



Original Article

Comparative Analysis Of Laparoscopic Versus Open Appendectomy In Complicated Appendicitis

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ABSTRACT

Background: Acute appendicitis remains one of the most common surgical emergencies worldwide, with complicated appendicitis presenting significant management challenges. While laparoscopic appendectomy has gained widespread acceptance for uncomplicated cases, its role in complicated appendicitis remains debated. This study compared laparoscopic and open appendectomy approaches in patients with complicated appendicitis, focusing on postoperative infection rates, hospital stay duration, and recovery time.

Methods: A prospective comparative study was conducted at SMCSI Medical College over one year, enrolling 100 patients with complicated appendicitis. Patients were allocated into two groups: laparoscopic appendectomy (n=50) and open appendectomy (n=50). Primary outcomes measured included surgical site infection rates, intra-abdominal abscess formation, duration of hospital stay, and time to return to normal activities. Secondary outcomes included operative time, conversion rates, and postoperative pain scores. Statistical analysis was performed using chi-square test and independent t-test, with $p < 0.05$ considered significant.

Results: The laparoscopic group demonstrated significantly lower surgical site infection rates compared to the open group (8% vs 24%, $p = 0.028$). Mean hospital stay was shorter in the laparoscopic group (4.2 ± 1.3 days vs 6.8 ± 2.1 days, $p < 0.001$). Recovery time, defined as return to normal activities, was significantly reduced in the laparoscopic group (12.4 ± 3.2 days vs 21.6 ± 5.8 days, $p < 0.001$). Intra-abdominal abscess formation showed no significant difference between groups (6% vs 10%, $p = 0.456$). Conversion rate from laparoscopic to open approach was 8%.

Conclusion: Laparoscopic appendectomy in complicated appendicitis demonstrated superior outcomes regarding postoperative infection rates, hospital stay duration, and recovery time compared to open appendectomy, supporting its feasibility and safety as the preferred approach in complicated cases when expertise is available.

Keywords: Laparoscopic appendectomy, Open appendectomy, Complicated appendicitis, Postoperative infection, Surgical site infection, Recovery time.

INTRODUCTION

Acute appendicitis represents the most prevalent abdominal surgical emergency globally, with a lifetime risk estimated between 7% and 8% in the general population.¹ The condition manifests across all age groups, though peak incidence occurs in the second and third decades of life. While the majority of cases present as uncomplicated appendicitis, approximately 20-30% of patients develop complicated appendicitis, characterized by gangrenous changes, perforation, periappendiceal abscess formation, or diffuse peritonitis.² The distinction between uncomplicated and complicated appendicitis carries profound implications for surgical decision-making, as complicated cases historically have been associated with higher morbidity rates, prolonged hospitalization, and increased healthcare costs.

The surgical management of appendicitis has undergone remarkable evolution since Charles McBurney first described the open appendectomy technique in 1894. For nearly a century, open appendectomy remained the undisputed gold standard treatment, with refinements in surgical technique and perioperative care progressively improving outcomes. However, the landscape of appendiceal surgery transformed dramatically in 1983 when Kurt Semm performed the first laparoscopic appendectomy, introducing minimally invasive surgical principles to this common procedure.³ The

subsequent decades witnessed an exponential increase in laparoscopic appendectomy adoption, particularly for uncomplicated cases, driven by demonstrated advantages including reduced postoperative pain, shorter hospital stays, faster return to normal activities, and superior cosmetic outcomes.

Despite the widespread acceptance of laparoscopic appendectomy for straightforward cases, considerable controversy persists regarding its application in complicated appendicitis. Traditional surgical dogma advocated for open appendectomy in complicated scenarios, citing concerns about inadequate source control, incomplete peritoneal lavage, increased risk of intra-abdominal abscess formation, and technical difficulties associated with laparoscopic manipulation of inflamed, friable tissues.⁴ These concerns were reinforced by early reports suggesting higher complication rates with laparoscopic approaches in complicated cases. However, technological advancements in laparoscopic instrumentation, enhanced optical systems, improved energy devices, and accumulating surgeon experience have challenged these conventional perspectives, prompting reassessment of the optimal surgical approach for complicated appendicitis.

The debate surrounding surgical approach selection in complicated appendicitis extends beyond mere technical feasibility to encompass critical patient-centered outcomes. Postoperative infectious complications represent a paramount concern in complicated appendicitis management, as bacterial contamination from perforated appendices or established abscesses creates a high-risk environment for surgical site infections and intra-abdominal septic complications.⁵ Traditional teaching suggested that open appendectomy provided superior access for thorough peritoneal lavage and complete abscess drainage, potentially reducing infectious complications. Conversely, proponents of laparoscopic techniques argue that magnified visualization enables meticulous identification of contaminated areas, while pneumoperitoneum facilitates widespread irrigation and aspiration throughout the abdominal cavity, potentially offering superior infection control compared to limited open access.

Hospital stay duration constitutes another critical outcome parameter with significant implications for patients, healthcare systems, and economic considerations. Prolonged hospitalization in appendicitis cases typically results from postoperative complications, inadequate pain control, delayed return of bowel function, or wound-related issues.⁶ The potential for laparoscopic surgery to reduce hospital stay through decreased tissue trauma, reduced postoperative ileus, and lower analgesic requirements represents an attractive proposition, particularly in resource-constrained healthcare environments. However, whether these advantages translate to complicated appendicitis cases, where local inflammation and contamination may negate the benefits of minimally invasive access, remains inadequately established.

Recovery time, encompassing return to normal daily activities, work resumption, and complete functional restoration, represents perhaps the most relevant outcome from the patient perspective. Open appendectomy necessarily involves larger incisions, greater muscular disruption, and more extensive tissue handling, factors theoretically associated with prolonged convalescence.⁷ Laparoscopic approaches minimize abdominal wall trauma through small port sites, potentially facilitating earlier mobilization and faster functional recovery. Nevertheless, the inflammatory burden and systemic response associated with complicated appendicitis might overshadow surgical approach differences, making recovery time comparisons particularly relevant for evidence-based surgical decision-making.

Contemporary literature presents conflicting evidence regarding optimal surgical approaches for complicated appendicitis, with studies reporting variable outcomes across different populations, institutional settings, and surgeon expertise levels. Several retrospective analyses and meta-analyses have attempted to synthesize existing evidence, yet methodological heterogeneity, inconsistent definitions of complicated appendicitis, and publication bias complicate definitive conclusions.⁸ Furthermore, the majority of existing studies originate from Western populations, with limited high-quality evidence from developing nations where patient demographics, disease presentation patterns, healthcare infrastructure, and resource availability differ substantially.

The Indian healthcare context presents unique considerations relevant to appendicitis management decisions. Delayed presentation remains common due to healthcare access barriers, financial constraints, and traditional medicine preferences, potentially increasing complicated appendicitis incidence.⁹ Additionally, the spectrum of causative organisms and antibiotic resistance patterns in Indian settings may influence postoperative infection risks differently compared to developed nations. Equipment availability, laparoscopic training opportunities, and institutional support for minimally invasive surgery vary considerably across Indian healthcare facilities, affecting the generalizability of international evidence to local practice environments.

Several recent technological and conceptual advances have renewed interest in laparoscopic management of complicated appendicitis. Enhanced recovery after surgery protocols, increasingly applied to appendectomy patients, emphasize minimally invasive techniques, optimized pain management, early mobilization, and rapid oral intake resumption—principles synergistic with laparoscopic approaches.¹⁰ Advanced laparoscopic instruments, including articulating devices, improved suction-irrigation systems, and specimen retrieval bags, have addressed previous technical limitations. Furthermore, growing recognition that not all complicated appendicitis cases present equivalent surgical challenges has prompted more nuanced categorization, distinguishing localized perforation from diffuse peritonitis, and gangrenous changes from established abscess formation.

Given the substantial patient volume, clinical equipoise regarding optimal surgical approach, and limited prospective comparative data from Indian tertiary care centers, this study was undertaken to provide high-quality evidence comparing laparoscopic and open appendectomy in complicated appendicitis cases. By focusing specifically on postoperative infection rates, hospital stay duration, and recovery time—outcomes of paramount importance to patients, surgeons, and healthcare administrators—this research aims to inform evidence-based surgical decision-making in complicated appendicitis management. The prospective design, standardized outcome definitions, and systematic follow-up protocol employed in this investigation address methodological limitations present in much of the existing literature, potentially yielding more robust and clinically applicable conclusions.

Understanding the comparative effectiveness of laparoscopic versus open appendectomy in complicated cases carries implications extending beyond individual patient management to encompass surgical training priorities, institutional resource allocation, and healthcare policy development. If laparoscopic approaches demonstrate superiority or equivalence in complicated appendicitis, expanded training in advanced laparoscopic techniques and institutional investment in laparoscopic infrastructure would be justified. Conversely, if open appendectomy proves superior for specific complicated appendicitis subtypes, preservation of open surgical skills and judicious approach selection would remain essential. This study endeavors to contribute meaningful evidence to this ongoing clinical controversy, ultimately serving the goal of optimizing patient outcomes in this common surgical emergency.

AIMS AND OBJECTIVES

The primary aim of this study was to compare the clinical outcomes of laparoscopic appendectomy versus open appendectomy in patients diagnosed with complicated appendicitis at SMCSI Medical College. The investigation specifically focused on evaluating postoperative infection rates, duration of hospital stay, and recovery time between the two surgical approaches. The study was designed to provide evidence-based guidance for surgical approach selection in complicated appendicitis cases, addressing the ongoing clinical controversy regarding optimal management strategies for this challenging patient population.

The primary objective was to compare the incidence of postoperative infectious complications, including surgical site infections and intra-abdominal abscesses, between patients undergoing laparoscopic appendectomy and those undergoing open appendectomy for complicated appendicitis. The secondary objectives included comparing the duration of postoperative hospital stay between the two groups, measuring as the interval from surgery completion to hospital discharge. Additionally, the study aimed to assess recovery time, defined as the duration required for patients to return to normal daily activities and preoperative functional status. Further objectives included comparing operative time, conversion rates from laparoscopic to open approach, postoperative pain scores, analgesic requirements, and overall complication rates between the two surgical techniques. The study also sought to identify preoperative and intraoperative factors associated with adverse outcomes in both surgical approaches, thereby informing patient selection and surgical planning in complicated appendicitis management.

MATERIALS AND METHODS

Study Design and Setting

This prospective comparative study was conducted in the Department of General Surgery at SMCSI Medical College over a period of one year from January 2024 to December 2024. The study protocol received approval from the Institutional Ethics Committee of SMCSI Medical College prior to patient enrollment. All patients provided written informed consent before participation. The study adhered to the principles outlined in the Declaration of Helsinki and followed Good Clinical Practice guidelines throughout its conduct.

Sample Size Calculation

Sample size calculation was performed using statistical software based on previous literature reporting postoperative infection rates of approximately 25% in open appendectomy and an anticipated reduction to 10% with laparoscopic approach for complicated appendicitis. With alpha error set at 0.05 and power of 80%, the minimum required sample size was calculated as 45 patients per group. Accounting for potential dropouts and incomplete follow-up, the final sample size was set at 50 patients in each group, totaling 100 patients for the study.

Patient Selection

Patients presenting to the emergency department or surgical outpatient department of SMCSI Medical College with clinical, laboratory, and radiological diagnosis of complicated appendicitis were screened for study eligibility. Complicated appendicitis was defined as the presence of one or more of the following features identified during preoperative imaging or intraoperative assessment: gangrenous appendix, perforated appendix, periappendiceal abscess, or localized peritonitis with purulent fluid collection.

Inclusion Criteria

Patients aged between 18 and 65 years diagnosed with complicated appendicitis based on clinical examination, laboratory investigations including elevated white blood cell count, and imaging studies demonstrating features of complicated appendicitis were included in the study. Patients willing to provide informed consent and commit to follow-

up visits were eligible for enrollment. Both male and female patients meeting the diagnostic criteria were considered for inclusion regardless of body mass index, provided they were fit for general anesthesia.

Exclusion Criteria

Patients with diffuse peritonitis requiring emergency laparotomy were excluded from the study. Additional exclusion criteria included patients with appendicular mass larger than 5 centimeters diameter, those with previous abdominal surgeries that might complicate laparoscopic access, pregnant women, patients with significant cardiopulmonary comorbidities precluding pneumoperitoneum, those with coagulopathy or bleeding disorders, and patients unable to provide informed consent. Patients with suspected appendiceal malignancy based on imaging findings were also excluded. Cases requiring interval appendectomy following initial conservative management were not included in this study.

Patient Allocation

Following confirmation of study eligibility and obtaining informed consent, patients were allocated to either the laparoscopic appendectomy group or the open appendectomy group through systematic allocation based on the sequence of presentation, with alternate patients assigned to each group. The first patient was allocated to the laparoscopic group, followed by open group allocation for the second patient, continuing this alternating pattern throughout the study period. This allocation method ensured equal distribution between groups while maintaining practical feasibility in the emergency surgical setting.

Preoperative Preparation

All patients underwent standardized preoperative assessment including complete blood count, renal function tests, liver function tests, serum electrolytes, coagulation profile, blood grouping and cross-matching, chest radiography, and electrocardiography. Computed tomography of the abdomen and pelvis with intravenous contrast was performed in all cases to confirm the diagnosis of complicated appendicitis and assess the extent of inflammation. Preoperative optimization included intravenous fluid resuscitation, correction of electrolyte imbalances, and administration of broad-spectrum intravenous antibiotics covering gram-negative and anaerobic organisms. The antibiotic regimen consisted of intravenous ceftriaxone 1 gram and metronidazole 500 milligrams administered one hour before surgery. All patients received prophylaxis against deep vein thrombosis with subcutaneous low molecular weight heparin according to institutional protocol.

Surgical Technique: Laparoscopic Appendectomy

Laparoscopic appendectomy was performed under general anesthesia with the patient in supine position. Pneumoperitoneum was established using Veress needle technique or open Hasson technique based on surgeon preference, maintaining intra-abdominal pressure at 12-14 millimeters of mercury. A 10-millimeter umbilical port was placed for the camera, with two additional 5-millimeter ports positioned in the suprapubic region and left lower quadrant. Following systematic exploration of the abdominal cavity, the appendix was identified and its base mobilized. The mesoappendix was divided using electrocautery or ultrasonic energy device. The appendiceal base was secured using endoloops or endoscopic staplers, and the appendix was transected. Thorough peritoneal lavage was performed using warm normal saline, with particular attention to the pelvis, paracolic gutters, and subhepatic space. The appendix was retrieved using an endobag to prevent wound contamination. In cases of significant contamination, drains were placed in the pelvis or abscess cavity. Port sites were closed using absorbable sutures with skin approximation using subcuticular sutures or skin adhesive.

Surgical Technique: Open Appendectomy

Open appendectomy was performed under general anesthesia through a right lower quadrant McBurney or Lanz incision measuring approximately 5-7 centimeters. The abdominal wall was opened in layers, splitting the external oblique, internal oblique, and transversus abdominis muscles. The peritoneum was opened carefully, and peritoneal fluid, if present, was sent for culture and sensitivity. The appendix was identified, mobilized, and delivered into the wound. The mesoappendix was ligated and divided. The appendiceal base was crushed, ligated using absorbable suture material, and the appendix was transected. The stump was inverted if technically feasible. Peritoneal lavage was performed using warm normal saline. In cases with significant contamination or abscess formation, abdominal drains were placed. The wound was closed in layers using absorbable sutures, with the decision regarding primary skin closure versus delayed primary closure made based on the degree of contamination.

Intraoperative Data Collection

During each surgical procedure, detailed intraoperative parameters were recorded including operative time measured from skin incision to skin closure, quantity of peritoneal contamination, presence and location of abscess, condition of the appendix, extent of peritoneal contamination, volume of irrigation fluid used, need for drain placement, and any intraoperative complications. For laparoscopic cases, conversion to open technique was documented with specific reasons recorded. All operative findings were photographed when possible and documented in standardized case report forms.

Postoperative Management

All patients received standardized postoperative care in the surgical ward. Intravenous broad-spectrum antibiotics were continued postoperatively for a minimum of 5 days, with the regimen adjusted based on culture and sensitivity results when available. Pain management followed a multimodal approach including intravenous paracetamol, nonsteroidal anti-inflammatory drugs when appropriate, and opioid analgesics as rescue medication. Pain intensity was assessed using the Visual Analog Scale at 6, 12, 24, and 48 hours postoperatively. Early mobilization was encouraged, with patients assisted to ambulate within 6-12 hours after surgery when feasible. Oral fluids were commenced once bowel sounds returned and the patient reported passage of flatus, progressing to a regular diet as tolerated. Drain output was monitored daily, with drains removed when output decreased below 50 milliliters per day and appeared serous. Wound dressings were inspected daily for signs of infection including erythema, induration, discharge, or dehiscence.

Follow-up Protocol

Patients were discharged when they tolerated oral diet, had adequate pain control with oral analgesics, showed no signs of complications, and could ambulate independently. Post-discharge follow-up was conducted at 1 week, 2 weeks, and 4 weeks. At each visit, systematic assessment was performed including wound examination, inquiry about return to normal activities, documentation of any complications, and assessment of overall recovery. Telephone follow-up was conducted at 6 weeks to confirm complete recovery and return to preoperative functional status. Any readmissions or emergency department visits related to the appendectomy were documented and investigated.

Outcome Measures

The primary outcome measures included surgical site infection rate, defined according to Centers for Disease Control criteria as superficial incisional infection, deep incisional infection, or organ-space infection occurring within 30 days of surgery. Intra-abdominal abscess formation was diagnosed based on clinical features and confirmed by imaging studies. Duration of hospital stay was calculated from the day of surgery to the day of discharge. Recovery time was defined as the number of days from surgery until the patient returned to normal daily activities including work, household duties, or studies, assessed through patient interview at follow-up visits.

Secondary outcome measures included operative time, conversion rate from laparoscopic to open approach, postoperative pain scores, total analgesic requirement, time to return of bowel function, overall complication rate including ileus, wound dehiscence, hemorrhage, and unplanned readmissions. Cost analysis comparing the two approaches was performed considering operative expenses, hospital stay costs, and medication expenses.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS software version 25.0. Continuous variables were expressed as mean with standard deviation and compared using independent samples t-test after confirming normal distribution through Shapiro-Wilk test. Categorical variables were expressed as frequencies with percentages and compared using chi-square test or Fisher exact test as appropriate. Mann-Whitney U test was employed for non-normally distributed continuous variables. Multivariate logistic regression analysis was performed to identify independent predictors of postoperative complications. A p-value less than 0.05 was considered statistically significant. Subgroup analyses were performed based on specific types of complicated appendicitis including gangrenous, perforated, and abscess-associated cases.

RESULTS

Patient Demographics and Baseline Characteristics

A total of 100 patients with complicated appendicitis were enrolled in this study, with 50 patients allocated to the laparoscopic appendectomy group and 50 patients to the open appendectomy group. The mean age of patients in the laparoscopic group was 32.4 years with a standard deviation of 11.2 years, while the open appendectomy group had a mean age of 34.1 years with a standard deviation of 12.6 years, showing no statistically significant difference between groups ($p=0.476$). Gender distribution demonstrated 28 males and 22 females in the laparoscopic group compared to 31 males and 19 females in the open group, which was not significantly different ($p=0.523$). The mean body mass index was 24.6 kilograms per meter squared with standard deviation 3.8 in the laparoscopic group versus 25.2 kilograms per meter squared with standard deviation 4.1 in the open group ($p=0.442$). The duration of symptoms before presentation showed no significant difference, with mean duration of 3.8 days with standard deviation 1.9 days in the laparoscopic group and 4.1 days with standard deviation 2.2 days in the open group ($p=0.476$). Preoperative white blood cell count averaged 14,800 cells per microliter with standard deviation 3,200 in the laparoscopic group and 15,200 cells per microliter with standard deviation 3,600 in the open group ($p=0.562$). The distribution of types of complicated appendicitis showed gangrenous appendix in 22 patients in the laparoscopic group and 24 patients in the open group, perforated appendix in 18 patients in the laparoscopic group and 16 patients in the open group, and periappendiceal abscess in 10 patients in the laparoscopic group and 10 patients in the open group, with no significant differences in these distributions ($p=0.865$).

Intraoperative Parameters

The mean operative time was significantly longer in the laparoscopic group at 78.4 minutes with standard deviation 18.6 minutes compared to 62.3 minutes with standard deviation 14.8 minutes in the open group, representing a statistically significant difference ($p<0.001$). Conversion from laparoscopic to open approach occurred in 4 patients, representing a

conversion rate of 8 percent. The reasons for conversion included dense adhesions in 2 cases, uncontrolled bleeding in 1 case, and extensive contamination requiring better access in 1 case. Intraoperative complications occurred in 3 patients in the laparoscopic group including 2 cases of minor bleeding controlled laparoscopically and 1 case of small bowel serosal injury repaired intracorporeally, compared to 5 patients in the open group including 3 cases of minor bleeding and 2 cases of inadvertent cecal injury ($p=0.465$). Drain placement was performed in 18 patients in the laparoscopic group and 22 patients in the open group ($p=0.423$). The mean volume of irrigation fluid used was 2,400 milliliters with standard deviation 600 milliliters in the laparoscopic group compared to 1,800 milliliters with standard deviation 500 milliliters in the open group ($p<0.001$).

Primary Outcomes: Postoperative Infections

Surgical site infection represented the primary outcome measure, occurring in 4 patients in the laparoscopic group, representing 8 percent of cases, compared to 12 patients in the open group, representing 24 percent of cases, demonstrating a statistically significant difference ($p=0.028$). Among surgical site infections in the laparoscopic group, 2 were superficial incisional infections at port sites, 1 was a deep incisional infection, and 1 was classified as organ-space infection. In the open group, 7 were superficial incisional infections, 3 were deep incisional infections, and 2 were organ-space infections. The mean time to diagnosis of surgical site infection was 6.8 days with standard deviation 2.4 days in the laparoscopic group and 5.9 days with standard deviation 2.1 days in the open group ($p=0.498$). Intra-abdominal abscess formation occurred in 3 patients in the laparoscopic group, representing 6 percent, and 5 patients in the open group, representing 10 percent, which did not reach statistical significance ($p=0.456$). All intra-abdominal abscesses were managed successfully with image-guided percutaneous drainage combined with appropriate antibiotic therapy, with no patient requiring reoperation for abscess management. Microbiological cultures from infected wounds or abscess collections yielded growth in 18 of 20 infected cases, with *Escherichia coli* being the most common organism identified in 11 cases, followed by *Klebsiella* species in 4 cases, *Enterococcus* species in 2 cases, and polymicrobial growth in 1 case. All patients with infections recovered completely following appropriate management without long-term sequelae.

Primary Outcomes: Hospital Stay Duration

The duration of postoperative hospital stay demonstrated significant differences between the two groups. The mean hospital stay in the laparoscopic appendectomy group was 4.2 days with standard deviation 1.3 days, ranging from 2 to 8 days, compared to 6.8 days with standard deviation 2.1 days in the open appendectomy group, ranging from 3 to 12 days, representing a highly significant difference ($p<0.001$). Subgroup analysis based on type of complicated appendicitis revealed that for gangrenous appendicitis, mean hospital stay was 3.8 days with standard deviation 1.1 days in the laparoscopic group versus 6.2 days with standard deviation 1.8 days in the open group ($p<0.001$). For perforated appendicitis, mean hospital stay was 4.6 days with standard deviation 1.4 days in the laparoscopic group compared to 7.4 days with standard deviation 2.3 days in the open group ($p<0.001$). For cases with periappendiceal abscess, mean hospital stay was 4.4 days with standard deviation 1.2 days in the laparoscopic group versus 6.9 days with standard deviation 2.2 days in the open group ($p=0.006$). Factors contributing to prolonged hospital stay included postoperative infections, delayed return of bowel function, inadequate pain control, and drain-related issues. Patients with surgical site infections had significantly longer hospital stays averaging 8.6 days with standard deviation 2.4 days compared to 4.8 days with standard deviation 1.6 days in patients without infections ($p<0.001$).

Primary Outcomes: Recovery Time

Recovery time, defined as return to normal daily activities, showed marked differences between surgical approaches. The mean recovery time in the laparoscopic group was 12.4 days with standard deviation 3.2 days, ranging from 7 to 21 days, significantly shorter than the open group where mean recovery time was 21.6 days with standard deviation 5.8 days, ranging from 12 to 35 days ($p<0.001$). Analysis by type of complicated appendicitis revealed that for gangrenous appendicitis, mean recovery time was 11.2 days with standard deviation 2.8 days in the laparoscopic group compared to 19.8 days with standard deviation 5.2 days in the open group ($p<0.001$). For perforated appendicitis, mean recovery time was 13.8 days with standard deviation 3.6 days in the laparoscopic group versus 23.4 days with standard deviation 6.4 days in the open group ($p<0.001$). Patients with periappendiceal abscess demonstrated mean recovery time of 12.6 days with standard deviation 2.9 days in the laparoscopic group compared to 22.1 days with standard deviation 5.6 days in the open group ($p<0.001$). Return to work or studies occurred at a mean of 18.6 days with standard deviation 4.8 days in the laparoscopic group compared to 28.4 days with standard deviation 7.2 days in the open group ($p<0.001$). Complete resolution of all symptoms and full functional recovery was achieved by 4 weeks in 46 patients in the laparoscopic group, representing 92 percent, compared to 34 patients in the open group, representing 68 percent ($p=0.002$).

Secondary Outcomes: Pain Scores and Analgesic Requirements

Postoperative pain assessment using the Visual Analog Scale demonstrated significantly lower pain scores in the laparoscopic group across all time points. At 6 hours postoperatively, mean pain score was 5.8 with standard deviation 1.4 in the laparoscopic group compared to 7.2 with standard deviation 1.6 in the open group ($p<0.001$). At 12 hours, mean pain scores were 4.6 with standard deviation 1.2 versus 6.4 with standard deviation 1.4 respectively ($p<0.001$). At 24 hours postoperatively, mean pain scores were 3.2 with standard deviation 1.1 in the laparoscopic group compared to 5.1 with standard deviation 1.3 in the open group ($p<0.001$). At 48 hours, pain scores averaged 2.1 with standard deviation 0.9 in the laparoscopic group versus 3.8 with standard deviation 1.2 in the open group ($p<0.001$). Total opioid analgesic requirement, calculated as morphine equivalents in milligrams, was significantly lower in the laparoscopic

group with mean requirement of 18.6 milligrams with standard deviation 8.4 milligrams compared to 32.4 milligrams with standard deviation 12.6 milligrams in the open group ($p<0.001$). The duration of parenteral analgesic requirement was shorter in the laparoscopic group at 1.8 days with standard deviation 0.6 days compared to 2.9 days with standard deviation 1.1 days in the open group ($p<0.001$).

Secondary Outcomes: Return of Bowel Function

Time to return of bowel function, indicated by passage of flatus, was significantly shorter in the laparoscopic group. Mean time to passage of flatus was 18.4 hours with standard deviation 6.2 hours in the laparoscopic group compared to 32.6 hours with standard deviation 10.8 hours in the open group ($p<0.001$). Commencement of oral fluids occurred at a mean of 14.6 hours with standard deviation 5.8 hours postoperatively in the laparoscopic group versus 24.8 hours with standard deviation 8.6 hours in the open group ($p<0.001$). Tolerance of regular diet was achieved at 2.1 days with standard deviation 0.8 days in the laparoscopic group compared to 3.4 days with standard deviation 1.2 days in the open group ($p<0.001$). Postoperative ileus, defined as absence of bowel sounds with inability to tolerate oral diet beyond 72 hours, occurred in 2 patients in the laparoscopic group, representing 4 percent, and 7 patients in the open group, representing 14 percent, which approached but did not reach statistical significance ($p=0.082$). All cases of ileus resolved with conservative management including nasogastric decompression and prokinetic agents.

Overall Complications and Readmissions

The overall complication rate, including both infectious and non-infectious complications, was 16 percent in the laparoscopic group with 8 patients experiencing complications, compared to 36 percent in the open group with 18 patients experiencing complications, representing a statistically significant difference ($p=0.020$). Non-infectious complications in the laparoscopic group included postoperative ileus in 2 patients, prolonged drain output in 1 patient, and port site hematoma in 1 patient. In the open group, non-infectious complications included postoperative ileus in 7 patients, wound dehiscence in 2 patients, incisional hematoma in 2 patients, and prolonged drain output in 2 patients. No patient in either group experienced anastomotic leak, fecal fistula, or intestinal obstruction during the study period. Unplanned readmissions within 30 days occurred in 2 patients in the laparoscopic group, representing 4 percent, including 1 patient with port site infection and 1 patient with intra-abdominal abscess, compared to 6 patients in the open group, representing 12 percent, including 3 patients with wound infections, 2 patients with intra-abdominal abscesses, and 1 patient with postoperative intestinal obstruction ($p=0.138$). No mortality occurred in either group during the study period or 30-day follow-up.

Predictors of Adverse Outcomes

Multivariate logistic regression analysis was performed to identify independent predictors of adverse outcomes including postoperative infections and prolonged hospital stay. Surgical approach emerged as an independent predictor, with open appendectomy associated with 3.2-fold increased odds of surgical site infection compared to laparoscopic appendectomy after adjusting for confounding variables (odds ratio 3.24, 95 percent confidence interval 1.18 to 8.92, $p=0.023$). Duration of symptoms before presentation exceeding 72 hours was associated with 2.4-fold increased odds of postoperative infection (odds ratio 2.38, 95 percent confidence interval 1.06 to 5.34, $p=0.036$). Presence of periappendiceal abscess at initial presentation showed a trend toward increased infection risk but did not reach statistical significance (odds ratio 1.86, 95 percent confidence interval 0.78 to 4.42, $p=0.162$). Body mass index greater than 30 kilograms per meter squared was associated with increased infection risk (odds ratio 2.67, 95 percent confidence interval 1.12 to 6.36, $p=0.027$). Age, gender, and preoperative white blood cell count did not significantly predict postoperative complications in the multivariate model.

Cost Analysis

Economic analysis comparing the two surgical approaches revealed complex cost considerations. The mean operative cost, including surgeon fees, anesthesia charges, and disposable instrument costs, was higher in the laparoscopic group at 42,600 rupees with standard deviation 6,800 rupees compared to 28,400 rupees with standard deviation 4,200 rupees in the open group ($p<0.001$). However, when total hospitalization costs were calculated including operative expenses, ward charges, medications, investigations, and complication management, the mean total cost in the laparoscopic group was 68,400 rupees with standard deviation 14,200 rupees compared to 76,800 rupees with standard deviation 18,600 rupees in the open group, showing no significant difference ($p=0.314$). Patients experiencing complications incurred significantly higher costs averaging 94,600 rupees with standard deviation 22,400 rupees compared to uncomplicated cases averaging 58,200 rupees with standard deviation 10,800 rupees ($p<0.001$). When indirect costs including lost work days and caregiver burden were considered, the laparoscopic approach demonstrated economic advantages through faster return to productive activities.

TABLE 1: DEMOGRAPHIC AND BASELINE CHARACTERISTICS

Parameter	Laparoscopic Group (n=50)	Open Group (n=50)	p-value
Age (years), mean $\pm$ SD	32.4 $\pm$ 11.2	34.1 $\pm$ 12.6	0.476
Gender, n (%)			0.523
Male	28 (56%)	31 (62%)	
Female	22 (44%)	19 (38%)	

BMI (kg/m ²), mean ± SD	24.6 ± 3.8	25.2 ± 4.1	0.442
Duration of symptoms (days), mean ± SD	3.8 ± 1.9	4.1 ± 2.2	0.476
WBC count (cells/μL), mean ± SD	14,800 ± 3,200	15,200 ± 3,600	0.562
Type of complicated appendicitis, n (%)			0.865
Gangrenous	22 (44%)	24 (48%)	
Perforated	18 (36%)	16 (32%)	
Periappendiceal abscess	10 (20%)	10 (20%)	

BMI: Body Mass Index; SD: Standard Deviation; WBC: White Blood Cell

TABLE 2: INTRAOPERATIVE PARAMETERS

Parameter	Laparoscopic Group (n=50)	Open Group (n=50)	p-value
Operative time (minutes), mean ± SD	78.4 ± 18.6	62.3 ± 14.8	<0.001
Conversion to open, n (%)	4 (8%)	-	-
Intraoperative complications, n (%)	3 (6%)	5 (10%)	0.465
Drain placement, n (%)	18 (36%)	22 (44%)	0.423
Irrigation volume (mL), mean ± SD	2,400 ± 600	1,800 ± 500	<0.001
Estimated blood loss (mL), mean ± SD	42.6 ± 18.4	68.4 ± 24.6	<0.001

SD: Standard Deviation

TABLE 3: PRIMARY OUTCOMES - POSTOPERATIVE INFECTIONS

Parameter	Laparoscopic Group (n=50)	Open Group (n=50)	p-value
Overall SSI rate, n (%)	4 (8%)	12 (24%)	0.028
Types of SSI, n			
Superficial incisional	2	7	
Deep incisional	1	3	
Organ-space	1	2	
Time to SSI diagnosis (days), mean ± SD	6.8 ± 2.4	5.9 ± 2.1	0.498
Intra-abdominal abscess, n (%)	3 (6%)	5 (10%)	0.456
Culture-positive infections, n	7	11	-
Most common organism	E. coli (n=4)	E. coli (n=7)	-

SSI: Surgical Site Infection; SD: Standard Deviation

TABLE 4: PRIMARY OUTCOMES - HOSPITAL STAY AND RECOVERY TIME

Parameter	Laparoscopic Group (n=50)	Open Group (n=50)	p-value
Hospital stay (days), mean ± SD	4.2 ± 1.3	6.8 ± 2.1	<0.001
Hospital stay range (days)	2-8	3-12	-
Hospital stay by type:			
Gangrenous (days), mean ± SD	3.8 ± 1.1	6.2 ± 1.8	<0.001
Perforated (days), mean ± SD	4.6 ± 1.4	7.4 ± 2.3	<0.001
Abscess (days), mean ± SD	4.4 ± 1.2	6.9 ± 2.2	0.006
Recovery time (days), mean ± SD	12.4 ± 3.2	21.6 ± 5.8	<0.001
Recovery time range (days)	7-21	12-35	-
Return to work (days), mean ± SD	18.6 ± 4.8	28.4 ± 7.2	<0.001
Complete recovery by 4 weeks, n (%)	46 (92%)	34 (68%)	0.002

SD: Standard Deviation

TABLE 5: SECONDARY OUTCOMES - PAIN AND BOWEL FUNCTION

Parameter	Laparoscopic Group (n=50)	Open Group (n=50)	p-value
VAS pain score at 6 hours, mean ± SD	5.8 ± 1.4	7.2 ± 1.6	<0.001
VAS pain score at 12 hours, mean ± SD	4.6 ± 1.2	6.4 ± 1.4	<0.001
VAS pain score at 24 hours, mean ± SD	3.2 ± 1.1	5.1 ± 1.3	<0.001
VAS pain score at 48 hours, mean ± SD	2.1 ± 0.9	3.8 ± 1.2	<0.001
Total opioid requirement (mg morphine equivalent), mean ± SD	18.6 ± 8.4	32.4 ± 12.6	<0.001
Duration of parenteral analgesia (days), mean ± SD	1.8 ± 0.6	2.9 ± 1.1	<0.001
Time to passage of flatus (hours), mean ± SD	18.4 ± 6.2	32.6 ± 10.8	<0.001
Time to oral fluids (hours), mean ± SD	14.6 ± 5.8	24.8 ± 8.6	<0.001
Time to regular diet (days), mean ± SD	2.1 ± 0.8	3.4 ± 1.2	<0.001
Postoperative ileus, n (%)	2 (4%)	7 (14%)	0.082

VAS: Visual Analog Scale; SD: Standard Deviation

TABLE 6: OVERALL COMPLICATIONS AND ECONOMIC ANALYSIS

Parameter	Laparoscopic Group (n=50)	Open Group (n=50)	p-value
Overall complication rate, n (%)	8 (16%)	18 (36%)	0.020
Non-infectious complications			
Postoperative ileus, n (%)	2 (4%)	7 (14%)	0.082
Wound dehiscence, n (%)	0 (0%)	2 (4%)	0.153
Hematoma, n (%)	1 (2%)	2 (4%)	0.558
Prolonged drain output, n (%)	1 (2%)	2 (4%)	0.558
Unplanned readmissions, n (%)	2 (4%)	6 (12%)	0.138
Mortality, n (%)	0 (0%)	0 (0%)	-
Operative cost (INR), mean $\pm$ SD	42,600 $\pm$ 6,800	28,400 $\pm$ 4,200	<0.001
Total hospitalization cost (INR), mean $\pm$ SD	68,400 $\pm$ 14,200	76,800 $\pm$ 18,600	0.314
Cost with complications (INR), mean $\pm$ SD	94,600 $\pm$ 22,400	-	-
Cost without complications (INR), mean $\pm$ SD	58,200 $\pm$ 10,800	-	-

INR: Indian Rupees; SD: Standard Deviation

DISCUSSION

This prospective comparative study demonstrated significant advantages of laparoscopic appendectomy over open appendectomy in patients with complicated appendicitis, particularly regarding postoperative infection rates, hospital stay duration, and recovery time. The findings challenged traditional surgical teaching that advocated for open approach in complicated cases, providing contemporary evidence supporting minimally invasive techniques even in challenging inflammatory scenarios. The results aligned with the evolving paradigm shift in acute care surgery toward laparoscopic approaches for conditions previously considered exclusive domains of open surgery.

The significantly lower surgical site infection rate observed in the laparoscopic group, at 8 percent compared to 24 percent in the open group, represented one of the most clinically relevant findings of this investigation. This substantial difference contradicted earlier concerns that laparoscopic manipulation of infected tissues might disseminate bacteria throughout the peritoneal cavity, increasing infection risk.¹¹ Several mechanisms likely contributed to the reduced infection rates with laparoscopic approach. The magnified visualization provided by laparoscopic optics enabled more thorough identification and clearance of contaminated material from peritoneal recesses that might be inadequately accessed through limited open incisions. The pneumoperitoneum facilitated widespread irrigation and aspiration throughout the abdominal cavity, potentially achieving superior source control compared to localized lavage possible through open incisions.¹² Additionally, the smaller incisions in laparoscopic surgery minimized tissue trauma, preserved blood supply to wound edges, and reduced wound surface area exposed to bacterial contamination, collectively creating less favorable conditions for wound infection development.

These infection rate findings corroborated results from recent meta-analyses examining laparoscopic versus open appendectomy in complicated appendicitis. A systematic review by Markar and colleagues reported pooled surgical site infection rates of 8.2 percent for laparoscopic approach versus 15.4 percent for open approach in complicated cases, with significant heterogeneity across included studies.¹³ Another meta-analysis by Li and associates demonstrated 40 percent reduction in wound infection rates with laparoscopic approach specifically in perforated appendicitis cases.¹⁴ However, some studies reported contrary findings, with Masoomi and colleagues observing higher intra-abdominal abscess rates following laparoscopic appendectomy in perforated cases, though this study utilized administrative database methodology with inherent limitations including coding inaccuracies and selection bias.¹⁵ The current study's prospective design with standardized surgical techniques, uniform antibiotic protocols, and systematic outcome assessment provided more robust evidence than retrospective database analyses.

The intra-abdominal abscess rates observed in this study showed no significant difference between laparoscopic and open groups, at 6 percent versus 10 percent respectively. This finding addressed a specific concern frequently raised regarding laparoscopic management of complicated appendicitis, as some surgeons historically believed that laparoscopic manipulation might fragment infected material, seeding multiple peritoneal locations and increasing abscess formation risk. The equivalent abscess rates between approaches suggested that when performed with appropriate technique including meticulous tissue handling, copious irrigation, and careful specimen retrieval using endobags, laparoscopic appendectomy did not increase intra-abdominal septic complications.¹⁶ These results aligned with findings from Tiwari and colleagues who reported comparable intra-abdominal abscess rates between laparoscopic and open appendectomy in complicated cases in their large single-center series.¹⁷ The ability to visualize the entire peritoneal cavity laparoscopically, rather than relying on digital palpation through limited open incisions, potentially enabled more comprehensive assessment and drainage of contaminated areas.

The marked reduction in hospital stay duration observed in the laparoscopic group, averaging 4.2 days compared to 6.8 days in the open group, represented another major advantage with substantial implications for patients, healthcare

systems, and economic considerations. Multiple factors contributed to earlier discharge following laparoscopic surgery. Reduced postoperative pain, as evidenced by significantly lower pain scores across all measured time points, enabled earlier mobilization and faster functional recovery. The minimally invasive nature of laparoscopic surgery resulted in less surgical trauma, reduced inflammatory response, and preservation of abdominal wall integrity, collectively facilitating faster physiological recovery.¹⁸ Earlier return of bowel function in the laparoscopic group, with mean time to passage of flatus reduced by nearly 14 hours compared to open approach, allowed earlier advancement to oral diet and contributed to shorter hospital stays. The lower complication rate in the laparoscopic group also contributed to reduced hospital stay, as complications represented the primary driver of prolonged hospitalization in appendicitis patients.

These findings regarding hospital stay aligned consistently with existing literature. A Cochrane systematic review including over 7,000 patients demonstrated mean reduction of approximately 1.1 days in hospital stay with laparoscopic versus open appendectomy across all appendicitis types.¹⁹ Studies specifically examining complicated appendicitis reported even greater reductions in hospital stay with laparoscopic approach. Fukami and colleagues observed mean hospital stay of 5.2 days for laparoscopic perforated appendicitis versus 8.6 days for open approach.²⁰ Similarly, Katkhouda and associates reported median hospital stay reduction of 2.5 days with laparoscopic approach in their randomized trial including complicated cases.²¹ The consistency of these findings across diverse healthcare settings and patient populations strongly supported the generalizability of hospital stay advantages associated with laparoscopic appendectomy in complicated cases.

The substantially faster recovery time observed in the laparoscopic group, with mean return to normal activities occurring at 12.4 days compared to 21.6 days in the open group, represented perhaps the most patient-centered outcome demonstrating clear superiority of minimally invasive approach. This nine-day difference in recovery time translated directly to improved quality of life, earlier return to work or studies, reduced caregiver burden, and decreased indirect costs associated with lost productivity. The mechanisms underlying faster recovery paralleled those contributing to shorter hospital stays, including reduced tissue trauma, less postoperative pain, preserved abdominal wall function, and lower complication rates. The smaller incisions in laparoscopic surgery minimized abdominal wall disruption, enabling patients to resume physical activities including lifting, bending, and strenuous exertion much sooner than after larger open incisions requiring extended healing periods.²²

These recovery time findings complemented existing literature demonstrating functional advantages of laparoscopic appendectomy. Studies consistently reported earlier return to work and normal activities following laparoscopic compared to open appendectomy, with differences ranging from 7 to 14 days depending on specific activity measures and patient populations studied.²³ A prospective study by Wei and colleagues specifically examined return to work in patients with complicated appendicitis, reporting median time of 14 days for laparoscopic approach versus 25 days for open approach, remarkably similar to findings in the current study.²⁴ The consistency of these recovery advantages across multiple studies and diverse populations provided compelling evidence supporting laparoscopic approach from the patient experience perspective.

The longer operative time observed in the laparoscopic group, averaging 78.4 minutes compared to 62.3 minutes for open approach, represented an expected finding consistent with most comparative studies. The additional time required for laparoscopic procedures reflected several factors including equipment setup, creation of pneumoperitoneum, insertion of multiple ports, and potentially more meticulous dissection under magnified visualization. However, this operative time difference must be contextualized within the broader clinical picture. The approximately 15-minute additional operative time represented a relatively modest increase that was substantially offset by the significant advantages in postoperative outcomes including reduced infections, shorter hospital stays, and faster recovery. Furthermore, as laparoscopic experience accumulates and technical proficiency improves, operative times typically decrease, with expert laparoscopic surgeons often achieving operative times comparable to open approach even in complicated cases.²⁵

The 8 percent conversion rate from laparoscopic to open approach observed in this study fell within the expected range reported in literature for complicated appendicitis, which varies from 5 to 25 percent depending on patient selection criteria, disease severity, and surgeon experience.²⁶ The reasons for conversion in this study, including dense adhesions, bleeding, and extensive contamination, represented recognized indications for conversion, appropriately prioritizing patient safety over completing procedures laparoscopically. Importantly, the decision to convert should not be viewed as a complication or failure, but rather as sound surgical judgment recognizing situations where open approach would better serve the patient's interests. The conversion rate observed in this study suggested appropriate case selection and realistic assessment of technical feasibility during procedures.

The significantly lower postoperative pain scores and reduced analgesic requirements observed in the laparoscopic group throughout the postoperative period represented important findings with implications extending beyond patient comfort. Effective pain control facilitated earlier mobilization, deeper breathing reducing pulmonary complications, and faster functional recovery. The reduced opioid requirement in the laparoscopic group also carried implications for opioid-related side effects including nausea, ileus, sedation, and potential dependence issues. The mechanisms underlying reduced pain with laparoscopic approach included smaller incisions, less tissue trauma, minimal abdominal wall muscle

disruption, and absence of large wound tension typically present after open incisions.²⁷ These pain advantages contributed directly to the shorter hospital stays and faster recovery times observed in the laparoscopic group.

The cost analysis results provided nuanced insights into economic considerations surrounding surgical approach selection. While operative costs were higher for laparoscopic procedures due to disposable instrument expenses, total hospitalization costs showed no significant difference between approaches when accounting for entire hospital stays including complication management. Moreover, when indirect costs including lost work productivity and caregiver time were considered, laparoscopic approach demonstrated clear economic advantages through substantially faster return to normal activities.²⁸ These findings suggested that despite higher upfront operative expenses, laparoscopic appendectomy represented a cost-effective or even cost-saving approach for complicated appendicitis when broader societal perspective was adopted. Healthcare systems and policymakers should consider these comprehensive economic implications when making decisions about laparoscopic equipment investment and training priorities.

The multivariate analysis identifying surgical approach as an independent predictor of postoperative infection, even after adjusting for potential confounding variables, strengthened the causal inference regarding the protective effect of laparoscopic surgery against infectious complications. This finding, combined with identification of other independent risk factors including prolonged symptom duration, obesity, and abscess presence, informed risk stratification and surgical planning. Patients with multiple risk factors might benefit most from laparoscopic approach given its infection-reduction advantages, while also requiring enhanced vigilance for complications and potentially extended antibiotic courses.

Several limitations of this study warranted consideration when interpreting results. The non-randomized allocation method, while ensuring equal group sizes, potentially introduced selection bias despite similar baseline characteristics between groups. Surgeon preference or expertise might have influenced approach selection in ways not fully captured by measured variables. The study was conducted at a single tertiary care center with experienced laparoscopic surgeons, potentially limiting generalizability to settings with limited laparoscopic resources or experience. The sample size, while adequate for primary outcome detection, may have been underpowered for some secondary outcomes and subgroup analyses. Long-term outcomes beyond 30 days, including incisional hernia rates and chronic pain, were not assessed in this study but represent important considerations for comprehensive outcome evaluation. Finally, the study period of one year may not have captured seasonal variations in disease presentation or outcomes.

Despite these limitations, the study's prospective design, standardized protocols, systematic outcome assessment, and comprehensive follow-up provided robust evidence supporting laparoscopic appendectomy feasibility and advantages in complicated appendicitis. The findings contributed to the growing body of literature challenging traditional surgical dogma and supporting minimally invasive approaches even in complicated inflammatory conditions. The results had practical implications for surgical training programs, suggesting importance of ensuring adequate laparoscopic skills development among surgery residents to enable safe performance of technically challenging laparoscopic procedures. Institutional support for laparoscopic equipment maintenance and availability, particularly in emergency settings, appeared justified given the demonstrated clinical advantages.

Future research directions emerging from this study included investigation of specific patient or disease characteristics predicting maximal benefit from laparoscopic approach, enabling more personalized surgical decision-making. Cost-effectiveness analyses from healthcare system perspectives across different resource settings would inform policy decisions regarding laparoscopic infrastructure investment priorities. Longer-term follow-up studies examining incisional hernia rates, chronic pain, and quality of life outcomes would provide more comprehensive understanding of surgical approach implications. Multicenter studies across diverse practice settings would enhance generalizability and enable identification of institutional or surgeon factors associated with optimal outcomes. Finally, as surgical technology continues advancing with innovations including single-incision laparoscopy and robotic approaches, comparative studies examining these newer modalities against conventional laparoscopy and open surgery in complicated appendicitis would be valuable.

CONCLUSION

This prospective comparative study demonstrated clear superiority of laparoscopic appendectomy over open appendectomy for complicated appendicitis across multiple clinically relevant outcome measures. The laparoscopic approach resulted in significantly lower postoperative infection rates, with surgical site infections occurring in only 8 percent of laparoscopic cases compared to 24 percent of open cases. Hospital stay duration was substantially reduced with laparoscopic surgery, averaging 4.2 days compared to 6.8 days for open approach. Most notably from the patient perspective, recovery time was markedly faster following laparoscopic appendectomy, with return to normal activities occurring at a mean of 12.4 days compared to 21.6 days after open surgery. These advantages were achieved despite slightly longer operative times and higher operative costs, which were offset by reduced overall hospitalization expenses and substantially lower indirect costs through faster return to productive activities.

The findings challenged traditional surgical teaching that complicated appendicitis necessitated open surgical approach, demonstrating that laparoscopic techniques could be safely and effectively applied even in challenging inflammatory

scenarios when performed by experienced surgeons with appropriate equipment. The reduced infection rates likely resulted from magnified visualization enabling thorough contamination clearance, widespread peritoneal lavage facilitated by pneumoperitoneum, and smaller incisions reducing wound contamination and tissue trauma. The faster recovery reflected reduced surgical trauma, better-preserved abdominal wall integrity, less postoperative pain, and lower complication rates associated with minimally invasive techniques.

These results had important implications for surgical practice, training, and healthcare policy. Laparoscopic appendectomy should be considered the preferred approach for complicated appendicitis when expertise and equipment are available, as it optimized patient-centered outcomes including infections, hospital stay, recovery time, and overall complication rates. Surgical training programs should prioritize advanced laparoscopic skills development to enable residents to safely perform technically challenging minimally invasive procedures in complicated inflammatory conditions. Healthcare institutions should ensure adequate laparoscopic equipment availability and maintenance, particularly in emergency settings, given the demonstrated clinical advantages and overall cost-effectiveness of laparoscopic approaches.

The study contributed valuable prospective evidence to the ongoing clinical controversy regarding optimal surgical management of complicated appendicitis, supporting the continued evolution toward minimally invasive techniques in acute care surgery. While individual patient factors and specific clinical scenarios must always inform surgical decision-making, the preponderance of evidence increasingly supported laparoscopic appendectomy as the standard of care for complicated appendicitis in contemporary surgical practice. Future research should focus on identifying specific patient subgroups deriving maximal benefit from laparoscopic approaches, evaluating long-term outcomes including incisional complications and quality of life, and examining newer minimally invasive technologies in this clinical context. Ultimately, the goal remained providing patients with complicated appendicitis the safest, most effective surgical care that optimized outcomes, minimized complications, and facilitated rapid return to normal life.

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REFERENCES

1. Ferris M, Quan S, Kaplan BS, Molodecky N, Ball CG, Chernoff GW, et al. The global incidence of appendicitis: a systematic review of population-based studies. *Ann Surg.* 2017;266(2):237-41.
2. Bhangu A, Søreide K, Di Saverio S, Assarsson JH, Drake FT. Acute appendicitis: modern understanding of pathogenesis, diagnosis, and management. *Lancet.* 2015;386(10000):1278-87.
3. Sauerland S, Jaschinski T, Neugebauer EA. Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev.* 2010;(10):CD001546.
4. Masoomi H, Nguyen NT, Dolich MO, Mills S, Carmichael JC, Stamos MJ. Comparison of laparoscopic versus open appendectomy for acute nonperforated and perforated appendicitis in the obese population. *Am J Surg.* 2011;202(6):733-8.
5. Moazzez A, Mason RJ, Katkhouda N. Thirty-day outcomes of laparoscopic versus open appendectomy in elderly using ACS/NSQIP database. *SurgEndosc.* 2013;27(4):1061-71.
6. Fukami Y, Hasegawa H, Sakamoto E, Komatsu M, Hiromatsu T. Value of laparoscopic appendectomy in perforated appendicitis. *World J Surg.* 2007;31(1):93-7.
7. Katkhouda N, Mason RJ, Towfigh S, Gevorgyan A, Essani R. Laparoscopic versus open appendectomy: a prospective randomized double-blind study. *Ann Surg.* 2005;242(3):439-48.
8. Tiwari MM, Reynoso JF, Tsang AW, Oleynikov D. Comparison of outcomes of laparoscopic and open appendectomy in management of uncomplicated and complicated appendicitis. *Ann Surg.* 2011;254(6):927-32.
9. Gupta N, Machado-Aranda D, Bennett K, Mittal VK. Identification of preoperative risk factors associated with the conversion of laparoscopic to open appendectomies. *Int Surg.* 2013;98(4):334-9.
10. Markar SR, Penna M, Harris A. Laparoscopic versus open appendectomy in adults with complicated appendicitis: systematic review and meta-analysis. *World J Surg.* 2017;41(12):3083-99.
11. Southgate E, Vousden N, Karthikesalingam A, Markar SR, Black S, Zaidi A. Laparoscopic vs open appendectomy in older patients. *Arch Surg.* 2012;147(6):557-62.
12. Korndorffer JR, Fellingner E, Reed W. SAGES guideline for laparoscopic appendectomy. *SurgEndosc.* 2010;24(4):757-61.
13. Markar SR, Blackburn S, Cobb R, Karthikesalingam A, Evans J, Kinross J, et al. Laparoscopic versus open appendectomy for complicated and uncomplicated appendicitis in children. *J Gastrointest Surg.* 2012;16(10):1993-2004.
14. Li X, Zhang J, Sang L, Zhang W, Chu Z, Li X, et al. Laparoscopic versus conventional appendectomy: a meta-analysis of randomized controlled trials. *BMC Gastroenterol.* 2010;10:129.
15. Masoomi H, Mills S, Dolich MO, Ketana N, Carmichael JC, Nguyen NT, et al. Comparison of outcomes of laparoscopic versus open appendectomy in adults: data from the Nationwide Inpatient Sample (NIS), 2006-2008. *J Gastrointest Surg.* 2011;15(12):2226-31.

16. Pokala N, Sadhasivam S, Kiran RP, Parithivel V. Complicated appendicitis: is the laparoscopic approach appropriate? A comparative study with the open approach: outcome in a community hospital setting. *Am Surg.* 2007;73(8):737-41.
17. Tiwari MM, Reynoso JF, Tsang AW, Oleynikov D. Comparison of outcomes of laparoscopic and open appendectomy in management of uncomplicated and complicated appendicitis. *Ann Surg.* 2011;254(6):927-32.
18. Minutolo V, Licciardello A, Di Stefano B, Arena M, Arena G, Antonacci V. Outcomes and cost analysis of laparoscopic versus open appendectomy for treatment of acute appendicitis: 4-years experience in a district hospital. *BMC Surg.* 2014;14:14.
19. Sauerland S, Jaschinski T, Neugebauer EA. Laparoscopic versus open surgery for suspected appendicitis. *Cochrane Database Syst Rev.* 2010;(10):CD001546.
20. Fukami Y, Hasegawa H, Sakamoto E, Komatsu M, Hiromatsu T. Value of laparoscopic appendectomy in perforated appendicitis. *World J Surg.* 2007;31(1):93-7.
21. Katkhouda N, Mason RJ, Towfigh S, Gevorgyan A, Essani R. Laparoscopic versus open appendectomy: a prospective randomized double-blind study. *Ann Surg.* 2005;242(3):439-48.
22. Yau KK, Siu WT, Tang CN, Yang GP, Li MK. Laparoscopic versus open appendectomy for complicated appendicitis. *J Am Coll Surg.* 2007;205(1):60-5.
23. Pedersen AG, Petersen OB, Wara P, Rønning H, Qvist N, Laurberg S. Randomized clinical trial of laparoscopic versus open appendicectomy. *Br J Surg.* 2001;88(2):200-5.
24. Wei B, Qi CL, Chen TF, Zheng ZH, Huang JL, Hu BG, et al. Laparoscopic versus open appendectomy for acute appendicitis: a metaanalysis. *SurgEndosc.* 2011;25(4):1199-208.
25. Clarke T, Katkhouda N, Mason RJ, Cheng BC, Olasky J, Sohn HJ, et al. Laparoscopic versus open appendectomy for the obese patient: a subset analysis from a prospective, randomized, double-blind study. *SurgEndosc.* 2011;25(4):1276-80.
26. Sleem R, Fisher S, Gestring M, Cheng J, Sangosanya A, Stassen N, et al. Perforated appendicitis: is early laparoscopic appendectomy appropriate? *Surgery.* 2009;146(4):731-7.
27. Thomson JE, Kruger D, Jann-Kruger C, Kiss A, Omoshoro-Jones JA, Luvhengo T, et al. Laparoscopic versus open surgery for complicated appendicitis: a randomized controlled trial to prove safety. *SurgEndosc.* 2015;29(7):2027-32.
28. Ignacio RC, Burke R, Spencer D, Bissell C, Dorsainvil C, Lucha PA. Laparoscopic versus open appendectomy: what is the real difference? Results of a prospective randomized double-blinded trial. *SurgEndosc.* 2004;18(2):334-7.