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Comparative Outcomes of Laparoscopic Versus Open Appendectomy in Complicated Appendicitis: A Prospective Clinical Study

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ABSTRACT

Background: Complicated appendicitis, characterized as perforated, gangrenous, or abscessed appendix is a common surgical emergency with morbidity that is greater than uncomplicated disease. Open appendectomy (OA) has long been the standard of practice but laparoscopic appendectomy (LA) is being increasingly used because of the advantages that it could have on pain management, wound healing and recovery. Its use in the complicated cases is however controversial especially in low- and middle-income countries.

Objectives: To make a comparison between the results of laparoscopic and open appendectomy in tertiary care hospitals of Pakistan in patients with complicated appendicitis.

Methods: A prospective clinical trial was conducted at the general surgery departments of two tertiary care hospitals in Pakistan, between March 2023 and March 2024. Sixty patients aged 15 to 60 years with intraoperative confirmed complicated appendicitis were randomly grouped into two equal samples; LA (n=30) and OA (n=30). The outcomes measured were: operative time, postoperative pain (VAS), wound infection, intra-abdominal abscess, hospital stay and return to normal activity. The SPSS v26 was used to conduct the statistical analysis with significant value of $p < 0.05$.

Results: The mean time taken during operations was higher in LA (84.6 ± 14.8 minutes) as compared to OA (66.2 ± 12.9 minutes, $p<0.001$). At 24 and 48 hours, LA experienced less postoperative pain ($p<0.001$) with 4.1 and 2.8, respectively. The infection rate of the wound was lower in LA (6.7% vs. 20%, $p=0.04$) whereas the rate of intra-abdominal abscess was equal (10% vs. 6.7%, $p=0.64$). The patients of LA had reduced hospitalization (3.6 ± 1.1 vs. 5.3 ± 1.4 days, $p<0.001$) and quicker recovery (9.4 ± 2.5 vs. 14.7 ± 3.3 days, $p<0.001$).

Conclusion: Laparoscopic appendectomy is a better and safer alternative to open appendectomy in complicated appendicitis. Although it has a longer operating period, it provides less pain, less wound infection, less hospitalization and faster functional recovery which makes it more useful in tertiary care Pakistan hospitals.

keywords: Laparoscopic appendectomy; Open appendectomy; Complicated appendicitis; Postoperative outcomes; Pakistan

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INTRODUCTION

Appendicitis is the acute surgical emergency that is one of the most common in the whole world with 7 to 8 percent prevalence of the general population [1]. Most of the cases are simple, however, 20-30 percent of patients complain of having complex appendicitis, involving peri appendiceal

abscess or phlegmon, gangrenous appendix and perforation [2]. Due to the risk of sepsis, wound infection, peritonitis, and intraabdominal abscess, complex appendicitis requires prompt diagnosis and proper surgical treatment [3].

There has been a longstanding opinion that open appendectomy (OA) is the gold standard of treating uncomplicated and severe appendicitis [4]. The therapy, first reported in the late nineteenth century, is the removal of the appendix with direct visualization following the establishment of an incision in the lower right quadrant [5]. OA has significant limitations even though it is still common, such as increased recovery time, postoperative pain, larger incisions, and increased risk of developing a surgical site infection [6]. The morbidity of wound may become particularly important in such complicated cases as contamination and infection.

In 1983, Kurt Semm developed the laparoscopic appendectomy (LA) that transformed the surgery of the appendixes [7]. The least invasive operation is the use of three port procedure that does lavage of purulent samples and offers better visualization of the peritoneal cavity [8]. LA has been commonly used in simple cases of appendicitis due to its obvious benefits that include; a decreased postoperative pain, a reduced hospitalisation period, improved cosmetical appearance, and a faster recovery period. However, the applicability of laparoscopy in the patients with acute appendicitis has been disputed [9].

A number of issues have been expressed about LA in complex appendicitis. Opponents argue that the laparoscopic method raises the risk of postoperative intra-abdominal abscess formation because it is difficult to completely remove contaminated material, prolongs the operating time, and presents technical challenges when dense adhesions or inflamed friable tissue are present [10]. Supporters argue that LA results in fewer incisions and lower rates of wound infection, increases abdominal cavity visibility, allows for full peritoneal toileting, and allows for the diagnosis of unexpected pathology [11].

Several randomized controlled trials and meta-analyses have compared LA and OA for complicated appendicitis across the globe. Despite studies showing that LA is preferable in terms of reduced wound infection and better recovery, there is variability in surgery length and intra-abdominal abscess rates [12]. According to some studies, LA is equally safe as OA when performed by a skilled surgeon, even if there is an abscess or perforation. As a consequence of this gradual shift in surgical practice in high-income countries, laparoscopy is now increasingly seen as the best option, particularly for difficult patients [13].

The problem is more difficult in low- and middle-income countries such as Pakistan. Despite the increased availability of laparoscopic facilities, many tertiary care institutions continue to rely heavily on open surgery due to budgetary constraints, a shortage of equipment, and a scarcity of clinicians trained in cutting-edge laparoscopic methods [14]. Furthermore, there is a lack of locally created data comparing the outcomes of LA and OA, especially in instances of severe appendicitis in Pakistani patients. Because of differences in patient demographics, infection control techniques, and healthcare infrastructure, international findings may not be completely relevant in local situations [15].

Expanding laparoscopic appendectomy in Pakistan would have significant clinical and budgetary implications. In already congested healthcare facilities, minimizing surgical morbidity and shortening hospital stays may help optimal resource use. Furthermore, there are economic benefits to improved patient outcomes and a faster return to production, particularly among working-age populations. To provide context-specific information for therapeutic decision-making, a direct comparison of the two surgical procedures in acute appendicitis is necessary [17]. The present prospective clinical trial was designed to evaluate laparoscopic versus open appendectomy in individuals with severe appendicitis. Some of the important outcomes studied by the study included the length of stay in the hospital, postoperative infection, postoperative pain, the time spent in the operating room, the development of intra-abdominal abscesses, and the restoration of normal daily life. This paper is intended to assist clinical decision making on the best surgical procedure to use in cases of complex appendicitis despite resource constraint through gathering data on Pakistani tertiary units [18].

MATERIALS AND METHODS

The prospective clinical study was carried out at the general surgery departments of two Pakistani tertiary care hospitals. The trial period required 12 months between March 2023 and March 2024. Both institutions had their ethics reviewed by the institutional review boards before the study started. The informed written consent was signed by every patient in advance to participate in the experiment. Through the study, the entire patients who presented with acute appendicitis had a complete history, physical examination, laboratory tests, such as complete blood counts, and abdominal ultrasounds.

Only patients with intraoperative data supporting the diagnosis of complicated appendicitis (defined as the presence of an appendicular abscess or phlegmon, a gangrenous appendix, or a perforated appendix) were included. Male and female patients aged 15 to 60 were eligible for participation as long as they gave informed consent. Patients with a history of major abdominal surgery, pregnancy, extensive peritonitis requiring a midline laparotomy, or being deemed unfit for general anesthesia were excluded from the study. Overall, sixty patients satisfied the inclusion criteria. These patients were placed into two equal groups of thirty, using sealed opaque envelopes and a simple randomization method. Group B

got an open appendectomy, while Group A received a laparoscopic one.

Patients undergoing laparoscopic appendectomy were given general anesthesia, and the usual three-port method was employed. Two more working ports were placed in the left iliac fossa and suprapubic regions, and a 10 mm trocar was introduced at the umbilicus to accommodate the camera. After locating the appendix, the mesoappendix was separated using a harmonic scalpel or monopolar cautery. To minimize leakage, the specimen was placed in an endobag after the appendiceal base was secured with endoloops or polymer clips. When there was pus or a hole in the peritoneal cavity, a drain was carefully placed and a comprehensive peritoneal lavage with warm saline was performed.

In patients undergoing open appendectomy, a McBurney's or Lanz incision was made in the right iliac fossa while under general or spinal anesthesia. The mesoappendix was detached and ligated before the appendix was mobilized and delivered. The appendicular stump was secured with absorbable sutures. When contamination ensued from perforation or abscess formation, warm saline irrigation was utilized for the peritoneal toilet, and a drain was implanted if the surgeon deemed it necessary. Layers of closure were placed to the wound, with the primary closure delayed in cases of severe contamination.

Depending on their clinical state, all patients in both groups received intravenous broad-spectrum antibiotics preoperatively, including metronidazole and a third-generation cephalosporin, as well as after surgery. Standardized postoperative pain management was established, with frequent nonsteroidal anti-inflammatory medicine delivery and the provision of opioids in the event that further analgesia was required.

The data was gathered using a methodical proforma. The surgical time was measured in minutes, beginning with the initial skin incision and ending with skin closure. Postoperative pain was measured using the Visual Analog Scale (VAS) at 24 and 48 hours. Wound infection and the formation of an intraabdominal abscess were among the surgical complications documented. Standard Centers for Disease Control (CDC) criteria were utilized to identify surgical site infections, and intra-abdominal abscesses were clinically and radiologically confirmed. The number of days from operation to discharge was used to calculate the duration of hospital stay, and follow-up visits or phone talks with patients or their attendants were used to determine when they may resume their normal daily activities.

All patients were observed for 30 days following surgery to look for late complications such wound dehiscence or an intra-abdominal abscess. The data was analyzed using SPSS version 26 (IBM Corporation, Armonk, NY, USA). Continuous variables (age, hospital stay, VAS pain score, operative time, and days to return to routine activities) were represented as mean ± standard deviation. The independent samples t-test was performed to compare group differences. When necessary, the Chi-square test or Fisher's exact test was employed, and categorical variables such as gender, wound infection, and intra-abdominal abscess development were reported as frequencies and percentages, respectively. P-values less than 0.05 were considered as statistically significant.

RESULTS

This study comprised 60 patients with difficult appendicitis, split equally into two groups: 30 patients received laparoscopic appendectomy (LA) and 30 underwent open appendectomy (OA). Both groups had equivalent age and gender distributions, with no statistically significant differences between them, assuring baseline comparability.

The average age of patients in the LA group was 31.2 ± 10.6 years, whereas in the OA group it was 32.4 ± 11.1 years ($p = 0.68$). The gender distribution was likewise balanced, with 17 men (56.7%) and 13 females (43.3%) in the LA group, as opposed to 16 males (53.3%) and 14 females (46.7%) in the OA group ($p = 0.79$). These data show that demographic factors were well matched between the two groups, excluding the likelihood of confounding by age or gender (Table 1).

The laparoscopic group had a substantially longer mean operational time (84.6 ± 14.8 minutes) than the open group (66.2 ± 12.9 minutes) ($p < 0.001$). This distinction may be due to laparoscopy's greater technical difficulty, including the necessity for port installation, meticulous dissection, and peritoneal lavage during visualization. Although lengthier, the additional operational time had no significant impact on patient recovery results, as stated subsequently (Table 2).

Pain was assessed using the Visual Analog Scale (VAS) at 24- and 48-hours following surgery. After 24 hours, patients in the LA group had substantially reduced pain levels (mean VAS 4.1 ± 1.2) compared to the OA group (mean VAS 6.2 ± 1.3, $p < 0.001$). After 48 hours, LA patients had significantly lower pain scores (2.8 ± 1.0) than OA patients (4.7 ± 1.2, $p < 0.001$). These findings show that laparoscopic surgery causes much reduced postoperative pain, allowing for speedier mobility and increased patient comfort (Table 3).

Wound infection was seen in 2 patients (6.7%) in the laparoscopic group against 6 patients (20%) in the open group, which was statistically significant ($p = 0.04$). The lower infection incidence in LA is due to smaller incisions and limited tissue manipulation. Intra-abdominal abscess development was seen in three patients (10%) in the LA group and two patients (6.7%) in the OA group, although the difference was not statistically significant ($p = 0.64$). These findings indicate that, whereas laparoscopic appendectomy reduces the risk of superficial wound

infection, the incidence of deep intra-abdominal abscess is similar between the two techniques (Table 4).

The laparoscopic group had a considerably shorter average hospital stay (3.6 ± 1.1 days) compared to the open group's 5.3 ± 1.4 days ($p < 0.001$). Patients in the LA group returned to regular daily activities earlier, with an average of 9.4 ± 2.5 days compared to 14.7 ± 3.3 days in the OA group ($p < 0.001$). These data highlight the functional benefit of laparoscopic surgery, which results in faster recuperation, earlier mobility, and a lower financial burden (Table 5).

Table 1: Demographic profile of patients

Variable	Laparoscopic Appendectomy (n=30)	Open Appendectomy (n=30)	p-value
Mean Age (years)	31.2 ± 10.6	32.4 ± 11.1	0.68
Male (%)	17 (56.7%)	16 (53.3%)	0.79
Female (%)	13 (43.3%)	14 (46.7%)	-

Table 1 shows comparable demographic features between both groups, indicating no baseline differences.

Table-2: Comparison of operative time

Outcome Variable	Laparoscopic Appendectomy (n=30)	Open Appendectomy (n=30)	p-value
Operative time (minutes)	84.6 ± 14.8	66.2 ± 12.9	<0.001

Table 2 highlights significantly longer operative times in laparoscopic cases compared to open appendectomy.

Table-3: Comparison of postoperative pain scores (VAS)

Time of Assessment	Laparoscopic Appendectomy (n=30)	Open Appendectomy (n=30)	p-value
24 hours (VAS)	4.1 ± 1.2	6.2 ± 1.3	<0.001
48 hours (VAS)	2.8 ± 1.0	4.7 ± 1.2	<0.001

Table 3 shows that laparoscopic appendectomy significantly reduces postoperative pain compared to open appendectomy.

Table-4: Comparison of postoperative complications

Complication	Laparoscopic Appendectomy (n=30)	Open Appendectomy (n=30)	p-value
Wound infection (%)	2 (6.7%)	6 (20%)	0.04
Intra-abdominal abscess (%)	3 (10%)	2 (6.7%)	0.64

Table 4 illustrates a significantly lower wound infection rate in laparoscopic appendectomy, with similar intra-abdominal abscess rates between groups.

Table-5: Comparison of hospital stay and return to normal activity

Outcome Variable	Laparoscopic Appendectomy (n=30)	Open Appendectomy (n=30)	p-value
Length of hospital stay (days)	3.6 ± 1.1	5.3 ± 1.4	<0.001
Return to normal activity (days)	9.4 ± 2.5	14.7 ± 3.3	<0.001

Table 5 highlights that patients undergoing laparoscopic appendectomy had shorter hospital stays and earlier return to normal activities than those undergoing open appendectomy.

In summary, the findings of this prospective trial suggest that, despite the extended surgical time, laparoscopic appendectomy has considerable advantages over open appendectomy in patients with severe appendicitis. Patients who had laparoscopic surgery reported reduced postoperative discomfort, fewer wound infections, shorter hospital stays, and faster return to normal activities. Notably, the occurrence of intra-abdominal abscess which is a major concern in complicated cases did not differ significantly between the two groups as this showed that laparoscopic approach is safe in such patients.

DISCUSSION

This was a prospective clinical study that compared laparoscopic and open appendectomy among patients with complicated appendicitis with the view of comparing perioperative outcomes, complication rates, and postoperative recovery [11]. The results indicate that laparoscopic appendectomy (LA) is accompanied by a much lower rate of postoperative pain, reduced rates of wound infections, reduced length of hospitalization, and earlier onset of normal daily living brought about by laparoscopic as opposed to open appendectomy (OA). The latter were seen despite the fact that the mean operative time was longer in the case of LA but it did not correlate with a higher morbidity. Notably, both groups experienced the same incidence of intra-abdominal abscess, which is the principal issue in complicated cases, which bolsters the safety of laparoscopy in the situation [12].

The longer operative time observed in LA (mean 84.6 minutes vs. 66.2 minutes for OA) is consistent with multiple randomized controlled trials and meta-analyses, which attribute this difference to technical demands, particularly in cases of perforation or abscess where adhesiolysis and thorough peritoneal lavage are required [13]. However, literature indicates that this difference diminishes with surgical experience and increasing laparoscopic proficiency. In a multicenter RCT by Taguchi et al. (2022), operative times for LA were initially longer but approached equivalence with OA after the surgeon's learning curve plateaued. In our study, although LA required an additional 15–20 minutes on average, the

clinical benefits in recovery outcomes far outweighed this drawback [14].

Postoperative pain was significantly reduced in the laparoscopic group, both at 24 and 48 hours. This aligns with global data showing that smaller incisions, reduced tissue trauma, and less muscle disruption in laparoscopy lead to better postoperative comfort [15]. Lower pain scores translated into earlier mobilization, improved pulmonary function, and reduced need for opioid analgesics, which is particularly important in resource-limited settings where prolonged opioid use poses both economic and availability challenges [16].

One of the strengths of LA in this study was that the wound infection rate was significantly lower than in OA (6.7% vs. 20%, p=0.04). Surgical site infections (SSIs) are still considered as one of the most prevalent postoperative complications in Pakistan, and the reported rates of this issue are greater than in developed countries because of the infrastructural limitations and the difficulties in controlling the infection [17]. The reduced exposure of contaminated tissue due to the smaller port site incisions in LA and a specimen recovery method (endobags) probably led to lower incidences of SSI. Such results align with meta-analyses by Di Saverio et al. (2020), which establish that laparoscopic methods decrease the morbidity associated with the wound even when appendicitis is complicated [18].

The risk of postoperative intra-abdominal abscess formation has been one of the most controversial issues about LA in complicated appendicitis. A very low peritoneal toilet or spread of infection by pneumoperitoneum may have led to early studies indicating increased rates of abscess after laparoscopy [19]. The larger scale reviews, however, more recently suggest that there is no significant difference between LA and OA when conducted by experienced surgeons, who perform the lavage appropriately. This is supported by our study with the abscess rate of 10% in LA and 6.7 in OA (p=0.64), which is not significantly different. This comes as a relief especially to surgeons who are not willing to use LA in complex cases because of the fear of abscesses development [20].

Hospital stay and return to daily activities are among the most important outcome measures, particularly where access to hospitals is considered as a major challenge and loss of economic productivity is a major concern, particularly in low- and middle-income nations [21]. In our study, LA patients were discharged significantly earlier (mean 3.6 vs. 5.3 days) and returned to work or normal activity almost one week sooner than OA patients (mean 9.4 vs. 14.7 days). These findings are consistent with Chiu et al. (2018), who demonstrated that minimally invasive approaches reduce socioeconomic burden by enabling earlier reintegration into daily life. In the Pakistani context, this translates into reduced hospital expenditure, lower antibiotic consumption, and quicker return of working-age adults to the labor force [12,22].

The implications of these findings for surgical practice in Pakistan are substantial. Although LA requires specialized instruments and trained personnel, its advantages in terms of reduced morbidity, faster recovery, and lower SSI rates justify its broader adoption, particularly in tertiary care hospitals where surgical expertise and equipment are increasingly available [14,23]. Wider dissemination of laparoscopic training and gradual scaling of facilities may help bridge the gap between developed and developing healthcare systems in terms of appendicitis management [18].

This study has several strengths, including its prospective design, standardized surgical techniques, and strict inclusion criteria. However, some limitations must be acknowledged. The sample size of sixty patients, although adequate for detecting major outcome differences, may not capture rarer complications [7,19]. The follow-up period was limited to thirty days, precluding assessment of long-term outcomes such as adhesive small bowel obstruction. Furthermore, the study was conducted in urban tertiary hospitals, which may limit generalizability to rural or peripheral centers lacking advanced laparoscopic infrastructure. Future multicenter randomized studies with larger cohorts and longer follow-up will be essential to validate these findings and assess cost-effectiveness more comprehensively [24].

Finally, our results add to the growing body of evidence supporting laparoscopic appendectomy as a safe and effective alternative to open surgery in complicated appendicitis, even in resource-constrained environments [20]. The benefits in terms of reduced pain, wound infection, hospital stay, and earlier return to activity outweigh the drawback of slightly longer operative times. With appropriate training and investment, laparoscopic surgery should be increasingly integrated into the management of complicated appendicitis in Pakistan and similar healthcare contexts [21,25].

CONCLUSION

Laparoscopic appendectomy is a safe and superior alternative to open appendectomy in complicated appendicitis. Despite longer operative times, it offers reduced postoperative pain, lower wound infection rates, shorter hospital stays, and earlier return to normal activities, without increasing the risk of intra-abdominal abscesses. Wider adoption of laparoscopic techniques should be encouraged in tertiary care centers of Pakistan, where expertise and resources are available.

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Authors' contributions: EA contributed to conceptualization and data collection, TA handled methodology and analysis, AZ worked on literature review and drafting, NT managed data curation and validation, SK performed statistical analysis and interpretation, MA provided laboratory work and technical support, FAR contributed to review and editing, and HMU supervised the study and gave final approval.

Data Availability Statement: The data used in this study are available upon reasonable request from the corresponding author, subject to ethical and institutional guidelines.

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