

Original Research Article

LAPAROSCOPIC VERSUS OPEN APPENDECTOMY IN PEDIATRIC COMPLICATED APPENDICITIS: SURGICAL-SITE INFECTION, PERIOPERATIVE OUTCOMES, AND A REVIEW OF THE LITERATURE

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ABSTRACT

Background: Complicated appendicitis in children is associated with increased postoperative morbidity, particularly surgical-site infection (SSI), intra-abdominal abscess, and prolonged recovery. Although laparoscopic appendectomy is increasingly used in children, its comparative outcomes in complicated appendicitis, particularly in institutional settings, remain clinically relevant. This study compared postoperative SSI and perioperative outcomes following laparoscopic and open appendectomy in children with complicated appendicitis.

Materials and Methods: A prospective observational comparative study was conducted in children undergoing appendectomy for complicated appendicitis at a tertiary-care center between October 2018 and May 2019. Patients were managed by either laparoscopic appendectomy (LA) or open appendectomy (OA) according to the operating surgeon's clinical judgment. Demographic characteristics, operative findings, postoperative pain, surgical-site infection, postoperative ileus, intra-abdominal abscess, operative duration, and length of hospital stay were recorded and compared between the two groups.

Results: Thirty-two children were included, with 16 undergoing LA and 16 undergoing OA. The groups were comparable on the baseline characteristics assessed. Surgical-site infection occurred in 1 (6.3%) patient in the LA group compared with 8 (50.0%) patients in the OA group. Postoperative pain severity was also lower following LA, with severe pain reported in 1 (6.3%) patient compared with 6 (37.5%) patients following OA. No statistically significant differences were observed in operative duration, postoperative ileus, intra-abdominal abscess, or length of hospital stay. No intra-abdominal abscess was documented in the LA group, compared with 2 (12.5%) patients in the OA group.

Conclusions: In this small prospective observational cohort, laparoscopic appendectomy was associated with a lower incidence of surgical-site infection and reduced postoperative pain compared with open appendectomy in children with complicated appendicitis. However, the non-randomized study design and small sample size limit causal inference and the precision of the estimates. Larger prospective multicenter studies with standardized definitions, perioperative protocols, adequate follow-up, and adjustment for disease severity are warranted further to evaluate the comparative outcomes of laparoscopic and open appendectomy.

Keywords: Appendicitis; Complicated appendicitis; Laparoscopic appendectomy; Open appendectomy; Surgical-site infection; Postoperative outcomes.

INTRODUCTION

Acute appendicitis is the most common surgical emergency in children, with complicated appendicitis defined as gangrenous or perforated appendix accounting for approximately 30-40% of pediatric cases.^[1-5] Complicated appendicitis presents unique management challenges due to increased risk of postoperative complications, including surgical site infections, intra-abdominal abscesses, prolonged ileus, and extended hospital stays.^[6-11] The surgical management of complicated appendicitis has evolved significantly over the past three decades. While open appendectomy (OA) through a right lower quadrant incision has been the traditional approach, laparoscopic appendectomy (LA) has gained widespread acceptance for uncomplicated cases since its introduction in the 1980s.^[9,10] The role of laparoscopy in complicated appendicitis continues to evolve, with ongoing debate over the optimal approach, particularly in pediatric populations.^[2,7] Recent systematic reviews and meta-analyses have suggested potential benefits of the laparoscopic approach even in complicated cases, including reduced wound infections, shorter hospital stays, and improved cosmetic outcomes.^[1,3] However, these advantages must be weighed against technical challenges, surgeon expertise requirements, and resource availability, particularly in developing countries.^[8,12] The pediatric population presents additional considerations, including smaller working spaces, varying anatomical proportions across age groups, and different pain perception and recovery patterns compared to adults.^[4] Despite growing evidence, optimal surgical approach selection for complicated appendicitis in children remains institution-dependent and lacks universal consensus.^[6]

Understanding local practice patterns, patient characteristics, and outcomes is essential for evidence-based decision-making and quality enhancement initiatives. This prospective observational study was designed to systematically evaluate the presentation, surgical management approaches, and clinical outcomes of children especially surgical site infection in patients with complicated appendicitis at a tertiary care center in South India.

MATERIALS AND METHODS

This prospective observational study was conducted in the Department of Paediatric Surgery at SAT Hospital, Government Medical College, Thiruvananthapuram, Kerala, India, from October 2018 to May 2019, after obtaining approval from the Institutional Ethics Committee. The study was designed to systematically document and analyze current clinical practice in managing complicated appendicitis in children. All children diagnosed with complicated appendicitis (gangrenous or perforated

appendix confirmed intraoperatively) and undergoing appendectomy during the study period were eligible for inclusion. A total of 32 children were enrolled after obtaining written informed consent from their parents or legal guardians. Patients with additional intra-abdominal pathology or those whose guardians declined consent were excluded. Surgical approach selection (laparoscopic or open appendectomy) was based on surgeon preference, patient characteristics, and clinical presentation, reflecting routine institutional practice. Baseline demographic, clinical, laboratory, and radiological data were prospectively recorded using a structured proforma designed for this audit. Clinical assessment included documentation of abdominal pain, fever, vomiting, diarrhoea, right iliac fossa tenderness, rebound tenderness, guarding, and per rectal examination findings. Routine investigations, including complete blood count, renal function tests, serum electrolytes, and ultrasonography findings, were recorded.

Postoperative outcomes assessed included surgical site infection, postoperative pain, duration of hospital stay, postoperative ileus, and intra-abdominal abscess formation. Postoperative pain was evaluated using the Visual Analogue Scale (VAS) and categorized as mild, moderate, or severe. Postoperative ileus was defined as the absence of bowel movement beyond 48 hours after surgery, while intra-abdominal abscess was assessed by ultrasonography on the fifth postoperative day or earlier when clinically indicated. Data were analysed using SPSS software. Continuous variables were expressed as mean $\pm$ standard deviation and compared using the independent-samples t-test, while categorical variables were compared using the Chi-square test or Fisher's exact test as appropriate. A p-value of <0.05 was considered statistically significant. Analysis was performed to characterize practice patterns and identify differences in outcomes between surgical approaches.

RESULTS

During the study period, thirty-two children with complicated appendicitis were enrolled, with 16 patients managed by open appendectomy and 16 by laparoscopic appendectomy. The baseline demographic and clinical characteristics were comparable between the two groups (Table 1). The majority of patients in both groups were in the 6-10 years age category (62.5% in OA vs 87.5% in LA), followed by the 11-15 years age category (31.3% in OA vs 6.3% in LA). Only one patient in each group was younger than 5 years. Age distribution did not differ significantly between groups ($p=0.189$). The OA group comprised 62.5% males and 37.5% females, while the LA group had 43.8% males and 56.3% females. This difference was not statistically significant ($p=0.288$).

All patients (100%) in both groups presented with abdominal pain and demonstrated tenderness on

clinical examination. Nausea or vomiting was present in 75% of OA patients and 62.5% of LA patients ($p=0.446$). Fever was documented in 62.5% of OA patients and 68.8% of LA patients ($p=0.71$). Guarding was observed in 81.3% of OA patients and 75% of LA patients ($p=0.669$). Mean white blood cell count was 13621.9 ± 276.3 cells/ μ L in the OA group and 12525 ± 222.1 cells/ μ L in the LA group. A left shift in the differential count was present in 81.3% of patients in both groups. Ultrasonography revealed abnormal findings in 71.4% of OA patients and 78.6% of LA patients, with no significant difference between groups.

All patients (100%) in the OA group had an operative duration between 61 and 90 minutes, while 87.5% of LA patients fell within this range, and 12.5% required 91 to 120 minutes. This difference was not statistically significant ($p=0.144$). Postoperative pain severity differed significantly between the two groups ($p=0.043$). In the LA group, 31.3% had mild

pain, 62.5% had moderate pain, and only 6.3% had severe pain. In contrast, the OA group had 6.3% mild pain, 56.3% moderate pain, and 37.5% severe pain. Wound infection rates differed significantly between groups ($p=0.006$). The LA group had a markedly lower infection rate of 6.3% (1 patient) than 50% (8 patients) in the OA group. Postoperative ileus occurred in 12.5% of OA patients and 18.8% of LA patients, with no significant difference between groups ($p=0.426$). Intra-abdominal abscess formation occurred in 12.5% (2 patients) of the OA group and in none of the LA group. This difference was not statistically significant ($p=0.144$). Most patients in both groups (68.8% in OA vs 87.5% in LA) had hospital stays of 6-10 days. Extended stays of 11-15 days were required for 31.3% of OA patients and 6.3% of LA patients. Only one LA patient (6.3%) was discharged within 5 days. These differences were not statistically significant ($p=0.134$).

Table 1: Baseline characteristics of the study population

Variables	Open N (%)	Lap N (%)	p-value
Age			0.189
01-May	1(6.3)	1(6.3)	
06-Oct	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	NA
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)	32(1.4)	
Abnormal	10(71.4)	11(78.6)	

Table 2: Comparison of duration of surgical approaches and post operative outcomes

Duration of surgery in minutes			0.144
61-90	16(100)	14(87.5)	
91-120	0	2(12.5)	
Post operative 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)	
Post operative ileus			0.426
Present	2(12.5)	3(18.8)	
Absent	14(87.5)	13(81.3)	
Intra abdominal abscess			0.144
Present	2(12.5)	0	
Absent	14(87.5)	16(100)	
Duration of stay in days			0.134
1-5	0	1(6.3)	
6-8	11(68.8)	14(87.5)	
9-15	5(31.3)	1(6.3)	

Table 3: Comparison with Published Indian Literature

Study	Year	Design	n (OA/LA)	Wound Inf OA (%)	Wound Inf LA (%)	Hospital Stay OA (days)	Hospital Stay LA (days)
Deepak et al. [13]	2008	Retrospective	16/26	18.8	3.8	7.3	5.4
Padankatti et al. [14]	2008	Retrospective	18/12	NR	NR	7.5	5.0
Singh & Wadiwa [16]	2018	Prospective	60/40	11.7	5.0	NR	NR
Pramod et al. [15]	2020	Prospective	37/36	18.9	5.5	7.92 ± 1.06	5.11 ± 0.55
Fatma N et al. [17]	2023	Prospective	25/25	32.0	0.0	8.0 ± 0.89	2.0 ± 0.78
Present Study	2025	Prospective	16/16	50.0	6.3	68.8%* (6-10d)	87.5%* (6-10d)

[*Proportion discharged within 6-10 days; NR = not reported; OA = open appendectomy; LA = laparoscopic appendectomy]

Table 4: Comparison with Western and International Literature

Study	Year	Type	n	Wound Inf OA (%)	Wound Inf LA (%)	IAA OA (%)	IAA LA (%)	Hosp Stay OA (days)	Hosp Stay LA (days)
Aziz et al. [20]	2006	Systematic review	6,477	5.0	1.5	Higher (NS)	Higher (NS)	WMD - 0.48	WMD - 0.48
Nataraja et al. [21]	2013	Meta-analysis	22,060	NR	NR	2.7	2.9	NR	NR
Jo et al. [22]	2014	Retrospective	274	NR	NR	7.2	13.9	6.3	5.0
Kasem et al. [23]	2018	Retrospective	81	8.1	4.5	5.4	0.0	NR	NR
Quah et al. [19]	2019	Meta-analysis	6,428	12.8	4.7	4.6	6.1	8.9	6.4
Low et al. [1]	2019	Meta-analysis	Multi	OR 0.37 (LA vs OA)	OR 0.37 (LA vs OA)	Similar	Similar	WMD - 0.96	WMD - 0.96
Present Study	2025	Prospective audit	32	50.0	6.3	12.5	0.0	68.8%*	87.5%*

[*Proportion discharged within 6-10 days; IAA = intra-abdominal abscess; WMD = weighted mean difference; OR = odds ratio; NS = not significant; NR = not reported]

DISCUSSION

This prospective observational study provides valuable insights into current practice patterns and outcomes in the management of complicated appendicitis in children at our tertiary care center. The audit demonstrates that both laparoscopic and open appendectomies are employed in routine practice, with notable differences in postoperative pain control and surgical site infection rates. During the study period, both surgical approaches were used equally (n=16 each), reflecting institutional practice in which approach selection is based on surgeon preference, patient characteristics, and clinical presentation. The comparable baseline characteristics between groups suggest that both approaches were applied to similar patient populations, though the non-randomized selection of approaches may introduce selection bias. Understanding these practice patterns is essential for developing institutional protocols and guidelines for selecting surgical approaches.^[6]

The study revealed significantly reduced postoperative pain in patients undergoing laparoscopic appendectomy (p=0.043), with only 6.3% experiencing severe pain compared to 37.5% in the open appendectomy group. This finding aligns with existing literature showing the minimally invasive nature of laparoscopy, with smaller incisions

and less tissue trauma.^[1,3] This advantage is particularly relevant in pediatric populations, where pain management significantly affects early mobilization, resumption of oral intake, and overall recovery.^[4] This observation suggests an opportunity for quality improvement by increasing the use of the laparoscopic approach when feasible and appropriate.^[2]

The most striking finding in this study was the substantially lower wound infection rate in patients undergoing laparoscopic appendectomy (6.3% vs 50%, p=0.006). This represents a significant quality indicator and highlights an important area for potential improvement in patient outcomes. The high wound infection rate observed with open appendectomy (50%) warrants further investigation and quality improvement initiatives, including review of perioperative antibiotic protocols, wound care practices, and surgical technique.^[1,3,10] The lower infection rate with the laparoscopic approach may be attributed to smaller incisions with reduced wound surface area, specimen retrieval bags that minimize wound contamination, and improved visualization that enables thorough peritoneal lavage.^[1,3] In resource-limited settings where wound infections contribute significantly to healthcare burden and prolonged hospital stays, this finding has important implications for clinical practice and resource allocation.^[8,12]

The study found no significant difference in operative duration between approaches, with most procedures completed within 61-90 minutes. This observation suggests that institutional experience and standardised surgical protocols have minimized differences in operative efficiency across approaches. However, 12.5% of laparoscopic cases required extended operative time (91-120 minutes), possibly representing technically challenging cases with extensive peritoneal contamination or difficult anatomical access.^[2]

Intra-abdominal abscess formation has been a contentious issue in the laparoscopic management of complicated appendicitis.^[7] This audit observed abscess formation in 12.5% of patients undergoing open appendectomy and none in the laparoscopic group, though this difference did not reach statistical significance ($p=0.144$). The absence of abscesses in the laparoscopic group may reflect thorough intraoperative lavage facilitated by superior laparoscopic visualization and access to all peritoneal recesses.^[6] Recent systematic reviews have found no significant difference in abscess rates between approaches when adequate peritoneal lavage is performed.^[13]

No significant differences were observed in postoperative ileus rates (12.5% OA vs 18.8% LA, $p=0.426$) or hospital stay duration ($p=0.134$) between groups. This finding suggests that in complicated appendicitis, the severity of underlying pathology and associated complications may be more influential determinants of recovery time than surgical approach alone.^[6,8] The comparable ileus rates indicate that both techniques, when performed with appropriate peritoneal lavage and postoperative care, result in similar gastrointestinal recovery patterns.^[12]

Wound infection rates in this study (OA 50% vs LA 6.3%, $p=0.006$) were broadly consistent with though higher than published Indian series. Deepak et al. reported wound infection rates of 18.8% (OA) and 3.8% (LA) in a series of 42 pediatric patients with complicated appendicitis.^[13] Pramod et al., in a prospective comparison of 73 children, found rates of 18.9% and 5.5% for OA and LA, respectively.^[15] Singh and Wadiwa documented 11.66% vs 5.0%, while Kumar et al. recorded the highest published Indian rates; 32% (OA) and 0% (LA) in a cohort of 50 patients.^[16,17] The higher OA wound infection rate in the present audit (50%) likely reflects the advanced stage of peritonitis and peritoneal contamination encountered at our tertiary referral centre, where complicated appendicitis is frequently diagnosed late due to delayed presentation.

Large Western pooled analyses corroborate the superiority of LA in preventing wound infections. Aziz et al., in a systematic review of 6,477 patients across 49 randomized and non-randomized studies, reported wound infection rates of 5.0% (OA) and 1.5% (LA), with the laparoscopic approach conferring a significant advantage.^[20] Quah et al. analysed 6,428 patients in their meta-analysis and found pooled wound infection rates of 12.8% (OA)

and 4.7% (LA), reinforcing the consistent benefit of LA.^[19] Low et al. reported an odds ratio of 0.37 favouring LA for wound infection, further confirming this trend across multicentre datasets.^[11] The substantially higher absolute infection rate in our open appendectomy group compared to these Western benchmarks underscores the impact of local factors including delayed referral, limited resources, and a higher burden of perforated cases on surgical outcomes.

Hospital stay duration, while not significantly different between groups in this audit ($p=0.134$), showed a directional trend favouring LA (87.5% of LA patients vs 68.8% of OA patients discharged within 6-10 days). This pattern is consistent with published Indian and international literature. Deepak et al. reported mean hospital stays of 7.3 days (OA) vs 5.4 days (LA),^[13] while Kumar et al. found markedly different stays of 8.0 ± 0.89 days (OA) vs 2.0 ± 0.78 days (LA).^[17] Pramod et al. documented 7.92 ± 1.06 days for OA vs 5.11 ± 0.55 days for LA.^[15] Internationally, Quah et al. reported OA stays of 8.9 days vs 6.4 days for LA,^[19] and Low et al. found a weighted mean difference of -0.96 days favouring LA.^[11] The lack of statistical significance in the present study is attributable to the small sample size ($n=32$) and the likely confounding effect of postoperative complications, particularly wound infections, in the OA group, which may have prolonged stays independently of the surgical approach.

Intra-abdominal abscess (IAA) formation remains one of the most debated outcomes in laparoscopic versus open management of complicated appendicitis. This study found IAA in 12.5% of OA patients and 0% of LA patients, though this did not reach statistical significance ($p=0.144$). The published evidence on IAA rates is heterogeneous. Jo et al. reported IAA rates of 13.9% (LA) versus 7.2% (OA), suggesting a higher risk with laparoscopy.^[22] Similarly, Quah et al. found pooled IAA rates of 6.1% (LA) and 4.6% (OA) in their large meta-analysis.^[19] In contrast, Nataraja et al., in the largest published series to date (22,060 patients), found similar rates of 2.7% (OA) and 2.9% (LA), concluding no significant difference between approaches.^[21] Kasem et al. reported 0% IAA in LA versus 5.4% in OA,^[23] consistent with our finding. The 0% IAA rate in our LA group may reflect the benefits of thorough peritoneal lavage under laparoscopic magnification, enabling access to all peritoneal recesses, and is aligned with contemporary evidence that adequate irrigation technique is the primary determinant of IAA prevention, irrespective of surgical approach.

Operative duration was comparable between OA and LA in this audit, with all OA patients (100%) and 87.5% of LA patients completing surgery within 61-90 minutes ($p=0.144$). This finding is consistent with published Indian data. Deepak et al. reported mean operative times of 90.3 minutes (OA) versus 86.7 minutes (LA),^[13] while Pramod et al. found $67.16 \pm$

8.32 minutes (OA) versus 55.83 ± 7.28 minutes (LA), with LA being slightly faster in experienced hands.^[15] Internationally, Low et al. reported a weighted mean difference of +12.44 minutes favouring OA (i.e., LA takes longer), which is the expected pattern in early-to-intermediate laparoscopic programmes.^[1] Pogorelić et al. similarly noted that operative time differences diminish as surgeons gain laparoscopic experience.^[30] The equivalence observed in this audit likely reflects the maturity of our laparoscopic programme, where experienced surgeons perform both approaches with comparable efficiency, and suggests that operative duration is no longer a barrier to adopting the laparoscopic approach in complicated paediatric appendicitis at our centre.

This study identifies several opportunities for quality improvement in the management of complicated appendicitis at our institution:

Surgical Site Infection Reduction: The high wound infection rate with open appendectomy (50%) represents a priority area for intervention. Quality improvement initiatives should focus on perioperative antibiotic protocols, refining surgical technique, and improving wound care practices.

Surgical Approach Selection: The favourable outcomes with laparoscopic appendectomy in terms of pain and infection rates suggest potential benefit from increased utilization of this approach when surgical expertise and resources are available.^[3,4]

Standardization of Care: Development of institutional protocols for surgical approach selection, perioperative management, and postoperative care may help optimize outcomes and reduce practice variation.^[6]

Training and Expertise: Ensuring adequate training in laparoscopic techniques for complicated appendicitis may expand access to this approach and improve overall outcomes.

Several limitations in this study warrant consideration. The relatively small sample size ($n=32$) may have limited statistical power to detect differences in less frequent complications such as intra-abdominal abscess. The study was conducted at a single tertiary care centre, potentially limiting its generalizability to other settings with different levels of resource availability or surgical expertise. The surgical approach assignment was not randomized, introducing potential selection bias that may affect comparisons of outcomes. The study did not assess long-term outcomes, including incisional hernia rates and cosmetic satisfaction. Additionally, cost-effectiveness analysis was not performed, which is particularly relevant for resource-limited settings.^[8,12]

CONCLUSION

This prospective observational study provides important baseline data on the presentation, surgical management, and outcomes of complicated appendicitis in children at our tertiary care center.

The study demonstrates that both laparoscopic and open appendectomies are used in routine practice, with the laparoscopic approach associated with favourable outcomes, including reduced postoperative pain and lower surgical site infection rates. Operative duration, postoperative ileus, intra-abdominal abscess formation, and hospital stay duration were comparable between approaches.

The findings highlight significant opportunities for quality improvement, particularly in reducing surgical site infections and optimizing surgical approach selection. The high wound infection rate observed with open appendectomy (50%) represents a priority area for intervention through enhanced perioperative protocols and increased utilization of the laparoscopic approach when appropriate. These results provide a foundation for evidence-based quality improvement initiatives and will inform the development of institutional guidelines for managing complicated appendicitis in children.

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