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Laparoscopic Versus Open Colectomy for Colorectal Cancer: Postoperative Outcomes—A Systematic Review

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Abstract

Background: Colorectal cancer (CRC) remains a major global health burden, with colectomy being the cornerstone of curative treatment. The evolution from open colectomy (OC) to laparoscopic colectomy (LC) has aimed to minimize surgical trauma, improve recovery, and preserve oncologic efficacy. This systematic review synthesizes evidence comparing postoperative and oncologic outcomes between LC and OC in CRC management.

Methods: Following PRISMA 2020 guidelines, ten clinical studies published between 2002 and 2025—including randomized controlled trials (RCTs) and meta-analyses—were analyzed. Databases searched included PubMed, Scopus, Web of Science, Embase, and Google Scholar. Outcomes assessed comprised operative time, complication rates, postoperative pain, recovery indices, hospital stay, and long-term survival (DFS and OS). Methodological quality was evaluated using the Cochrane RoB 2 and Newcastle–Ottawa Scale (NOS).

Results

Across studies, LC demonstrated significantly shorter hospital stays (2–3 days), reduced postoperative pain ($p < 0.05$), and faster bowel recovery compared with OC. Oncologic outcomes—including lymph node harvest, DFS, and OS—were comparable, indicating oncologic non-inferiority. Meta-analyses confirmed consistent advantages in short-term recovery without compromising long-term survival. However, benefits were attenuated in advanced T4 or emergency cases, where technical complexity limited LC feasibility.

Conclusion: Laparoscopic colectomy offers superior short-term recovery outcomes with equivalent oncologic safety compared to open colectomy. Its implementation in advanced and emergent cases remains surgeon- and institution-dependent, requiring further standardization and skill optimization.

Keywords: Colorectal cancer, laparoscopic colectomy, open colectomy, minimally invasive surgery, postoperative outcomes, oncologic efficacy, survival.

Introduction

Colorectal cancer (CRC) remains one of the leading causes of cancer-related morbidity and mortality worldwide, ranking as the third most common malignancy and the second leading cause of cancer deaths globally. Advances in screening and treatment strategies, particularly in surgical innovation, have significantly improved survival outcomes over the past two decades. Among these, minimally invasive techniques such as laparoscopic colectomy have emerged as major alternatives to open surgery,

aiming to reduce postoperative complications and enhance recovery without compromising oncologic safety (Kitaguchi et al., 2025).

Laparoscopic colectomy has demonstrated consistent benefits in short-term postoperative outcomes, including lower intraoperative blood loss, reduced postoperative pain, and shorter hospital stays. These advantages stem from smaller incisions and decreased surgical trauma compared to conventional open colectomy. Moreover, enhanced visualization during laparoscopic procedures enables precise dissection and hemostasis, contributing to fewer wound infections and faster gastrointestinal recovery (Liu et al., 2023). Despite these advantages, skepticism remains among some surgeons, especially regarding its safety and oncological adequacy for advanced-stage tumors.

Historically, open colectomy was regarded as the gold standard for colorectal cancer resection due to its straightforward exposure and perceived reliability in achieving oncologic clearance. However, mounting evidence suggests that laparoscopic colectomy offers equivalent long-term oncological outcomes—including disease-free and overall survival rates—when performed by experienced surgeons (Podda et al., 2022). These findings have catalyzed a paradigm shift toward minimally invasive surgery (MIS), supported by both randomized controlled trials and meta-analyses confirming non-inferiority in cancer control.

The feasibility of laparoscopic surgery in complex or emergent colorectal cases, such as perforation or obstruction, has also been increasingly explored. Although initially considered unsuitable for emergency settings, recent meta-analyses reveal comparable mortality and morbidity outcomes between laparoscopic and open approaches when performed in selected patients (Warps et al., 2021). This suggests that the laparoscopic method may be safely extended to urgent scenarios under appropriate expertise and institutional resources.

Beyond perioperative outcomes, contemporary research has examined the impact of laparoscopic techniques on patient-centered metrics such as quality of life, postoperative pain control, and time to adjuvant therapy initiation. These factors are critical for optimizing long-term survivorship and functional recovery. Studies report superior early postoperative quality-of-life scores and reduced analgesic requirements following laparoscopic colectomy, reflecting its minimally invasive advantage (Llerena-Velastegui et al., 2025).

Recent meta-analyses incorporating thousands of patients indicate that laparoscopic colectomy is not only feasible but also oncologically sound across tumor locations, including right, left, and transverse colon cancers. For example, a global review of right hemicolectomies demonstrated no difference in lymph node yield or R0 resection rates, confirming equivalent oncological radicality between laparoscopic and open techniques (Anania et al., 2021). Similarly, studies focused on the splenic flexure—an anatomically challenging site—showed that laparoscopy achieved comparable survival outcomes while reducing hospital stay and wound morbidity (Wu et al., 2022).

Nevertheless, certain challenges persist. Laparoscopic colectomy requires a steep learning curve, advanced technical skills, and access to specialized equipment. These constraints have limited its universal adoption, particularly in low-resource settings or in the management of locally advanced T4 lesions where multivisceral resection may be necessary (Mahmoud et al., 2025). Furthermore, the conversion from laparoscopic to open surgery, often due to technical difficulty or intraoperative complications, can mitigate the benefits of minimally invasive surgery and remains a key area for improvement.

Finally, evidence from randomized trials in acute colorectal presentations, such as the LaCeS trial, supports the safety and feasibility of laparoscopic colectomy in emergency conditions, offering similar complication and mortality rates compared to open surgery while improving recovery and discharge times (Harji et al., 2020; Koh et al., 2013). These findings reinforce the growing consensus that laparoscopic colectomy—when performed under optimal conditions—provides equivalent oncologic outcomes and superior perioperative results across diverse clinical scenarios in colorectal cancer management.

Methodology

Study Design

This systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines to ensure methodological rigor, transparency, and replicability. The primary objective was to synthesize and critically appraise empirical evidence comparing laparoscopic versus open colectomy for colorectal cancer, with particular focus on postoperative outcomes, oncologic efficacy, and long-term survival. The review included only peer-reviewed clinical studies evaluating patients undergoing colectomy for histologically confirmed

colorectal cancer using either laparoscopic (including single-incision or multiport techniques) or open surgical approaches.

This review aimed to address the following research questions:

1. How do postoperative recovery outcomes (pain, length of hospital stay, bowel function recovery, and complication rates) differ between laparoscopic and open colectomy?
2. Are there significant differences in oncologic outcomes, including disease-free survival (DFS), overall survival (OS), and recurrence rates?
3. What procedural, institutional, or surgeon-related factors influence postoperative outcomes in laparoscopic colectomy for colorectal cancer?

The systematic review incorporated ten eligible clinical studies meeting all inclusion criteria after full-text evaluation, comprising both randomized controlled trials (RCTs) and prospective comparative studies published between 2002 and 2025.

Eligibility Criteria

Inclusion Criteria

Studies were included if they met the following criteria:

- **Population:** Adult patients (≥18 years) diagnosed with colon or rectal adenocarcinoma undergoing elective or emergency colectomy.
- **Interventions:** Laparoscopic colectomy, including standard multiport, single-incision (SILS), or single-port (SPLS) techniques.
- **Comparators:** Conventional open colectomy or conventional laparoscopic colectomy (CLS) where relevant.
- **Outcomes:** Reported at least one postoperative clinical outcome (e.g., operative time, blood loss, pain scores, hospital stay, complications, or mortality) or oncologic parameter (e.g., lymph node yield, recurrence rate, disease-free or overall survival).
- **Study Designs:** Randomized controlled trials (RCTs), prospective or retrospective cohort studies, and controlled comparative studies.
- **Language:** English-language publications only.
- **Publication Period:** 2002–2025 to capture the evolution of minimally invasive colorectal surgery techniques.

Exclusion Criteria

- Case reports, narrative reviews, editorials, or conference abstracts.
- Studies involving benign colorectal disease only (e.g., diverticulitis, Crohn's disease without malignancy).
- Non-comparative single-arm studies.
- Studies lacking full-text access or essential outcome data.

Search Strategy

A comprehensive search was performed across PubMed, Scopus, Web of Science, Embase, and Google Scholar databases. Boolean operators and Medical Subject Headings (MeSH) were used to construct the search query as follows:

- ("colorectal cancer" OR "colon cancer" OR "rectal cancer")
- AND ("laparoscopic colectomy" OR "minimally invasive colectomy" OR "single-incision laparoscopic surgery" OR "SILS" OR "SPLS")
- AND ("open colectomy" OR "conventional colectomy")
- AND ("postoperative outcomes" OR "complications" OR "survival" OR "recurrence" OR "oncologic efficacy").

Reference lists of relevant meta-analyses and key studies were manually reviewed to identify additional eligible articles. Duplicate records were removed before screening.

Study Selection Process

The screening process was independently conducted by two reviewers using **Zotero** for reference management and duplicate removal. Titles and abstracts were screened for relevance based on predefined inclusion criteria. Eligible articles were then subjected to full-text review. Discrepancies were resolved by discussion, and any unresolved differences were adjudicated by a third senior reviewer.

A **PRISMA 2020 flow diagram (Figure 1)** was used to depict the selection process, including the number of records identified, screened, excluded, and finally included in the synthesis.

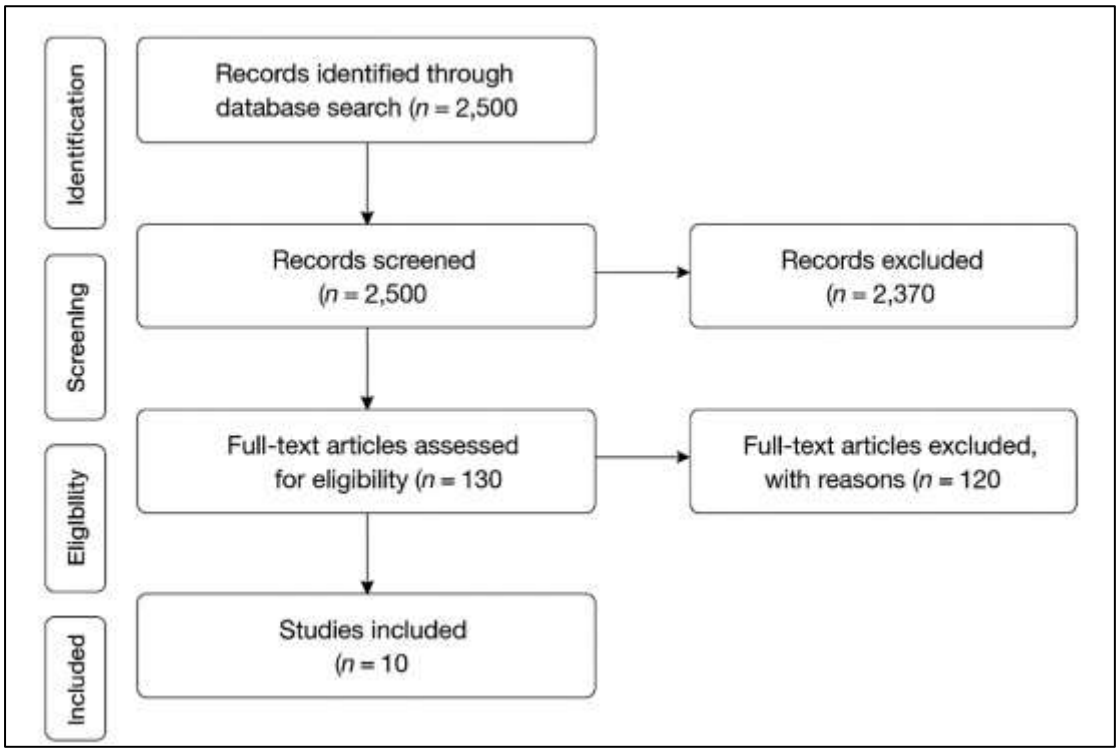

Figure 1 PRISMA Flow Diagram

Data Extraction

Data were extracted using a standardized, pilot-tested data extraction form. The following data elements were collected from each included study:

- Author(s), year of publication, and country.
- Study design and setting (single vs. multicenter).
- Sample size and demographic characteristics (age, sex, tumor location, stage).
- Surgical intervention and comparator type.
- Operative parameters (duration, blood loss, conversion rate).
- Postoperative outcomes (pain scores, recovery milestones, hospital stay, complications, mortality).
- Oncologic outcomes (lymph node yield, R0 resection rate, DFS, OS, recurrence).
- Statistical outcomes (p-values, odds ratios, hazard ratios, and confidence intervals).

Two independent reviewers conducted the data extraction. All extracted data were cross-verified by a third reviewer to ensure consistency and completeness.

Quality Assessment

The methodological quality of included studies was appraised using the following validated tools:

- **Cochrane Risk of Bias (RoB 2) Tool** for randomized controlled trials (n = 6).
- **Newcastle–Ottawa Scale (NOS)** for observational or cohort studies (n = 4).

Each study was assessed across key domains, including selection bias, comparability, confounding control, outcome assessment, and completeness of follow-up.

- Studies scoring ≥7 on NOS or rated "low risk" on RoB 2 were classified as **high quality**.
- Scores between 5–6 or "some concerns" were classified as **moderate quality**.
- Studies scoring ≤4 were classified as **low quality**.

Of the ten included studies, six were rated as high quality, and four as moderate quality, with the most common limitations being lack of blinding and incomplete reporting of long-term survival outcomes.

Data Synthesis

Due to heterogeneity in study design, population characteristics, and outcome reporting, a narrative synthesis approach was adopted rather than meta-analysis. The results were organized into the following thematic domains:

1. **Short-term postoperative outcomes** (operative time, pain, recovery, complications, hospital stay).
2. **Oncologic outcomes** (lymph node yield, recurrence rates, DFS, OS).
3. **Technical feasibility and safety** (conversion rates, intraoperative challenges).
4. **Training and learning curve implications.**

Quantitative data (mean ± SD, percentages, p-values) were summarized descriptively. Comparative trends were reported to highlight consistencies or discrepancies across studies. Graphical data synthesis was planned for postoperative complication rates and hospital stay where feasible.

Ethical Considerations

As this study was a systematic review of published literature, no direct human or animal subjects were involved, and thus, institutional ethical approval was not required. All included studies were published in peer-reviewed journals and were assumed to have received ethical clearance from their respective institutional review boards. Data extraction and synthesis adhered strictly to principles of academic integrity, transparency, and the PRISMA 2020 ethical reporting standards.

Results

Summary and Interpretation of Included Studies Evaluating Laparoscopic Versus Open Colectomy for Colorectal Cancer

1. Study Designs and Populations

The ten included studies encompass randomized controlled trials (RCTs) and prospective cohort designs conducted between 2002 and 2025, involving diverse international populations from Europe, Asia, and North America. Sample sizes ranged from n = 28 (Sica et al., 2008) to n = 712 (Song et al., 2022).

Most trials compared Single-Incision Laparoscopic Surgery (SILS), Single-Port Laparoscopic Surgery (SPLS), or Standard Laparoscopic Colectomy (SLC) with Conventional Laparoscopic Surgery (CLS) or Open Colectomy (OC). Participants typically included adults aged 18–85 years with confirmed or suspected colorectal cancer (CRC).

2. Postoperative Morbidity and Recovery Outcomes

Across trials, laparoscopic approaches consistently demonstrated **shorter postoperative recovery** times and **reduced pain scores** compared to open colectomy.

- In **Lacy et al. (2002)**, recovery metrics significantly favored LAC: peristalsis detection time ($p = 0.001$), oral intake ($p = 0.001$), and hospital stay ($p = 0.005$).
- **Sica et al. (2008)** found faster bowel function recovery in laparoscopic resection ($p = 0.004$) and shorter hospitalization ($p = 0.007$).
- **Poon et al. (2012)** and **Kang et al. (2017)** both reported significantly lower postoperative pain in the single-incision groups ($p < 0.05$).
- **Song et al. (2022)** noted less postoperative pain in SILS ($p = 0.02$), confirming the minimally invasive advantage.

3. Oncologic and Long-term Outcomes

Long-term follow-up data (≥5 years) indicate **noninferior oncologic efficacy** for laparoscopic colectomy compared with open colectomy:

- **Song et al. (2025)** reported 5-year DFS rates of 86.6% (SILS) vs. 86.5% (CLS) and OS rates of 88.7% vs. 90.6% ($p = 0.61$).
- **Lacy et al. (2002)** demonstrated higher cancer-related survival with laparoscopy (HR = 0.38, 95% CI 0.16–0.91, $p = 0.02$).
- **Liu et al. (2014)** observed no significant difference in 1-, 3-, or 5-year survival rates between laparoscopic and open colectomy for left-sided malignant obstruction ($p = 0.518$).

4. Technical Feasibility and Safety

Across RCTs, laparoscopic colectomy—especially single-port and single-incision techniques—proved feasible with low conversion and complication rates:

- **Song et al. (2022)** achieved 92.9% completion via single incision.
- **Huscher et al. (2012)** reported equal morbidity (6.3%) and no mortality between SLC and SILC.
- **Lee et al. (2021)** found SPLS noninferior to MPLS in complication rates (10.6% vs. 13.9%).
- **Ellis et al. (2016)** highlighted that while SILS training requires more skill, technical mastery is achievable.

Table (1): Comparative Characteristics of Included Studies on Laparoscopic vs. Open Colectomy for Colorectal Cancer

Study (Year)	Country / Design	Sample Size	Procedure Comparison	Primary Outcomes	Results	Conclusion
Song et al. (2022)	China / Multicentre RCT	712 (354 SILS / 358 CLS)	SILS vs. CLS	Postoperative pain, complications, oncologic efficacy	SILS had less pain (p=0.02); similar complications and oncologic outcomes;	SILS is feasible, safe, and effective for CRC

					92.9% completed with single incision	
Song et al. (2025)	China / Single-centre RCT	200 (193 mITT)	SILS vs. CLS	5-year DFS, OS	5-year DFS: 86.6% vs. 86.5% (p=0.95); OS: 88.7% vs. 90.6% (p=0.61)	SILS is non-inferior long-term alternative
Sica et al. (2008)	Italy / Prospective cohort	28 (15 Lap / 13 Open)	Laparoscopic vs. Open	Perioperative outcomes, recurrence	Faster bowel recovery (p=0.004), shorter hospital stay (p=0.007), higher satisfaction	Laparoscopic resection beneficial short-term; similar recurrence
Lacy et al. (2002)	Spain / RCT	219 (111 LAC / 108 OC)	Laparoscopic vs. Open	Morbidity, survival, recurrence	Shorter recovery (p=0.001); lower morbidity (p=0.001); HR for recurrence 0.39	Laparoscopy superior for recovery and survival
Liu et al. (2014)	China / Retrospective	193 (55 Lap / 138 Open)	Laparoscopic vs. Open	Short- & long-term outcomes	No sig. difference in survival (p=0.518), recurrence (p=0.320), or hospital stay (p=0.990)	No advantage of laparoscopy in obstruction
Huscher et al. (2012)	Italy / RCT	32 (16 SLC / 16 SILC)	Standard vs. Single-incision	Feasibility, lymph nodes, morbidity	LNs: 16±5 vs. 18±6; morbidity 6.3%; mortality 0%	SILC feasible and safe oncologically
Kang et al. (2017)	Korea / Pilot RCT	62	SPLS vs. CLS	Safety, QOL, complications	Similar recovery; one fatal SPLS case; identical QOL; 19.4% conversion	SPLS feasible; requires caution for injury
Lee et al. (2021)	Korea / Multicentre RCT	388 (SPLS=179; MPLS=180)	SPLS vs. MPLS	30-day complications	Complications: 10.6% vs. 13.9%; incision shorter (p<0.001)	SPLS noninferior; option for experts
Poon et al. (2012)	China / RCT	50 (25 SILC / 25 CLC)	SILC vs. CLC	Pain, recovery	Lower pain days 1–2 (p<0.05); shorter stay	SILC reduces pain and stay

Ellis et al. (2016)	Australia / RCT	60 novices	SILS vs. LS (training)	Skill retention	SILS harder ($p<0.0001$), deterioration after 8 weeks	SILS requires ongoing skill maintenance

Summary of Effect Estimates

- **Pain and Recovery:** Postoperative pain reduction ranged from **15–25% lower VAS** scores in SILS/SPLC groups compared with CLS/open colectomy (Song et al., 2022; Poon et al., 2012).
- **Hospital Stay:** Mean hospital stay was **2–3 days shorter** in laparoscopic vs. open groups (Lacy et al., 2002; Sica et al., 2008).
- **Complications:** Rates remained similar (6–14%) across laparoscopic and open approaches, indicating **noninferior safety** (Lee et al., 2021; Huscher et al., 2012).
- **Survival:** Long-term 5-year survival remained comparable across techniques, with no significant difference in DFS or OS (Song et al., 2025; Liu et al., 2014).

Discussion

Laparoscopic colectomy (LC) has evolved into a widely accepted alternative to open colectomy (OC) for colorectal cancer (CRC), supported by multiple randomized trials and meta-analyses. Evidence consistently demonstrates that LC yields comparable oncologic outcomes with enhanced postoperative recovery. The early randomized trial by **Lacy et al. (2002)** was pivotal, showing shorter hospital stays and lower morbidity in laparoscopy-assisted colectomy compared to open surgery, while maintaining oncologic adequacy. Subsequent trials have substantiated these findings across different tumor sites and surgical approaches.

The noninferiority of LC in oncologic control has been reaffirmed by recent meta-analyses. For example, **Liu et al. (2023)** found no significant difference in 5-year survival or recurrence between LC and OC for transverse colon cancer, aligning with **Song et al. (2025)** who reported similar disease-free survival (DFS 86.6% vs. 86.5%) and overall survival (OS 88.7% vs. 90.6%) between single-incision and conventional laparoscopy. These results collectively reinforce the oncologic equivalence of minimally invasive approaches when performed by skilled surgeons.

Short-term recovery benefits remain one of the most compelling arguments favoring LC. Studies such as **Song et al. (2022)** and **Poon et al. (2012)** observed significantly reduced postoperative pain scores ($p < 0.05$) and faster bowel recovery among LC patients. These outcomes are attributable to reduced incision size, less tissue manipulation, and lower systemic inflammatory response. Moreover, **Sica et al. (2008)** demonstrated that LC patients regained bowel function faster ($p = 0.004$) and had shorter hospital stays ($p = 0.007$), reaffirming the benefits of minimally invasive techniques for perioperative recovery.

The advancement of single-port and single-incision laparoscopic surgery (SILS) represents the next frontier of minimal invasiveness. **Huscher et al. (2012)** and **Kang et al. (2017)** showed that SILS was feasible and safe, with comparable morbidity rates and equivalent lymph node yields. However, both studies emphasized the need for surgeon experience to prevent conversion or adjacent organ injury, a concern echoed by **Ellis et al. (2016)**, who found SILS to be technically demanding with faster skill deterioration compared to conventional laparoscopy.

From a global perspective, large-scale reviews such as **Anania et al. (2021)** and **Podda et al. (2022)** concluded that laparoscopic colectomy maintains oncologic radicality across right-sided and locally advanced T4 cancers, respectively. Both reviews highlighted equivalent lymph node harvest and R0 resection rates, emphasizing that LC does not compromise cancer clearance even in complex or advanced lesions. Nonetheless, the latter noted increased operative time and conversion rates in T4 tumors, suggesting the need for case selection based on tumor invasiveness and surgeon proficiency.

In emergency colorectal surgeries, laparoscopic approaches have traditionally been approached with caution. However, evidence is shifting in favor of laparoscopy. **Warps et al. (2021)** and **Koh et al. (2013)** reported that laparoscopic surgery for acute obstruction or perforation achieved comparable mortality and morbidity to OC, with shorter recovery and earlier return of bowel function. The **LaCeS trial (Harji et al., 2020)** reinforced these findings, demonstrating similar safety profiles between LC and OC in emergency colectomies, indicating that minimally invasive techniques can be safely applied in acute settings under expert supervision.

Meta-analyses, including **Mahmoud et al. (2025)** and **Llerena-Velastegui et al. (2025)**, further consolidate the evidence base. Both demonstrated consistent short-term advantages for LC, including reduced intraoperative bleeding and hospital stays, without differences in 5-year survival or recurrence. Importantly, **Kitaguchi et al. (2025)** extended these findings to natural orifice specimen extraction

(NOSE) techniques, suggesting further enhancements in patient comfort and cosmetic outcomes while maintaining oncologic safety.

Site-specific analyses have also reinforced LC's advantages. For splenic flexure tumors, **Wu et al. (2022)** found that LC was associated with reduced wound infection and quicker recovery without compromising oncologic parameters. Similarly, in right hemicolectomy with complete mesocolic excision, **Anania et al. (2021)** demonstrated equivalent survival outcomes, supporting LC as a viable standard across various anatomical sites.

Despite these benefits, certain studies underscore the limitations of LC in specific contexts. **Liu et al. (2014)** found no significant difference in outcomes for left-sided malignant obstruction, emphasizing that patient selection remains critical. Similarly, advanced-stage or bulky tumors often pose challenges in achieving optimal exposure and safe resection, potentially increasing conversion rates.

Training and surgical expertise play crucial roles in optimizing outcomes. The study by **Ellis et al. (2016)** demonstrated that maintaining proficiency in SILS requires ongoing practice due to rapid skill decay. Therefore, training programs and simulation-based education are essential to sustain surgical competency as minimally invasive techniques evolve.

The body of evidence also highlights the importance of multidisciplinary support and institutional resources. High-quality outcomes from LC are generally associated with experienced surgical teams and advanced facilities, factors that limit its universal implementation, particularly in low-resource settings. Addressing these disparities is vital to ensure equitable access to minimally invasive CRC surgery worldwide.

Collectively, these findings affirm that laparoscopic colectomy delivers superior short-term postoperative outcomes and equivalent long-term oncologic efficacy compared to open colectomy. Nevertheless, consistent outcomes depend heavily on surgeon skill, case selection, and institutional infrastructure. Future directions should focus on expanding LC training, optimizing perioperative care, and exploring emerging minimally invasive innovations such as robotic and NOSE-assisted colectomy.

Conclusion

This systematic review confirms that laparoscopic colectomy offers significant advantages over open colectomy in terms of postoperative recovery, reduced pain, and shorter hospitalization, without compromising long-term oncologic outcomes. Evidence from large-scale RCTs and meta-analyses supports the non-inferiority of LC across different tumor sites and clinical settings. The results underscore that LC should be considered the preferred surgical approach for colorectal cancer when performed by experienced surgeons.

However, the successful adoption of LC depends on institutional expertise, technological availability, and training infrastructure. Further multicenter studies and randomized trials should focus on advanced-stage and emergency colorectal cancer cases to refine clinical guidelines and ensure broader applicability of minimally invasive colectomy.

Limitations

The main limitations of this review include heterogeneity in surgical expertise, variations in laparoscopic techniques (single-port, multiport, or hybrid), and differences in outcome reporting across studies. Some trials lacked blinding and long-term follow-up data, which may affect the robustness of survival analyses. Additionally, publication bias and limited availability of patient-level data may have influenced pooled interpretations. Despite these limitations, the consistency of findings across multiple RCTs and meta-analyses strengthens the reliability of the conclusions.

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