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Evaluation Of Laparoscopic Versus Open Appendectomy In Terms Of Recovery Time, Complications, And Hospital Stay: A Cross-Sectional Study

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ABSTRACT

Background: Appendicitis is one of the most common surgical emergencies worldwide. While open appendectomy (OA) has been the gold standard treatment for over a century, laparoscopic appendectomy (LA) has gained popularity in recent decades. This study aimed to evaluate and compare the outcomes of laparoscopic versus open appendectomy in terms of recovery time, postoperative complications, and duration of hospital stay.

Methods: A cross-sectional study was conducted at the Department of General Surgery, KAHER's J.G.M. Medical College, Hubballi, from January 2023 to December 2023. A total of 120 patients diagnosed with acute appendicitis were included in the study. Patients were divided into two groups: 60 patients underwent laparoscopic appendectomy (LA group) and 60 underwent open appendectomy (OA group). Demographic data, operative time, postoperative pain scores, analgesic requirements, time to oral intake, complications, length of hospital stay, and time to return to normal activities were recorded and analyzed. Statistical analysis was performed using SPSS version 25.0.

Results: Both groups were comparable in terms of demographic characteristics and severity of appendicitis. The mean operative time was significantly longer in the LA group (58.35 ± 12.42 minutes) compared to the OA group (42.18 ± 9.75 minutes) ($p<0.001$). However, the LA group demonstrated significantly reduced postoperative pain scores (Visual Analog Scale scores of 3.2 ± 1.1 vs. 5.4 ± 1.3, $p<0.001$), lower analgesic requirements (1.2 ± 0.5 vs. 2.3 ± 0.7 doses, $p<0.001$), shorter time to oral intake (14.6 ± 4.3 vs. 21.8 ± 6.2 hours, $p<0.001$), reduced wound infection rates (3.3% vs. 15%, $p=0.026$), shorter hospital stay (2.1 ± 0.8 vs. 4.2 ± 1.4 days, $p<0.001$), and earlier return to normal activities (12.3 ± 3.2 vs. 18.7 ± 4.6 days, $p<0.001$).

Conclusion: Despite longer operative times, laparoscopic appendectomy offers significant advantages over open appendectomy in terms of reduced postoperative pain, lower analgesic requirements, decreased wound infection rates, shorter hospital stay, and quicker return to normal activities. These findings support the use of laparoscopic appendectomy as the preferred approach for the management of acute appendicitis.

Keywords: *Appendicitis, Laparoscopic appendectomy, Open appendectomy, Recovery time, Complications, Hospital stay*

1. INTRODUCTION

Acute appendicitis is one of the most common surgical emergencies encountered in clinical practice, with a lifetime risk of approximately 7-8%.[1] Since its first description by McBurney in 1894, open appendectomy (OA) has been the standard treatment for acute appendicitis for more than a century.[2] The procedure is typically performed through a right lower quadrant incision (McBurney's point) with division of the abdominal musculature. Open appendectomy has stood the test of time due to its efficacy, safety, and relatively low complication rates.

The advent of minimally invasive surgery revolutionized the field of general surgery, offering potential advantages such as reduced surgical trauma, decreased postoperative pain, improved cosmesis, and faster recovery. Laparoscopic appendectomy (LA) was first described by Semm in 1983 and has since gained widespread acceptance.[3] The procedure involves the creation of pneumoperitoneum and placement of three small ports for access, visualization, and manipulation of the appendix.

Over the past four decades, numerous studies have compared laparoscopic and open approaches for appendectomy, with varying results. Early concerns regarding laparoscopic appendectomy included longer operative times, higher costs, and a potential increase in intra-abdominal abscess formation, particularly in cases of perforated appendicitis.[4] However, advances in surgical techniques, equipment, and surgeon expertise have addressed many of these concerns, leading to the increased adoption of the laparoscopic approach worldwide.

The advantages of laparoscopic appendectomy reported in literature include reduced postoperative pain, decreased wound infection rates, earlier return to oral intake, shorter hospital stay, and quicker return to normal activities.[5] These benefits are particularly pronounced in certain patient populations, such as the obese, elderly, and women of childbearing age, where the diagnostic capabilities of laparoscopy can be especially valuable.[6] Additionally, laparoscopy allows for better visualization of the peritoneal cavity, facilitating the identification and management of concomitant pathologies.

Despite the increasing popularity of laparoscopic appendectomy, there remains a lack of consensus regarding the optimal approach for all patient populations and clinical scenarios. Some surgeons advocate for a selective approach based on patient characteristics, disease severity, and surgeon expertise, while others favor the routine use of laparoscopy for all cases of suspected appendicitis.[7] The debate is further complicated by variations in surgical techniques, institutional resources, and surgeon preferences across different healthcare settings.

Several meta-analyses and systematic reviews have attempted to synthesize the evidence comparing laparoscopic and open appendectomy. A Cochrane review by Sauerland et al. in 2010 analyzed 67 randomized controlled trials and concluded that laparoscopic appendectomy offered certain advantages over open appendectomy, particularly in terms of wound infections, postoperative pain, and return to normal activities.[8] However, the review also noted longer operative times and higher procedural costs associated with the laparoscopic approach.

Cost considerations are particularly relevant in resource-limited settings, where the additional expenses associated with laparoscopic equipment, disposable instruments, and prolonged operative times may outweigh the potential benefits of reduced hospital stay and earlier return to work.[9] In such contexts, a careful evaluation of the cost-effectiveness of laparoscopic versus open appendectomy is essential for informed decision-making at both individual and institutional levels.

The evolution of surgical techniques has also led to modifications of both approaches. Single-incision laparoscopic appendectomy, natural orifice transluminal endoscopic surgery (NOTES), and robotic-assisted appendectomy represent further refinements of the minimally invasive approach, albeit with limited evidence supporting their routine use.[10] Similarly, small-incision open appendectomy and ambulatory appendectomy protocols have been developed to enhance recovery after conventional open surgery.

The COVID-19 pandemic introduced additional considerations in the management of acute appendicitis, with concerns regarding the potential for viral aerosolization during laparoscopic procedures and resource allocation in overwhelmed healthcare systems. Some institutions temporarily reverted to open appendectomy or implemented conservative, non-operative management strategies during the height of the pandemic.[11] This highlighted the need for adaptable approaches based on evolving circumstances and underscored the importance of evidence-based decision-making in surgical practice.

The present study was designed to evaluate and compare the outcomes of laparoscopic versus open appendectomy in our institution, with a focus on recovery time, postoperative complications, and duration of hospital stay. By analyzing our local experience, we aim to contribute to the existing body of evidence and inform clinical decision-making regarding the optimal approach for appendectomy in our specific healthcare context.

The significance of this study lies in its potential to influence surgical practice patterns, optimize resource utilization, and improve patient outcomes in the management of acute appendicitis. By comparing key perioperative and postoperative parameters between laparoscopic and open appendectomy, we seek to identify the approach that offers the greatest benefit to our patient population while considering the practical constraints of our healthcare environment.

In conclusion, while both laparoscopic and open appendectomy are effective treatments for acute appendicitis, the optimal approach remains a subject of ongoing debate. The present study aims to provide a comprehensive comparison of these techniques in terms of recovery time, complications, and hospital stay, contributing valuable data to inform clinical decision-making and enhance patient care in the management of this common surgical condition.

AIMS AND OBJECTIVES

The study was undertaken with the primary aim of evaluating and comparing the outcomes of laparoscopic appendectomy versus open appendectomy in patients diagnosed with acute appendicitis. The specific objectives of the study were defined as follows:

1. To compare the duration of hospital stay between patients undergoing laparoscopic appendectomy and those undergoing open appendectomy.
2. To assess and compare the postoperative complications, including wound infection, intra-abdominal abscess, ileus, and other surgical site infections, between the two surgical approaches.
3. To evaluate the differences in recovery time, as measured by time to oral intake, time to ambulation, and time to return to normal activities, between laparoscopic and open appendectomy groups.
4. To compare the operative time, intraoperative blood loss, and conversion rate from laparoscopic to open procedure between the two surgical techniques.
5. To assess the differences in postoperative pain scores and analgesic requirements between patients undergoing laparoscopic versus open appendectomy.
6. To analyze the cost-effectiveness of laparoscopic appendectomy compared to open appendectomy in our institutional setting.

The study was designed as a cross-sectional observational study to provide a comprehensive comparison of these two widely practiced surgical approaches for appendicitis, with the ultimate goal of determining the optimal technique that offers the greatest benefit to patients in terms of reduced morbidity, shorter recovery time, and improved quality of care.

2. MATERIALS AND METHODS

Study Design and Setting

A hospital-based cross-sectional study was conducted at the Department of General Surgery, KAHER's Jagadguru Gangadhar Mahaswamigalu Moorusaviramath Medical College, Hubballi, from January 2023 to December 2023.

Sample Size Calculation

The sample size was calculated using the formula:

$n = (Z\alpha/2 + Z\beta)^2 \times [\sigma1^2 + \sigma2^2] / (\mu1 - \mu2)^2$

Where:

- $Z\alpha/2 = 1.96$ (for 95% confidence interval)
- $Z\beta = 0.84$ (for 80% power)
- $\sigma1$ = Standard deviation in the first group (LA) = 1.2 days (for hospital stay)
- $\sigma2$ = Standard deviation in the second group (OA) = 1.5 days (for hospital stay)
- $\mu1 - \mu2$ = Expected mean difference = 0.8 days

The calculated sample size was 56 patients per group. Considering a potential dropout rate of 5%, the final sample size was determined to be 60 patients per group, for a total of 120 patients.

Study Population

A total of 120 patients diagnosed with acute appendicitis were included in the study. Patients were allocated to either the laparoscopic appendectomy (LA) group (n=60) or the open appendectomy (OA) group (n=60) based on surgeon preference, patient characteristics, and operating room availability. The allocation was not randomized but reflected the real-world clinical decision-making process in our institution.

Inclusion Criteria

1. Patients aged between 18 and 65 years
2. Clinical diagnosis of acute appendicitis confirmed by ultrasonography or computed tomography
3. American Society of Anesthesiologists (ASA) physical status I or II
4. Patients willing to participate in the study and provide informed consent

Exclusion Criteria

1. Pregnant women
2. Patients with generalized peritonitis or appendicular mass
3. Patients with significant comorbidities (ASA III or higher)
4. Previous major abdominal surgery
5. Conversion from laparoscopic to open procedure (for outcome analysis)
6. Patients unwilling to participate in the study

Preoperative Evaluation

All patients underwent a thorough clinical evaluation, including detailed history and physical examination. Laboratory investigations included complete blood count, serum electrolytes, renal function tests, liver function tests, and coagulation profile. Radiological evaluation consisted of abdominal ultrasonography and/or computed tomography scan as indicated. Preoperative antibiotic prophylaxis with intravenous ceftriaxone (1g) and metronidazole (500mg) was administered to all patients.

SurgicalTechniques

Laparoscopic Appendectomy

Laparoscopic appendectomy was performed under general anesthesia with endotracheal intubation. The patient was positioned supine with slight Trendelenburg tilt and left lateral rotation. Pneumoperitoneum was established using a Veress needle or open (Hasson) technique at the umbilicus, with carbon dioxide insufflation to a pressure of 12-14 mmHg. A 10mm port was placed at the umbilicus for the 30-degree laparoscope, and two additional 5mm ports were placed in the left lower quadrant and suprapubic region.

The appendix was identified and grasped. The mesoappendix was divided using bipolar electrocautery or ultrasonic energy device. The base of the appendix was secured with two endoloops (pre-tied ligatures) and divided between them. The specimen was retrieved through the umbilical port using a specimen bag. The abdomen was irrigated with normal saline as needed, and the ports were removed under direct visualization. Fascial closure was performed at the umbilical port site, and all skin incisions were closed with subcuticular sutures.

Open Appendectomy

Open appendectomy was performed under spinal or general anesthesia. A McBurney's or Lanz incision (approximately 3-5 cm) was made in the right lower quadrant. The external oblique aponeurosis was incised, and the muscle fibers were split in the direction of their course. The peritoneum was entered, and the cecum was identified and delivered into the wound. The appendix was mobilized, and the mesoappendix was ligated and divided. The base of the appendix was ligated with absorbable suture material and the appendix was excised. The stump was invaginated with a purse-string suture at the surgeon's discretion. The wound was closed in layers after ensuring hemostasis.

Postoperative Care

All patients received standard postoperative care, including intravenous fluids, analgesics, and antibiotics. Oral intake was initiated once bowel sounds were present, and patients were encouraged to ambulate as early as tolerated. Postoperative pain was assessed using a Visual Analog Scale (VAS) at 6, 12, 24, and 48 hours after surgery. Analgesics were administered based on pain scores and patient requirements. Patients were discharged when they were afebrile, tolerating oral diet, ambulatory, and had adequate pain control with oral analgesics.

Follow-up Protocol

All patients were followed up at 1 week, 2 weeks, and 4 weeks after discharge. During follow-up visits, patients were assessed for wound healing, postoperative complications, and return to normal activities. Telephone follow-up was conducted for patients unable to attend in-person visits.

Data Collection

The following data were collected for each patient:

1. Demographic characteristics (age, gender, body mass index)
2. Preoperative parameters (duration of symptoms, laboratory values, radiological findings)
3. Intraoperative parameters (operative time, intraoperative findings, blood loss)
4. Postoperative parameters (pain scores, analgesic requirements, time to oral intake, time to ambulation)
5. Complications (wound infection, intra-abdominal abscess, ileus, others)
6. Length of hospital stay

7. Time to return to normal activities

Outcome Measures

The primary outcome measures were:

1. Length of hospital stay (days)
2. Postoperative complications (wound infection, intra-abdominal abscess, ileus)
3. Time to return to normal activities (days)

Secondary outcome measures included:

1. Operative time (minutes)
2. Postoperative pain scores (VAS)
3. Analgesic requirements (number of doses)
4. Time to oral intake (hours)
5. Time to ambulation (hours)
6. Cosmetic satisfaction (assessed at 4-week follow-up)

Statistical Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation and compared using Student's t-test or Mann-Whitney U test, as appropriate. Categorical variables were expressed as frequencies and percentages and compared using Chi-square test or Fisher's exact test. A p-value < 0.05 was considered statistically significant. Multivariate analysis was performed to adjust for potential confounding factors.

3. RESULTS

Demographic and Preoperative Characteristics

A total of 120 patients who underwent appendectomy during the study period were included in the analysis, with 60 patients in the laparoscopic appendectomy (LA) group and 60 patients in the open appendectomy (OA) group. The demographic and preoperative characteristics of both groups are presented in Table 1.

Table 1: Demographic and Preoperative Characteristics

Parameter	LA Group (n=60)	OA Group (n=60)	p-value
Age (years), mean ± SD	32.4 ± 10.2	34.1 ± 11.5	0.382
Gender, n (%)			0.715
- Male	34 (56.7%)	36 (60.0%)	
- Female	26 (43.3%)	24 (40.0%)	
BMI (kg/m²), mean ± SD	24.8 ± 3.6	25.2 ± 3.8	0.541
Duration of symptoms (hours), mean ± SD	28.3 ± 14.2	30.1 ± 15.8	0.497
WBC count (×10³/µL), mean ± SD	13.8 ± 3.2	14.2 ± 3.5	0.502
C-reactive protein (mg/L), mean ± SD	42.5 ± 28.7	45.8 ± 30.2	0.531
Radiological findings, n (%)			0.874
- Uncomplicated appendicitis	45 (75.0%)	44 (73.3%)	
- Complicated appendicitis	15 (25.0%)	16 (26.7%)	
ASA score, n (%)			0.850

Parameter	LA Group (n=60)	OA Group (n=60)	p-value
- ASA I	42 (70.0%)	43 (71.7%)	
- ASA II	18 (30.0%)	17 (28.3%)	

SD: Standard deviation; BMI: Body mass index; WBC: White blood cell; ASA: American Society of Anesthesiologists

There were no statistically significant differences between the two groups in terms of age, gender distribution, body mass index, duration of symptoms, white blood cell count, C-reactive protein levels, radiological findings, or ASA scores. This indicates that the baseline characteristics of the patients in both groups were comparable.

Intraoperative Findings and Parameters

The intraoperative findings and parameters for both groups are summarized in Table 2.

Table 2: Intraoperative Findings and Parameters

Parameter	LA Group (n=60)	OA Group (n=60)	p-value
Operative time (minutes), mean ± SD	58.35 ± 12.42	42.18 ± 9.75	<0.001*
Intraoperative blood loss (mL), mean ± SD	15.8 ± 8.2	35.6 ± 12.4	<0.001*
Intraoperative findings, n (%)			0.926
- Normal appendix	2 (3.3%)	1 (1.7%)	
- Inflamed appendix	43 (71.7%)	43 (71.7%)	
- Suppurative appendicitis	10 (16.7%)	11 (18.3%)	
- Gangrenous appendicitis	3 (5.0%)	3 (5.0%)	
- Perforated appendicitis	2 (3.3%)	2 (3.3%)	
Conversion to open procedure, n (%)	3 (5.0%)	N/A	N/A

SD: Standard deviation; *Statistically significant

The mean operative time was significantly longer in the LA group compared to the OA group (58.35 ± 12.42 minutes vs. 42.18 ± 9.75 minutes, $p<0.001$). However, the intraoperative blood loss was significantly lower in the LA group compared to the OA group (15.8 ± 8.2 mL vs. 35.6 ± 12.4 mL, $p<0.001$). There were no significant differences in the intraoperative findings between the two groups.

Three patients (5.0%) in the LA group required conversion to open appendectomy due to dense adhesions (2 patients) and technical difficulties (1 patient). These patients were excluded from the subsequent analysis of postoperative outcomes to maintain the integrity of the comparison between the two approaches.

Postoperative Outcomes and Complications

The postoperative outcomes and complications for both groups are presented in Table 3.

Table 3: Postoperative Outcomes and Complications

Parameter	LA Group (n=57)	OA Group (n=60)	p-value
VAS pain score, mean ± SD			
- 6 hours	5.2 ± 1.3	7.1 ± 1.4	<0.001*
- 12 hours	4.1 ± 1.2	6.3 ± 1.3	<0.001*

Parameter	LA Group (n=57)	OA Group (n=60)	p-value
- 24 hours	3.2 ± 1.1	5.4 ± 1.3	<0.001*
- 48 hours	1.8 ± 0.9	3.9 ± 1.2	<0.001*
Analgesic requirements (doses), mean ± SD	1.2 ± 0.5	2.3 ± 0.7	<0.001*
Time to oral intake (hours), mean ± SD	14.6 ± 4.3	21.8 ± 6.2	<0.001*
Time to ambulation (hours), mean ± SD	8.2 ± 2.5	15.7 ± 4.3	<0.001*
Postoperative complications, n (%)			
- Wound infection	2 (3.5%)	9 (15.0%)	0.026*
- Intra-abdominal abscess	1 (1.8%)	0 (0.0%)	0.301
- Ileus	2 (3.5%)	5 (8.3%)	0.258
- Urinary retention	1 (1.8%)	3 (5.0%)	0.327
- Pneumonia	0 (0.0%)	1 (1.7%)	0.328
Length of hospital stay (days), mean ± SD	2.1 ± 0.8	4.2 ± 1.4	<0.001*
Time to return to normal activities (days), mean ± SD	12.3 ± 3.2	18.7 ± 4.6	<0.001*
Cosmetic satisfaction score (1-10), mean ± SD	8.6 ± 1.1	6.2 ± 1.5	<0.001*

SD: Standard deviation; VAS: Visual Analog Scale; *Statistically significant

Patients in the LA group reported significantly lower pain scores at all time points (6, 12, 24, and 48 hours) compared to the OA group ($p<0.001$). Consequently, the analgesic requirements were also significantly lower in the LA group (1.2 ± 0.5 doses vs. 2.3 ± 0.7 doses, $p<0.001$).

The time to oral intake and time to ambulation were significantly shorter in the LA group compared to the OA group (14.6 ± 4.3 hours vs. 21.8 ± 6.2 hours, $p<0.001$, and 8.2 ± 2.5 hours vs. 15.7 ± 4.3 hours, $p<0.001$, respectively).

Regarding postoperative complications, the incidence of wound infection was significantly lower in the LA group compared to the OA group (3.5% vs. 15.0%, $p=0.026$). There were no significant differences in the incidence of intra-abdominal abscess, ileus, urinary retention, or pneumonia between the two groups.

The mean length of hospital stay was significantly shorter in the LA group compared to the OA group (2.1 ± 0.8 days vs. 4.2 ± 1.4 days, $p<0.001$). Similarly, the time to return to normal activities was significantly shorter in the LA group (12.3 ± 3. 2 days vs. 18.7 ± 4.6 days, $p<0.001$).

Patients in the LA group reported higher cosmetic satisfaction scores compared to those in the OA group (8.6 ± 1.1 vs. 6.2 ± 1.5, $p<0.001$).

Subgroup Analysis by Appendicitis Severity

A subgroup analysis was performed to compare the outcomes between the LA and OA groups stratified by the severity of appendicitis (uncomplicated vs. complicated). The results are presented in Table 4.

Table 4: Subgroup Analysis by Appendicitis Severity

Parameter	Uncomplicated Appendicitis			Complicated Appendicitis		
	LA Group (n=43)	OA Group (n=44)	p-value	LA Group (n=14)	OA Group (n=16)	p-value

Parameter	Uncomplicated Appendicitis			Complicated Appendicitis		
Operative time (minutes), mean ± SD	53.2 ± 10.5	38.5 ± 8.2	<0.001*	72.8 ± 14.6	52.4 ± 11.8	<0.001*
VAS pain score (24h), mean ± SD	2.9 ± 1.0	5.1 ± 1.2	<0.001*	4.1 ± 1.2	6.2 ± 1.3	<0.001*
Wound infection, n (%)	1 (2.3%)	4 (9.1%)	0.182	1 (7.1%)	5 (31.3%)	0.107
Intra-abdominal abscess, n (%)	0 (0.0%)	0 (0.0%)	N/A	1 (7.1%)	0 (0.0%)	0.275
Length of hospital stay (days), mean ± SD	1.8 ± 0.6	3.5 ± 1.1	<0.001*	3.2 ± 0.9	6.1 ± 1.5	<0.001*
Time to return to normal activities (days), mean ± SD	11.2 ± 2.8	16.5 ± 3.9	<0.001*	15.7 ± 3.5	24.8 ± 5.2	<0.001*

SD: Standard deviation; VAS: Visual Analog Scale; *Statistically significant

In both uncomplicated and complicated appendicitis subgroups, the LA group had significantly longer operative times but lower pain scores, shorter hospital stays, and earlier return to normal activities compared to the OA group. The differences in wound infection rates were not statistically significant in either subgroup, likely due to the smaller sample sizes after stratification.

Cost Analysis

A comparative analysis of the costs associated with both procedures was conducted, taking into account the direct costs of the surgical procedure, hospital stay, and medication use. The results are summarized in Table 5.

Table 5: Cost Analysis

Parameter	LA Group (n=57)	OA Group (n=60)	p-value
Procedural costs (INR), mean ± SD	32,500 ± 3,800	18,200 ± 2,500	<0.001*
Hospital stay costs (INR), mean ± SD	10,500 ± 4,000	21,000 ± 7,000	<0.001*
Medication costs (INR), mean ± SD	3,200 ± 800	5,400 ± 1,200	<0.001*
Total direct costs (INR), mean ± SD	46,200 ± 6,200	44,600 ± 8,400	0.244
Indirect costs (lost productivity) (INR), mean ± SD	15,400 ± 4,800	23,400 ± 7,200	<0.001*
Total costs (INR), mean ± SD	61,600 ± 9,500	68,000 ± 12,300	0.002*

SD: Standard deviation; INR: Indian Rupee; *Statistically significant

The procedural costs were significantly higher in the LA group compared to the OA group (32,500 ± 3,800 INR vs. 18,200 ± 2,500 INR, p<0.001). However, the hospital stay costs and medication costs were significantly lower in the LA group. The total direct costs were slightly higher in the LA group, but the difference was not statistically significant (46,200 ± 6,200 INR vs. 44,600 ± 8,400 INR, p=0.244).

When indirect costs related to lost productivity were considered, the total costs were significantly lower in the LA group compared to the OA group (61,600 ± 9,500 INR vs. 68,000 ± 12,300 INR, p=0.002).

4. DISCUSSION

Appendectomy is one of the most commonly performed emergency surgical procedures worldwide. While open appendectomy has been the gold standard treatment for acute appendicitis for over a century, laparoscopic appendectomy has gained increasing popularity in recent decades. The present study was designed to compare these two approaches in terms of recovery time, complications, and hospital stay, providing valuable insights into their relative efficacy and safety in

our institutional setting.

Our study demonstrated that laparoscopic appendectomy was associated with several significant advantages over open appendectomy, including reduced postoperative pain, lower analgesic requirements, decreased wound infection rates, shorter hospital stay, and earlier return to normal activities. These findings are consistent with several previous studies and meta-analyses comparing the two approaches.

The demographic and preoperative characteristics of patients in both groups were comparable, indicating a well-balanced study population and minimizing the potential for selection bias. The mean age of patients in our study (32.4 ± 10.2 years in the LA group and 34.1 ± 11.5 years in the OA group) is consistent with the typical age distribution of acute appendicitis, which predominantly affects young adults.[12]

One of the most consistent findings in studies comparing laparoscopic and open appendectomy is the longer operative time associated with the laparoscopic approach. Our study corroborated this observation, with a mean operative time of 58.35 ± 12.42 minutes for laparoscopic appendectomy compared to 42.18 ± 9.75 minutes for open appendectomy ($p<0.001$). This difference can be attributed to several factors, including the technical complexity of laparoscopic procedures, the need for establishment of pneumoperitoneum, and the learning curve associated with minimally invasive surgery.[13] However, it is worth noting that the operative time for laparoscopic appendectomy has been decreasing with increasing surgeon experience and advancements in laparoscopic equipment, as evidenced by the trend in published literature over time.[14]

Despite the longer operative time, laparoscopic appendectomy was associated with significantly reduced intraoperative blood loss compared to open appendectomy (15.8 ± 8.2 mL vs. 35.6 ± 12.4 mL, $p<0.001$). This finding is consistent with the principles of minimally invasive surgery, which emphasizes meticulous dissection and hemostasis under magnified visualization. The clinical significance of this difference in blood loss is likely minimal, as the total volume is small in both groups and would not typically necessitate blood transfusion.

The conversion rate from laparoscopic to open appendectomy in our study was 5.0% (3 out of 60 patients), which is comparable to the conversion rates reported in the literature, ranging from 1% to 15%.[15] The main reasons for conversion in our study were dense adhesions and technical difficulties, which are consistent with the common causes of conversion reported in other studies. The relatively low conversion rate in our study suggests appropriate patient selection and adequate laparoscopic expertise among the operating surgeons.

Postoperative pain is a significant determinant of patient satisfaction and recovery after surgery. Our study demonstrated consistently lower pain scores in the laparoscopic group at all time points assessed (6, 12, 24, and 48 hours postoperatively), with correspondingly reduced analgesic requirements. This finding aligns with numerous previous studies and is attributed to the smaller incisions and reduced tissue trauma associated with the laparoscopic approach.[16] The reduced pain facilitates earlier ambulation and oral intake, contributing to the enhanced recovery observed in the laparoscopic group.

Wound infection is one of the most common complications following appendectomy, with reported rates varying from 3% to 20% depending on the severity of appendicitis and the surgical approach.[17] In our study, the incidence of wound infection was significantly lower in the laparoscopic group compared to the open group (3.5% vs. 15.0%, $p=0.026$). This difference can be explained by several factors, including the extraction of the appendix through a specimen bag in laparoscopic surgery, which minimizes wound contamination, and the smaller incisions that reduce the exposure of subcutaneous tissues to potential pathogens.

The concern regarding an increased risk of intra-abdominal abscess formation after laparoscopic appendectomy, particularly in cases of perforated appendicitis, has been raised in some studies.[18] However, our study did not find a significant difference in the incidence of intra-abdominal abscess between the two groups (1.8% in the LA group vs. 0.0% in the OA group, $p=0.301$). This finding is consistent with more recent studies and meta-analyses, which suggest that with proper technique, including adequate peritoneal lavage and appropriate antibiotic therapy, the risk of intra-abdominal abscess after laparoscopic appendectomy is not significantly increased compared to open appendectomy.[19]

The length of hospital stay is an important outcome measure with significant implications for healthcare costs and resource utilization. Our study found a significantly shorter hospital stay in the laparoscopic group compared to the open group (2.1 ± 0.8 days vs. 4.2 ± 1.4 days, $p<0.001$). This finding is consistent with numerous previous studies and meta-analyses, which have consistently demonstrated reduced hospital stay as one of the key advantages of laparoscopic appendectomy.[20] The shorter hospital stay can be attributed to reduced postoperative pain, earlier return of bowel function, and decreased wound-related complications associated with the laparoscopic approach.

Time to return to normal activities, including work or school, is a critical outcome measure from the patient's perspective and has significant socioeconomic implications. Our study demonstrated that patients in the laparoscopic group returned to normal activities significantly earlier than those in the open group (12.3 ± 3.2 days vs. 18.7 ± 4.6 days, $p<0.001$). This difference of approximately 6 days represents a substantial reduction in lost productivity and can partially offset the higher procedural costs associated with laparoscopic appendectomy.

The subgroup analysis stratified by the severity of appendicitis (uncomplicated vs. complicated) revealed that the advantages of laparoscopic appendectomy, including reduced pain, shorter hospital stay, and earlier return to normal activities, were maintained in both subgroups. This finding suggests that the benefits of the laparoscopic approach are not limited to uncomplicated cases of appendicitis but extend to more complex presentations as well. However, the operative time was notably longer for complicated appendicitis in both groups, reflecting the technical challenges associated with managing advanced inflammatory processes.

Cost considerations are increasingly important in healthcare decision-making, particularly in resource-limited settings. Our cost analysis revealed that while the procedural costs were significantly higher for laparoscopic appendectomy, the reduced hospital stay and medication costs partially offset this difference, resulting in comparable total direct costs between the two approaches. When indirect costs related to lost productivity were considered, laparoscopic appendectomy emerged as the more cost-effective option, with significantly lower total costs compared to open appendectomy. This finding highlights the importance of considering both direct and indirect costs in economic evaluations of surgical interventions.

Several limitations of our study warrant consideration. First, the non-randomized design may have introduced selection bias, despite the comparable baseline characteristics of the two groups. Second, the single-center nature of the study may limit the generalizability of our findings to other healthcare settings with different patient populations, surgical expertise, and resource availability. Third, the exclusion of patients who required conversion from laparoscopic to open appendectomy from the outcome analysis may have inflated the benefits of the laparoscopic approach, although this is a common practice in similar studies to maintain the integrity of the comparison between the two techniques. Finally, the relatively short follow-up period (4 weeks) may have precluded the detection of late complications or long-term outcomes.

Despite these limitations, our study provides valuable insights into the comparative effectiveness of laparoscopic and open appendectomy in our specific healthcare context. The consistent advantages observed with the laparoscopic approach, including reduced postoperative pain, lower wound infection rates, shorter hospital stay, and earlier return to normal activities, support its preferential use for the management of acute appendicitis, particularly in settings with adequate laparoscopic expertise and resources.

Future research directions include prospective randomized controlled trials with larger sample sizes and longer follow-up periods, cost-effectiveness analyses incorporating quality-adjusted life years, and studies investigating the role of emerging technologies such as single-incision laparoscopic surgery and robotic-assisted appendectomy. Additionally, research comparing laparoscopic appendectomy with non-operative management strategies for uncomplicated appendicitis would provide valuable insights into the evolving landscape of appendicitis treatment.

In conclusion, our study demonstrates that laparoscopic appendectomy offers significant advantages over open appendectomy in terms of postoperative outcomes, despite the longer operative time and higher procedural costs. These findings contribute to the growing body of evidence supporting the widespread adoption of the laparoscopic approach for the management of acute appendicitis, with appropriate consideration of patient factors, surgeon expertise, and institutional resources.

5. CONCLUSION

The present study compared laparoscopic and open appendectomy in terms of recovery time, complications, and hospital stay in patients with acute appendicitis. Based on our findings, several conclusions can be drawn:

1. Laparoscopic appendectomy is associated with significantly reduced postoperative pain and lower analgesic requirements compared to open appendectomy, contributing to enhanced patient comfort and satisfaction.
2. The incidence of wound infection is significantly lower with the laparoscopic approach, while there is no significant difference in the occurrence of intra-abdominal abscess or other complications between the two techniques.
3. Patients undergoing laparoscopic appendectomy experience shorter hospital stays and earlier return to normal activities, resulting in reduced healthcare resource utilization and minimized socioeconomic impact.
4. Despite longer operative times, the laparoscopic approach demonstrates comparable direct costs and lower total costs when indirect costs related to lost productivity are considered, suggesting favorable cost-effectiveness.
5. The advantages of laparoscopic appendectomy are maintained across different severity levels of appendicitis, indicating its applicability in both uncomplicated and complicated cases.

These findings support the use of laparoscopic appendectomy as the preferred approach for the management of acute appendicitis in appropriate clinical settings, with consideration of patient factors, surgeon expertise, and institutional resources. The reduced morbidity, enhanced recovery, and favorable cost-effectiveness associated with the laparoscopic approach contribute to improved patient outcomes and healthcare efficiency in the treatment of this common surgical condition.

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