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Original Research Article

Incidence of Wound Infections in Laparoscopic Versus Open Surgery for Perforated Appendix

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Conflict of interest: Nil

Abstract

Background: Perforated appendicitis is associated with a high risk of postoperative wound infection and morbidity. The optimal surgical approach, laparoscopic versus open appendectomy, remains debated in complicated cases.

Aim: To compare the incidence and severity of postoperative wound infections and overall outcomes between laparoscopic and open appendectomy in patients with perforated appendix.

Materials and Methods: The present comparative study included 200 adult patients (18–60 years) with perforated appendicitis, divided equally into laparoscopic (n = 100) and open appendectomy (n = 100) groups. Demographic variables, co-morbidities, postoperative wound infections, complications, and hospital stay were analyzed. Regression and ROC curve analyses were performed to identify predictors of postoperative complications.

Results: The incidence of wound infection was significantly lower in the laparoscopic group compared to the open group (10% vs 25%, $p < 0.01$). Moderate-to-severe wound infections and overall postoperative complications were more frequent following open appendectomy (44% vs 20%). The mean hospital stay was shorter in the laparoscopic group (4.5 ± 1.5 days) compared to the open group (6.5 ± 2.0 days). Multivariate regression identified open appendectomy as an independent predictor of postoperative complications. ROC analysis showed higher predictive accuracy of disease severity and hospital stay for complications in the open surgery group.

Conclusion: Laparoscopic appendectomy significantly reduces wound infection rates, postoperative complications, and hospital stay in perforated appendicitis, supporting its use as the preferred surgical approach when expertise is available.

Keywords: Perforated Appendicitis, Laparoscopic Appendectomy, Open Appendectomy, Wound Infection, Surgical Site Infection.

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Introduction

Acute appendicitis is the most common surgical emergency worldwide, with an estimated lifetime risk of approximately 7–8% in the general population [1]. The condition can progress from simple inflammation to perforated appendicitis, particularly when diagnosis or surgical intervention is delayed, leading to peritonitis and increased postoperative complications [2].

Perforation occurs in up to 30% of patients presenting with appendicitis and carries a substantially higher risk of surgical site infections (SSI) and other morbidities compared with uncomplicated appendicitis [3]. Post-operative wound infections are among the most common and clinically significant complications following appendectomy, particularly in perforated appendicitis. A surgical site infection (SSI) is defined as an infection that occurs at or near the surgical incision within 30 days of the procedure. It can involve superficial tissues (skin and subcutaneous tissue), deeper soft tissues (fascia and muscle), or even organ/space structures such as the peritoneal cavity [4-8].

The risk of SSI increases dramatically in complicated appendicitis such as gangrenous or perforated cases, compared with uncomplicated

appendicitis. In uncomplicated disease, wound infection rates are relatively low; however, in perforated appendicitis, they range from about 9% up to 34% in some series due to fecal contamination and a high bacterial load [9-13]. This elevated incidence is consistent with the classification of perforated appendicitis as a "dirty-infected" surgical field, in which the risk of infection is inherently high because bacteria are present in the operative site even before closure [4,14-16].

Surgical site infections after appendectomy not only increase patient morbidity but also prolong hospital stays, delay wound healing, and raise healthcare costs.[15] Deep or organ/space infections may lead to additional complications such as abscess formation and systemic sepsis if not promptly diagnosed and treated [17].

Multiple factors influence the occurrence of postoperative wound infections. Patient-related factors include advanced age, poorly controlled diabetes, obesity, smoking, and immunosuppression, all of which impair immune response and wound healing [18]. Procedure-related factors include the extent of contamination (clean-contaminated vs contaminated vs dirty), duration of surgery, adequacy and timing of antibiotic prophylaxis, and the operative approach (open vs laparoscopic) [4,6, 19-22]

Surgical site infections (SSI) remain one of the most common and clinically important postoperative complications following appendectomy, particularly in complicated cases such as perforated appendicitis. SSI includes superficial incisional infections, deep incisional infections, and organ/space infections (such as intra-abdominal abscesses) occurring within 30 days after surgery [23]. The overall incidence of SSI after appendectomy varies widely in the literature, from 0% up to 37.4%, reflecting differences in patient populations, levels of contamination, and surgical techniques employed [24]. In large systematic reviews of more than 700,000 patients across multiple countries, the average global SSI rate after appendectomy was approximately 7.0%, with significantly higher rates observed in settings with open surgery and complicated appendicitis [25].

Wound infection rates are strongly influenced by the degree of appendiceal inflammation. In uncomplicated appendicitis, SSI rates are relatively low (<5%), but in perforated appendicitis, the risk increases substantially due to heavy bacterial contamination of tissue and wound edges. For example, clinical observational studies have reported wound infection rates as high as 34% in perforated cases. Similarly, it has been observed that SSI is the most common postoperative morbidity, contributing to prolonged hospital stays, increased need for antibiotics, delayed return to work, and elevated healthcare costs [26-28].

Surgical approach plays a key role in the incidence of postoperative wound infections. Laparoscopic appendectomy (LA) has gained widespread adoption over the last two to three decades due to its minimally invasive nature, smaller incisions, and theoretically reduced exposure of tissues to contamination. Multiple randomized and observational studies have demonstrated that LA is associated with lower incisional SSI rates compared with open appendectomy (OA). A meta-analysis of randomized controlled trials showed a significantly lower incidence of wound infection with LA [29]. Large retrospective cohort studies also corroborate these findings, reporting lower incisional SSI rates with LA compared to OA (e.g., LA 1.9% vs OA 4.2% in a multicenter Chinese cohort). [30].

Published comparative data specifically in complicated or perforated appendicitis also support the advantage of laparoscopic techniques. A retrospective analysis found that postoperative wound infections occurred significantly more often in patients undergoing OA than those managed laparoscopically in complicated appendicitis [6]. Another prospective cohort study documented that the SSI rate following laparoscopy was markedly lower than open surgery (e.g., 10.77% vs 27.69%). Additional regional data from retrospective surgical audits show consistent trends of higher SSI incidence in OA compared to LA across diverse populations [9,11, 22, 27].

Despite some historical concerns about potential risks such as intra-abdominal abscess formation with LA, modern evidence suggests that these complications are not higher than with OA and that LA often achieves comparable or better overall postoperative outcomes when performed by experienced surgeons [29].

Given the potential impact of the surgical approach on SSI, especially in perforated appendicitis, it is imperative to evaluate and quantify differences in wound infection incidence between LA and OA in a well-defined population. For example, inadequate or delayed antibiotic prophylaxis and late presentation of perforated appendicitis are strongly associated with increased SSI risk [22]. Additionally, open appendectomy in contaminated fields (such as perforated appendicitis) exposes a larger wound surface area and is generally associated with higher wound infection rates, sometimes reported up to around 13–23% in older clinical series [9]. Conversely, the laparoscopic approach, with smaller incisions and reduced tissue exposure, has been associated with reduced

incisional SSI in several cohorts and meta-analyses [17].

Understanding these infection patterns and risk factors is crucial for optimizing surgical outcomes.

Preventive strategies recommended by guidelines include proper perioperative antibiotic administration (covering both aerobic and anaerobic organisms), meticulous aseptic surgical technique, careful wound handling and closure, and, when feasible, the adoption of minimally invasive approaches such as laparoscopy to reduce wound contamination [27].

These insights underline the need to specifically evaluate wound infection outcomes in perforated appendicitis when comparing laparoscopic versus open surgical approaches, the focus of the present study.

Hence, this study was undertaken to compare the incidence and severity of wound infections, overall postoperative complications, and hospital stay between laparoscopic and open appendectomy in adults with perforated appendicitis.

Aim: Compared the incidence of postoperative wound infections in laparoscopic versus open appendectomy for perforated appendicitis.

Objectives

- Determined and compared wound infection rates in laparoscopic and open appendectomy.
- Compared overall postoperative complications between the two surgical approaches.
- Assessed the severity of wound infections in both groups, and evaluated the length of hospital stay.
- Identified independent risk factors for postoperative complications using regression analysis.

Materials and Methods

Study Site: This study was conducted at Department Of General Surgery, Dr. Kns Memorial Institute of Medical Sciences, Gadia, Barabanki, Up, India, between January 2024 to November 2025. The study was approved by the Institutional Human Ethics Committee, and written informed consent was also obtained from all participants.

Study Design: Prospective observational study.

Study Subjects: Conducted on 200 adult patients of rural Barabanki District, UP, with perforated appendicitis undergone appendectomy.

Study Group: Patients were randomly allocated into two groups based on the surgical approach: Group A (LAP): Laparoscopic appendectomy (n = 100). Group B (Open): Open appendectomy (n = 100) .Both sexes and all adult age groups (18–30, 31–40, 41–50, and 51–60 years) were included.

Sample Size: 200 patients.

Formula and calculation:

$$n = \frac{(1.96 + 0.84)^2 \, [0.10(1 - 0.10) + 0.25(1 - 0.25)]}{(0.10 - 0.25)^2}$$

1. Sum Z values: $1.96 + 0.84 = 2.8$
2. Square the sum: $2.8^2 = 7.84$
3. Variances:
   - $0.10 \times 0.90 = 0.09$
   - $0.25 \times 0.75 = 0.1875$
   - Sum: $0.09 + 0.1875 = 0.2775$
4. Multiply by 7.84: $7.84 \times 0.2775 \approx 2.1756$
5. Difference in proportions squared: $(0.10 - 0.25)^2 = (-0.15)^2 = 0.0225$
6. Divide: $2.1756/0.0225 \approx 96.7$

*Calculated required sample size ≈ 97 patients per group to detect the expected difference with 80% power and 95% confidence.

With 100 patients per group (total 200 patients), the study is adequately powered.

Inclusion Criteria:

- Adults (18–60 years) diagnosed with perforated appendicitis
- Informed consent obtained

Exclusion Criteria:

- Patients with immunocompromised states (HIV, chronic steroid therapy)
- Patients with previous abdominal surgeries
- Pregnant women
- Patients with severe co-morbidities precluding surgery

Surgical Procedure

- **Group A:** Laparoscopic appendectomy performed under general anesthesia using standard 3-port technique.
- **Group B:** Open appendectomy performed via a right lower quadrant (gridiron) incision under general anesthesia.

Postoperative Care

- Standardized perioperative antibiotics administered.
- Wound care performed according to institutional protocols.

- Patients monitored for signs of wound infection for 30 days postoperatively.

Outcome Measure

- **Primary Outcome:** Incidence of postoperative wound infection (superficial, deep, or organ/space) within 30 days.
- **Secondary Outcomes:** Length of hospital stay, postoperative complications, influence of age and sex on wound infection.

Statistical Analysis

Data Collection and Analysis: Data recorded on demographic variables, surgical approach, age, sex, and wound infection occurrence.

Statistical analysis performed using Chi-square test for categorical variables. SPSS-26.3 was also used for statistical analysis.

Multivariate logistic regression was used to identify independent predictors of overall outcomes, complications and severity. $p < 0.05$, considered significant.

Results

A total of 200 patients with perforated appendicitis were included in the study, with 100 patients in the laparoscopic appendectomy (LA) group and 100 patients in the open appendectomy (OA) group.

The two groups were comparable with respect to baseline demographic characteristics, co-morbidities, type and location of perforation.

Table 1: Demographic Characteristics of the Study Population

Variable	LA (n = 100)	OA (n = 100)	P value
Male	40 (40.0%)	42 (42.0%)	0.77
Female	60 (60.0%)	58 (58.0%)	0.77
Age (mean ± SD, years)	38.6 ± 11.2	39.1 ± 10.9	0.72

Both groups were demographically comparable, with no statistically significant differences in age or sex distribution.

Table-1A: Age wise demographic distribution of study subjects in two groups

Variable	LA (n=100)	OA (n=100)	P value
Male	40	42	0.77
Female	60	58	0.77
Age 18–30	30	28	0.66
Age 31–40	25	27	0.68
Age 41–50	25	25	0.00
Age 51–60	20	20	0.00

Table 2: Distribution of Co-morbid Diseases in the Study Groups

Comorbid Disease	LA (n = 100)	OA (n = 100)	P value
Hypertension	14 (14.0%)	18 (18.0%)	0.43
Diabetes Mellitus	12 (12.0%)	16 (16.0%)	0.41
Coronary artery disease	5 (5.0%)	7 (7.0%)	0.55
COPD	4 (4.0%)	6 (6.0%)	0.52
Chronic kidney disease	3 (3.0%)	4 (4.0%)	0.70
Hypothyroidism	6 (6.0%)	8 (8.0%)	0.58
Bronchial asthma	5 (5.0%)	6 (6.0%)	0.76
Others co-morbidity	30 (30.0%)	38 (38.0%)	0.21

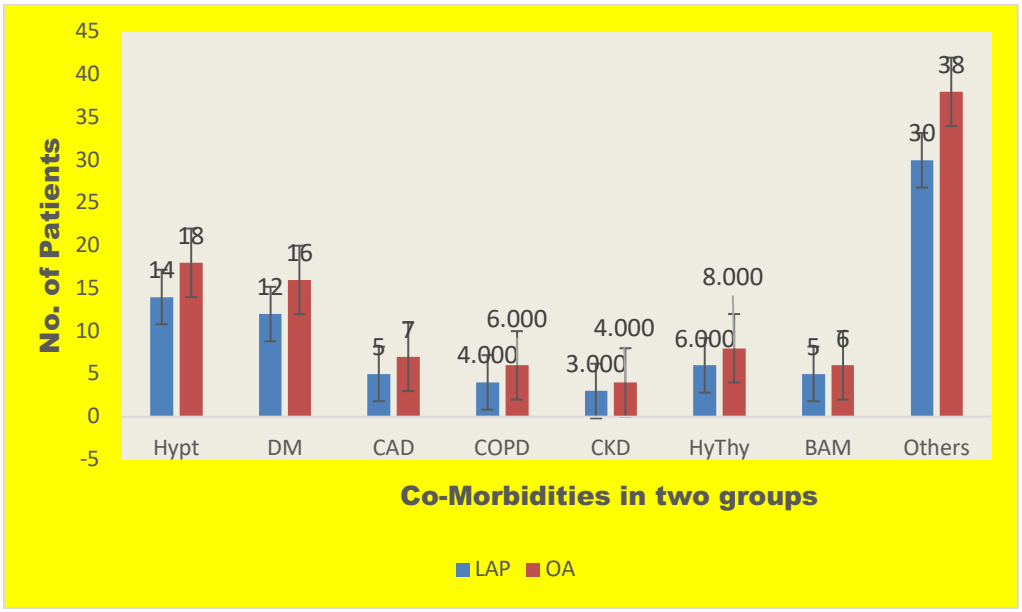

Figure 1: Distribution of Co-morbid Diseases in the Study Groups

The prevalence of co-morbid conditions was similar between the two groups, with no statistically significant differences, indicating good baseline comparability.

Table 3: Location of the Perforated Appendix

Location	LA (%)	OA (%)	P value
Retrocecal	35	38	0.65
Pelvic	22	20	0.72
Subcecal	15	14	0.84
Pre-ileal	10	9	0.81
Post-ileal	8	7	0.79
Paracecal	6	8	0.58
Paracolic	4	4	1.00

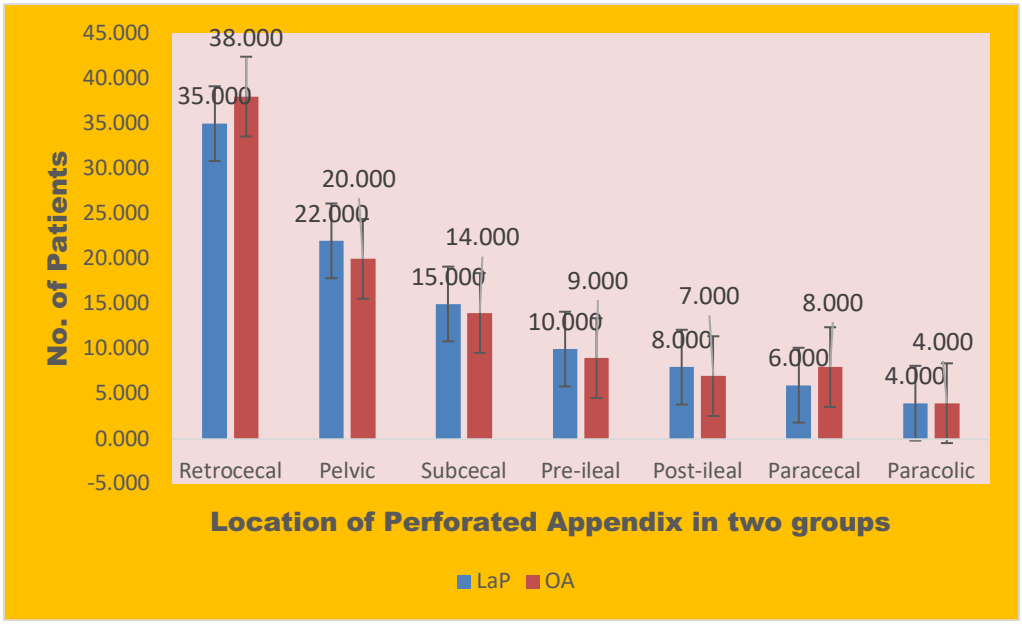

Figure 2: Location of the Perforated Appendix

Retrocecal appendix was the most common location in both groups. No significant difference in anatomical location was observed.

Table 4: Distribution of Complicated Appendix by Severity

Severity	LA (%)	OA (%)	P value
Localized perforation	28	30	0.75
Perforation with localized peritonitis	32	34	0.76
Perforation with generalized peritonitis	25	27	0.74
Appendicular mass with perforation	10	7	0.45
Gangrenous perforation	5	2	0.25

The severity of perforated appendicitis was comparable in both groups, confirming similar disease burden.

Table 5: Postoperative Outcomes and Complications

Outcome	LA (n = 100)	OA (n = 100)	P value
Wound infection	10 (10.0%)	25 (25.0%)	<0.01
Intra-abdominal abscess	4 (4.0%)	6 (6.0%)	0.52
Postoperative ileus	2 (2.0%)	5 (5.0%)	0.28
Fever / minor infection	3 (3.0%)	6 (6.0%)	0.31
Total complications	20 (20.0%)	44 (44.0%)	<0.001
Mean hospital stay (days)	4.5 ± 1.5	6.5 ± 2.0	<0.01

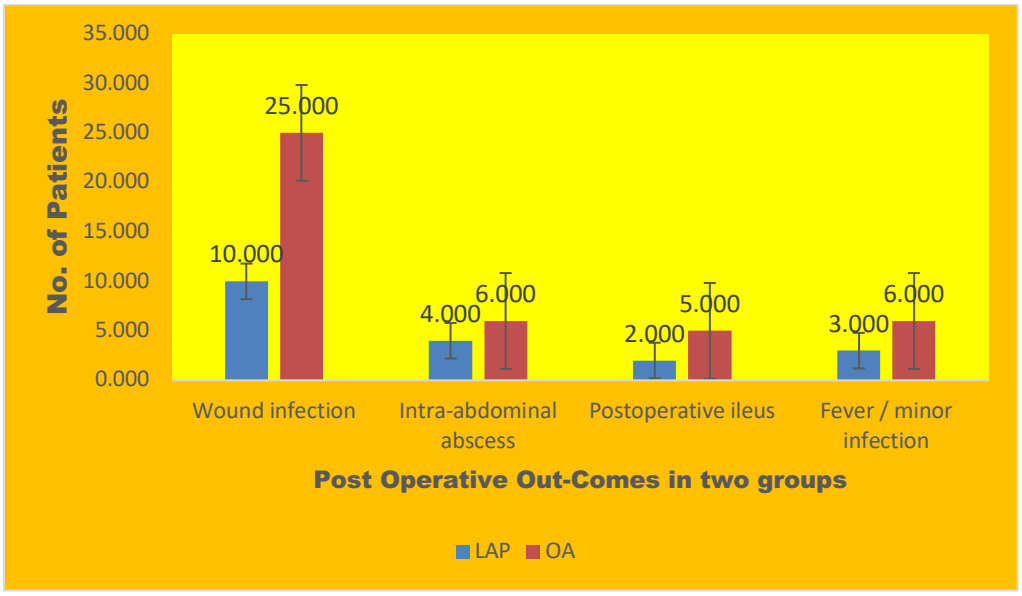

Figure 3: Postoperative Outcomes and Complications

Wound infection and overall postoperative complications were significantly lower in the laparoscopic group. Hospital stay was significantly shorter following laparoscopic appendectomy.

Table 6: Severity of Wound Infection

Severity	LA (%)	OA (%)
Mild	6	10
Moderate	3	10
Severe	1	5

Open appendectomy was associated with higher rates of moderate and severe wound infections compared to laparoscopic surgery.

Table 7: Post-Operative Wound-Related Management

Management Parameter	LA (%)	OA (%)	P value
Extended antibiotics (>5 days)	30	45	0.03
Wound drainage required	3	10	0.04
Re-suturing required	1	7	0.03
ICU admission	0	4	0.04

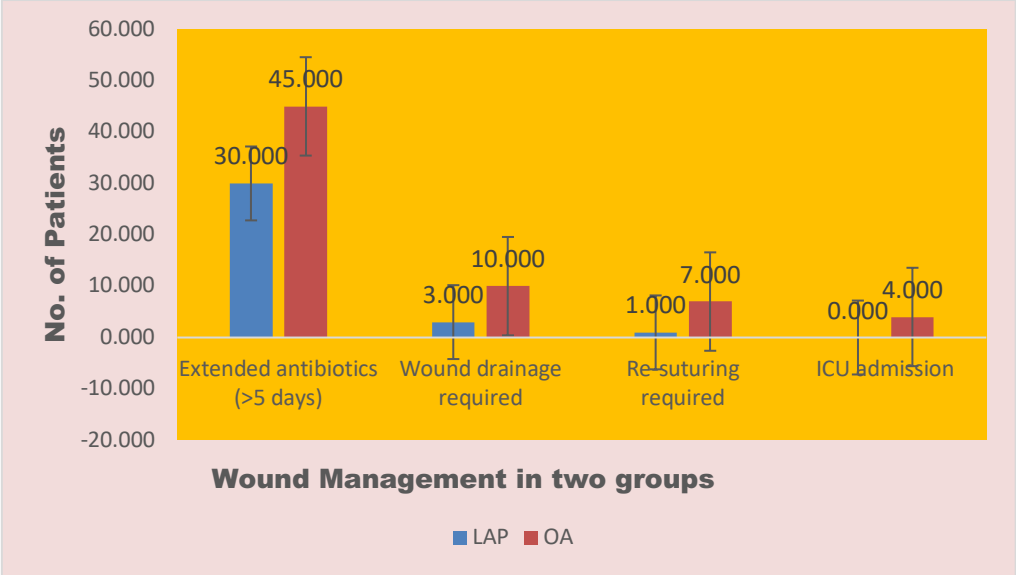

Figure 4: Post-Operative Wound-Related Management

Patients undergoing open appendectomy required significantly more intensive postoperative wound management.

Table 8: Logistic Regression Analysis for Postoperative Complications

Variable	Adjusted OR	95% CI	P value
Open surgery (vs laparoscopic)	3.05	1.65–5.63	<0.001
Presence of co-morbidities	1.85	1.05–3.28	0.03
Age	1.05	0.87–1.26	0.62
Male sex	1.20	0.66–2.17	0.54

Open appendectomy was an independent predictor of postoperative complications, while age and sex were not significant risk factors.

Table 9: Combined ROC Curve Analysis

Predictor Variable	Outcome	AUC (LA)	AUC (OA)	Interpretation
Severity of appendicitis	Wound infection	0.71	0.78	Fair–Good
Hospital stay	Wound infection	0.76	0.83	Good–Very good
Severity of wound infection	Overall complications	0.81	0.89	Very good–Excellent

Predictive accuracy for postoperative complications was consistently higher in the open surgery group, indicating greater morbidity associated with open appendectomy.

Laparoscopic appendectomy demonstrated significantly lower wound infection rates, fewer overall complications, reduced severity of infections, and shorter hospital stay compared to open appendectomy, despite comparable disease severity and patient characteristics.

Discussion

Perforated appendicitis represents a complex surgical condition associated with substantial postoperative morbidity. Surgical site infection (SSI) remains the most frequent complication and a major determinant of prolonged hospital stay and increased healthcare costs [3, 29, 30]. Although laparoscopic appendectomy has become the standard approach for uncomplicated appendicitis, its role in perforated appendicitis has been debated due to concerns regarding technical difficulty, risk of intra-abdominal abscess, and longer operative time [31,33]. The present study was conducted to evaluate the incidence, severity, and predictors of wound infection following laparoscopic versus open appendectomy in adult patients with perforated appendicitis.

In the present study, it was observed that the wound infection occurred in 10% of patients undergoing laparoscopic appendectomy compared to 25% in those undergoing open appendectomy, a statistically significant difference. This finding was consistent with multiple meta-analyses and randomized controlled trials demonstrating reduced SSI rates with laparoscopic surgery in complicated appendicitis [6,7,30,32]. A study reported significantly lower wound infection rates following laparoscopic appendectomy compared to open surgery, attributing this advantage to smaller incisions and reduced wound contamination [34]. Similarly, another study in a Cochrane review,

confirmed that laparoscopic appendectomy results in fewer wound infections, even in perforated cases [1]. The wound infection rate observed in the present laparoscopic group closely parallels the 8–12% reported in these studies [1, 34, 35].

Conversely, studies reporting higher wound infection rates following open appendectomy (ranging from 20% to 40%) support our findings in the open surgery group [4,5,32, 36]. Larger incisions, increased tissue trauma, and direct exposure of the surgical wound to infected peritoneal contents likely contribute to this increased risk.

Beyond incidence, the present study advocated that moderate-to-severe wound infections were predominantly observed in the open appendectomy group. Severe wound infections often necessitate wound drainage, re-suturing, prolonged antibiotic therapy, and occasionally ICU admission, all of which were more common in the open group.

A study, similarly reported that laparoscopic appendectomy not only reduced wound infection rates but also decreased the severity of postoperative wound complications [37]. In contrast, some earlier studies suggested no difference in infection severity between laparoscopic and open surgery; however, these studies often included heterogeneous patient populations or smaller sample sizes [38].

Overall postoperative complications were significantly higher in the open appendectomy group (44%) compared to the laparoscopic group (20%). This difference reflected the cumulative burden of wound infection, postoperative ileus, fever, and intra-abdominal abscess.

A previous similar study emphasized that the postoperative morbidity in perforated appendicitis is strongly associated with the extent of surgical trauma and contamination, factors minimized by laparoscopic techniques [40]. Similar reductions in postoperative complications with laparoscopic appendectomy have also been reported by other studies [17,39].

However, some studies have reported comparable complication rates between laparoscopic and open surgery in perforated appendicitis [24,25]. These dissimilar findings may be related to surgeon experience, patient selection, or variations in perioperative antibiotic protocols. Advances in laparoscopic expertise and instrumentation in recent years likely explain the improved outcomes observed in more contemporary studies, including the present one. Hospital stay was significantly shorter in the laparoscopic group (4.5 ± 1.5 days) compared to the open group (6.5 ± 2.0 days). This finding is consistent with most published literature [26–29]. Reduced postoperative pain, fewer wound complications, earlier ambulation, and faster return of bowel function are recognized benefits of minimally invasive surgery.

A previous study reported a reduction in hospital stay of approximately two days in patients undergoing laparoscopic appendectomy for complicated appendicitis [41]. In contrast, earlier studies that failed to demonstrate a difference in hospital stay were often conducted during the early adoption phase of laparoscopy, when operative times were longer and postoperative protocols less standardized [35,42].

In the present study, the severity and anatomical location of the perforated appendix were comparable between the two groups, eliminating disease severity as a confounding factor. Retrocecal and pelvic appendices were the most common locations, consistent with previous reports [43].

Several studies have suggested that severe disease, particularly generalized peritonitis and gangrenous perforation, was associated with increased postoperative complications [43-45]. Our ROC analysis supports this, demonstrating that severity of appendicitis is a significant predictor of wound infection, particularly in the open appendectomy group. Interestingly, the predictive value of disease severity was lower in the laparoscopic group, suggesting that laparoscopy mitigates the adverse impact of severe disease.

Co-morbidities such as diabetes mellitus and hypertension were evenly distributed between groups and were independently associated with increased postoperative complications. Previous studies have identified diabetes as a risk factor for SSI due to impaired wound healing and immune dysfunction [3,46]. However, even after adjusting for comorbidities, open appendectomy remained an independent predictor of postoperative complications in our regression analysis.

Multivariate logistic regression identified open appendectomy as an independent risk factor for postoperative complications (OR = 3.05). This finding aligns with prior studies that identified surgical approach as a key determinant of postoperative morbidity [26,38,47].

ROC curve analysis further demonstrated that hospital stay and severity of wound infection had higher predictive accuracy for adverse outcomes in the open surgery group. The higher AUC values in the open group reflect greater vulnerability to postoperative complications, whereas laparoscopic surgery appears to buffer the effects of severe disease and infection.

The present study adds to the growing evidence supporting laparoscopic appendectomy as the preferred approach in perforated appendicitis when

surgical expertise is available. Lower wound infection rates, reduced severity of complications, and shorter hospital stay translate into improved patient outcomes and reduced healthcare resource utilization.

Strengths and Limitations of the Study

Prospective comparative design with equal sample size in both laparoscopic and open appendectomy groups. Inclusion of only perforated appendicitis cases ensured a homogeneous and clinically relevant study population.

Comprehensive assessment of postoperative outcomes, including incidence and severity of wound infections, overall complications, hospital stay, and predictive analyses using regression and ROC curves. Comparable baseline characteristics and co-morbidities between groups minimized selection bias. Findings were consistent with contemporary published literature, enhancing external validity.

Single-center study, which may limit generalizability of the results to other settings. Operative time and cost analysis were not included, which could further inform comparative effectiveness. Long-term outcomes such as incisional hernia and quality of life were not assessed. Pediatric and elderly patients beyond 60 years were excluded, limiting applicability to these populations.

Conclusion

Laparoscopic appendectomy is associated with a significantly lower incidence and severity of postoperative wound infections compared to open appendectomy in patients with perforated appendicitis. It also results in fewer overall postoperative complications and a shorter hospital stay. Disease severity, hospital stay, and wound infection severity were important predictors of adverse outcomes, with open surgery emerging as an independent risk factor for postoperative morbidity. These findings support laparoscopic appendectomy as the preferred surgical approach for perforated appendicitis when adequate expertise and facilities are available.

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