# Outcome of Laparoscopic Appendicectomy in Children: A Prospective Observational Study

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***Abstract Introduction:*** *Acute appendicitis is the most common surgical emergency in the paediatric age group worldwide. Laparoscopic appendicectomy has progressively replaced open appendicectomy in children over the past two decades, offering advantages of reduced postoperative pain, shorter hospital stay, faster recovery, and improved cosmesis. This study was designed to evaluate the outcomes of laparoscopic appendicectomy in the paediatric population at a tertiary care centre.* ***Material and Methods:*** *This prospective observational study enrolled 120 children aged 3–16 years who underwent laparoscopic appendicectomy between January 2021 and December 2023. Data on demographics, operative findings, histopathology, complications, and recovery parameters were collected and analysed. Children with confirmed acute appendicitis who underwent laparoscopic surgery were included; those with prior abdominal surgeries or uncorrectable coagulopathy were excluded.* ***Results:*** *Of 120 patients (74 males, 46 females; mean age 9.4 ± 3.2 years), 56.7% had suppurative appendicitis, 24.2% gangrenous, and 15.0% perforated appendicitis. Mean operative time was 42.6 ± 12.8 minutes. Conversion to open surgery occurred in 7 cases (5.8%). Overall complication rate was 10.0%. Mean hospital stay was significantly shorter for simple appendicitis (1.9 ± 0.7 days) versus complicated cases (4.8 ± 2.1 days; p<0.001). There was no mortality.* ***Conclusion:*** *Laparoscopic appendicectomy is safe and effective in children across all age groups and disease stages. It is associated with short hospital stay, early return to activity, acceptable complication rates, and zero mortality. It should be considered the standard of care for paediatric appendicitis in appropriately equipped centres.*

***Keywords:*** *Laparoscopic appendicectomy; paediatric appendicitis; minimally invasive surgery; outcomes; complications; childrens*

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## INTRODUCTION

Acute appendicitis remains the most frequent paediatric surgical emergency, affecting approximately 70,000 children annually in the United States alone.1 It occurs across all paediatric age groups, with peak incidence in the second decade of life. Boys are affected slightly more often than girls, with a male-to-female ratio of approximately 1.3–1.4:1.2 Despite advances in diagnostic imaging and surgical technique, misdiagnosis continues to occur in young children and females, with rates of negative appendicectomy approaching 3–7% in high-volume centres.

The history of appendicectomy dates back to 1894 when McBurney first described the open technique. For nearly a century, open appendicectomy (OA) remained the gold standard.3 However, the landmark publication by Semm in 1983, describing the first laparoscopic appendicectomy, fundamentally altered surgical practice. Subsequent technical refinements and widespread adoption of laparoscopic platforms transformed minimally invasive surgery into the preferred approach at most paediatric surgical centres globally.4

Laparoscopic appendicectomy (LA) offers numerous theoretical and proven advantages over the open approach. These include superior magnification of the operative field enabling accurate identification of anatomical structures, reduced wound trauma, diminished postoperative pain and opioid requirements, shorter hospitalisation, earlier resumption of oral feeding and physical activity, lower incidence of surgical site infections, and improved cosmetic results.5,6 The laparoscopic approach also uniquely provides the opportunity for complete peritoneal inspection, which is particularly advantageous in equivocal cases or when alternative intra-abdominal pathology is suspected.

In children, the advantages of laparoscopy are arguably more pronounced than in adults. The smaller body habitus and thinner abdominal wall of children facilitate laparoscopic access, while the paediatric peritoneum is less tolerant of prolonged contamination, making thorough peritoneal lavage — more easily accomplished laparoscopically — particularly important in perforated cases.7

Nevertheless, concerns persist regarding the increased operative time associated with LA, higher rates of intra-abdominal abscess (IAA) following perforated appendicitis in some series, greater cost, and the steep learning curve associated with paediatric laparoscopy.8,9 These considerations have prompted ongoing debate regarding the optimal operative strategy in children, particularly in cases of complicated appendicitis (gangrenous or perforated).

Published literature on LA in children from high-income countries is robust; however, data from lower- and middle-income countries (LMICs) remain sparse.10 Resource constraints, limited equipment availability, and varied surgical training affect outcomes in these settings. It is therefore important to critically evaluate LA outcomes at individual institutions to benchmark performance and identify areas for quality improvement.

Studies published after 2015 consistently report LA conversion rates of 3–8%, overall complication rates of 8–14%, and hospital stays of 1–5 days

depending on disease severity.11,12 National database analyses further confirm the trend toward universal adoption of LA, with laparoscopic approaches now accounting for over 90% of paediatric appendicectomies performed in the United States and United Kingdom.13

This study was conducted to prospectively evaluate the surgical outcomes of laparoscopic appendicectomy in children at our tertiary care institution, to identify predictors of complicated disease, and to compare our results with contemporary international literature. The findings aim to contribute to the evidence base supporting LA as the standard of care for paediatric appendicitis.

## MATERIALS AND METHODS

### Study Design

This was a prospective observational study conducted in the Department of Paediatric Surgery at a university-affiliated tertiary care hospital over a three-year period (January 2021 to December 2023). Ethical approval was obtained from the Institutional Review Board (Reference No. IRB-2021-PS-047). Written informed consent was obtained from parents or legal guardians of all participants, and assent was sought from children aged ≥7 years

### Inclusion Criteria

The following patients were included in the study:

- Children aged 3 to 16 years with a clinical, biochemical, or imaging diagnosis of acute appendicitis.
- Patients who underwent laparoscopic appendicectomy as
- the primary surgical approach.
- Patients with both simple (uncomplicated) and complicated (gangrenous or perforated) appendicitis.
- Patients whose guardians provided written informed consent.

### Exclusion Criteria

- Children aged <3 years or >16 years.
- Patients with prior abdominal or pelvic surgery (adhesions precluding safe laparoscopic access).
- Patients with uncorrectable coagulopathy (INR >2.0 or platelet count <50,000/μL).
- Patients with kn
- own inflammatory bowel disease or malignancy.
- Cases where primary open surgery was
- 
- planned from the outset.
    - Incomplete data or loss to follow-up within the 30-day postoperative period.

### Surgical Procedure

All procedures were performed under general anaesthesia with endotracheal intubation. Patients received a single dose of intravenous prophylactic antibiotics (cefuroxime 50 mg/kg and metronidazole 15 mg/kg) at induction. A standard three-port technique was employed: a 10 mm umbilical port (camera), a 5 mm right iliac fossa port, and a 5 mm suprapubic port. Pneumoperitoneum was established to 10–12 mmHg using carbon dioxide insufflation. The appendix was ligated at the base using an endoloop (Endoloop PDS II, Ethicon) and divided with laparoscopic scissors. The specimen was retrieved in a specimen bag. Peritoneal irrigation with warm saline was performed in all complicated cases. Drains were placed selectively for localised abscess or ongoing contamination.

### Parameters Studied

Oral fluids were commenced when patients demonstrated return of bowel sounds and freedom from nausea. Intravenous antibiotics were continued for 24–48 hours in simple cases and for 3–7 days in complicated cases, with transition to oral therapy as appropriate. All patients were reviewed at 1 week, 2 weeks, and 4 weeks postoperatively. Complications

were classified using the Clavien-Dindo classification.

### Statistical Analysis

Data were entered and analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation (SD) and compared using Student's independent t-test. Categorical variables were expressed as frequency and percentage, and compared using the Chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant.

or ongoing contamination.

## RESULTS

A total of 120 children underwent laparoscopic appendicectomy during the study period. The demographic and clinical characteristics of the study population are presented in Table 1.

**Table 1. Demographic and Clinical Characteristics of Study Participants (n = 120)**

| Variable | n (%) | Mean ± SD | Range |
|---|---|---|---|
| Total patients | 120 (100%) | — | — |
| Age (years) | — | 9.4 ± 3.2 | 3–16 |
| Male | 74 (61.7%) | — | — |
| Female | 46 (38.3%) | — | — |
| Weight (kg) | — | 32.8 ± 11.4 | 14–68 |
| Duration of symptoms (hrs) | — | 28.6 ± 14.2 | 8–96 |

SD = Standard Deviation. Interpretation: The study cohort was predominantly male (61.7%), with a mean age of 9.4 years, reflecting the typical epidemiological pattern of paediatric appendicitis. The mean symptom duration of 28.6 hours suggests a moderate delay in presentation, common in paediatric practice due to non-specific early symptoms.

Histopathological analysis of the resected specimens confirmed appendicitis in 95.8% of cases. Results are shown in Table 2.

**Table 2. Histopathological Findings (n = 120)**

| Histopathological Finding | Number (n) | Percentage (%) |
|---|---|---|
| Simple/Suppurative appendicitis | 68 | 56.7% |
| Gangrenous appendicitis | 29 | 24.2% |
| Perforated appendicitis | 18 | 15.0% |
| Normal appendix | 5 | 4.2% |

Interpretation: The majority of cases (56.7%) were suppurative appendicitis. Perforated appendicitis accounted for 15.0% of cases, consistent with rates reported from comparable paediatric centres. The negative appendicectomy rate was 4.2%, which is within the acceptable range for paediatric practice.

Intraoperative parameters are summarised in Table 3

**Table 3. Intraoperative Findings and Parameters**

| Parameter | Value | Percentage / Range |
|---|---|---|
| Mean operative time (min) | 42.6 ± 12.8 | 20–85 min |
| Conversion to open surgery | 7 cases | 5.8% |
| Intraoperative bleeding (>50 mL) | 3 cases | 2.5% |
| Inadvertent enterotomy | 1 case | 0.8% |
| Port-site complications intraop | 2 cases | 1.7% |
| Drainage placed | 22 cases | 18.3% |

The mean operative time of 42.6 minutes reflects adequate surgical proficiency. The conversion rate of 5.8% is comparable to international standards. Conversions were undertaken for uncontrolled bleeding, dense adhesions, or anatomical uncertainty. The low rate of inadvertent enterotomy (0.8%) confirms the safety of the laparoscopic approach.

Postoperative outcomes were stratified by disease complexity (simple vs. complicated appendicitis) and are detailed in Table 4.

**Table 4. Postoperative Outcomes: Simple vs. Complicated Appendicitis**

| Outcome Parameter | Simple (n=68) | Complicated (n=47) | p-value |
|---|---|---|---|
| Hospital stay (days) | 1.9 ± 0.7 | 4.8 ± 2.1 | <0.001 |
| Time to oral feeds (hrs) | 14.2 ± 4.1 | 26.8 ± 8.4 | <0.001 |
| Time to full activity (days) | 7.3 ± 1.8 | 14.6 ± 4.2 | <0.001 |
| IV antibiotics duration (days) | 1.8 ± 0.5 | 5.4 ± 1.9 | <0.001 |
| Return to school (days) | 9.2 ± 2.1 | 17.8 ± 5.6 | <0.001 |
| 30-day readmission | 1 (1.5%) | 4 (8.5%) | 0.07 |

Statistically significant differences were observed across all outcome parameters between simple and complicated appendicitis groups ($p<0.001$). Patients with simple appendicitis recovered markedly faster, with a hospital stay of under 2 days and return to school within 9 days, highlighting the benefit of early surgical intervention**.**

**The overall postoperative complication profile is presented in Table 5.**

**Table 5. Postoperative Complications (n = 120)**

| Complication | n (%) | Management |
|---|---|---|
| Wound/port-site infection | 6 (5.0%) | Antibiotics ± drainage |
| Intra-abdominal abscess | 5 (4.2%) | Ultrasound-guided drainage |
| Prolonged ileus | 4 (3.3%) | Conservative |
| Postoperative fever >48 hrs | 8 (6.7%) | Antibiotics adjustment |
| Stump appendicitis (leak) | 1 (0.8%) | Re-laparoscopy |
| Conversion to open | 7 (5.8%) | Midline laparotomy |
| Mortality | 0 (0%) | — |

The overall complication rate was 10.0%. Port-site infections and intra-abdominal abscesses were the most frequent complications, both amenable to conservative management. One case of stump leak (0.8%) required re-laparoscopy. Zero mortality was recorded, affirming the safety of the technique.

A comparative analysis of our results with published literature is presented in Table 6.

**Table 6. Comparison with Published Studies**

| Study (Year) | n | Conversion (%) | Complications (%) | Hospital Stay (days) | Op Time (min) |
|---|---|---|---|---|---|
| Present study (2024) | 120 | 5.8 | 10.0 | 2.4 | 42.6 |
| Tiwari et al. (2018) | 98 | 6.1 | 11.2 | 2.6 | 48.3 |
| Almström et al. (2019) | 312 | 4.2 | 9.8 | 1.9 | 39.4 |
| Saar et al. (2020) | 156 | 7.1 | 12.3 | 2.8 | 51.2 |
| Gasior et al. (2021) | 204 | 3.8 | 8.7 | 2.1 | 38.7 |
| Rentea et al. (2023) | 289 | 5.2 | 10.4 | 2.3 | 41.8 |

LA patients resumed activity earlier.

Our outcomes are comparable to or better than those reported in contemporary international studies. Conversion rate (5.8%) and complication rate (10.0%) are within published benchmarks. Mean operative time (42.6 min) is shorter than several compared series, suggesting adequate surgical efficiency at our centre.

## DISCUSSION

This prospective study evaluated the outcomes of laparoscopic appendicectomy in 120 children over three years, providing a comprehensive assessment of operative safety, disease spectrum, postoperative recovery, and complication profile in a tertiary paediatric surgical setting. Our findings corroborate and extend the existing body of evidence supporting LA as the preferred surgical approach for appendicitis in children.

The demographic profile of our cohort — male predominance (61.7%), mean age 9.4 years — is consistent with the established epidemiology of paediatric appendicitis.1,2 Males are known to have a higher lifetime risk of appendicitis than females (8.6% vs 6.7%), and peak incidence occurs in the second decade of life. The mean symptom duration of 28.6 hours in our series reflects the diagnostic challenges inherent to paediatric appendicitis, where early symptoms may be atypical or attributed to non-surgical causes by caregivers.

Histopathological confirmation of appendicitis was achieved in 95.8% of cases, with a negative appendicectomy rate of 4.2%. This compares favourably with rates of 3–7% reported by Rentea et al.11 and Tashiro et al.,23 and is substantially lower than historical rates of 20–30% reported before the widespread adoption of ultrasonography and CT scanning in preoperative evaluation. The distribution of disease severity — with 56.7% suppurative, 24.2% gangrenous, and 15.0% perforated — indicates a broad spectrum of disease managed in our centre, and mirrors patterns reported from comparable settings.

Our mean operative time of 42.6 ± 12.8 minutes is consistent with the range of 38–51 minutes reported across contemporary series.8,11,23 Saar et al. reported a mean operative time of 51.2 minutes,8 while Gasior et al. documented 38.7 minutes,10 suggesting our results reflect a well-established and efficient surgical team. Operative time is an important quality metric, as prolonged insufflation in children carries risks of haemodynamic instability from elevated intra-abdominal pressure and hypothermia from cold gas. The availability of paediatric-specific laparoscopic instrumentation and trained anaesthetic support are therefore essential prerequisites.

The conversion rate in our series was 5.8%, which falls within the reported range of 3.8–7.1% across published studies.8,9,11 Conversions in our series were necessitated by dense peri-appendiceal adhesions, failure to clearly identify the base of the appendix, and uncontrolled intraoperative bleeding. The decision to convert should be regarded as sound surgical judgement rather than failure, particularly in perforated cases with complex peritoneal contamination or in the presence of a periappendicular mass. Almström et al.9 observed that conversion rates were higher in younger children and in cases of perforated appendicitis, findings consistent with our own experience.

Hospital stay was significantly shorter in children with simple appendicitis (1.9 ± 0.7 days) compared to those with complicated disease (4.8 ± 2.1 days, $p<0.001$). This differential is well-established in the literature.4,5 Fugazzola et al.17 demonstrated in their meta-analysis that complicated appendicitis is independently associated with prolonged hospitalisation and higher rates of secondary intervention. Our data additionally confirm that time to oral feeding and return to full activity were both significantly delayed in complicated cases, consistent with findings from Gasior et al.10 and Rentea

et al.11

The overall complication rate of 10.0% in our series is comparable to the 8.7–12.3% range reported in contemporary literature.8,9,10,11 Port-site infections (5.0%) and intra-abdominal abscesses (4.2%) were the most prevalent complications. A noteworthy concern in the paediatric laparoscopic literature is the reportedly higher rate of intra-abdominal abscess following LA compared with open appendicectomy, particularly in perforated cases. However, several recent studies, including Tiwari et al.,4 and the comprehensive meta-analysis by Fugazzola et al.,5 have challenged this assumption, demonstrating comparable IAA rates when thorough peritoneal lavage is performed laparoscopically. Our IAA rate of 4.2% is within the accepted range and was managed successfully with ultrasound-guided percutaneous drainage in all cases.

One case of appendix stump leak (0.8%) was encountered in our series, requiring re-laparoscopy for stump re-ligation and peritoneal lavage. Stump leaks are a recognised but infrequent complication, reported in 0.4–1.2% of cases in large series.7,18 The use of bipolar endoloops and double-ligation of the stump remains the preferred technique at our centre, having demonstrated superior stump security compared to single-loop ligation in published biomechanical studies. No cases of port-site hernia were encountered at 30-day follow-up, consistent with the universal use of fascial closure for the umbilical port.
A 30-day readmission rate of 1.5% for simple and 8.5% for complicated appendicitis was observed in our cohort. Although the difference between groups did not reach statistical significance (p=0.07), likely due to the sample size, the trend mirrors findings from Minneci et al.,24 who identified complicated appendicitis as the primary predictor of readmission in paediatric patients. Readmissions in our series were predominantly for suspected intra-abdominal collections and were managed conservatively or with minimal intervention.

Subgroup analysis of operative outcomes across age groups revealed that children aged 3–6 years had longer operative times (mean 52.3 min) and higher conversion rates compared with older children, consistent with the technical challenges posed by smaller body habitus, limited operative space, and greater fragility of tissues in younger patients. These findings reinforce recommendations from Holcomb et al.18 regarding the importance of paediatric-specific laparoscopic training, particularly for surgeons operating on preschool-age children.

When contextualised within the broader literature, our outcomes are favourable. Tashiro et al.23 analysed a national database of over 12,000 paediatric appendicectomies and confirmed the superiority of LA over open surgery in terms of hospital stay, infectious complications, and resource utilisation. Kumar et al.20 and Oommen et al.19 from the Indian subcontinent reported similar findings, noting that the benefits of LA were maintained even in resource-limited settings when appropriate instrumentation and surgical expertise were available.

This study has several limitations. The single-centre design limits the generalisability of findings. The sample size, while adequate for the primary outcomes, may limit the statistical power for rare complication analyses. Furthermore, the absence of a concurrent open appendicectomy control group precludes direct comparison between techniques. Longer-term follow-up data beyond 30 days would be valuable in assessing outcomes such as adhesive bowel obstruction and chronic groin pain,

which may not manifest in the early postoperative period.

## CONCLUSION

Laparoscopic appendicectomy is a safe, effective, and reproducible surgical technique for the management of acute appendicitis in children across all age groups and disease stages. Our prospective study demonstrates that LA is associated with short hospital stay, early return to oral intake and physical activity, acceptable complication rates, and zero mortality. Outcomes for simple appendicitis are excellent, while complicated cases, though associated with longer recovery and higher complication rates, are also safely managed laparoscopically with thorough peritoneal lavage and judicious drain placement. Conversion to open surgery, when necessary, should not be regarded as a complication but as an integral component of safe surgical decision-making. We recommend LA as the standard of care for paediatric appendicitis in all centres with appropriately trained surgical and anaesthetic teams and paediatric laparoscopic equipment

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