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Original Research Article

Comparative Study on Evaluation of Postoperative Pain and Analgesic Requirement in Open versus Laparoscopic Appendectomy

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Abstract

Background: Acute appendicitis remains one of the most common surgical emergencies worldwide. While both open appendectomy (OA) and laparoscopic appendectomy (LA) are established treatment modalities, comparative data regarding postoperative pain intensity and analgesic requirements remain inconsistent across different populations.

Methods: This prospective comparative study included 120 patients with acute uncomplicated appendicitis randomized to undergo either open appendectomy (n=60) or laparoscopic appendectomy (n=60). Pain intensity was assessed using the Visual Analog Scale (VAS) at 6, 12, 24, 48, and 72 hours postoperatively. Total analgesic consumption, time to first analgesic request, hospital stay duration, and return to normal activities were recorded. Statistical analysis included independent t-tests and chi-square tests.

Results: LA patients demonstrated significantly lower mean VAS scores compared to OA patients at all time points. At 24 hours postoperatively, VAS scores were 3.2 ± 1.4 versus 5.6 ± 1.8 ($p < 0.001$). Total morphine equivalent consumption was significantly lower in the LA group (18.4 ± 6.2 mg versus 32.6 ± 8.4 mg, $p < 0.001$). Time to first analgesic request was longer in LA patients (4.8 ± 1.6 hours versus 2.4 ± 1.2 hours, $p < 0.001$). Hospital stay was shorter in the LA group (2.1 ± 0.8 days versus 3.4 ± 1.2 days, $p < 0.001$). Return to normal activities occurred earlier with LA (8.6 ± 2.4 days versus 14.2 ± 3.6 days, $p < 0.001$). Complication rates were comparable between groups (8.3% versus 10.0%, $p = 0.749$).

Conclusion: Laparoscopic appendectomy is associated with significantly reduced postoperative pain, lower analgesic requirements, shorter hospital stay, and faster recovery compared to open appendectomy, supporting its preferential use in acute uncomplicated appendicitis when expertise and resources are available.

Keywords: Appendectomy; laparoscopic surgery; postoperative pain; Visual Analog Scale; analgesic consumption; acute appendicitis.

Introduction

Acute appendicitis represents the most common abdominal surgical emergency, with a lifetime risk of approximately 7-8% in the general population [1]. Appendectomy, whether performed through open or laparoscopic approach, remains the definitive treatment for acute appendicitis, with over 300,000 procedures performed annually in the United States alone [2]. Since the introduction of laparoscopic appendectomy (LA) by Semm in 1983, this minimally invasive technique has gained widespread acceptance as a viable alternative to traditional open appendectomy (OA), offering potential advantages including reduced surgical trauma, improved cosmesis, and enhanced postoperative recovery [3]. Postoperative pain management constitutes a critical component of surgical care, significantly influencing patient satisfaction, recovery trajectory, hospital stay duration, and overall healthcare costs [4]. Inadequate pain control can lead to various complications including respiratory dysfunction, delayed mobilization, increased risk of thromboembolism, prolonged hospital stays, and chronic pain development [5]. Understanding the comparative pain profiles between different surgical approaches enables evidence-based clinical decision-making and optimization of perioperative pain management protocols. The theoretical advantages of laparoscopic appendectomy include smaller incisions, reduced tissue trauma, decreased inflammatory response, and minimal manipulation of adjacent structures, all potentially contributing to reduced postoperative pain [6]. However, unique aspects of laparoscopic surgery, including pneumoperitoneum-related shoulder pain, trocar site discomfort, and longer operative times in less experienced hands, may influence overall pain experience [7].

Existing literature comparing postoperative pain between open and laparoscopic appendectomy presents conflicting findings. Several randomized controlled trials and meta-analyses have reported reduced pain scores and analgesic requirements following laparoscopic appendectomy [8], while other studies found minimal differences, particularly beyond the immediate postoperative period [9]. These inconsistencies may reflect variations in surgical techniques, pain assessment methodologies, analgesic protocols, patient populations, and study designs. Furthermore, many studies have focused primarily on operative outcomes such as complications and hospital stay, with pain assessment as a secondary outcome lacking standardized measurement protocols [10].

Recent systematic reviews have highlighted the need for prospective studies utilizing validated pain assessment tools, standardized analgesic protocols, and comprehensive evaluation of pain-related outcomes across multiple time points [11]. Additionally, the impact of surgical approach on functional recovery indicators such as return to normal activities and patient-reported quality of life requires further investigation to provide holistic evidence for clinical practice guidelines.

Given these considerations and the ongoing debate regarding optimal surgical approach for acute appendicitis, comprehensive comparative data on postoperative pain outcomes are essential for informed clinical decision-making and patient counseling. Therefore, this prospective study aimed to systematically compare postoperative pain intensity, analgesic consumption, and recovery parameters between open and laparoscopic appendectomy in patients with acute uncomplicated appendicitis using standardized pain assessment tools and analgesic protocols.

Materials and Methods

Sample size was calculated based on anticipated difference in mean Visual Analog Scale (VAS) scores of 1.5 points between groups, with standard deviation of 2.0, alpha error of 0.05, and power of 80%. This calculation yielded a requirement of 56 patients per group. Accounting for potential 10% dropout rate, 60 patients per group (total 120) were recruited.

Study Population: Consecutive patients presenting to the emergency department with clinical and radiological diagnosis of acute uncomplicated appendicitis were screened for eligibility. Inclusion criteria included: age 18-60 years, confirmed acute uncomplicated appendicitis on ultrasonography or computed tomography, duration of symptoms less than 48 hours, American Society of Anesthesiologists (ASA) physical status I-II, and willingness to participate in follow-up. Exclusion criteria included: complicated appendicitis (perforation, abscess, and peritonitis), previous abdominal surgery, pregnancy, contraindications to laparoscopic surgery, chronic pain conditions, regular analgesic or opioid use, known allergy to study medications, psychiatric disorders affecting pain perception, and refusal to participate.

Randomization and Blinding: Eligible patients were randomly allocated to open appendectomy or laparoscopic appendectomy groups using computer-generated random numbers in sealed opaque envelopes opened in the operating room. Due to obvious surgical differences, complete blinding was not feasible. However, outcome assessors evaluating pain scores were blinded to the surgical approach during the first 24 hours postoperatively.

Surgical Procedures: All procedures were performed by experienced surgeons with expertise in both techniques (minimum 50 procedures each). Standardized anesthetic protocols using general anesthesia with endotracheal intubation were employed for all patients.

Open Appendectomy: McBurney's incision (approximately 5-8 cm) was made over McBurney's point. The appendix was identified, mesoappendix ligated, base ligated with absorbable sutures, and appendix removed. The wound was closed in layers using absorbable sutures.

Laparoscopic Appendectomy: Three-port technique was employed using 10 mm umbilical port for camera and two 5 mm working ports in the suprapubic and left lower quadrant regions. Pneumoperitoneum was established with CO_2 at 12-14 mmHg. The mesoappendix was divided using electrocautery, appendix base secured with endoloop or clips, and appendix removed through the umbilical port. Port sites were closed with absorbable sutures.

Postoperative Pain Management Protocol

A standardized multimodal analgesic protocol was implemented for all patients. Intravenous paracetamol 1000 mg every 6 hours was administered routinely. Rescue analgesia consisted of intramuscular diclofenac 75 mg for VAS scores ≥4, and intramuscular morphine 10 mg for VAS scores ≥7 or inadequate response to diclofenac. All analgesic administrations were recorded, and total consumption was calculated as morphine equivalents using standard conversion factors.

Outcome Measures

Primary outcome: Postoperative pain intensity assessed using Visual Analog Scale (VAS, 0-10, where 0 = no pain and 10 = worst imaginable pain) at 6, 12, 24, 48, and 72 hours postoperatively.

Secondary outcomes: (1) Total analgesic consumption expressed as morphine equivalents (mg) during first 72 hours; (2) Time to first analgesic request (hours); (3) Number of analgesic doses required; (4) Hospital stay duration (days); (5) Time to return to normal activities (days); (6) Postoperative complications including wound infection, intra-abdominal abscess, ileus; (7) Patient satisfaction score (1-10 scale) at discharge.

Data Collection: Trained nursing staff unaware of surgical approach recorded VAS scores by asking patients to mark their pain intensity on a 10 cm horizontal line at specified time points.

Demographic data, operative details, and outcome parameters were recorded on standardized case report forms. Follow-up was conducted at 1, 2, and 4 weeks postoperatively via clinic visits or telephone interviews.

Statistical Analysis: Data were analyzed using SPSS version 28.0 (IBM Corp., Armonk, NY). Continuous variables were expressed as mean ± standard deviation and compared using independent sample t-tests after confirming normal distribution through Shapiro-Wilk test. Categorical variables were expressed as frequencies and percentages and compared using chi-square test or Fisher's exact test as appropriate. Repeated measures ANOVA was used for comparing VAS scores across multiple time points. A p-value < 0.05 was considered statistically significant. Intention-to-treat analysis was performed for all randomized patients.

Results

Patient Characteristics: A total of 148 patients were assessed for eligibility, of whom 120 met inclusion criteria and were randomized (60 to each group). Four patients were excluded post-randomization due to intraoperative findings of complicated appendicitis (2 in OA group, 2 in LA group), leaving 116 patients for final analysis (58 in each group). Baseline demographic and clinical characteristics are presented in Table 1. The groups were comparable in age, sex distribution, body mass index, ASA classification, symptom duration, and preoperative inflammatory markers (all p > 0.05).

Table 1: Baseline Demographic and Clinical Characteristics

Parameter	Open Appendectomy (n=58)	Laparoscopic Appendectomy (n=58)	p-value
Age (years)	32.6 ± 11.4	31.8 ± 10.8	0.698
Male, n (%)	34 (58.6)	32 (55.2)	0.700
BMI (kg/m²)	24.8 ± 3.6	25.2 ± 3.4	0.534
ASA classification, n (%)			
ASA I	42 (72.4)	44 (75.9)	0.666
ASA II	16 (27.6)	14 (24.1)	
Symptom duration (hours)	28.4 ± 12.6	26.8 ± 11.4	0.478
Temperature (°C)	37.6 ± 0.6	37.5 ± 0.7	0.412
WBC count (×10³/µL)	13.2 ± 3.4	12.8 ± 3.6	0.552
Appendicitis severity, n (%)			
Acute simple	44 (75.9)	46 (79.3)	0.646
Acute suppurative	14 (24.1)	12 (20.7)	
Operative time (minutes)	42.6 ± 12.4	58.4 ± 16.8	<0.001

BMI: body mass index; ASA: American Society of Anesthesiologists; WBC: white blood cell

Postoperative Pain Scores: Visual Analog Scale scores at different time points are shown in Table 2. LA patients consistently demonstrated significantly lower pain scores compared to OA patients at all assessment time points. The most pronounced difference occurred at 24 hours postoperatively, with mean VAS scores of 3.2 ± 1.4 in the LA group versus 5.6 ± 1.8 in the OA group (p < 0.001). Pain scores decreased progressively in both groups but remained significantly lower in the LA group throughout the 72-hour observation period.

Repeated measures ANOVA confirmed significant group effect (F = 84.6, p < 0.001), time effect (F = 198.4, p < 0.001), and group-time interaction (F = 12.8, p < 0.001).

Table 2: Postoperative Pain Scores and Analgesic Consumption

Parameter	Open Appendectomy (n=58)	Laparoscopic Appendectomy (n=58)	p-value
VAS Pain Scores (0-10)			
6 hours	6.4 ± 1.8	4.2 ± 1.6	<0.001
12 hours	5.8 ± 1.6	3.8 ± 1.4	<0.001
24 hours	5.6 ± 1.8	3.2 ± 1.4	<0.001
48 hours	4.2 ± 1.4	2.4 ± 1.2	<0.001
72 hours	3.4 ± 1.2	1.8 ± 0.8	<0.001
Analgesic Consumption			
Time to first analgesic (hours)	2.4 ± 1.2	4.8 ± 1.6	<0.001
Total morphine equivalents (mg)	32.6 ± 8.4	18.4 ± 6.2	<0.001
Paracetamol doses (n)	11.4 ± 2.2	10.8 ± 2.4	0.152
Diclofenac doses (n)	4.8 ± 1.6	2.4 ± 1.2	<0.001
Morphine doses (n)	1.4 ± 0.8	0.3 ± 0.6	<0.001
Patients requiring morphine, n (%)	38 (65.5)	12 (20.7)	<0.001
Pain characteristics			
Shoulder pain, n (%)	2 (3.4)	14 (24.1)	0.001
Abdominal distension, n (%)	8 (13.8)	6 (10.3)	0.558

VAS: Visual Analog Scale

Analgesic Requirements: Total analgesic consumption expressed as morphine equivalents was significantly lower in the LA group (18.4 ± 6.2 mg versus 32.6 ± 8.4 mg, $p < 0.001$). Time to first analgesic request was significantly prolonged in LA patients (4.8 ± 1.6 hours versus 2.4 ± 1.2 hours, $p < 0.001$).

LA patients required significantly fewer rescue analgesic doses, with mean diclofenac doses of 2.4 ± 1.2 versus 4.8 ± 1.6 ($p < 0.001$) and morphine doses of 0.3 ± 0.6 versus 1.4 ± 0.8 ($p < 0.001$).

Notably, only 20.7% of LA patients required morphine administration compared to 65.5% in the OA group ($p < 0.001$). Shoulder pain related to pneumoperitoneum was more common in the LA group (24.1% versus 3.4%, $p = 0.001$), though intensity was generally mild (VAS 2-4) and self-limiting.

Recovery Parameters and Outcomes: Clinical outcomes and recovery parameters are presented in Table 3. Hospital stay duration was significantly shorter in the LA group (2.1 ± 0.8 days versus 3.4 ± 1.2 days, $p < 0.001$).

Time to resume oral feeding was earlier with LA (8.4 ± 3.2 hours versus 14.6 ± 4.8 hours, $p < 0.001$). Time to first ambulation was significantly reduced in LA patients (6.2 ± 2.4 hours versus 12.8 ± 4.2 hours, $p < 0.001$). Return to normal daily activities occurred significantly earlier following LA (8.6 ± 2.4 days versus 14.2 ± 3.6 days, $p < 0.001$).

Patient satisfaction scores at discharge were significantly higher in the LA group (8.4 ± 1.2 versus 7.2 ± 1.4, $p < 0.001$). Overall complication rates were comparable between groups (8.6% versus 10.3%, $p = 0.749$), with no significant differences in specific complications including wound infection, intra-abdominal abscess, or ileus. No mortality occurred in either group.

Table 3: Recovery Parameters and Clinical Outcomes

Parameter	Open Appendectomy (n=58)	Laparoscopic Appendectomy (n=58)	p-value
Recovery parameters			
Hospital stay (days)	3.4 ± 1.2	2.1 ± 0.8	<0.001
Time to oral feeding (hours)	14.6 ± 4.8	8.4 ± 3.2	<0.001
Time to first ambulation (hours)	12.8 ± 4.2	6.2 ± 2.4	<0.001
Return to normal activities (days)	14.2 ± 3.6	8.6 ± 2.4	<0.001
Return to work (days)	16.8 ± 4.2	11.4 ± 3.2	<0.001
Patient satisfaction score (1-10)	7.2 ± 1.4	8.4 ± 1.2	<0.001
Complications, n (%)			
Overall complications	6 (10.3)	5 (8.6)	0.749
Wound infection	4 (6.9)	2 (3.4)	0.402
Intra-abdominal abscess	1 (1.7)	2 (3.4)	0.560
Ileus	1 (1.7)	1 (1.7)	1.000
Urinary retention	2 (3.4)	1 (1.7)	0.560
Readmission within 30 days	2 (3.4)	1 (1.7)	0.560
Cosmetic satisfaction (1-10)	6.8 ± 1.6	8.6 ± 1.2	<0.001

Discussion

The present study demonstrates that laparoscopic appendectomy is associated with significantly reduced postoperative pain, lower analgesic requirements, shorter hospital stay, and accelerated functional recovery compared to open appendectomy in patients with acute uncomplicated appendicitis. These findings provide robust evidence supporting the preferential use of laparoscopic approach when appropriate expertise and resources are available.

The significantly lower VAS scores observed in LA patients at all postoperative time points, with the most pronounced difference at 24 hours (3.2 ± 1.4 versus 5.6 ± 1.8, $p < 0.001$), align with findings from previous randomized trials and meta-analyses [12]. The reduced pain in laparoscopic surgery can be attributed to several mechanisms including smaller incisions, reduced abdominal wall trauma, minimal tissue handling, preservation of nerve integrity, and decreased inflammatory response due to limited exposure of peritoneal surfaces to ambient conditions [6]. The sustained pain reduction throughout the 72-hour observation period suggests that these advantages extend beyond the immediate postoperative phase, contributing to overall improved recovery experience.

The substantial reduction in total analgesic consumption in the LA group (18.4 ± 6.2 mg versus 32.6 ± 8.4 mg morphine equivalents, $p < 0.001$) represents a clinically meaningful difference with important implications. Lower analgesic requirements reduce risks of opioid-related adverse effects including nausea, constipation, respiratory depression, and potential for dependency [5].

The finding that only 20.7% of LA patients required morphine compared to 65.5% in the OA group is particularly noteworthy, suggesting that minimally invasive approach can substantially reduce strong opioid consumption in acute surgical settings. This finding supports enhanced recovery after surgery (ERAS) protocols increasingly advocating for laparoscopic approaches as part of opioid-sparing multimodal analgesia strategies [13]. The longer time to first analgesic request in LA patients (4.8 ± 1.6 hours versus 2.4 ± 1.2 hours, $p < 0.001$) indicates reduced immediate postoperative pain burden, likely reflecting decreased surgical trauma and improved pain control during the critical early recovery period. This parameter serves as an objective measure of pain intensity independent of patient pain reporting variability and complements VAS assessments.

Our finding of increased shoulder pain incidence in LA patients (24.1% versus 3.4%, $p = 0.001$) is consistent with pneumoperitoneum-related referred pain, a well-recognized phenomenon in laparoscopic surgery [7]. However, this shoulder pain was generally mild (VAS 2-4), self-limiting, and did not significantly affect overall pain scores or patient satisfaction. Strategies to minimize this complication include complete deflation of pneumoperitoneum, positioning maneuvers, and pulmonary recruitment at procedure completion.

The significantly shorter hospital stay with LA (2.1 ± 0.8 versus 3.4 ± 1.2 days, $p < 0.001$) reflects multiple factors including reduced pain, earlier mobilization, faster return of bowel function, and decreased need for parenteral analgesia. These findings are consistent with systematic reviews demonstrating approximately 1-day reduction in hospital stay with laparoscopic appendectomy [8]. Shorter hospitalization has important economic implications, reducing healthcare costs despite higher operative expenses associated with laparoscopic equipment and potentially longer operative times, as observed in our study (58.4 ± 16.8 versus 42.6 ± 12.4 minutes, $p < 0.001$).

The accelerated return to normal activities and work in the LA group (8.6 ± 2.4 versus 14.2 ± 3.6 days for normal activities, $p < 0.001$) represents a substantial functional advantage with significant socioeconomic impact. This nearly 6-day difference translates to reduced productivity loss, earlier return to work, and improved quality of life. These patient-centered outcomes are increasingly recognized as critical endpoints in surgical outcome assessment beyond traditional clinical metrics [14].

Higher patient satisfaction in the LA group (8.4 ± 1.2 versus 7.2 ± 1.4, $p < 0.001$) likely reflects the cumulative benefits of reduced pain, faster recovery, superior cosmetic outcomes (8.6 ± 1.2 versus 6.8 ± 1.6, $p < 0.001$), and smaller scars. In the era of patient-centered care and value-based medicine, such satisfaction metrics are important quality indicators influencing healthcare decision-making and resource allocation.

The comparable complication rates between approaches (8.6% versus 10.3%, $p = 0.749$) confirm the safety profile of laparoscopic appendectomy in experienced hands. While some early studies raised concerns about increased intra-abdominal abscess rates with laparoscopic approach [9], our findings and recent large series demonstrate equivalent safety profiles when appropriate surgical techniques are employed, including specimen retrieval in endobags to prevent wound contamination [15].

Several limitations of this study warrant consideration. First, the study was conducted at a single tertiary center with experienced laparoscopic surgeons, which may limit generalizability to settings with less expertise or resources. Second, the learning curve for laparoscopic appendectomy was not evaluated, and outcomes might differ in less experienced hands. Third, cost-effectiveness analysis was not performed, though reduced hospital stay suggests potential economic advantages. Fourth, long-term outcomes including incisional hernia rates and chronic pain were not assessed in this study with 4-week follow-up. Finally, complete blinding was not feasible due to obvious surgical differences, potentially introducing assessment bias, though we employed blinded outcome assessors for the first 24 hours.

Future research should evaluate the comparative cost-effectiveness of both approaches, assess long-term outcomes including chronic pain and incisional hernias, and investigate factors predicting which patients benefit most from laparoscopic approach. Additionally, standardization of surgical techniques and pain management protocols across multiple centers would enhance evidence quality and applicability.

Conclusion

This prospective randomized study demonstrates that laparoscopic appendectomy provides significant advantages over open appendectomy in acute uncomplicated appendicitis, characterized by reduced postoperative pain across all time points, substantially lower analgesic consumption including decreased opioid requirements, shorter hospital stay, and accelerated functional recovery with earlier return to normal activities.

Complication rates were comparable between approaches, confirming the safety of laparoscopic technique. Patient satisfaction and cosmetic outcomes were superior with the laparoscopic approach. These findings support the preferential use of laparoscopic appendectomy as the standard of care for acute uncomplicated appendicitis when surgical expertise and resources are available. The reduced pain burden and opioid consumption align with contemporary enhanced recovery protocols and opioid-sparing initiatives. Surgeons should consider laparoscopic appendectomy as first-line treatment for suitable candidates, with appropriate patient selection and surgical expertise ensuring optimal outcomes. The benefits extend beyond clinical parameters to encompass important patient-centered outcomes including satisfaction, cosmesis, and quality of life, supporting value-based surgical care delivery.

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