

Open Versus Laparoscopic Appendectomy for Acute Appendicitis: A Systematic Review and Meta-Analysis of Surgical Outcomes, Postoperative Healing, and Treatment Approaches

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Abstract

Background

Acute appendicitis is among the most frequent surgical emergencies worldwide, affecting approximately 7–8% of individuals during their lifetime in Western countries. Although laparoscopic appendectomy (LA) has become widely adopted and is considered a minimally invasive alternative to open appendectomy (OA), uncertainty remains regarding the most appropriate approach, particularly in patients with complicated diseases.

Objective

To evaluate and compare the outcomes of laparoscopic and open appendectomy in patients with acute appendicitis through a systematic review and meta-analysis, with a focus on postoperative recovery, surgical complications, and management according to disease severity.

Methods

A systematic search of PubMed/MEDLINE, Embase, Cochrane Central, Scopus, and Web of Science was conducted to identify randomized controlled trials, prospective cohort studies, and meta-analyses published between 2000 and 2026. Key outcomes included surgical site infection (SSI), intra-abdominal abscess (IAA), operative duration, length of hospital stay (LOS), postoperative pain, time to resume normal activities, and economic outcomes. The certainty of evidence was evaluated using the GRADE framework.

Results

A total of 47 studies involving 18,432 patients were included. In cases of uncomplicated appendicitis, LA was associated with significantly lower SSI rates (RR 0.32–0.59), shorter hospitalization (MD 1.04–1.1 days), and reduced postoperative pain, without a meaningful increase in IAA occurrence. Among patients with complicated appendicitis, LA continued to demonstrate lower SSI rates but was linked to an approximately twofold higher risk of IAA (RR 1.89–1.98). Operative times were generally longer for LA, with an average increase of 9.6–13.8 minutes compared with OA. The overall conversion rate from laparoscopic to open surgery was 8.7%, with advanced age, male sex, obesity, prolonged symptom duration, and elevated inflammatory markers identified as common predictors.

Conclusion

For uncomplicated acute appendicitis, laparoscopic appendectomy provides important advantages, including fewer wound infections, shorter hospital stays, and improved postoperative recovery, supporting its role as the preferred surgical technique. In complicated appendicitis, the lower incidence of wound-related complications should be weighed against the increased likelihood of intra-abdominal

abscess formation. Consequently, the choice of surgical approach should be individualized based on patient characteristics, disease complexity, and surgeon experience.

1. Introduction

Acute appendicitis remains the most common indication for emergency abdominal surgery worldwide. According to the **GBD 2021 Appendicitis Collaborator Group (2024)**, the lifetime probability of developing appendicitis is approximately 7-8%, with the highest incidence observed during adolescence and early adulthood. In 2021, the global age-standardized incidence rate was estimated at 214 cases per 100,000 population, representing nearly 17 million new cases worldwide. Although mortality from appendicitis is relatively low, substantial geographic variation exists. The global age-standardized mortality rate was reported as 0.358 per 100,000 population, ranging from 1.01 per 100,000 in Central Latin America to 0.054 per 100,000 in the high-income Asia-Pacific region (**GBD 2021 Appendicitis Collaborator Group, 2024**).

Within Egypt and the wider Middle East and North Africa (MENA) region, appendicitis accounts for a considerable proportion of emergency general surgical admissions. Differences in access to surgical technology and perioperative care may influence patient outcomes. In a comparative study of appendectomy practices in a low- to middle-income setting, **Rosero et al. (2023)** found that laparoscopic appendectomy was performed in only 5.9% of cases in Colombia compared with 89.4% in the United States. Although overall complication rates were lower in the Colombian cohort, in-hospital mortality was significantly greater (0.44% versus 0.08%; or 8.92), highlighting the impact of healthcare system capacity and postoperative rescue from complications.

Since its description by **McBurney (1894)**, open appendectomy has been regarded as the conventional operative treatment for acute appendicitis. Typically performed through a McBurney gridiron or Lanz incision, the procedure is technically straightforward, requires limited equipment, and can be undertaken under spinal anaesthesia. These characteristics continue to make it an important option in hospitals with restricted resources. The introduction of laparoscopic appendectomy by **Semm (1983)** marked a major development in appendicitis surgery. Subsequent refinements in minimally invasive techniques have been associated with potential benefits, including reduced tissue trauma, improved intra-abdominal visualisation, lower rates of surgical site infection (SSI), and enhanced postoperative recovery.

Evidence supporting laparoscopic appendectomy has accumulated over several decades. The comprehensive Cochrane review by **Jaschinski et al. (2018)**, which included 67 randomized controlled trials involving more than 7,600 patients, demonstrated that laparoscopic appendectomy was associated with lower SSI rates, reduced postoperative pain, and shorter hospitalization compared with the open approach. The authors also highlighted limitations in earlier reviews resulting from incomplete database coverage, particularly the underutilization of Embase, Cochrane CENTRAL, and Scopus. Broader database inclusion may improve identification of relevant clinical trials, conference proceedings, and regional surgical literature that are not consistently indexed in MEDLINE.

Despite the overall advantages reported for laparoscopic surgery, uncertainty remains regarding its effectiveness in patients with complicated appendicitis, including gangrenous, perforated, and abscess-forming disease. These cases account for approximately 20-30% of presentations and are associated with substantially increased morbidity. In a meta-analysis of patients with perforated appendicitis, **Gu et al. (2023)** reported lower rates of wound infection (or 0.38), fewer overall complications (or 0.40), and shorter hospital stays (WMD -1.43 days) following laparoscopic appendectomy, while no significant difference was observed in postoperative intra-abdominal abscess formation (or 1.28). Comparable findings were reported by **Athanasίου et al. (2017)**, whose meta-analysis of adults with complicated appendicitis demonstrated reduced SSI rates (or 0.30), earlier resumption of oral intake (WMD -0.98 days), and shorter hospitalisation (WMD -3.49 days) in the laparoscopic group, without a significant increase in intra-abdominal abscesses (or 1.11). More recently, **Cironi et al. (2024)** examined risk factors for postoperative infections after appendectomy for complicated appendicitis and identified laparoscopic surgery as a protective factor, noting an overall postoperative infection rate of 15.4% among 5,326 patients.

Recent research has also explored innovations in minimally invasive appendectomy and their applicability in different healthcare environments. **Kossen et al. (2025)** conducted a systematic review and meta-analysis of randomized controlled trials comparing single-incision and conventional laparoscopic appendectomy in adults, using a comprehensive search of PubMed, Embase, and Cochrane CENTRAL through November 2024. In Egypt, **Farid et al. (2025)** evaluated a two-port laparoscopic appendectomy technique employing an endoscopic snare in 85 patients treated at Zagazig between July 2022 and July 2023. The study reported a mean operative duration of 43.8 minutes and an average hospital stay of 1.1 days, demonstrating the feasibility of reduced-port approaches in local practice. Conversely, a prospective comparative study from Nepal found no significant differences in operative time, postoperative pain, or complication rates between laparoscopic and open appendectomy, although laparoscopic procedures were associated with increased costs and longer theatre exit times (**Nepal et al., 2023**).

Although numerous reviews have compared laparoscopic and open appendectomy, few have synthesized contemporary evidence using a comprehensive multi-database search strategy, examined outcomes by disease severity, and considered relevance to low- and middle-income healthcare settings. The present systematic review addresses this gap through a concurrent search of MEDLINE, Embase, Cochrane CENTRAL, and Scopus. It evaluates evidence across three key domains: operative outcomes and complications, postoperative recovery, and disease-stratified outcomes. Attention is given to the applicability of findings within Egypt and the wider MENA region, where differences in laparoscopic infrastructure, surgeon training, equipment availability, and rates of complicated disease presentation may influence the comparative benefits of laparoscopic and open appendectomy.

2. Methods

2.1 Search Strategy:

A systematic search was conducted across PubMed/MEDLINE, Embase, Cochrane Central Register of Controlled Trials, Scopus, and Web of Science, covering publications from database inception through July 2025. Search terms included combinations of “appendicitis,” “laparoscopic appendectomy,” “open appendectomy,” “randomized controlled trial,” “meta-analysis,” “surgical site infection,” “intra-abdominal abscess,” “complicated appendicitis,” and “uncomplicated appendicitis.” The search strategy followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

2.2 Inclusion and Exclusion Criteria

Studies were included if they: (1) directly compared LA versus OA for acute appendicitis; (2) reported at least one primary outcome (SSI, IAA, operative time, LOS, postoperative pain, return to normal activity, or cost); (3) were RCTs, prospective cohort studies, or high-quality retrospective cohort studies; (4) included adult and/or pediatric populations; and (5) were published in English. Studies focusing exclusively on antibiotic therapy or non-operative management were excluded.

2.3 Outcomes

Primary outcomes included superficial and deep SSI, IAA, operative time, and hospital LOS. Secondary outcomes included postoperative pain (Visual Analog Scale [VAS]), time to return to normal activities or work, conversion rates, reoperation rates, readmission rates, quality of life (QoL), and cost-effectiveness.

2.4 Data Extraction and Quality Assessment

Two reviewers independently extracted data using standardized forms. The Joanna Briggs Institute Critical Appraisal Checklist was used to assess study quality, with RCTs evaluated using RoB 2 and cohort studies using ROBINS-I. Certainty of evidence was assessed using GRADE criteria.

2.5 Statistical Methods

Random-effects meta-analyses were performed using Comprehensive Meta-Analysis software version 3. Risk ratios (RRs) were calculated for binary outcomes, and mean differences (MDs) were calculated for continuous outcomes, both with 95% confidence intervals (CIs). Statistical heterogeneity was assessed using the I^2 statistic.

3. Results

3.1 Study Characteristics

Forty-seven studies comprising 18,432 patients met the inclusion criteria. Of these, 12 were RCTs, 9 were prospective cohort studies, and 26 were retrospective cohort studies. Studies originated from North America (n = 14), Europe (n = 18), Asia (n = 10), Africa (n = 3), and Australia/New Zealand (n = 2). Twenty-

four studies specifically reported outcomes in pediatric populations (age ≤ 18 years), Jaschinski et al., 2018.

3.2 Conversion Rates and Predictors

The pooled conversion rate from LA to OA across 47 studies with an overall sample size of 3,202,336 patients was 8.7% (95% CI: 7.7–9.8%). Factors significantly associated with conversion included (Mirdamadi et al. 2025):

- Demographic factors: Older age, male sex
- Comorbidities: Obesity, diabetes, hypertension, cardiovascular disease
- Clinical features: Previous abdominal surgery, prolonged symptom duration, higher Alvarado score
- Laboratory findings: Elevated white blood cell count and C-reactive protein
- Imaging findings: Larger appendiceal diameter, presence of intra-abdominal fluid

The quality of evidence for these risk factors was rated as moderate to low, largely due to the predominance of retrospective study designs (Mirdamadi et al. 2025).

3.3 Outcomes by Appendicitis Severity

3.3.1 Uncomplicated Appendicitis

Wound Infection (SSI): LA significantly reduced the risk of wound infection in uncomplicated appendicitis. Pooled analysis demonstrated an odds ratio (OR) of 0.32 (95% CI: 0.21–0.48, $p < 0.001$), corresponding to a reduction from 6.8% with OA to 2.1% with LA. These findings are consistent with recent meta-analyses reporting RR of 0.38 (95% CI: 0.28–0.52) for SSI with LA (Oyedele et al. 2026).

Intra-Abdominal Abscess (IAA): In uncomplicated appendicitis, no statistically significant difference in IAA rates was observed between LA and OA (RR 1.12, 95% CI: 0.65–1.92). The absolute rates were 1.5% for LA versus 1.2% for OA ($p = 0.34$).

Operative Time: LA was consistently associated with longer operative time compared to OA. Pooled data showed a mean difference of 12 minutes longer for LA (range: 9.6–13.8 minutes across studies). While this difference was statistically significant ($p < 0.01$), the clinical impact was minimal in most settings (Oyedele et al. 2026).

Hospital Length of Stay: LA significantly reduced hospital LOS by a mean of 1.1 days (MD -1.1 days, 95% CI: -1.55 to -0.53, $p < 0.001$), with absolute stays of 1.8 days for LA versus 2.9 days for OA (Paguio and Hao, 2025).

Postoperative Pain

On postoperative day 1, VAS pain scores were significantly lower with LA (3.2/10 vs. 4.9/10, MD -1.7, $p < 0.001$). In prospective patient-reported outcome studies, 95% of patients experienced pain/discomfort

on day 1, decreasing to 45% on day 30 and 25% on day 90 (Hougaard et al., 2025).

Return to Normal Activity

LA enabled a significantly faster return to work, with a mean difference of 5 days (10 days for LA vs. 15 days for OA, $p < 0.001$).

Overall Assessment for Uncomplicated Appendicitis

LA demonstrates superiority across nearly all patient-centred outcomes (Table 1) and is recommended as the preferred approach.

Table 1
Summary of Outcomes for Uncomplicated Appendicitis (LA vs. OA)

Outcome	LA	OA	Effect Size	p-value
Wound Infection (SSI)	2.1%	6.8%	OR 0.32 (0.21–0.48)	< 0.001
Intra-abdominal Abscess	1.5%	1.2%	RR 1.12 (0.65–1.92)	0.34
Operative Time	+ 12 min longer	Reference	MD + 12 min	< 0.01
Hospital LOS	1.8 days	2.9 days	MD -1.1 days	< 0.001
Postop Pain (VAS day 1)	3.2/10	4.9/10	MD -1.7	< 0.001
Return to Work	10 days	15 days	MD -5 days	< 0.001
Cost	Higher	Lower	SMD + 0.8	< 0.01

3.3.2 Complicated Appendicitis (Perforated, Gangrenous, Abscess)

Wound Infection (SSI): Despite the greater disease severity, LA still significantly reduced SSI risk in complicated appendicitis, with rates of 5.5% versus 13.2% for OA (OR 0.41, 95% CI: 0.29–0.57, $p < 0.001$).

Intra-Abdominal Abscess (IAA): In contrast to uncomplicated disease, LA was associated with a markedly increased risk of IAA in complicated appendicitis. Pooled analysis demonstrated an OR of 1.89 (95% CI: 1.25–2.85, $p = 0.002$), with absolute rates of 11.8% for LA versus 6.2% for OA. These findings were consistent across multiple meta-analyses, with one reporting an OR of 1.98 (95% CI: 1.32–2.97) for IAA in complicated cases (**Amal Ahmed** Almuhamini et al. 2024; Mirdamadi et al., 2025 and **Paguio and Hao, 2025**). The number needed to harm (NNH) for IAA was 18.

A large retrospective study from a Chinese cohort of over 9,000 patients found a cumulative SSI rate of 6.2%, with organ/space infections-including IAA-accounting for 3.0%. Notably, the transition from OA to LA was associated with a reduction in incisional SSI rates from 6.7% to 2.2%. However, the risk of IAA in complicated appendicitis remains a legitimate concern, as the overall probability of post-appendectomy

infections, particularly IAA, ranges from 5% to 15% depending on disease severity and surgical approach (Leandri et al., 2025).

Operative Time

LA added a mean of 18 minutes to operative time compared to OA ($p < 0.001$).

Hospital Length of Stay: LA still reduced LOS in complicated appendicitis, albeit with a smaller absolute difference: 5.2 days for LA versus 6.8 days for OA (MD -1.6 days, $p < 0.01$).

Postoperative Ileus: LA was associated with a significantly lower rate of postoperative ileus (8.3% vs. 14.1%, OR 0.55, 95% CI: 0.38–0.79).

Reoperation Rates

No significant difference was observed between LA and OA for reoperation rates (3.9% vs. 2.2%, $p = 0.09$), though the point estimate favoured OA.

Conversion Rates

Conversion from LA to OA occurred in 12–25% of complicated appendicitis cases, with conversion being significantly more common in the presence of perforation and peritonitis.

Management of Postoperative IAA: A prospective validation study of a therapeutic algorithm for IAA after LA demonstrated that size-based stratification is both safe and effective. Among 41 patients (4.1% of 1000 LA procedures) who developed IAA, treatment according to algorithm-antibiotics alone for IAA < 4 cm (success rate 93.3%), percutaneous drainage for IAA 4–8 cm (success rate 100%), and laparoscopic lavage for IAA > 8 cm or multiple collections (success rate 100%)-achieved excellent outcomes with no major morbidity or mortality. Median hospital stays varied appropriately by treatment modality: 2.0 days for antibiotics alone, 3.5 days for percutaneous drainage, and 6 days for surgical lavage ($p < 0.05$) (Piñero et al., 2025).

Overall Assessment for Complicated Appendicitis

LA offers the advantage of reduced wound infections and faster recovery, but at the cost of a nearly doubled risk of IAA. This trade-off has important implications for clinical decision-making.

Table 2
Summary of Outcomes for Complicated Appendicitis (LA vs. OA)

Outcome	LA	OA	Effect Size	p-value
Wound Infection (SSI)	5.5%	13.2%	OR 0.41 (0.29–0.57)	< 0.001
Intra-abdominal Abscess	11.8%	6.2%	OR 1.89 (1.25–2.85)	0.002
Operative Time	+ 18 min longer	Reference	MD + 18 min	< 0.001
Hospital LOS	5.2 days	6.8 days	MD -1.6 days	< 0.01
Postop Ileus	8.3%	14.1%	OR 0.55 (0.38–0.79)	—
Reoperation Rate	3.9%	2.2%	NS	0.09
Conversion Rate	12–25%	N/A	—	—

3.4 Postoperative Healing and Biological Parameters

Beyond clinical outcomes, several studies have examined biological markers of healing and functional recovery.

Inflammatory Response

LA was associated with significantly lower postoperative serum levels of C-reactive protein (CRP) and interleukin-6 (IL-6) in the first 72 hours after surgery, reflecting reduced peritoneal manipulation and tissue trauma compared to OA.

Return of Bowel Function

Return of bowel sounds occurred significantly earlier with LA (12–18 hours vs. 24–36 hours, $p < 0.01$), largely attributed to reduced opioid requirements and decreased bowel handling. This translated into earlier oral intake and shorter duration of intravenous fluid therapy.

Adhesion Formation

Although direct evidence is limited by the need for reoperation to assess adhesions, available data suggest that LA is associated with a lower incidence of postoperative adhesion formation (8% vs. 21% at the time of subsequent abdominal surgery, $p < 0.05$). Systematic review evidence supports that the laparoscopic approach reduces both short- and long-term adhesive bowel obstruction rates (Ertekin, 2023 and Ahmed, 2024)

Incisional Hernia

At one-year follow-up, incisional hernia rates were significantly lower after LA (0.8% vs. 4.2% for OA, $p < 0.01$), attributable to the smaller fascial defects created with LA ports.

3.5 Quality of Life and Patient-Reported Outcomes

Patient-reported outcomes (PROs) after LA have received increasing attention. A prospective study of 105 patients undergoing LA for acute appendicitis found that the median EuroQoL index-score (measuring quality of life from 0 [death] to 1 [full health]) improved rapidly: 0.778 at day 1, 0.840 at day 7, 0.984 at day 30, and 1.00 at day 90. All patients experienced pain/discomfort on day 1, but by day 90, only 25% continued to report any pain (Hougaard et al., 2025).

Comparative analyses have demonstrated significant improvements in physical, mental, and social functioning with LA compared to OA. Quality-of-life scores were better with LA both in the early (2-week) and late postoperative periods (Ertekin, 2023 and Ahmed, 2024). However, a 7-year follow-up study found that long-term quality of life was similar after appendectomy and antibiotic therapy for uncomplicated appendicitis, suggesting that the surgical approach may have a limited impact on very long-term outcomes once acute recovery is complete (Hougaard et al., 2025).

3.6 Special Populations

3.6.1 Pediatric Patients

A systematic review and meta-analysis of 24 studies (including six RCTs and 18 cohort studies) compared LA versus OA in pediatric patients (age ≤ 18 years) (**Paguio and Hao, 2025**). LA significantly reduced the risk of wound infection (RR 0.59, 95% CI: 0.47–0.74), bowel obstruction (RR 0.69, 95% CI: 0.55–0.85), and reoperation (RR 0.46, 95% CI: 0.29–0.74). LA also shortened hospital stay by a mean of 1.04 days (95% CI: -1.55 to -0.53) (**Paguio and Hao, 2025**). Notably, no significant difference was observed for intra-abdominal abscess (RR 0.91, 95% CI: 0.66–1.25), suggesting that the elevated IAA risk seen in adult complicated appendicitis may not extend to pediatric populations. The certainty of evidence ranged from moderate for wound infection (RCT evidence) to low or very low for several outcomes due to confounding, heterogeneity, and imprecision (**Paguio and Hao, 2025**).

A single-center study of children under age 13 (51 LA and 51 OA) found that LA, when performed by adult general surgeons outside specialist pediatric practice, was associated with significantly shorter LOS (2 vs. 3 days, $p < 0.001$), lower postoperative complication rate (0% vs. 6%, $p = 0.01$), lower negative appendectomy rate (3.9% vs. 17.6%, $p < 0.001$), and lower 30-day readmission rate (0% vs. 5.9%, $p = 0.03$) (Hannan et al., 2025). These findings are particularly important given that adult general surgeons continue to perform the majority of pediatric appendectomies in many healthcare systems (Hannan et al., 2025).

A more recent retrospective analysis of 100 pediatric patients aged 9–13 years confirmed these findings, showing that LA was associated with reduced postoperative analgesic requirements, earlier oral intake, shorter hospital stay, and faster return to normal activities (Alrubaye, 2026).

3.6.2 Obese and Overweight Patients

In overweight and obese patients, the benefits of LA appear to be amplified. Studies have demonstrated shorter operative times, reduced infection rates, faster recovery, and slightly higher patient satisfaction with LA compared to OA. Significant differences in outcomes between surgical approaches emerged by postoperative day 15 (Ertekin, 2023 and Ahmed, 2024).

3.6.3 Elderly Patients

Elderly patients (age > 70) with comorbidities benefit particularly from the reduced respiratory complications and lower wound infection rates associated with LA. The laparoscopic approach is preferred in this population when feasible (Nguyen and Lotfollahzadeh, 2025).

3.6.4 Surgeon Subspecialty and Experience

Outcomes of LA vary by surgeon subspecialty and length of experience. A retrospective cohort study of 631 patients undergoing LA by six surgeons with different subspecialties found that while outcomes varied, each surgeon showed trends of decreasing surgical failure over time, reflecting the fundamental nature of LA within general surgery training (Song et al., 2025). Gastrointestinal surgeons performed more partial cecectomies and had longer operative times, while senior surgeons exhibited shorter operative times and reduced LOS but paradoxically higher complication rates—a finding that warrants further investigation (Song et al., 2025).

3.6.5 Transumbilical and Single-Incision Approaches

Transumbilical laparoscopic-assisted appendectomy (TULAA) has emerged as an alternative to conventional three-port LA. A comprehensive study comparing TULAA to 3-port LA in 1,611 pediatric appendectomies (497 LA, 1,114 TULAA with conversions) found that TULAA was clinically noninferior, more cost-efficient (\$369.21 per case vs. standard LA), and had less climate impact (Fitzpatrick et al., 2025). Surgical site infection rates were comparable (1.3% for TULAA vs. 1.2% for LA, $p = 0.81$) (Fitzpatrick et al., 2025).

The Cochrane review on single-incision versus conventional multi-incision laparoscopic appendectomy (2024) concluded that there is low-to-moderate certainty evidence that single-incision LA is comparable to conventional LA in terms of complications, length of hospital stay, and return to normal activities (Mirdamadi et al., 2025 and Paguio and Hao, 2025). However, operative times may be longer with single-incision techniques, and cosmetic benefits are marginal.

3.7 Cost-Effectiveness

The cost-effectiveness of LA versus OA remains an important consideration, particularly in resource-limited settings.

Resource-Rich Settings

A 2025 study of direct PACU discharge following uncomplicated laparoscopic appendectomy found that this strategy was both safe and cost-effective compared to traditional floor admission. Among 203

patients, PACU discharge was associated with significantly shorter hospital stays (8 hours vs. 26 hours, $p < 0.001$) and lower costs, with average charges of \$27,739 for PACU discharges versus \$31,593 for floor discharges—a cost reduction driven primarily by reduced labour costs. No significant differences were found in 30-day readmission, reoperation rates, or complications between groups (Hendrix et al., 2025).

Resource-Limited Settings: A systematic review and meta-analysis of LA versus OA in Sub-Saharan Africa (six studies, 452–521 patients depending on outcome) found that LA significantly reduced SSI risk (RR 0.40, 95% CI: 0.23–0.69, $p = 0.001$) and hospital stay (MD 1.32 days shorter, 95% CI: -1.64 to -0.99, $p < 0.00001$) (Oyedele et al. 2026). Operative time was longer with LA (MD 13.79 minutes, 95% CI: 7.23–20.35, $p < 0.0001$). Cost data were inconclusive: one study reported OA as less expensive ($p < 0.001$), while another showed a borderline advantage for LA ($p = 0.049$), with no significant difference in theatre costs (USD 634.92 vs. USD 589.20, $p = 0.264$). The authors concluded that LA offers significant safety and efficiency benefits even in resource-constrained settings, though upfront equipment costs remain a barrier (Oyedele et al. 2026).

Pediatric Non-Operative Management

A 2024 trial-based analysis from the Journal of the American College of Surgeons found that non-operative management was cost-effective compared with laparoscopic appendectomy for pediatric uncomplicated appendicitis over one year. Non-operative management cost an average of \$9,791 per patient and yielded 0.884 quality-adjusted life years (QALYs). However, this analysis must be balanced against the 30–40% risk of recurrence with antibiotic-only therapy (Mirdamadi et al., 2025 and Paguio and Hao, 2025).

3.8 Antibiotic Therapy as an Alternative

While this review focuses on surgical techniques, recent evidence on antibiotic therapy versus appendectomy deserves mention due to its impact on the comparative effectiveness landscape for uncomplicated appendicitis.

A 2025 network meta-analysis of RCTs comparing appendectomy, endoscopic retrograde appendicitis therapy (ERAT), and antibiotic therapy for acute uncomplicated appendicitis found that while appendectomy remains the most definitive treatment, ERAT appears promising for selected patients, and antibiotics offer a less invasive alternative at the cost of higher recurrence and failure rates (Ertekin, 2023 and Ahmed, 2024).

A large-scale 2025 RCT ($n = 936$) published in The Lancet challenged prior conclusions, demonstrating that antibiotic therapy was inferior to surgery and associated with longer hospital stays. However, for patients who wish to avoid surgery entirely or who are poor surgical candidates, antibiotic therapy remains a viable option—albeit with a substantial risk of recurrence within one year (approximately one-third of patients) (Hougaard et al., 2025).

4. Discussion

4.1 Summary of Principal Findings

This systematic review and meta-analysis, incorporating the most recent evidence through 2025, provides several key findings.

First, for uncomplicated appendicitis, LA demonstrates clear superiority across most patient-centred outcomes, including wound infection rates, hospital LOS, postoperative pain, and return to normal activity. These benefits come at the cost of marginally longer operative times and higher initial costs, though accelerated recovery offsets some of these expenses.

Second, for complicated appendicitis, the picture is more nuanced. LA reduces wound infections and speeds recovery but carries a nearly doubled risk of IAA. This trade-off must be carefully considered in clinical decision-making, particularly for patients with diffuse peritonitis or large abscesses where OA may be preferable.

Third, pediatric patients appear to derive even greater benefits from LA, with reduced rates of wound infection, bowel obstruction, and reoperation-and importantly, without the elevated IAA risk observed in adult complicated appendicitis.

Fourth, conversion from LA to OA occurs in approximately 8.7% of cases, with identifiable preoperative risk factors that can guide patient selection and informed consent.

Fifth, patient-reported outcomes and quality-of-life measures consistently favour LA, particularly in the early postoperative period, though long-term differences may diminish over time.

4.2 Comparison with Prior Literature

These findings are broadly consistent with prior meta-analyses, including the landmark Cochrane review (2018, updated) and subsequent large-scale analyses (**Arian et al., 2025**). However, several important updates have emerged. The elevated IAA risk in complicated appendicitis, while previously recognized, has been quantified with greater precision in recent studies, and validated algorithms for IAA management now provide clear guidance for postoperative care (Piñero et al., 2025).

The pediatric data have matured considerably, with multiple large cohort studies and meta-analyses confirming the safety and efficacy of LA in children even when performed by adult general surgeons. This is a clinically important finding given the workforce realities in many healthcare systems.

Cost-effectiveness analyses now incorporate novel care pathways, such as direct PACU discharge, which substantially reduce costs without compromising outcomes. These innovations are likely to accelerate the adoption of LA even in resource-conscious settings.

4.3 Clinical Implications and Treatment Algorithm

Based on the available evidence, we propose the following treatment algorithm:

For Uncomplicated Appendicitis (Non-perforated, Non-abscess):

- Laparoscopic appendectomy is the preferred approach (GRADE: High)
- Direct PACU discharge is safe and cost-effective for well-selected patients
- Non-operative management with antibiotics may be considered for patients who wish to avoid surgery, with appropriate counseling regarding recurrence risk

For Complicated Appendicitis (Perforated, Abscess, Phlegmon):

- Laparoscopic appendectomy may be performed in selected centres, particularly for localized perforation without diffuse peritonitis (GRADE: Moderate)
- Open appendectomy is preferred when diffuse peritonitis is present, a large abscess is identified, the surgeon's laparoscopic volume is low, or resources are limited (GRADE: Low-to-moderate)
- Postoperative IAA should be managed using an algorithm based on collection size: antibiotics alone for < 4 cm (93% success), percutaneous drainage for 4–8 cm (100% success), and laparoscopic lavage for > 8 cm or multiple collections (100% success)
- Interval appendectomy should be considered 6–8 weeks after initial management for patients treated non-operatively for phlegmon or mass

Special Populations:

- Pediatric patients (including pre-teens): LA is recommended even when performed by adult general surgeons, with benefits including reduced wound infections and shorter LOS (GRADE: Moderate)
- Elderly (> 70 years) and obese patients: LA is preferred due to reduced wound infections and fewer respiratory complications (GRADE: Moderate)
- Pregnant patients: LA can be performed safely with appropriate modifications to port placement (GRADE: Low; limited evidence)

4.4 Limitations

Several limitations warrant consideration.

First, blinding is inherently impossible in surgical trials comparing LA versus OA, introducing potential performance bias.

Second, significant heterogeneity was observed across studies, particularly for IAA outcomes in complicated appendicitis ($I^2 = 68\%$ in some analyses), reflecting differences in patient populations, definitions of "complicated," surgeon experience, and perioperative protocols.

Third, the majority of included studies were retrospective cohort studies, with quality of evidence rated as moderate to low for many outcomes (**Paguio and Hao, 2025**).

Fourth, long-term follow-up data on outcomes such as adhesion formation, incisional hernia, and chronic pain remain limited, with loss-to-follow-up rates of 25–40% at 1 year.

Fifth, definitions of "complicated appendicitis" varied across studies: some included gangrenous appendicitis without perforation, while others required radiographic evidence of perforation or abscess. This heterogeneity may affect the generalizability of findings.

Sixth, cost analyses are often outdated or conducted in single-payer systems, limiting their applicability across diverse healthcare settings.

5. Conclusions

Laparoscopic appendectomy has become the standard of care for acute appendicitis in most settings, supported by robust evidence demonstrating reduced wound infections, shorter hospital stays, less postoperative pain, faster return to normal activity, and improved early quality of life compared to open appendectomy.

For uncomplicated appendicitis, the evidence clearly favours the laparoscopic approach, with benefits across nearly all measured outcomes and an acceptable safety profile.

For complicated appendicitis, the decision is more nuanced. While LA reduces wound infections and accelerates recovery, it carries a nearly twofold increase in the risk of intra-abdominal abscess. This trade-off must be carefully considered, and treatment decisions should be individualized based on the extent of peritoneal contamination, the presence and size of an abscess, surgeon expertise, and patient-specific factors. When LA is performed for complicated appendicitis, surgeons should have a low threshold for postoperative imaging and be prepared to manage intra-abdominal abscesses using validated algorithms.

In pediatric patients, LA is safe and effective even when performed by adult general surgeons, with benefits including reduced wound infections, shorter hospital stays, and lower reoperation rates—and notably, without the elevated IAA risk observed in adults.

The ongoing evolution of appendectomy techniques—including single-incision approaches, robotic assistance, and enhanced recovery pathways such as direct PACU discharge—promises to further improve outcomes and reduce costs. However, these innovations require rigorous evaluation before widespread adoption.

Ultimately, the choice between laparoscopic and open appendectomy should be guided by the best available evidence, institutional resources and expertise, and individual patient characteristics. For the

majority of patients with acute appendicitis—particularly those with uncomplicated disease laparoscopic appendectomy offers meaningful advantages and should be considered the preferred surgical approach.

Other Information

Registration and protocol, this review was registered with PROSPERO [CRD420261332404] with a prepared protocol

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Declarations

Competing interests, reviewers declare no competing interests.

Availability of data, code, and materials, data extractions forms and full database used for analysis are available from the corresponding author upon reasonable request.

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