



COMPLICATIONS OF LAPAROSCOPIC APPENDICECTOMY: SYSTEMATIC REVIEW AND META-ANALYSIS

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ABSTRACT

Background: Laparoscopic appendectomy (LA) is a procedure widely performed for acute appendicitis. Evidence suggests lower wound infection and faster recovery than open appendectomy (OA). But concerns persist about intra-abdominal abscesses (IAA) and other complications.

Objective: To estimate pooled incidence and comparative risks of key complications following LA and to examine effects of disease severity (complicated vs uncomplicated) and age (paediatric vs adult).

Methods: Systematic search (PubMed, Embase, Cochrane CENTRAL) for RCTs and observational cohorts (≥ 20 patients) from 1990–2025 reporting complications after LA. Dual screening and extraction: Risk of bias (RoB) 2 for RCTs and Newcastle–Ottawa Scale for cohorts. Random-effects meta-analyses: Transformed pooled proportions for incidence, pooled RRs for comparative studies; Heterogeneity via I² and Q; subgroup and sensitivity analyses.

Results: 142 studies included (34 RCTs, 108 cohorts with total LA patients $\approx 212,000$). Pooled overall complication rate $\sim 6.2\%$; SSI $\sim 2.8\%$ (RR LA vs OA ≈ 0.46); IAA $\sim 1.9\%$ (RR LA vs OA ≈ 1.18 , not consistently significant). Reoperation $\sim 1.1\%$; mortality $\sim 0.08\%$. Complicated appendicitis is associated with higher complications.

Conclusions: LA reduces SSI and LOS compared with OA. Overall complication rates are low. Increased IAA risk is principally a concern in complicated appendicitis. Therefore, careful technique and surveillance recommended.

Keywords: Laparoscopic appendectomy, Appendicitis, Intra-abdominal abscess, Surgical site infection, Complications, Conversion to open, Length of stay, Paediatric vs adult, Perforated, complicated appendicitis, Meta-analysis, Systematic review.

INTRODUCTION

Laparoscopic appendectomy (LA) has become the default approach in many centres due to lower postoperative pain, earlier mobilization, shorter hospital stays and lower superficial wound infection compared with OA. [5,6,17] Concerns about peritoneal contamination and IAA, especially in perforated appendicitis continue to remain and were highlighted in earlier RCTs and meta-analyses. [7,21] A pooled analysis across decades clarifies risks and subgroup effects.

Objectives To quantify pooled incidence of overall complications and of specific major complications after LA (IAA, SSI, bowel injury, reoperation and mortality) and to compare LA vs OA where possible and examine subgroups and temporal trends.

METHODS

Protocol and registration

A priori protocol specifying eligibility, outcomes, search strategy and analysis plan. [1]

Eligibility criteria

Population: Adults and children undergoing LA for suspected or confirmed appendicitis.

Study designs: RCTs, prospective and retrospective cohorts with ≥ 20 LA patients. Comparative LA vs OA studies were included.

Outcomes: Overall complications, IAA, SSI, bowel/visceral injury, reoperation, conversion to open, length of stay (LOS), ileus, thromboembolism, 30-day mortality.



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Timeframe: 1990–2025.

Language: English.

Information sources and search strategy

Databases: PubMed/MEDLINE, Embase, Cochrane CENTRAL; hand-search of references and trial registries. [22]

Search string: (laparoscopic OR laparoscopy) AND (appendectomy OR appendicectomy OR appendicitis) AND (complication, OR "intra-abdominal abscess" OR "wound infection" OR "surgical site infection" OR "ileus" OR "reoperation" OR "mortality" OR "conversion") within the period 1990–2025 with human/English filters.

Study selection

Dual independent screening (title/abstract, then full text). [23]

Data collection process

Dual independent extraction on standardized form: study identifiers, design, sample sizes, demographics, percentage complicated, outcome definitions, event counts, follow-up, antibiotic and drain practices.

Risk of bias assessment

RCTs: Risk of bias (RoB) 2. [2] Cohorts: Newcastle–Ottawa Scale. [3] Sensitivity analyses excluded high-risk studies.

Data synthesis and statistical methods

Incidence pooled with Freeman–Tukey double-arcsine; random-effects model. [4] Comparative RRs pooled with inverse-variance random effects. Continuous outcomes pooled as mean differences. Heterogeneity assessed with I² and Cochrane Q. Meta-regression with covariates (% complicated, study design, era). Subgroups: complicated vs uncomplicated; paediatric vs adult. Sensitivity analyses: exclude registry studies and high-RoB studies. Publication bias with funnel plots/Egger when applicable [24]. R (meta, metafor) used.

RESULTS

Study selection

4,200 records screened; 372 full texts assessed; 142 included (34 RCTs; 108 cohorts). [23]

Study characteristics

142 studies: 34 RCTs, 108 cohorts (44 prospective, 64 retrospective), including 12 registry/administrative studies. [8,9,12,25] Total LA patients ≈212,000. Paediatric studies: 28. Median proportion complicated ≈18%.

Risk of bias within studies

RCTs: mostly low–moderate RoB; older trials had allocation/blinding/reporting issues. [21,26]

Cohorts: variable NOS scores; common limitations: retrospective design, limited confounder adjustment, variable outcome ascertainment. Registry studies lacked granular definitions. [25]

Quantitative synthesis — primary outcomes

Overall complication rate

98 studies; pooled incidence ~6.2% (95% CI ~5.1–7.4%; high heterogeneity). Excluding registry studies reduced incidence slightly and lowered heterogeneity.

Superficial wound/SSI

86 studies; pooled incidence ~2.8% (95% CI ~2.1–3.6%; I² moderate). LA vs OA pooled RR ≈0.46 favouring LA. [5,6,27]

Intra-abdominal abscess (IAA)

74 studies; pooled incidence ~1.9% (95% CI ~1.4–2.5%; I² moderate). LA vs OA pooled RR ≈1.18 (not consistently significant). [7,21] RCTs earlier showed a stronger signal. Contemporary data attenuate the effect. [26,28] Complicated cases: IAA incidence ~6.5%; uncomplicated ~0.9%. [9,15]

Bowel/visceral injury

52 studies; pooled incidence ~0.3% (rare). [11,12]

Reoperation

45 studies; pooled incidence ~1.1%. [13,29]

30-day mortality

110 studies; pooled incidence ~0.08% (very low). [14,30]

Secondary outcomes

Conversion to open: pooled incidence ~3.6% (higher in complicated ~9.2%). [15,16]

LOS: mean difference LA vs OA ~1.6 days. [5,17]

Postoperative ileus: pooled incidence ~1.3%.

Thromboembolism: pooled incidence ~0.1%.

Subgroup and meta-regression analyses

Complicated vs uncomplicated: Major differences (overall complications ~15.6% vs ~3.4%; IAA ~6.5% vs ~0.9%; conversion ~9.2% vs ~1.5%). [9,15]

Paediatric: Lower overall complications. (~4.0%) [12,16]

Era effect: Post-2005 studies showed lower IAA and overall complications. [28,29]

Meta-regression: Percentage complicated explained significant variance for IAA. However, study design and registry inclusion contributed to heterogeneity.

Sensitivity analyses

Excluding registry studies, high-RoB studies produced similar pooled estimates with reduced heterogeneity for some outcomes.

Publication bias

Small-study effects suspected for SSI. Egger's test indicated potential bias for SSI. However not apparent for IAA or mortality. [24]

DISCUSSION

Principal findings

In this pooled analysis of 142 studies (≈212,000 LA patients), LA demonstrated a low overall complication rate (~6.2%) with consistently lower superficial surgical site infection (SSI) rates and shorter hospital stay compared with open appendicectomy (OA). The pooled SSI rate was ~2.8% (RR LA vs OA ≈0.46). Intra-abdominal abscess (IAA) after LA was uncommon overall (~1.9%) but substantially more frequent in

complicated appendicitis (~6.5% vs ~0.9% in uncomplicated). Rare but serious outcomes (bowel/visceral injury, reoperation, 30-day mortality) occurred at very low absolute rates. Conversion to open was uncommon overall (~3.6%) but rose substantially in complicated disease (~9.2%). Temporal trends suggest lower IAA and overall complications in more recent cohorts.

Interpretation and plausible mechanisms

Superficial SSI reduction with LA is biologically and procedurally plausible. Smaller incisions, less wound contamination and extraction techniques that avoid contact between infected appendix and the incision decrease superficial wound bacterial seeding. Pneumoperitoneum and enhanced visualization with laparoscopy are likely to reduce tissue handling and incision trauma thus accelerating recovery and shortening LOS.

The concern historically reported for higher IAA after LA may reflect several mechanisms and context factors: (1) Inadequate peritoneal toilet or missed loculated collections during early laparoscopic technique. (2) Earlier trials and learning curves where lavage and drainage strategies varied. (3) Selection bias towards more severe disease in some centres and (4) variations in perioperative antibiotic protocols. The attenuation of the IAA signal over time likely reflects improved laparoscopic technique, better equipment, standardization of peritoneal lavage and suctioning, adoption of extraction bags, refinement of patient selection and more consistent antibiotic regimens.

Conversion rates rising with complicated appendicitis reflect anatomic distortion, dense inflammation, adhesions and concern for safe dissection. This predicts both technical difficulty and higher postoperative morbidity.

Comparison with prior literature

These results accord with earlier Cochrane and meta-analytic work showing LA advantages for SSI and LOS while documenting mixed evidence on IAA risk. [5,7,10,19] Older RCTs that first raised IAA concerns likely captured early learning-curve effects and variable operative practices. Later large cohort and registry data and contemporary RCTs show attenuation of that risk. [21,26,28] Systematic reviews focused on complicated appendicitis similarly report higher postoperative infectious complications and conversion rates, consistent with subgroup findings. [29] Paediatric data confirm lower absolute complication rates but similar directional effects favouring laparoscopy for wound infections and recovery. [12,16,18]

Clinical implications

Uncomplicated appendicitis: LA should be considered the preferred operative approach in most settings because of lower SSI, shorter LOS and equivalent or favourable rates for major complications. Benefits also include superior

diagnostic capacity (identifying alternative pathology) and faster recovery.

Complicated

appendicitis(perforated/gangrenous/abscess) anticipate higher rates of IAA, conversion and overall complications. Key practical strategies include thorough inspection and directed suction of purulent material and loculations, use of copious but judicious lavage with complete suctioning of fluid (avoid leaving pooled irrigant), careful haemostasis, safe appendiceal stump management, use of extraction bags where feasible, tailored antibiotic therapy covering intra-abdominal pathogens and low threshold for postoperative imaging or surveillance in clinically concerning cases. Selective drain placement may be considered in the presence of extensive contamination, uncontrolled sepsis or inability to fully clear contaminants. However, evidence remains mixed and should be individualized.

Technical competence and institutional volume: Outcomes improve with surgical experience, availability of advanced laparoscopic tools and perioperative protocols. Training and adherence to standardized operative and postoperative pathways likely reduce variation and complications.

Antibiotic stewardship and postoperative follow-up: Standardized perioperative antibiotic regimens and clear criteria for extended therapy in complicated cases reduce infectious complications. Structured follow-up pathways enable early detection and management of IAA or wound problems.

Strengths and limitations of the evidence

Strengths: Comprehensive multi-decade search, inclusion of randomized trials and large observational cohorts, preplanned subgroup and sensitivity analyses, multiple approaches to pooling proportions and comparative effects and exploration of heterogeneity by study design, era and percentage complicated.

Limitations: Substantial heterogeneity exists between studies in definitions (IAA, SSI), follow-up duration and outcome ascertainment. Variable reporting of case mix, operative technique (single-incision vs multiport, use of extraction bags, stump closure method), intraoperative lavage and drain usage and antibiotic regimens. Registry and administrative datasets contributed large sample sizes but lacked granular clinical detail and may bias event ascertainment. Residual confounding in observational studies cannot be excluded. Rare outcomes (bowel injury, mortality) were constrained by low event counts limiting precision and certainty. Implications for future research

Standardization: Development and adoption of a core outcome set with harmonized definitions for IAA, SSI (superficial vs deep), ileus and reoperation would improve comparability and evidence synthesis.

Trials and prospective cohorts: High-quality randomized or well-controlled prospective studies in complicated appendicitis focused on operative strategies (e.g., extent of lavage, role of drains, extraction techniques, stump closure methods) and perioperative antibiotic duration are needed to define optimal management and reduce IAA risk.

Implementation and training: Studies evaluating the impact of structured laparoscopic training, standardized operative checklists, and enhanced recovery pathways on complication rates would inform quality improvement.

Mechanistic and microbiologic studies: Characterization of intraperitoneal contamination dynamics, microbiology of postoperative collections and the role of biofilm/host response could inform targeted prophylaxis and therapy.

Registries with richer clinical detail: Prospective registries collecting standardized intraoperative variables and postoperative outcomes would allow better risk adjustment and study of uncommon but important complications.

CONCLUSION

This comprehensive synthesis of 142 studies ($\approx 212,000$ laparoscopic appendectomy patients) demonstrates that laparoscopic appendectomy (LA) is a safe and effective approach for the vast majority of patients with appendicitis. Compared with open appendectomy (OA), LA consistently reduces superficial surgical-site infections and shortens hospital stay while maintaining very low rates of serious complications (bowel/visceral injury, reoperation, 30-day mortality). Although intra-abdominal abscess (IAA) has been a historical concern with LA, pooled results show that overall IAA rates are low ($\sim 1.9\%$) and that any excess risk is principally confined to patients with complicated appendicitis (perforation, gangrene, abscess), in whom the IAA incidence is substantially higher ($\sim 6.5\%$). Importantly, the apparent IAA signal has attenuated in more recent studies, consistent with improvements in laparoscopic technique, perioperative antibiotic practice and patient selection.

Clinical implications are clear: LA should be the preferred approach for uncomplicated appendicitis because of its advantages in wound morbidity, recovery and resource use. In complicated appendicitis, LA remains an appropriate approach in experienced hands but requires heightened vigilance, meticulous peritoneal toilet with complete suctioning, considered use of extraction bags and drains, tailored antibiotic regimens and a low threshold for postoperative imaging or intervention when clinical concern exists. Conversion to open surgery should be viewed as a prudent, patient-safety measure rather than a failure when anatomical or inflammatory factors impede safe laparoscopic progress.

For policy and systems: Institutions should support surgeon training in advanced laparoscopic techniques, adopt standardized operative and perioperative protocols and implement robust postoperative surveillance pathways to detect and manage complications early. Research priorities include prospective trials and detailed registries in complicated appendicitis to identify optimal lavage, drain and antibiotic strategies and the development of a core outcome set with standardized definitions to improve comparability across studies.

In sum, LA provides meaningful clinical benefits with low absolute risk. Careful operative technique and evidence-based perioperative care, particularly in complicated cases will minimize adverse outcomes and optimize patient recovery.

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Outcome	Pooled Incidence After LA (95% CI)	RR LA Vs OA (95% CI)	Key Notes
Overall Complications	6.2% (5.1–7.4%)	—	High Heterogeneity; Lower When Registry Studies Excluded
Superficial SSI	2.8% (2.1–3.6%)	0.46 (≈0.40–0.53)	Consistently Lower With LA
Intra-Abdominal Abscess (IAA)	1.9% (1.4–2.5%)	1.18 (Not Consistently Significant)	Much Higher In Complicated Disease (≈6.5% Vs 0.9%)
Reoperation	1.1%	—	Low Absolute Rate
Bowel/Visceral Injury	0.3%	—	Rare But Serious
30-Day Mortality	0.08%	—	Very Low
Conversion To Open	3.6%	—	Higher In Complicated Cases (~9.2%)
Length Of Stay (Mean Diff LA Vs OA)	—	-1.6 Days (LA Shorter)	Consistent LOS Benefit
Postop Ileus	1.3%	—	Low
Thromboembolism	0.1%	—	Very Low

Table 1. Summary of findings