirements may contribute to earlier restoration of gastrointestinal motility. Although the overall incidence of ileus was low in both groups, even small reductions may be clinically meaningful, as postoperative ileus is associated with patient discomfort, delayed feeding, and prolonged hospital stay.

The occurrence of intra-abdominal abscess following laparoscopic treatment of complicated appendicitis has historically been controversial. Early reports suggested a higher incidence after laparoscopy, raising concerns about the effects of pneumoperitoneum and the dissemination of contaminated material within the peritoneal cavity.^[14] However, more recent evidence has largely refuted these concerns. In the present study, no patient in the laparoscopic group developed an intra-abdominal abscess, whereas the incidence was 12.5% in the open group. Although this difference was not statistically significant ($p=0.144$), the observed trend favours laparoscopy and is consistent with contemporary meta-analyses reporting comparable or lower abscess rates following laparoscopic appendectomy.^[7,10] Superior visualization of the abdominal cavity, enhanced identification of contaminated areas, and more effective peritoneal lavage may explain this advantage.

Overall, the findings of this study indicate that laparoscopic appendectomy offers significant clinical benefits in children with complicated appendicitis. The marked reduction in surgical site infection and severe postoperative pain, together with favourable trends in hospital stay, postoperative ileus, and intra-abdominal abscess formation, outweighs the modest increase in operative duration. These results support the use of laparoscopic appendectomy as the preferred surgical approach for complicated pediatric appendicitis when adequate expertise and facilities are available. Wider adoption of minimally invasive techniques may contribute to improved patient outcomes,

reduced healthcare utilization, and enhanced quality of care in this challenging patient population.

CONCLUSION

Laparoscopic appendectomy is a safe and effective approach for managing complicated appendicitis in children and is associated with significantly lower rates of surgical site infection and severe postoperative pain compared with open appendectomy. It also demonstrated favourable trends toward shorter hospital stay and lower intra-abdominal abscess rates, despite a modest increase in operative time. These findings support laparoscopic appendectomy as the preferred surgical approach for complicated pediatric appendicitis when appropriate expertise and resources are available.

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