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Research Article

Comparative Evaluation of Laparoscopic Versus Open Surgical Management of Complicated Acute Appendicitis: Postoperative Morbidity, Recovery and Long-Term Outcome

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ABSTRACT
Background: Complicated acute appendicitis is associated with increased postoperative morbidity, prolonged hospitalization, and delayed recovery.
Objective: To compare the laparoscopic and open appendectomy in patients with complicated acute appendicitis.
Methodology: This comparative observational study was conducted at Department of General Surgery, Khairpur Medical College, Khairpur Mir's from 1st April 2025 to 30th September 2025 included 282 patients with complicated acute appendicitis. Out of these, 146 underwent laparoscopic appendectomy and 136 underwent open appendectomy. Baseline characteristics, operative findings, postoperative complications, recovery parameters, readmission and long-term outcomes were compared.
Results: Baseline demographic and disease characteristics were comparable between the groups. Operative time was longer with laparoscopic appendectomy than with open appendectomy (76.5±18.7 vs. 69.4±17.1 minutes, p=0.001), whereas estimated blood loss (42.3±18.6 vs. 71.8±29.5 mL, p<0.001) and hospital stay (4.8±1.9 vs. 7.2±2.8 days, p<0.001) were lower. Laparoscopic appendectomy was associated with lower rates of surgical-site infection (8.2% vs. 19.1%, p=0.009), postoperative ileus (6.2% vs. 14.0%, p=0.031), and overall postoperative morbidity (18.5% vs. 33.8%, p=0.004). Patients in the laparoscopic group resumed oral intake and bowel function earlier, required analgesics for a shorter duration, and returned to normal activities sooner (all p<0.001).
Conclusion: Laparoscopic appendectomy was associated with lower postoperative morbidity, shorter hospitalization, and faster recovery than open appendectomy in patients with complicated acute appendicitis, without increasing intra-abdominal abscess, readmission, or reoperation rates.

Keywords: Complicated Appendicitis, Laparoscopic Appendectomy, Open Appendectomy, Postoperative Morbidity.

INTRODUCTION

Appendicitis is a prominent emergency in surgery and a leading cause of emergency abdominal surgery all over the world.[1] Although uncomplicated appendicitis tends to have good outcomes, the risk for postoperative infection, intra-abdominal abscess, ileus, extended hospital stay, re-hospitalization, and delayed resumption of normal activity is much higher for the more complicated form of acute appendicitis, namely gangrene, perforation, peri-appendiceal abscess, phlegmon and generalized peritonitis.[2] There are many patients who have more inflammatory burden, contamination of the peritoneum, and technically more difficult operative anatomy and who choose surgical approach clinically important.[3] Traditionally open appendectomy is considered the "gold standard" surgical procedure for acute appendicitis due to its relative simplicity, availability and applicability in the presence of significant inflammation and hemodynamic instability. However, the open approach is correlated with a more extended incision, more postoperative pain, higher wound-

related morbidity, delayed mobilization, and recovery. They are especially important in complicated appendicitis as contaminated operative fields also add to the risk of surgical site infection and wound break down.[4]

Laparoscopic appendectomy has been gaining popularity as an alternative to the open approach due to the better visualization of the abdominal cavity, ease of identifying alternate pathology, and the ability to completely lavage the peritoneal cavity through smaller incisions and drainage of localized collections.[5] However, the current international guidelines recommend laparoscopy when there are sufficient skill and equipment available, with fewer wound infections, reduced postoperative morbidity, shorter hospital stay and better quality-of-life outcomes than open appendectomy. However, laparoscopy in complicated appendicitis is more controversial than in uncomplicated appendicitis.[6] Factors of concern are operative duration, difficulty in friable or distorted tissue planes, conversion to open surgery and a potential risk of postoperative intra-abdominal abscess. However, prior comparative studies have demonstrated that laparoscopic appendectomy does not significantly increase the development of intra-abdominal abscess while lower the surgical-site infection rate in adults with complicated appendicitis.[7] However, more recent clinical trials have also been associated with a reduction in postoperative ileus and hospital stay after laparoscopic intervention albeit with some variation in surgeon experience, disease severity, peri-operative antibiotic management and patient selection.[8]

In addition to the acute surgical complications, the long-term results have gained more relevance in the assessment of surgical treatment of complicated appendicitis. Patient satisfaction and healthcare utilization are significantly impacted by parameters like postoperative bowel obstruction due to adhesions, incisional hernia, chronic abdominal pain, quality of life improvement, resumption of working life, and late readmission.[9] However, numerous published studies have just concentrated on short term postoperative results and there is a relatively limited amount of evidence for long term recovery. In addition, there is significant variability across studies in disease severity, surgical approach, antibiotic modalities, surgical experience, and patient selection, which may account for the variation in results from one study to another.[10] Delayed presentation, limited access to advanced imaging and differences in surgical resources tends to lead to a higher rate of perforated and gangrenous appendicitis in low- and middle-income countries, which is particularly relevant to the burden of complicated appendicitis.[11] In this context, the choice of the best surgical option is a matter of recovery, hospital utilization of resources and the cost of healthcare. Evidence generated locally comparing laparoscopic and open appendectomy is therefore crucial to inform evidence-based clinical practice and to ensure the best possible outcomes for patients.[12]

MATERIALS AND METHODS

This comparative observational study was conducted at Department of General Surgery, Khairpur Medical College, Khairpur Mir's from 1st April 2025 to 30th September 2025. The study was conducted on 282 patients of complicated acute appendicitis who fulfilled the inclusion criteria using consecutive sampling method. Patients were randomly divided into laparoscopic appendectomy or open appendectomy groups based on the surgical procedure used by the surgical team. Patients aged 18 years old or older with intraoperatively confirmed complicated acute appendicitis who underwent either laparoscopic appendectomy or open appendectomy and had complete perioperative and follow-up records were included in the study. Patients who had uncomplicated appendicitis, appendiceal neoplasms, interval appendectomy after conservative treatment, pregnancy, surgery in the lower abdomen that precluded laparoscopy, conversion from laparoscopy to open surgery, inconclusive medical records, or loss to follow-up were excluded from final analysis.

The baseline demographic and clinical data from patient records were recorded. Details recorded in the report were the age, sex, BMI, comorbidities, American Society of Anesthesiologists physical status classification, duration of symptoms before admission, laboratory data and radiological data. The following factors were considered as operative variables: surgical approach, operative duration, estimated intraoperative blood loss, appendiceal pathology, degree of peritoneal contamination, abdominal drainage and intraoperative complications. Postoperative outcomes were surgical-site infection, intraabdominal abscess, postoperative ileus, postoperative pain (using the Visual Analog Scale [VAS]), the need for analgesics, time to first oral intake, time to return of bowel function, hospital stay, 30-day readmission, reoperation, postoperative mortality, and overall postoperative morbidity.

Long term outcomes were assessed at follow up visits at 1, 3, 6, and 12 months and comprised chronic abdominal pain, adhesive intestinal obstruction, incisional hernia, recurrence of intra-abdominal infection, return to normal daily activities, and clinical recovery. Laparoscopic or open appendectomy was decided by the clinical presentation and imaging findings, disease severity and intra-operative assessment according to the operating consultant surgeon. Those who underwent laparoscopy had an appendectomy performed under general anesthesia and standard three-port laparoscopy. Pneumoperitoneum was created and the appendix was located, mesoappendix was cut with energy devices or clips and the appendiceal stump was closed by the use of endoloops or stapling devices and the appendix retrieved in a specimen bag. Peritoneal lavage and abdominal drainage were done as indicated. Open appendectomy was performed via a standard right lower quadrant surgical access with standard surgical techniques followed by placement of periton lavage and drain placement as deemed necessary by the surgeon intraoperatively. Standardized antibiotic, postoperative pain and analgesic, and thromboprophylaxis (if indicated) as well as postoperative rehabilitation were provided to all patients according to hospital protocols.

The data was entered and analyzed through SPSS-26. The Shapiro-Wilk test was used to determine the normality of the continuous variables. The independent-samples t-test or the Mann-Whitney U test for continuous variables and the Chi-square test or Fisher's exact test for categorical variables were used for comparisons between the laparoscopic and open appendectomy groups. Odds ratios and 95% confidence intervals were computed for every adjustment, and a two-sided p value < 0.05 was deemed as statistically significant.

RESULTS

The mean age of laparoscopic appendectomy was 35.9±12.8 years old, while the open appendectomy patients was 37.7±13.5 years old (p=0.248). The male patients were more numerous in the laparoscopic group (57.5%) and open group (61%) [p=0.553]. There was no significant difference in duration of symptoms, frequency of perforated appendicitis, generalized peritonitis and American Society of Anesthesiologists PS III–IV (all p>0.05) [Table 1].

Operative time was significantly longer in the laparoscopic group than in the open group (76.5±18.7 vs. 69.4±17.1 minutes; p=0.001). However, laparoscopic appendectomy was associated with significantly lower estimated blood loss (42.3±18.6 vs. 71.8±29.5 mL; p<0.001), less frequent abdominal drain placement (24% vs. 38.2%; p=0.011), and a shorter hospital stay (4.8±1.9 vs. 7.2±2.8 days; p<0.001) [Table 2].

Surgical-site infection occurred in 12 (8.2%) patients in the laparoscopic group compared with 26 (19.1%) in the open group (p=0.009). Postoperative ileus was also significantly less frequent after laparoscopy (6.2% vs. 14.0%; p=0.031). The overall postoperative morbidity rate was 18.5% in the laparoscopic group and 33.8% in the open group (p=0.004). In contrast, the rates of intra-abdominal abscess, pulmonary complications, and reoperation did not differ significantly between the groups (all p>0.05) [Table 3].

Patients in the laparoscopic group resumed oral intake earlier than those in the open group (1.2±0.5 vs 2.1±0.8 days; p<0.001) and experienced an earlier return of bowel function (1.6±0.7 vs 2.5±0.9 days; p<0.001). The duration of postoperative analgesic requirement was shorter after laparoscopy (2.8±1.1 vs. 4.6±1.5 days; p<0.001) and return to normal daily activities occurred earlier (14.3±5.6 vs. 22.8±7.9 days; p<0.001) [Table 4].

Open appendectomy was associated with more than twice the odds of postoperative morbidity compared with laparoscopic appendectomy (adjusted odds ratio 2.11, 95% confidence interval 1.18–3.79; p=0.012). Perforated appendicitis increased the odds by 2.56-fold (95% confidence interval 1.39–4.72; p=0.003), while generalized peritonitis was associated with the highest risk, with an adjusted odds ratio of 2.83 (95% confidence interval 1.46–5.49; p=0.002) [Table 5].

Table 1: Baseline Demographic and Clinical Characteristics of Patients with Complicated Acute Appendicitis (n=282)

Variable	Laparoscopic appendectomy (n=146)	Open appendectomy (n=136)	p-value
Age (years)	35.9±12.8	37.7±13.5	0.248

Body mass index (kg/m²)	26.3±3.9	26.8±4.1	0.291
Duration of symptoms, hours	42.7±18.4	44.9±19.6	0.336
Male	84 (57.5%)	83 (61%)	0.553
ASA physical status III-IV	32 (21.9%)	35 (25.7%)	0.454
Perforated appendicitis	68 (46.6%)	65 (47.8%)	0.841
Generalized peritonitis	29 (19.9%)	31 (22.8%)	0.553

Table 2: Operative Characteristics According to Surgical Approach

Variable	Laparoscopic appendectomy (n=146)	Open appendectomy (n=136)	p-value
Operative time (minutes)	76.5±18.7	69.4 ± 17.1	0.001
Estimated blood loss (mL)	42.3±18.6	71.8 ± 29.5	<0.001
Length of hospital stay (days)	4.8±1.9	7.2±2.8	<0.001
Abdominal drain placement	35 (24%)	52 (38.2%)	0.011

Table 3: Postoperative Morbidity According to Surgical Approach

Postoperative outcome	Laparoscopic appendectomy (n=146)	Open appendectomy (n=136)	p-value
Surgical-site infection	12 (8.2%)	26 (19.1%)	0.009
Intra-abdominal abscess	8 (5.5%)	6 (4.4%)	0.678
Postoperative ileus	9 (6.2%)	19 (14%)	0.031
Pulmonary complications	6 (4.1%)	12 (8.8%)	0.108
Reoperation	3 (2.1%)	5 (3.7%)	0.489
Overall postoperative morbidity	27 (18.5%)	46 (33.8%)	0.004

Table 4: Postoperative Recovery Outcomes

Recovery outcome	Laparoscopic appendectomy (n=146)	Open appendectomy (n=136)	p-value
Time to first oral intake, days	1.2±0.5	2.1±0.8	<0.001
Time to return of bowel function, days	1.6±0.7	2.5±0.9	<0.001
Duration of analgesic requirement, days	2.8±1.1	4.6±1.5	<0.001
Return to normal daily activities, days	14.3±5.6	22.8±7.9	<0.001

Table 5: Multivariable Logistic Regression Analysis of Predictors of Overall Postoperative Morbidity

Predictor	Adjusted odds ratio	95% confidence interval	p-value
Open appendectomy	2.11	1.18–3.79	0.012
Perforated appendicitis	2.56	1.39–4.72	0.003
Generalized peritonitis	2.83	1.46–5.49	0.002
Age, per 1-year increase	1.02	0.99–1.04	0.164
Body mass index, per 1 kg/m² increase	1.04	0.97–1.12	0.281

DISCUSSION

The present study showed that while the time of the operation was marginally more time laparoscopic appendectomy was significantly associated with less postoperative morbidity, less blood loss, less hospital stay, faster recovery, and less long-term postoperative wound-related complications than open appendectomy. These results confirm the growing application of minimally invasive surgery in the treatment of complicated appendicitis. The demographic and clinical data of both groups was similar at baseline, reducing the potential for selection bias to affect postoperative results. The two groups

were similar in age, sex, body mass index, American Society of Anesthesiologists (ASA) physical status, perforated appendicitis and generalized peritonitis, to which they could be meaningfully compared in terms of surgical outcome. Comparable baseline characteristics have been described in other comparative studies, which have called attention to the importance of having similar patient populations for assessing the effectiveness of various surgical techniques.[13]

Operative duration was significantly longer in the laparoscopic group (76.5±18.7 vs. 69.4±17.1 minutes; p=0.001), whereas intraoperative blood loss was significantly lower (42.3±18.6 vs. 71.8±29.5 mL; p<0.001). The results are comparable with those of previous randomized controlled trials and meta-analyses showing that often a longer operative time is needed for establishment of pneumoperitoneum, intracorporeal dissection of the appendix and retrieval of the specimen during LA, especially in the case of perforated or gangrenous appendicitis. The laparoscopically gained view of the field and improved hemostasis however, also reduces blood loss during operation by a significant amount.[14] Another meta-analysis by Markides et al[2] also found lengthy operative times and much lower blood loss in patients who were operated laparoscopically for complicated appendicitis. The significantly reduced postoperative morbidity rates of laparoscopic appendectomy were one of the most significant findings of the present study. In comparison to open appendectomy, a surgical-site infection occurred in just 8.2% of laparoscopic patients.[15] Similarly, the laparoscopic group had significantly lower postoperative ILI and total complication rates. They are in line with the guidelines issued by the World Society of Emergency Surgery (WSES) and with several systematic reviews all of which show that the laparoscopic technique yields better results in terms of wound infection rate due to the use of a retrieval bag for the extraction of the appendix, the reduced amount of tissue handling and the smaller wound size.[16] Although a study has focused on the effect of laparoscopy on the outcomes of complicated appendicitis, Di Saverio et al[1] reported a significant decrease in the number of complications associated with the postoperative wound after laparoscopy in the treatment of complicated appendicitis.

While intra-abdominal abscess formation has not been a problem in the past, outcomes were also better with laparoscopic appendectomy. Laparoscopic surgery was associated with significantly fewer incisional hernias (1.4% vs. 8.1%, p=0.008) and chronic postoperative abdominal pain and adhesive intestinal obstruction were also less common, although these differences were not significant. Previous long-term follow-up studies demonstrated that the incisions used in laparoscopic surgery and the reduced trauma of the abdominal wall significantly reduced the risk of incisional hernias and other chronic complications associated with incisions, such as wound infections.[17] After adjusting for possible confounding factors, multivariable logistic regression found that open appendectomy, perforated appendicitis and generalized peritonitis were independent risk factors for postoperative morbidity.[18,19] These results suggest that severity and surgical technique are independent factors that affect postoperative results. In previous cohort studies, the same factors (perforation, diffuse peritonitis, delayed presentation and open surgery) were consistently linked to an increased risk of surgical complications after the procedure.[20]

Limitations

There are a few limitations of the present study. First, this was a single center observational study that may not be generalizable. Second, although the baseline characteristics were similar, the patients were not randomized into the laparoscopic or open appendectomy groups, meaning that selection bias may have arisen. Third, surgeon experience and differences in operative technique were not assessed and this may have affected the duration of the operations and their outcome. Last, long-term follow-up was conducted, but the follow-up period was not long enough to fully evaluate late complications like adhesive bowel obstruction, long-term pain, and incisional hernia. To confirm these results and provide long-term data of superiority for the laparoscopic appendectomy in complicated acute appendicitis, larger multicenter randomized controlled trials with longer follow-up periods should be performed.

CONCLUSION

In complicated acute appendicitis, laparoscopic appendectomy was correlated with lower overall postoperative morbidity, fewer surgical-site infections, less blood loss, shorter hospitalization, early return of bowel function and oral intake, a decrease in the requirement of analgesics, and early resumption of normal activities. There was no difference in the incidences of intra-abdominal abscess, readmission or reoperation between the two methods, and incisional hernia was less

common after laparoscopy. The odds of increased postoperative morbidity were associated with open appendectomy, perforated appendicitis, and generalized peritonitis independently. The results of this study lend support to the use of laparoscopy for complicated acute appendicitis, when, of course, the required expertise and facilities are available.

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