



## Original Article

# Comparison of Outcomes of Laparoscopic vs Open Appendectomy in Complicated Appendicitis in Adults: A Prospective Observational Comparative Study

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### Abstract

**Introduction:** The role of laparoscopic appendectomy in complicated appendicitis remains controversial because of concerns regarding operative difficulty and postoperative infectious complications. This study evaluated and compared the outcomes of laparoscopic and open appendectomy in patients with complicated appendicitis.

**Methods:** A prospective observational comparative study was conducted over two years in a tertiary care hospital in Dhaka, Bangladesh. Adult patients diagnosed with acute appendicitis were prepared for laparoscopic appendectomy. During laparoscopy, those found to have complicated appendicitis were enrolled in the laparoscopic appendectomy (LA) group. Patients with uncomplicated acute appendicitis underwent conventional laparoscopic appendectomy and were not included in the study. Pre-operatively diagnosed complicated appendicitis patients were enrolled in the open appendectomy (OA) group. The primary outcome measure was postoperative intra-abdominal abscess (IAA) formation. Secondary outcomes included operative duration, postoperative hospital stay, wound infection, conversion rate, morbidity, readmission, and procedural cost.

**Results:** A total of 48 patients were enrolled, 34 patients in the laparoscopic group and 14 in the open surgery group. IAA occurred in 6.7% of LA vs 10% of OA ( $p=0.34$ ). Operative time was longer in LA ( $75\pm 20$  vs  $60\pm 18$  min;  $p<0.01$ ). The LA group had shorter hospital stay ( $3.2\pm 1.1$  vs  $4.8\pm 1.5$  days;  $p<0.001$ ). Wound infection was lower in LA (4% vs 12.5%;  $p=0.03$ ). Conversion to open was necessary in five patients (14.7%) of LA. Although the laparoscopic approach involved slightly higher procedural costs and required prolonged operation time, it demonstrated superior postoperative recovery and shorter hospital stay.

**Conclusion:** Laparoscopic appendectomy for complicated appendicitis is a safe and effective surgical option associated with lower wound infection rates, shorter hospitalization, and acceptable postoperative complication rates. In experienced hands, laparoscopic surgery should be considered a preferred approach in selected patients with complicated appendicitis.

**Keywords:** Laparoscopic appendectomy, complicated appendicitis, intra-abdominal abscess, minimally invasive surgery.

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## Introduction

Acute appendicitis remains one of the most common surgical emergencies worldwide and continues to account for a substantial proportion of emergency abdominal operations. Since the first laparoscopic appendectomy (LA) was performed by Semm in 1983, minimally invasive surgery has become increasingly popular because of its potential advantages over conventional open surgery.<sup>1</sup>

Complicated appendicitis (CA), which includes perforated appendicitis, gangrenous appendicitis, appendicular abscess, phlegmon, and diffuse peritonitis, presents significant diagnostic and therapeutic challenges to surgeons.<sup>2</sup> Traditionally, open appendectomy (OA) has been considered the standard treatment for complicated appendicitis because of concerns regarding severe inflammation, distorted anatomy, extensive contamination, and technical difficulties during laparoscopic intervention.<sup>2</sup>

Open surgery in complicated appendicitis is often associated with larger incisions, increased tissue trauma, prolonged recovery, and higher rates of wound-related complications.<sup>2</sup> In contrast, advances in laparoscopic instrumentation, improved surgical expertise, and better perioperative management have expanded the role of laparoscopy in complicated appendicitis with several potential advantages.<sup>1,3</sup> However, the role of laparoscopic appendectomy in complicated appendicitis is still in debate. Earlier studies suggested an increased risk of postoperative intra-abdominal abscess (IAA) following laparoscopic surgery because of pneumoperitoneum-related bacterial dissemination and challenges in achieving adequate source control.<sup>3</sup> More recent systematic reviews and meta-analyses have demonstrated that laparoscopic appendectomy is associated with lower wound infection rates, reduced postoperative pain, shorter hospital stay, and comparable rates of intra-abdominal abscess formation when compared with open appendectomy.<sup>2,3</sup>

Several patient-related and disease-related factors have been shown to influence postoperative outcomes in complicated appendicitis. Delayed presentation, advanced age, elevated inflammatory markers, presence of appendicolith, perforation and diffuse peritoneal contamination have all been associated with increased morbidity, prolonged hospitalization, and higher conversion rates.<sup>3</sup> Therefore, careful patient selection and individualized perioperative management remain important determinants of surgical success.<sup>3,4</sup>

Another important consideration during laparoscopic management is the method of appendiceal stump closure. Several techniques have been described, including endoloop ligation, laparoscopic clips, endoscopic staplers, and intracorporeal suturing.<sup>2-5</sup> Current evidence suggests that endoloops and laparoscopic clips provide safe and cost-effective alternatives to staplers while maintaining comparable postoperative outcomes, even in cases of gangrenous or perforated appendicitis.<sup>4,5</sup> The optimal surgical technique for appendiceal stump closure and the appropriate duration of postoperative antibiotic therapy also remain topics of ongoing debate.<sup>6</sup>

Recent studies and meta-analyses have increasingly supported laparoscopic appendectomy as a feasible and safe option in complicated appendicitis when performed by experienced surgeons. Nevertheless, patient-related factors, delayed presentation, degree of contamination, and surgeon expertise continue to influence postoperative outcomes.<sup>2,3</sup>

The present study was conducted to evaluate the clinical outcomes of laparoscopic management of complicated appendicitis in a tertiary care hospital in Dhaka, Bangladesh and to compare these findings with outcomes following open appendectomy.

## Materials and Methods

This prospective observational comparative study was carried out at Dhaka Community Medical College and Hospital, Moghbazar, Dhaka, Bangladesh, between February 2022 and December 2023. Before commencement of the study, the protocol was approved by the IRB of the institution. Patient selected according to the selection criteria and both verbal and written consents were taken after providing details of the procedure. Purposive sampling done. A total of 48 patients were enrolled in the study. 34 patients were in the LA group and 14 were in the OA group. Adult patients diagnosed as acute appendicitis were prepared for laparoscopic appendectomy. During laparoscopy, those found to have complicated appendicitis (perforation, gangrene, abscess, or phlegmon) were enrolled in the laparoscopic appendectomy (LA) group. Appendectomy was performed with adequate peritoneal lavage. Appendiceal stump closure was achieved using endoloop, laparoscopic clips, or intracorporeal suturing according to operative findings.

In patients with appendicular abscess and friable appendiceal base or bowel loops, appendectomy was deferred, and extensive irrigation with pelvic drainage was performed.

Conversion to open surgery was undertaken when laparoscopic dissection became technically unsafe because of dense adhesions or unclear anatomy.

Patients with uncomplicated acute appendicitis underwent conventional laparoscopic appendectomy and were not included in the study. Pre-operatively diagnosed complicated appendicitis patients were enrolled in the open appendectomy (OA) group. Open appendectomy was performed using McBurney's incision, Rutherford-Morrison incision, or lower midline incision, depending on the extent of disease and patient characteristics. In cases with appendicular abscess, extraperitoneal drainage was performed when necessary. Patients aged <18, pregnant, with an immunocompromised status, or who refused consent for the study were excluded from the study. Every patient was assured of the confidentiality of

information. Patients who did not give consent to participate in the study were assured of being given the same quality of care. All patients received broad-spectrum intravenous antibiotics preoperatively, typically ceftriaxone combined with metronidazole. Postoperative antibiotic therapy was continued for 7–10 days and modified according to culture sensitivity reports when indicated.

Clinical and operative data were recorded using a structured data collection form and analyzed using SPSS version 23. Continuous variables were compared using Student's t-test or Mann–Whitney U test, while categorical variables were analyzed using chi-square test or Fisher's exact test. A p-value below 0.05 was considered statistically significant.

## Results

### Demographic Characteristics

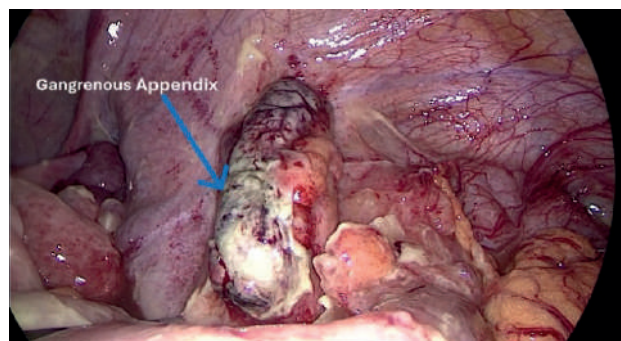
The baseline demographic characteristics of the two study groups were comparable. No statistically significant difference was observed between groups regarding age, sex distribution, or body mass index.

**Table I:** Demographic Characteristics of Study Participants

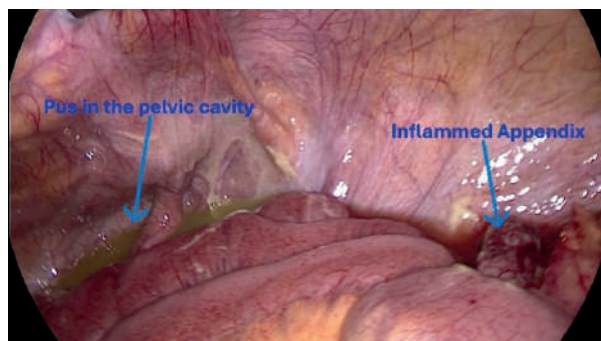
| Parameter           | Laparoscopic Appendectomy        | Open Appendectomy                | p-value* |
|---------------------|----------------------------------|----------------------------------|----------|
| Age (mean $\pm$ SD) | 33.5 $\pm$ 12.1 years            | 34.2 $\pm$ 11.8 years            | 0.67     |
| Male (%)            | 66%                              | 55%                              | 0.91     |
| Female (%)          | 34%                              | 45%                              | —        |
| BMI (mean $\pm$ SD) | 24.8 $\pm$ 3.5 kg/m <sup>2</sup> | 25.2 $\pm$ 3.8 kg/m <sup>2</sup> | 0.45     |

\*P-values for continuous variables (age and BMI) were calculated using the Independent Samples Student's t-test. P-value for sex distribution was calculated using the Chi-square test.

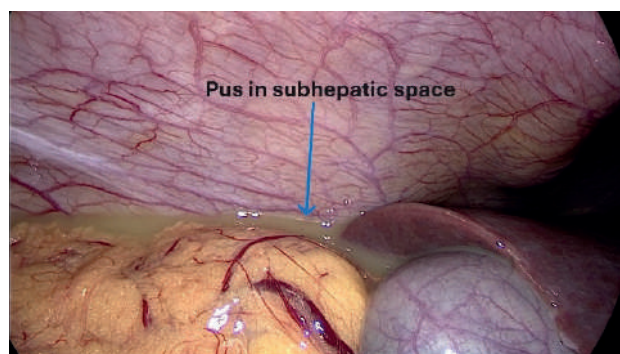
### Condition of complicated appendix:



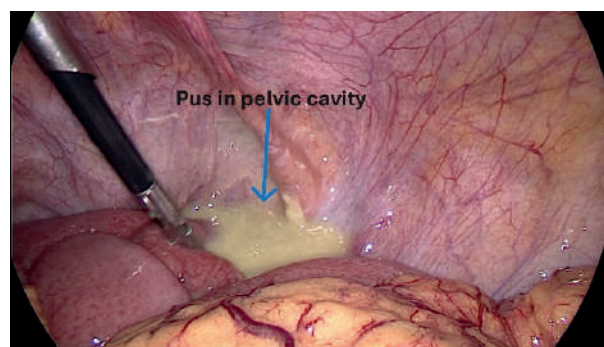
**Figure 1:** Gangrenous Appendix



**Figure 2:** Inflamed appendix with pus in pelvic cavity



**Figure 3:** *Pus in the subhepatic space*



**Figure 4:** *Pus in the pelvic cavity*

#### Duration of Symptoms Before Surgery

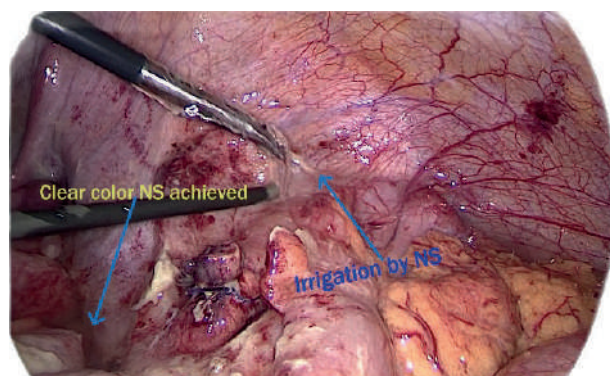
Both groups of study population presented with a comparable duration of preoperative symptoms.

**Table II:** Duration of Preoperative Symptoms

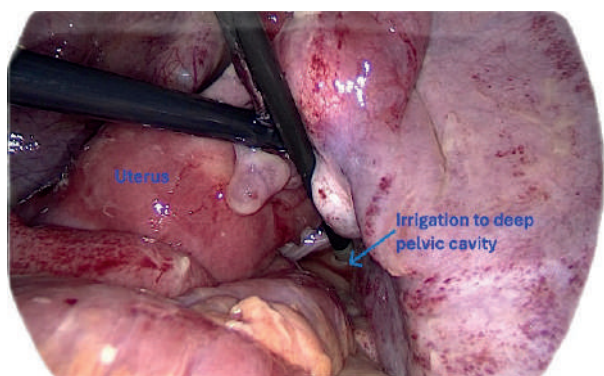
| Parameter                   | LA Group  | OA Group  | p-value* |
|-----------------------------|-----------|-----------|----------|
| Duration of Symptoms (days) | 2.3 ± 1.1 | 2.6 ± 1.3 | 0.36     |

\*P-value calculated using the Independent Samples Student's t-test.

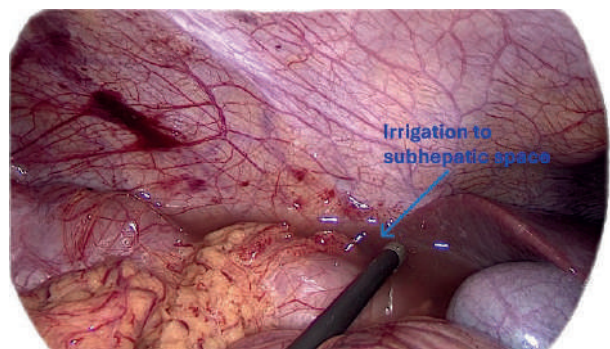
#### Advantages of laparoscopic surgery



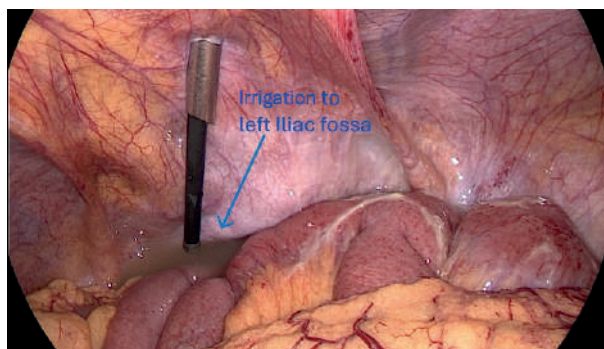
**Figure 5:** *Irrigation to the paracolic region achieved*



**Figure 6:** *Irrigation to the deep pelvic cavity*



**Figure 7:** *Irrigation to the subhepatic space*



**Figure 8:** *Irrigation to the left iliac fossa*

### Operative Time and Hospital Stay

The Operative duration was significantly longer in the laparoscopic appendectomy. However, postoperative hospital stay was substantially shorter among patients treated laparoscopically.

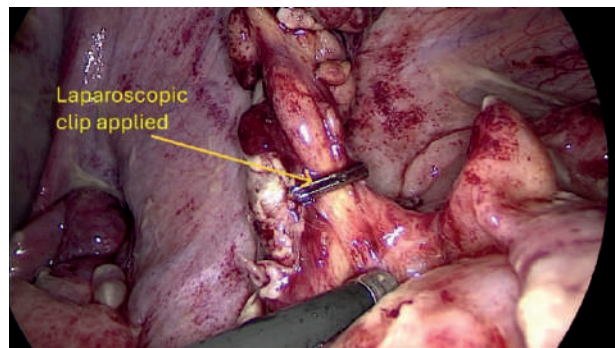
Conversion from laparoscopic to open surgery was required in five patients (14,7%) due to dense adhesions and difficult anatomical dissection.

**Table III:** Operative Time and Hospital Stay

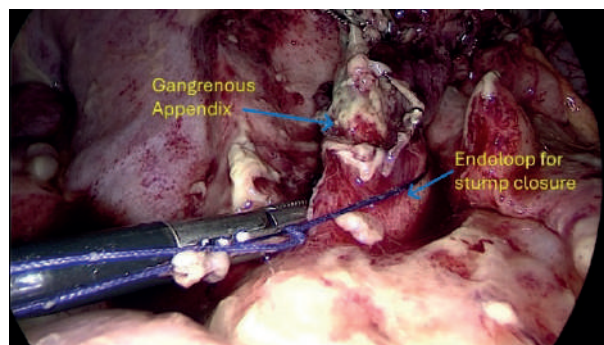
| Parameter                | LA Group    | OA Group    | p-value* |
|--------------------------|-------------|-------------|----------|
| Operative Time (minutes) | 75.2 ± 20.3 | 60.1 ± 18.4 | <0.001   |
| Hospital Stay (days)     | 3.2 ± 1.1   | 4.8 ± 1.5   | <0.001   |

\*P-values calculated using the Independent Samples Student's t-test

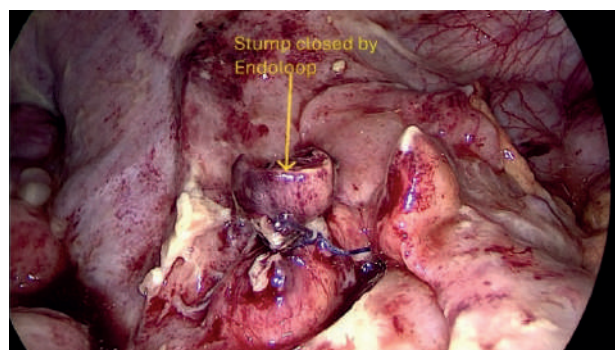
### Appendicular base



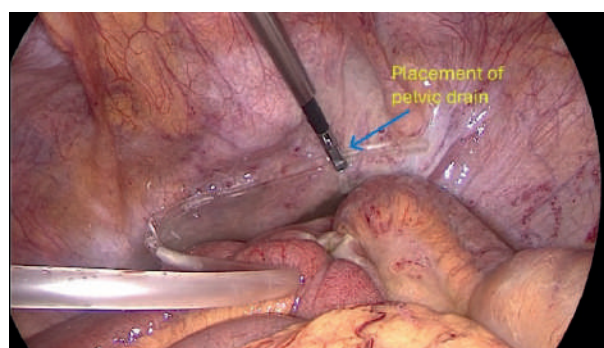
**Figure 9:** Laparoscopic clip in the mesoappendix



**Figure 10:** Gangrenous appendix with Endo-loop



**Figure 11:** Stump closed by endo-loop



**Figure 12:** Placement of pelvic drain

### Postoperative Complications

Wound infection occurred significantly less frequently in the laparoscopic group. The incidence of intra-abdominal abscess was lower following laparoscopic appendectomy, although the difference was not statistically significant.

**Table IV:** Postoperative Complications

| Complication               | LA Group | OA Group | p-value* |
|----------------------------|----------|----------|----------|
| Intra-abdominal Abscess    | 6.7%     | 10.0%    | 0.34     |
| Wound Infection            | 4.0%     | 12.5%    | 0.03     |
| Readmission within 30 Days | 5.0%     | 7.5%     | 0.45     |

\*P-values calculated using Fisher's Exact Test because of small expected cell frequencies.

### Discussion

The widespread adoption of minimally invasive surgery has substantially changed the management of appendicitis over recent decades. Although open appendectomy has traditionally been regarded as the standard approach for perforated, gangrenous, or abscess-forming appendicitis, increasing evidence supports the safety and effectiveness of laparoscopic appendectomy in these challenging clinical scenarios.<sup>1-3</sup>

In the present study, baseline demographic characteristics, including age, sex distribution, body mass index, and duration of preoperative symptoms, were comparable between the laparoscopic appendectomy (LA) and open appendectomy (OA)

groups. Findings of this study correlate with that of other researchers' work.<sup>2,3,7,8</sup> The absence of significant differences in baseline characteristics minimized potential confounding factors and facilitated a meaningful comparison of postoperative outcomes between the two treatment modalities.<sup>2,3</sup>

One of the most important findings of this study was the significantly lower wound infection rate observed in the laparoscopic group compared with the open surgery group. Wound infection developed in only 4.0% of patients undergoing laparoscopic appendectomy compared with 12.5% of patients undergoing open appendectomy. Similar findings have been consistently reported in several systematic reviews and meta-analyses evaluating the role of laparoscopy in complicated appendicitis.<sup>2,3,9</sup> The reduced incidence of wound infection associated with laparoscopic surgery is likely multifactorial. Smaller incisions, minimal tissue handling, reduced exposure of surgical wounds to contaminated intra-abdominal contents, and improved specimen retrieval techniques all contribute to lower rates of surgical site infection.<sup>1-3,7,8</sup> Furthermore, the use of specimen retrieval bags and limited direct contact between infected tissues and the abdominal wall may further reduce bacterial contamination during laparoscopic procedures.<sup>8</sup>

Intra-abdominal abscess (IAA) formation is a common postoperative complication following appendectomy in complicated appendicitis.<sup>1,2</sup> Earlier investigators suggested that the laparoscopic approach was associated with a higher incidence of intra-abdominal abscess formation. It was postulated that pneumoperitoneum might facilitate dissemination of infected fluid throughout the abdominal cavity and thereby increase the risk of postoperative abscess formation.<sup>1,2</sup> However, more recent evidence has challenged this hypothesis.<sup>2,3</sup>

In the present study, postoperative intra-abdominal abscess occurred in 6.7% of patients in the laparoscopic group compared with 10.0% in the open surgery group. Although this difference did not reach statistical significance, the findings indicate that laparoscopic surgery does not increase the risk of postoperative abscess formation when meticulous surgical technique, adequate source control, and thorough peritoneal lavage are performed.<sup>2,3,8</sup> Several contemporary systematic reviews have similarly reported comparable rates of intra-abdominal abscess formation between laparoscopic and open

appendectomy for complicated appendicitis.<sup>2,3,9</sup> Hajibandeh demonstrated no significant increase in postoperative abscess formation following laparoscopic surgery, while Yu reported equivalent infectious outcomes between the two approaches.<sup>2,3</sup> These findings support the growing consensus that surgeon experience and adequacy of source control are more important determinants of postoperative abscess formation than the operative approach itself.<sup>3,8</sup>

A notable advantage of laparoscopy observed during the current study was the ability to perform extensive peritoneal exploration and lavage. The laparoscopic approach allowed visualization of all abdominal quadrants, including the deep pelvis, paracolic gutters, and subhepatic space, facilitating effective removal of purulent collections. Similar advantages have been highlighted by previous authors investigating minimally invasive approaches in complicated intra-abdominal infections.<sup>1,3</sup>

Operative time was significantly longer in the laparoscopic group compared with the open surgery group,  $75.2 \pm 20.3$  min vs  $60.1 \pm 18.4$  min. This finding is consistent with previous studies and meta-analyses evaluating laparoscopic appendectomy in complicated appendicitis.<sup>1-3,5,7,9</sup> Longer operative duration may be attributed to technical challenges associated with dense inflammatory adhesions, distorted anatomy, abscess cavities, friable tissues, and extensive contamination commonly encountered in complicated appendicitis.<sup>1-3</sup> The learning curve associated with advanced laparoscopic procedures may also contribute to prolonged operative times.<sup>4</sup> Several studies have demonstrated progressive reductions in operative duration as surgeon experience increases and standardized laparoscopic protocols are implemented.<sup>4,9</sup> Therefore, the longer operative time observed in laparoscopic surgery should be interpreted within the context of surgical expertise and institutional experience.<sup>3,4,9</sup>

Despite the longer operative duration, patients undergoing laparoscopic appendectomy experienced significantly shorter hospital stays. The mean postoperative hospitalization period in the laparoscopic group was  $3.2 \pm 1.1$  days compared with  $4.8 \pm 1.5$  days in the open surgery group. Similar reductions in hospital stay have been reported in multiple randomized trials, cohort studies, and systematic reviews.<sup>2-5,7,9,10</sup> Several factors likely contribute to earlier discharge following laparoscopic surgery. Reduced postoperative

pain, decreased inflammatory response, faster return of gastrointestinal function, earlier mobilization, and lower wound-related morbidity all facilitate accelerated recovery.<sup>2,9,10</sup> These advantages are particularly important in resource-limited healthcare settings where reduction of hospital occupancy may substantially improve healthcare efficiency.

The conversion rate from laparoscopic to open appendectomy in this study was 14.7% (five patients), which falls within the range reported in previous literature. Published conversion rates for complicated appendicitis generally vary between 5% and 15%, depending on disease severity, surgeon experience, and patient-related factors.<sup>1-3,10</sup> Dense adhesions and difficulty identifying the appendiceal base were the most common reasons for conversion in the present study. Conversion should not be considered a surgical failure but rather a prudent intraoperative decision undertaken to maximize patient safety when adequate laparoscopic dissection becomes difficult or unsafe.<sup>3,8</sup> The decision to convert should remain individualized and based on operative findings rather than arbitrary procedural thresholds.

Management of the appendiceal stump remains an important technical consideration during laparoscopic appendectomy. In the current study, endoloop ligation was the most frequently utilized method of stump closure, followed by laparoscopic clips. Both techniques produced satisfactory outcomes without increased postoperative complications. Similar findings have been reported by Ates et al. and Ceresoli et al., who demonstrated comparable safety profiles among endoloops, clips, and other stump closure methods.<sup>4,5</sup> Although endoscopic staplers provide reliable closure, their substantially higher cost may limit routine use in many healthcare systems, particularly in developing countries.<sup>11,12</sup> Consequently, endoloops and laparoscopic clips remain attractive alternatives because they provide effective stump closure while maintaining cost-effectiveness.<sup>4,5,11</sup>

Appropriate antibiotic therapy remains an essential component of management in complicated appendicitis. Recent evidence increasingly supports shorter and targeted postoperative antibiotic regimens following adequate surgical source control.<sup>6,8,13</sup> Excessively prolonged antibiotic therapy may increase healthcare costs, antimicrobial resistance, and medication-related adverse effects without improving clinical outcomes. Current international guidelines

recommend tailoring antibiotic duration according to operative findings, source control adequacy, and clinical response. We started empirical antibiotics as ceftriaxone and metronidazole preoperatively and tailored them upon receiving the culture and sensitivity report of pus or wound swab.

Economic considerations are also important when comparing laparoscopic and open appendectomy. In the present study, laparoscopic surgery was associated with approximately 15% higher procedural costs. Increased expenditure was largely related to specialized equipment, disposable instruments, and laparoscopic accessories.<sup>11,12</sup> However, the higher operative costs were partially offset by shorter hospitalization, fewer wound complications, and more rapid postoperative recovery. Previous investigators have similarly concluded that when total healthcare expenditures are considered, laparoscopic appendectomy may be economically competitive with open surgery despite higher initial procedural costs.<sup>10,14</sup>

Overall, the present study adds to the growing body of literature supporting laparoscopic appendectomy as a safe, effective, and clinically advantageous treatment option for complicated appendicitis. Although operative duration may be longer and procedural costs may be slightly higher, the benefits of reduced wound infection, shorter hospitalization, improved visualization, and faster recovery strongly favor the laparoscopic approach in appropriately selected patients.<sup>2,3,8,10</sup>

Among the limitations of the study, it was a single-center observational study without randomization, which may introduce selection bias. Surgeon preference and expertise may also have influenced operative decision-making. Furthermore, long-term follow-up was limited, and late postoperative complications such as adhesive bowel obstruction could not be assessed. Moreover, sample size was small. Future multicenter randomized studies with larger sample sizes are recommended to further validate the findings of the present study.

## Conclusion

Laparoscopic appendectomy for complicated appendicitis is associated with favorable postoperative outcomes, including lower wound infection rates, shorter hospital stay, and acceptable rates of intra-abdominal abscess formation. Although operative

duration and procedural costs may be higher compared with open surgery, the overall clinical benefits favor laparoscopic management when performed by experienced surgeons in appropriately selected patients. Conversion to open surgery should not be considered a surgical failure but rather a surgeon's challenge to maximize patient safety. The decision to convert should remain individualized and based on operative findings rather than arbitrary procedural thresholds.

### Conflict of interest and funding

The authors have none to declare.

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This study was not funded.

### Ethical Approval

Ethical clearance taken from IRB of Dhaka Community Medical College Hospital.

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