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RESEARCH

Laparoscopic versus open ileostomy closure: a systematic review and meta-analysis of postoperative outcomes

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Abstract

Purpose This study aims to compare laparoscopic versus open in ileostomy reversal techniques from multiple perspectives and to gain insight into the potential advantages and limitations of laparoscopic techniques and provide guidance on finding the best anastomosis for ileostomy reversal.

Methods This systematic review and meta-analysis has been pre-registered with PROSPERO. The registration number is CRD42025640754. A rigorous literature search was conducted across multiple databases, including Embase, PubMed, Cochrane Library, and China National Knowledge Infrastructure. The primary outcome measure was the incidence of overall postoperative complications, and the secondary outcomes included operative time, estimated blood loss, and the length hospital stay.

Results This research included 11 studies with a total of 867 cases, showing that the laparoscopic surgery group had a significantly lower overall complication rate compared to the open surgery group (OR = 0.40, 95% CI: 0.27–0.59, $P < 0.00001$). Further investigation of specific postoperative complications revealed that laparoscopic surgery significantly reduced the risk of bowel obstruction (OR = 0.39, 95% CI: 0.18–0.83, $P = 0.01$) and wound infection (OR = 0.41, 95% CI: 0.23–0.73, $P = 0.003$), with no significant difference observed for anastomotic leaks (OR = 0.40, 95% CI: 0.11–1.43, $P = 0.16$). Although laparoscopic surgery required a longer operative time ($P = 0.002$), it resulted in significantly shorter hospital stays ($P < 0.00001$) and did not increase estimated blood loss ($P = 0.50$). In addition, both extracorporeal laparoscopic surgery and intracorporeal laparoscopic surgery can effectively reduce the occurrence of postoperative complications and shorten the length of hospital stay compared with open surgery.

Conclusion Laparoscopic-assisted ileostomy closure (both intracorporeal and extracorporeal techniques) demonstrates significant clinical benefits, including reduced postoperative complication rates, shortened hospitalization duration, and optimized recovery trajectories.

Keywords Laparoscopy · Ileostomy · Postoperative complications · Surgical · Recovery

Xiao-Qiang Zhang and Run-xi Tang are co-first authors.

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Introduction

Ileostomy creation is a widely used surgical procedure in colorectal surgery, particularly following low anterior resections and other high-risk anastomoses [1]. This protective measure serves to divert fecal stream, thereby mitigating the severity of abdominopelvic sepsis secondary to anastomotic leakage (AL) and reducing the necessity for reoperative intervention [2, 3]. However, while loop ileostomy serves as a protective measure, it comes with significant complications that can impact patient quality of life [4]. These complications include dehydration, acute renal failure, stoma-related issues, and in some cases, even life-threatening conditions such as peritonitis or sepsis [5].

Once the ileostomy has served its purpose, reversal is necessary to restore intestinal continuity and physiological bowel function. However, this restorative procedure presents substantial surgical challenges, with reported morbidity rates ranging from 14 to 33%, with common complications including bowel obstruction, wound infections, anastomotic leakage, and intestinal fistulas [6]. Additionally, the reversal procedure typically requires a second operation, which introduces new risks and increases the overall healthcare burden. Complications such as small bowel obstruction often occur due to adhesions, and these can significantly extend the length of hospital stays and increase medical costs [7].

In recent years, various surgical techniques have been developed and applied to reduce the risk of complications associated with ileostomy reversal [8]. The spectrum of surgical approaches has evolved from conventional open procedures to minimally invasive laparoscopic techniques [9]. Based on the extent of laparoscopic involvement, the procedure can be classified into extracorporeal laparoscopic surgery (ELS) and intracorporeal laparoscopic surgery (ILS). ILS involves complete intracorporeal execution of anastomotic and surgical procedures, thereby minimizing bowel exteriorization and excessive tissue manipulation. In contrast, ELS combines the benefits of both open and laparoscopic techniques. It uses laparoscopy for exploration and adhesion release, followed by pulling the ileostomy loop outside the body for anastomosis [10] (Fig. 1).

In comparison to traditional open surgery (OS), laparoscopic-assisted ileostomy reversal has gained increasing attention due to its minimally invasive advantages [11–14]. This technique offers better visualization of the surgical field, making it easier to perform adhesion release, stoma mobilization, and hernia repair. Contemporary evidence demonstrates that laparoscopic reversal is associated with superior clinical outcomes, including reduced postoperative morbidity, accelerated recovery, and decreased length of hospitalization when compared to open procedures [15–17]. Particularly, totally laparoscopic techniques offer additional benefits by minimizing bowel exteriorization, thereby reducing the incidence of adhesion-related small bowel obstruction and incision-associated complications. However, laparoscopic surgery still presents challenges in patients with extensive adhesions or obesity, as the complexity of the procedure may increase surgical difficulty [18].

Given these variations in outcomes, this systematic review and meta-analysis aims to systematically evaluate and compare the efficacy of laparoscopic versus open ileostomy reversal techniques. The primary objective is to determine the incidence of overall postoperative complications, while secondary objectives include comparative analysis of operative time, estimated blood loss (EBL), and length of hospital stay. We aim to provide evidence-based insights into whether laparoscopic reversal offers significant clinical advantages over traditional open approaches. By synthesizing data from multiple studies, this meta-analysis will clarify the potential benefits and limitations of

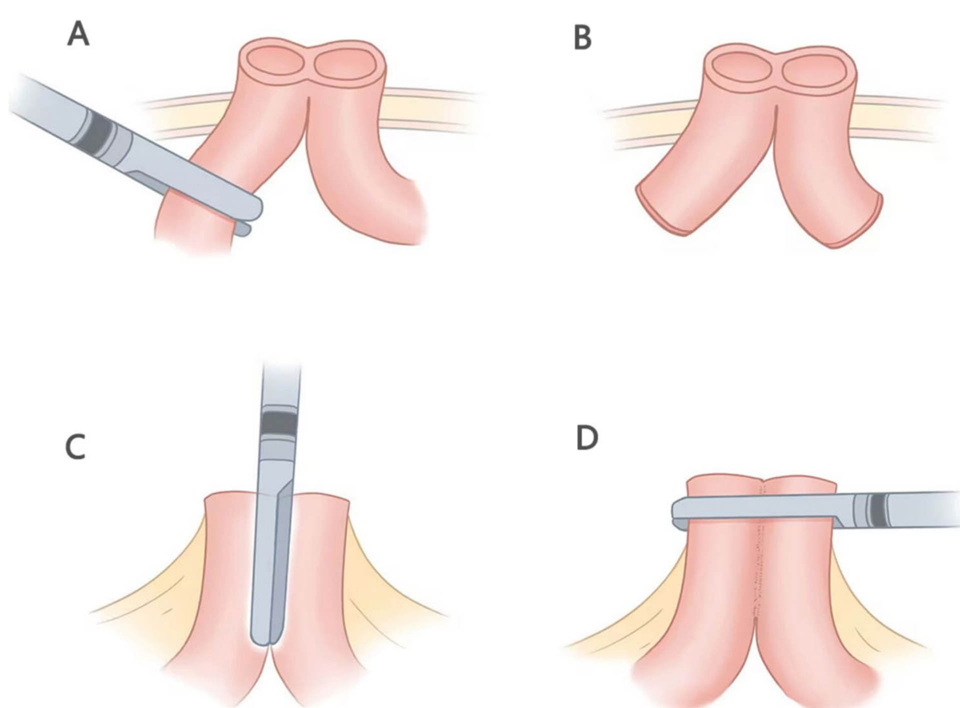

Fig. 1 Schematic diagram of laparoscopic ileostomy reversal: **A**-**B**: Mobilization and transection of the stoma loop; **C**: Side-to-side anastomosis between proximal and distal ileum; **D**: Closure of the common enterotomy in proximal and distal ileum

laparoscopic techniques, ultimately guiding decision-making in colorectal surgical practice.

Methods

This systematic review was conducted in accordance with the PRISMA Checklist (Supplementary Information) and was pre-registered with PROSPERO (CRD: 42,025,640,754). The link is https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42025640754.

Definitions

Postoperative complications were rigorously defined according to internationally accepted criteria. AL was diagnosed based on clinical evidence of enteric content leakage from the surgical anastomosis, corroborated by imaging studies (computed tomography demonstrating extraluminal contrast extravasation or abscess formation) and/or reoperation findings. Wound infection encompassed both superficial and deep surgical site infections as per CDC guidelines, requiring either (1) purulent drainage from the incision with positive microbial culture or (2) localized erythema/induration with systemic inflammatory response (body temperature > 38 °C, leukocyte count > 12,000/mm^3) necessitating therapeutic antibiotics or wound debridement.

Intestinal obstruction was defined as the radiographic confirmation of bowel dilatation (small bowel diameter > 3 cm, colon > 6 cm) with clinical signs of nausea/vomiting and failure to pass flatus/stool for > 24 h postoperatively. Estimated blood loss (EBL) was quantified through a standardized protocol combining intraoperative suction canister volumetric measurement (subtracting irrigation fluid volume) with surgical gauze weight differential (preoperative dry weight vs postoperative blood-saturated weight).

Inclusion and exclusion criteria

The studies included in this meta-analysis were conducted according to the PICOS principles, and the inclusion criteria were patients undergoing ileostomy closure due to various indications (including but not limited to neoplasia, diverticular disease, inflammatory bowel disease (IBD), etc.) (*P*); interventions involving laparoscopic ileostomy closure techniques (including ELS or ILS) (*I*); comparison with conventional open surgical closure (*C*); primary outcome measurement of overall postoperative complications and secondary outcomes including operative time, EBL, and length of hospital stay (*O*); study designs limited to randomized controlled trials (RCT) and cohort studies (*S*); and with no restrictions on publication language, sample size, or publication time.

The exclusion criteria were as follows: (1) studies with incomplete data; (2) data was repeated (when two studies had overlapped data, the study with a larger sample size would be included); (3) the single arm studies, case reports, case series, letters to the editor, comments, conferences, and reviews; (4) studies involving patients who had undergone ostomy.

Search strategy

The databases searched included Embase, Cochrane Library, PubMed, and China National Knowledge Infrastructure (CNKI). The "Laparoscopy" search terms utilized were "Laparoscopy" OR "Peritoneoscopy" OR "Celioscopy" OR "Surgical Procedures, Laparoscopic" OR "Laparoscopic Assisted Surgery" OR "Surgeries, Laparoscopic Assisted" OR "Laparoscopic Surgery". The "Ileostomy" search terms are "Ileostomy" OR "Loop Ileostomy" OR "Ileostomies, Loop" OR "Continent Ileostomy" OR "Ileostomies, Continent" OR "Tube Ileostomy" OR "Ileostomies, Tube" OR "Incontinent Ileostomy" OR "Ileostomy, Incontinent". The search was conducted until December 1, 2024.

Data extraction

Baseline data for each study were extracted, including the first author, year, country, study design content, number of patients, age, sex, body mass index (BMI), and the American Society of Anesthesiologists (ASA) grade. Postoperative complications and postoperative recovery were collected, including AL, wound infection, intestinal obstruction, length of hospital stay, operative time, and EBL. The selected articles were independently evaluated by two researchers who completed the data extraction. Both extractors were trained before starting the work. Disagreements that arose during the process were resolved by negotiation.

Assessment of risk of bias in included studies

The methodological quality of the included RCT was assessed by two reviewers using the Jadad scale, whereas the Newcastle–Ottawa Quality Assessment Scale (NOS) was used for cohort studies. The Cochrane Collaboration tool was used by two authors to assess independently the risk of bias of RCT by evaluating the following bias domains: selection, performance, detection, attrition, selective reporting, and other risks of bias. Cohort studies with a NOS score of < 7 points were classified as having a risk of bias. A third investigator adjudicated when there was a large discrepancy in the ratings. Specific scoring details of the included studies can be found in the Supplementary Materials.

Outcome definitions and subgroup stratification

The primary outcomes of the current meta-analysis were postoperative complications, including AL, wound infection, and intestinal obstruction. Secondary outcomes mainly included length of hospital stay, operation time, and EBL. Furthermore, to enhance the clinical relevance of our findings, we performed a subgroup analysis stratifying outcomes based on the surgical approach (ILS versus ELS) within the laparoscopic cohort.

Statistical analysis

Continuous variables were analyzed as mean differences (MD) with 95% confidence intervals (CI) using inverse-variance weighting. Dichotomous outcomes were expressed as odds ratios (OR) via Mantel–Haenszel (MH) weighting. Heterogeneity was quantified through I^2 statistics and Cochran's Q-test, with thresholds determining model selection: random-effects models (DerSimonian-Laird method) for substantial heterogeneity ($I^2 > 50\%$ or Q-test $P < 0.10$), and fixed-effects models otherwise.

Sensitivity analyses excluded studies with NOS scores of <7 to assess robustness. Publication bias was evaluated through funnel plot symmetry testing: Begg's rank correlation test for outcomes with < 10 studies and Egger's regression for ≥ 10 studies, with $P < 0.05$ indicating significant asymmetry. For studies reporting medians with interquartile ranges (IQRs), means and standard deviations (SD) were derived using validated conversion methods by Hozo et al. and Wan et al. [19, 20].

All analyses were performed using Review Manager 5.3 (Cochrane Collaboration) and R 4.3.1 with the "meta" and "metafor" packages, ensuring reproducibility through scripted analytic pipelines.

Results

Study characteristics and baseline information

A total of 197 studies (52 studies in PubMed, 88 studies in Embase, 55 studies in CNKI, and 2 studies in the Cochrane Library) were retrieved in the initial search, and 21 studies were screened after excluding duplicated records. After title and abstract review, 16 studies were selected for full-text evaluation, ultimately yielding 11 studies that met inclusion criteria for comparative analysis of laparoscopic versus open ileostomy reversal techniques (Fig. 2).

This systematic review and meta-analysis included 11 studies involving 867 patients. Of these, 441 patients (50.9%) underwent laparoscopic procedures, with further stratification revealing 322 cases (37.1%) treated via intracorporeal laparoscopic surgery and 119 cases (13.7%) via extracorporeal laparoscopic surgery. The open surgery group comprised 426 patients (49.1%). The comparative analyses consisted of seven studies directly comparing intracorporeal laparoscopic and open approaches, three studies evaluating extracorporeal laparoscopic versus open techniques, and one three-arm study simultaneously analyzing intracorporeal laparoscopic, open, and extracorporeal laparoscopic approaches.

There were 10 retrospective studies, one RCT. Two studies were conducted in USA [9, 15, 21], one studies were conducted in Ireland [17], and eight studies were conducted in China [16, 22–29]. The sample size and the scores of the NOS of each study are shown in Table 1. The quality of randomized controlled studies is assessed in Table 1. The baseline characteristics of the patients is detailed in Table 2.

Complications

The primary outcome of this meta-analysis was the incidence of complications following ileostomy reversal, including data from 11 studies with a total of 867 cases. The pooled analysis demonstrated a statistically significant reduction in overall postoperative complications in the laparoscopic group compared to the open surgery group (OR = 0.40, 95% CI: 0.27–0.59, $P < 0.00001$). The analysis exhibited low statistical heterogeneity ($I^2 = 22\%$, $P = 0.23$) (Fig. 3).

To further investigate specific postoperative complications between the two surgical approaches, a subgroup analysis was conducted. For bowel obstruction, 10 studies involving 833 patients showed that laparoscopic surgery significantly reduced the risk compared to open surgery (OR = 0.39, 95% CI: 0.18–0.83, $P = 0.01$), with low heterogeneity ($I^2 = 0\%$, $P = 0.76$). Similarly, the evaluation of wound infection across 10 studies ($n = 735$ patients) demonstrated a significantly lower incidence in the laparoscopic group (OR = 0.41, 95% CI: 0.23–0.73, $P = 0.003$), with negligible heterogeneity ($I^2 = 0\%$, $P = 0.99$). In addition, the analysis of AL in five studies ($n = 394$ patients) showed no statistically significant difference between the two surgical approaches (OR = 0.40, 95% CI: 0.11–1.43, $P = 0.16$), with low heterogeneity ($I^2 = 0\%$, $P = 1.00$) (Fig. 4).

Secondary outcomes

In terms of secondary outcomes, comparisons of other surgical and recovery metrics revealed that laparoscopic surgery had a significantly longer operative time than open surgery (MD = 14.61, 95% CI: 5.28–23.94, $P = 0.002$). However, the laparoscopic approach resulted in a substantially reduced length of hospital stay (MD = − 1.34, 95% CI: − 1.92–0.75, $P < 0.00001$). There was no significant

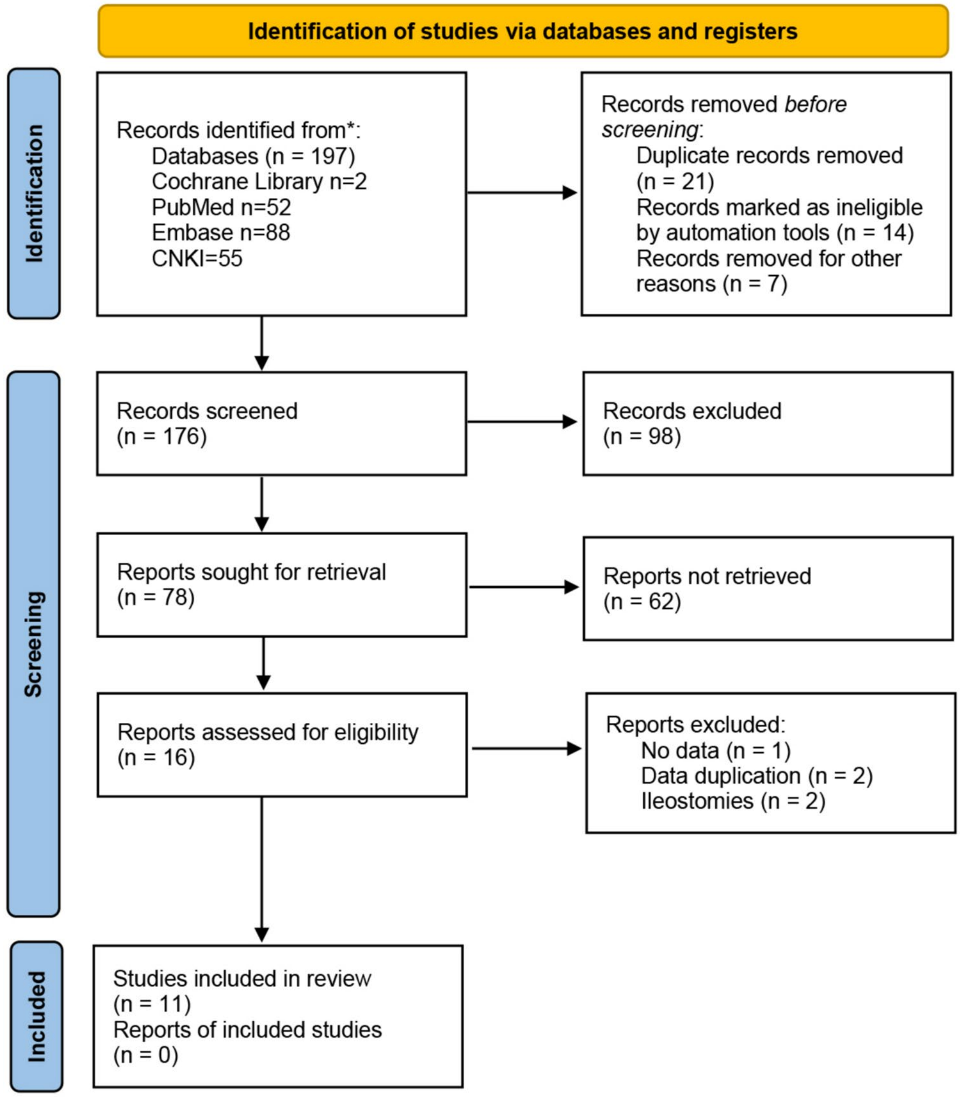

Fig. 2 PRISMA 2020 study selection flow diagram

difference in EBL between the two groups (MD = − 3.43, 95% CI: − 13.46–6.60, $P = 0.50$) (Fig. 5).

Subgroup analysis

A subgroup analysis of postoperative complications associated with laparoscopic approaches revealed a significant reduction in complication rates compared to OS. Specifically, ELS showed a marked decrease in postoperative complications (OR = 0.40, 95% CI: 0.18–0.89, $P = 0.02$). Similarly, ILS demonstrated a significant advantage (OR = 0.43, 95% CI: 0.28–0.66, $P = 0.0001$).

Further analysis of operative outcomes revealed nuanced differences. For operative time, ELS was associated with a non-significant prolongation of 27.16 min compared to OS (95% CI: − 8.45–62.77, $P = 0.13$). In contrast, ILS exhibited a statistically significant increase of 11.15 min over OS (95% CI: 3.73–18.57, $P = 0.003$). Despite longer operative durations, both laparoscopic subgroups demonstrated superior clinical benefits in hospitalization. Hospitalization time was notably shorter in ELS (MD = − 1.76, 95% CI: − 3.49–0.04, $P = 0.05$) and ILS (MD = − 1.25, 95% CI: − 1.88–0.61, $P = 0.0001$) (Fig. 6).

Sensitivity analysis and publication bias

Funnel plots and Begg's test were used to assess the publication bias of the included studies. For overall complications (Begg's $P = 0.2429$; Egger's $P = 0.2555$), bowel obstruction (Begg's $P = 0.7884$; Egger's $P = 0.3470$), and wound infection (Begg's $P = 0.5312$; Egger's $P = 0.8614$), neither test indicated significant asymmetry ($P > 0.05$ for all comparisons). After sensitivity analysis of postoperative overall complications, the incidence of postoperative overall complications in the laparoscopic group was still lower than that in the laparotomy group, and there were significant

Table 1 Characteristics of the studies included in the meta-analysis

Author	Year	Country	Study type	Language	Surgical modality	*N*	AL	Ileus	Wound infections	LOS (day)	Duration of surgery (min)	EBL (ml)	NOS
Liang Guogang	2024	China	Retrospective Single center	Chinese	OS	30	1	3	7	8.1 ±2.3	85.1 ±22.5	23.8 ±19.5	7
					ILS	27	0	1	3	5.3 ±1.1	103.4 ±12.6	5 ±7.8	
Luo Shou	2021	China	Retrospective Single center	Chinese	OS	33	NA	2	5	7.36 ±2.3	89.4 ±17.5	NA	7
					ILS	27	NA	0	1	6 ±1.6	98 ±24.5	NA	
Ning Wu	2016	China	Retrospective Single center	Chinese	OS	41	NA	4	2	8.59 ±5.56	100.39 ±37.06	39.46 ±65.39	7
					ELS	25	NA	0	0	7.8 ±1.83	163.4 ±59.51	59.6 ±52.2	
Royds	2013	Ireland	RCT Single center	English	OS	34	NA	3	0	5 ±2.8	50 ±57.3	NA	NA
					ELS	40	NA	1	2	4 ±3.1	65 ±46.9	NA	
Su	2020	China	Retrospective Single center	English	OS	34	1	1	9	7 ±2.8	77.5 ±111.2	20 ±57.3	9
					ILS	30	0	0	2	6 ±2.6	88 ±39.6	20 ±26.8	
Sujatha-Bhaskar, S	2019	USA	Retrospective Single center	English	OS	50	NA	1	NA	3.4 ±2.3	140.7 ±47.1	26.7 ±32.4	9
					ILS	33	NA	0	NA	2.5 ±0.9	172.4 ±42.2	24.2 ±20.7	
					ELS	49	NA	4	NA	3.8 ±3.8	157.6 ±39.9	25.7 ±17.7	
Wan, J	2021	China	Retrospective Single center	English	OS	12	0	NA	2	10.8 ±3.7	142.5 ±41.7	NA	9
					ILS	48	1	NA	2	10.3 ±4	128.2 ±41.7	NA	
Wang, G	2024	China	Retrospective Single center	Chinese	OS	13	NA	0	3	12.7 ±3.3	139.7 ±39.2	94.2 ±88.1	7
					ELS	21	NA	1	4	8.9 ±2.2	142.5 ±45.4	73.1 ±91.3	
Xu, Z	2022	China	Retrospective Multi-center	English	OS	59	NA	1	6	6 ±1.5	84.3 ±24.3	20 ±15.2	7
					ILS	48	NA	0	3	4.9 ±2.86	88.5 ±28.9	20 ±15.3	
Yang Xiao-bo	2020	China	Retrospective Single center	Chinese	OS	40	1	6	4	7.5 ±1.6	143.5 ±48.9	35.7 ±32.4	9
					ILS	40	0	0	1	6.7 ±1.3	170.4 ±52.2	40.2 ±21.7	
Young	2015	USA	Retrospective Single center	English	OS	80	4	1	2	5.7 ±4.6	93 ±46	40 ±81	9
					ILS	53	1	1	0	5.3 ±4	109 ±45	31 ±32	

Abbreviations: *NA* measurement not available, *NOS* Newcastle–Ottawa Scale, *USA* the United States of America, *RCT* randomized controlled trial, *OS* open surgery, *ELS* extracorporeal laparoscopic surgery, *ILS* intracorporeal laparoscopic surgery, *AL* anastomotic leakage, *LOS* length of stay, *EBL* estimated blood loss

Table 2 Summary of characteristics between laparoscopy group and laparotomy group

Characteristics	Studies	Participants	MD/OR (95% Cl)	Model	Heterogeneity
Age	9	353/383	1.12 [– 0.75, 2.99]; $P = 0.24$	FE	$I^2 = 6\%$; $P = 0.38$
Male	11	441/476	0.99 [0.75, 1.30]; $P = 0.94$	FE	$I^2 = 0\%$; $P = 0.88$
BMI	8	350/395	0.56 [0.01, 1.11]; $P = 0.04$	FE	$I^2 = 0\%$; $P = 0.69$
Comorbidities					
Hypertension	7	305/384	1.24 [0.89, 1.73]; $P = 0.20$	FE	$I^2 = 39\%$; $P = 0.12$
Diabetes mellitus (DM)	7	305/384	1.28 [0.86, 1.91]; $P = 0.22$	FE	$I^2 = 50\%$; $P = 0.05$
Chronic hepatic or renal disease	4	213/273	1.00 [0.28, 3.61]; $P = 0.99$	FE	$I^2 = 0\%$; $P = 0.66$
Cardiac disease	6	280/343	0.64 [0.34, 1.19]; $P = 0.16$	FE	$I^2 = 12\%$; $P = 0.34$
Smoking	3	175/220	0.78 [0.40, 1.51]; $P = 0.46$	FE	$I^2 = 0\%$; $P = 0.65$
ASA					
1–2	4	166/139	0.82 [0.32, 2.13]; $P = 0.68$	FE	$I^2 = 0\%$; $P = 0.97$
3–4	4	166/139	1.22 [0.47, 3.15]; $P = 0.68$	FE	$I^2 = 0\%$; $P = 0.97$
Pathology					
Malignant tumor	9	393/433	2.34 [1.60, 3.40]; $P < 0.0001$	FE	$I^2 = 0\%$; $P = 0.86$
Diverticular disease	7	300/313	0.54 [0.18, 1.67]; $P = 0.29$	FE	$I^2 = 0\%$; $P = 0.64$
Inflammatory bowel disease	9	361/366	0.61 [0.24, 1.53]; $P = 0.29$	RE	$I^2 = 65\%$; $P = 0.04$
Other	7	300/313	0.72 [0.35, 1.47]; $P = 0.37$	FE	$I^2 = 0\%$; $P = 0.94$
Time to reversal (days)	6	223/234	17.03 [– 7.15, 41.21]; $P = 0.17$	FE	$I^2 = 3\%$; $P = 0.40$
Preoperative neoadjuvant therapy	6	280/346	1.34 [0.96, 1.88]; $P = 0.08$	FE	$I^2 = 45\%$; $P = 0.09$
Antecedent surgery approach					
Open	3	135/180	0.22 [0.11, 0.42]; $P < 0.00001$	FE	$I^2 = 0\%$; $P = 0.44$
Laparoscopic	3	135/180	1.18 [0.34, 4.12]; $P = 0.79$	RE	$I^2 = 85\%$; $P = 0.001$
Laparoscopic/robotic	3	135/180	2.55 [1.01, 6.42]; $P = 0.05$	RE	$I^2 = 73\%$; $P = 0.03$

Abbreviations: *OR* odds ratio, *MD* mean difference, *Cl* confidence intervals, *ASA* American Society of Anesthesiologists classification of physical status, *BMI* body mass index, *FE* the fixed effects model, *RE* the random effects model

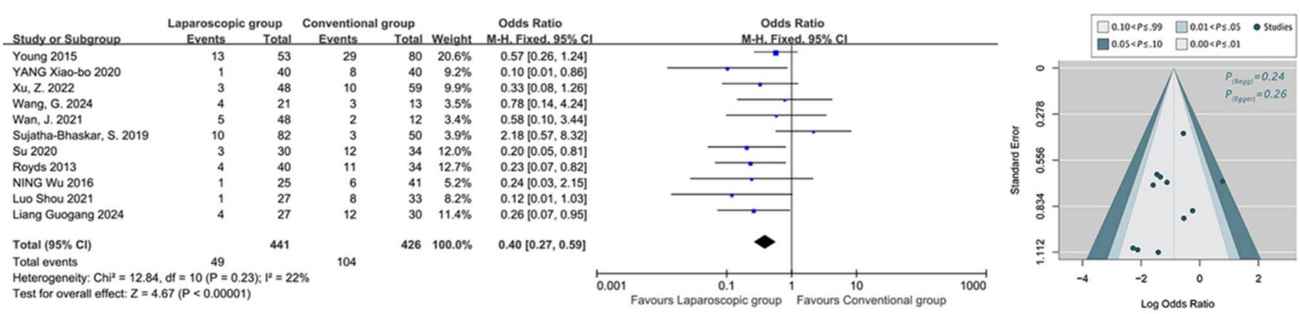

Fig. 3 The overall complications in the laparoscopic surgery group and laparotomy group

differences between the data (OR = 0.46, 95% CI: 0.29–0.74, $P = 0.001$) (Fig. 7).

Discussion

This meta-analysis, which included data from 11 studies comprising a total of 867 cases, demonstrated that the overall postoperative complication rate in the laparoscopic surgery group was significantly lower than in the open surgery group, regardless of whether ILS or ELS techniques were used. Subgroup analyses revealed that laparoscopic surgery significantly reduced the risks of bowel obstruction and wound infection, although no significant difference was found between the two groups in terms of anastomotic leakage. While the surgical time in the laparoscopic surgery group was slightly longer, the length of hospital stay was notably shorter, underscoring the advantages of laparoscopic techniques in enhancing postoperative recovery.

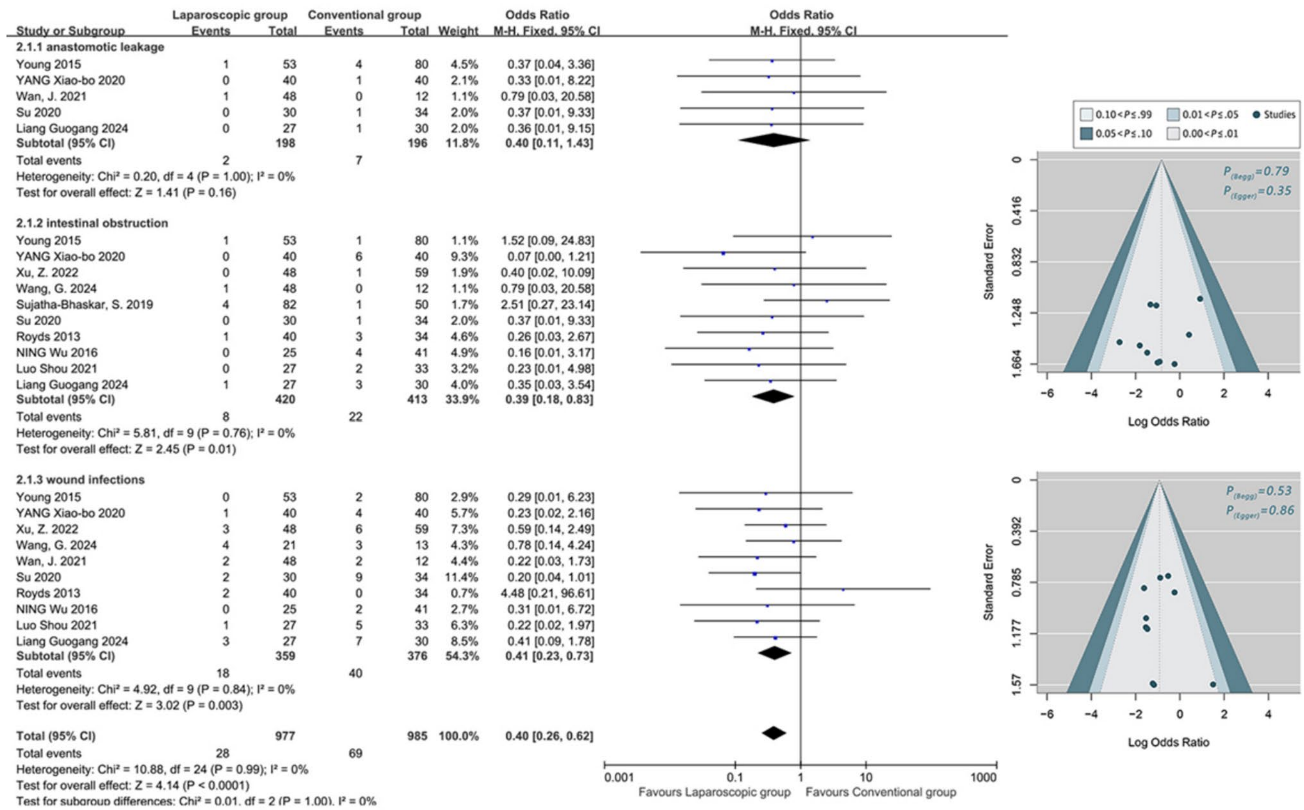

Fig. 4 The specific postoperative complications in the laparoscopic surgery group and laparotomy group included anastomotic leakage, intestinal obstruction, and wound infection

A randomized controlled trial by Royds et al. demonstrated that the integration of laparoscopic exploration and adhesiolysis with conventional ileostomy closure significantly reduces postoperative morbidity and enhances intestinal functional recovery [17]. Adhesive small bowel obstruction represents a prevalent complication following ileostomy reversal [30, 31]. Poskus et al. reported that among 132 patients who underwent open ileostomy, 6.8% developed bowel obstruction [32]. For traditional open surgery, 8.1% of patients who had ileostomy reversal were readmitted, with half of them requiring reoperation [31]. In contrast, laparoscopic techniques provide superior visualization of the surgical area, facilitating precise adhesiolysis and meticulous stoma site dissection [33]. This technique also enables smaller incisions and better wound closure (e.g., purse-string sutures), reducing trauma [34–36]. This comprehensive approach not only reduce small bowel-related complications but also mitigates the risk of internal hernia [37].

Furthermore, a significant proportion of patients undergoing protective ileostomy have a history of colorectal cancer resection. Laparoscopic exploration provides an opportunity for comprehensive abdominal cavity assessment, potentially identifying occult tumor recurrences or metastatic lesions that may evade detection through conventional imaging modalities. These tumors may not be detectable through preoperative imaging, and suspicious lesions may require biopsy for further investigation.

Russek et al. reported that laparoscopic ileostomy closure usually typically requires longer operative times compared to conventional open procedures. However, in patients without complex abdominal pathology, the duration of laparoscopic surgery has become comparable to open techniques [18]. With increased surgical experience, better coordination, and improved techniques, laparoscopic surgery times are expected to decrease significantly. Importantly, laparoscopic techniques minimize direct bowel manipulation and reduce visceral exposure time, thereby preserving the abdominal microenvironment and promoting faster restoration of gastrointestinal function. Mari et al. have demonstrated an association between intracorporeal approach and reduction in the surgical stress response which clinically manifests as earlier gastrointestinal recovery, shortening hospital stays [38].

In obese patients with substantial abdominal wall thickness, exteriorizing the stoma after releasing the intestinal loop can be particularly challenging, as exposure of the intestinal loop and mesentery may lead to excessive stretching and an increased risk of tissue damage [39]. Therefore,

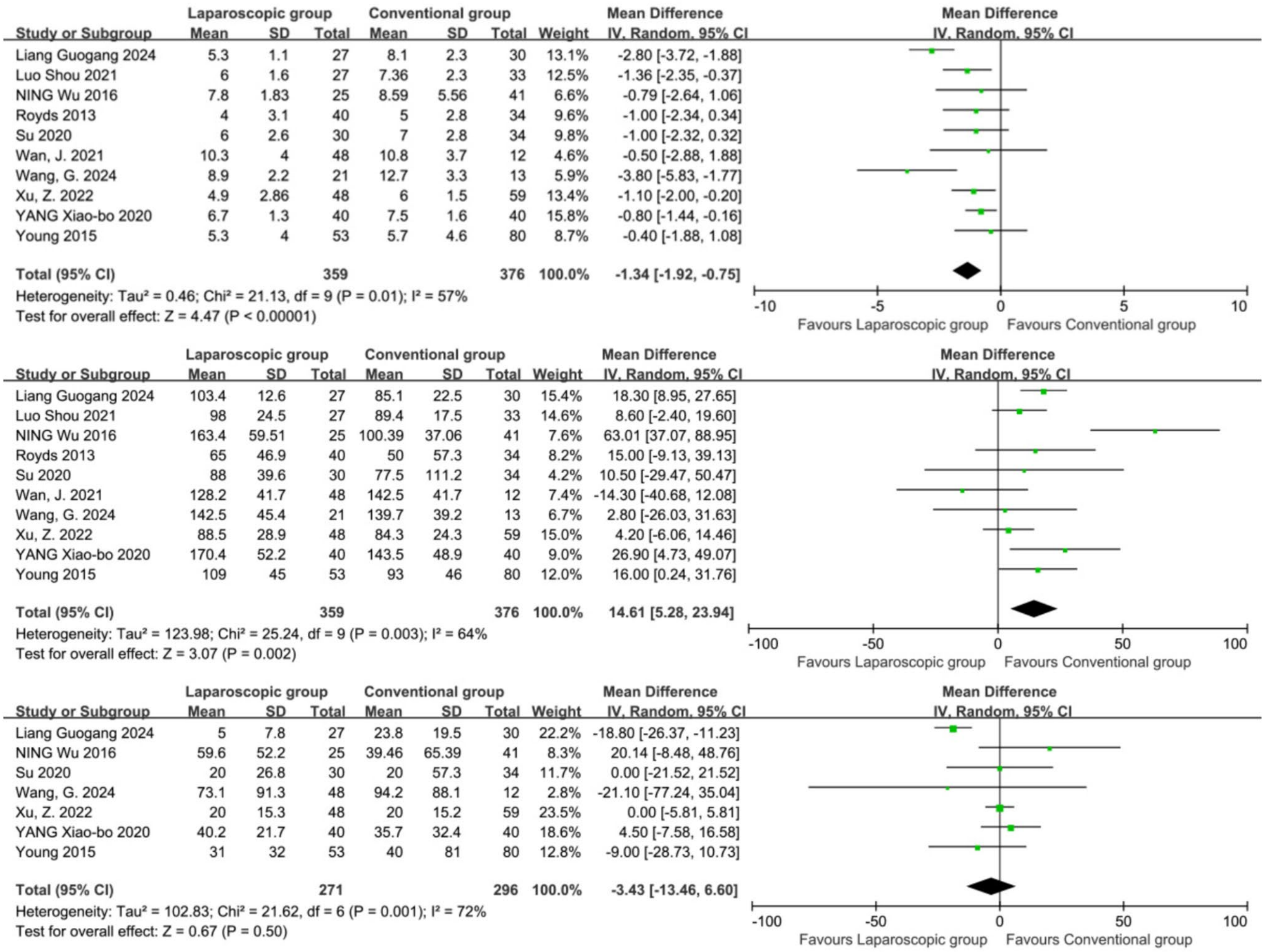

Fig. 5 Secondary outcomes in the laparoscopic and laparotomy groups included length of hospital stay, duration of surgery, and estimated blood loss

ILS is generally considered a safer and more straightforward surgical option. Moreover, studies have confirmed that laparoscopic procedures offer significant advantages in reducing the risk of surgical site infections among obese patients.

Regarding economic considerations, while laparoscopic procedures currently incur higher direct costs, ongoing advancements in medical device technology are anticipated to reduce the expense of intracorporeal stapling devices. Furthermore, laparoscopic surgery can decrease hospitalization duration and expedite postoperative recovery facilitating earlier return to normal activities, potentially offsetting initial costs through reduced overall healthcare utilization. As a result, the cost gap between the two surgical approaches may gradually narrow. Research by Crawshaw et al. has also demonstrated a strong correlation between minimally invasive colectomy and a significant reduction in healthcare expenditures [40].

Notably, a recent meta-analysis by Rondelli et al. reported that only ILS showed advantages in reducing postoperative complications and shortening hospitalization, whereas ELS exhibited comparable outcomes to OS [41]. Contrastingly, the meta-analysis by McKechnie et al. revealed that laparoscopic stoma reversal may effectively reduce postoperative hospitalization duration and superficial surgical site infection rates without prolonging operative time [42]. Our updated study, employing an expanded sample size and rigorous subgroup analyses, demonstrated that laparoscopic surgery prolongs operative time but significantly shortens hospital stays. Furthermore, both ILS and ELS approaches demonstrated superiority over OS. These findings hold significant clinical implications for surgical practice. Given the technical complexity and steeper learning curve associated with ILS, ELS may serve as an effective transitional strategy for surgeons acquiring proficiency in minimally invasive techniques.

Although laparoscopic surgery enables precise control of the surgical area and reduces the complexity of bowel processing, it also has limitations. As an example,

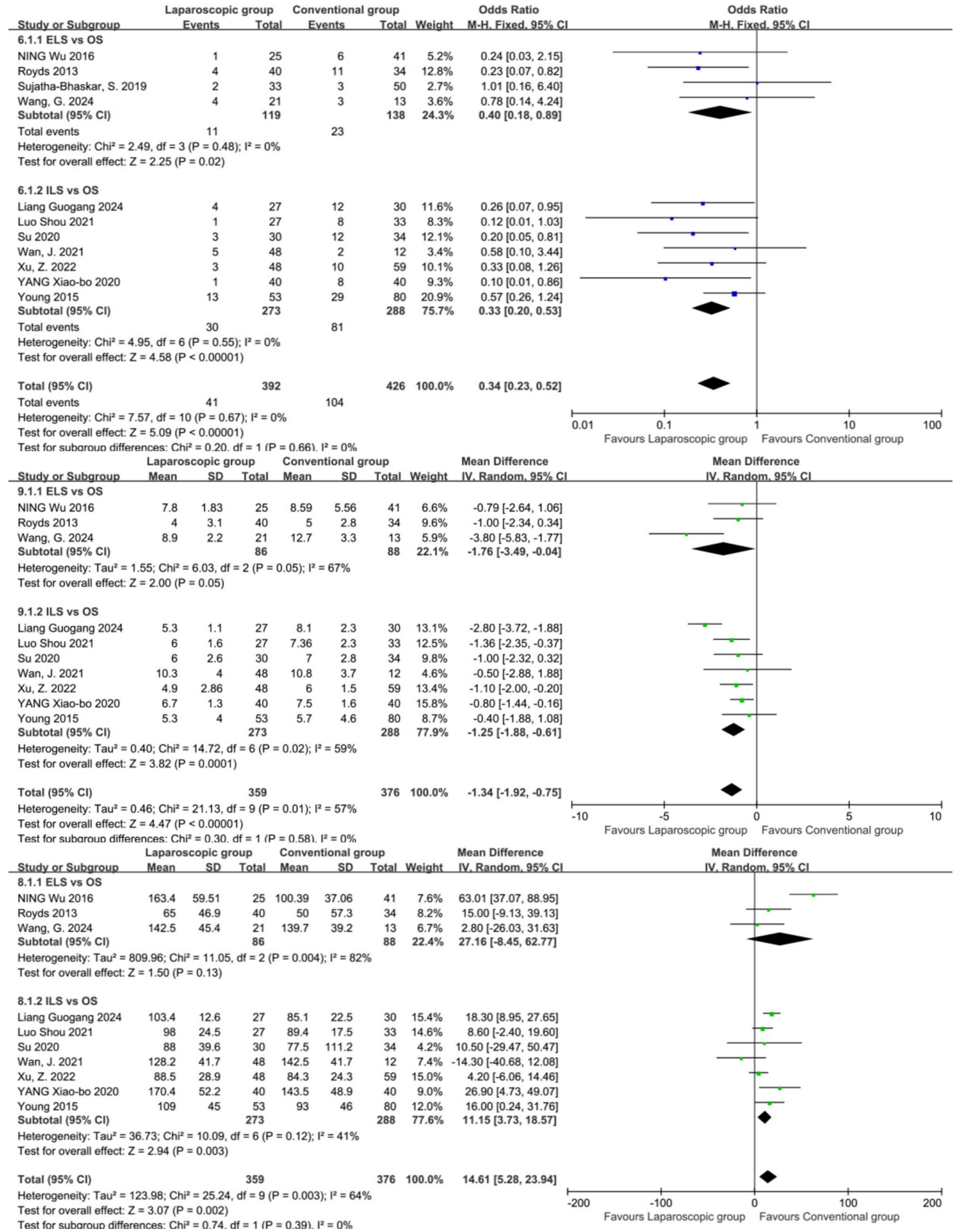

Fig. 6 Overall postoperative complications, length of hospital stay, and duration of surgery in ELS vs OS and ILS vs OS

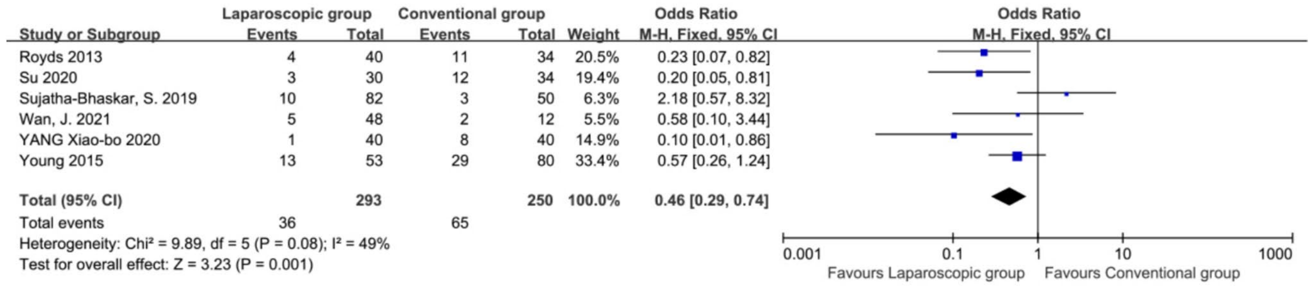

Fig. 7 Sensitivity analysis of overall postoperative complications

laparoscopic adhesion release carries a risk of complications including visceral injury and hemorrhage [43]. However, with the stepped trocar placement strategy, the auxiliary hole is prioritized for adhesion release and then the main operating hole, combined with continuous intraoperative intra-abdominal pressure monitoring, can reduce bowel puncture injuries by 67%. In ileostomy reduction, adhesions are loosened, the stoma site is removed, and the intestine has adequate mobility. For obese patients or those with thickened abdominal walls, the incision may need to be enlarged to provide adequate surgical space, which in turn may increase the risk of complications associated with the incision.

This meta-analysis has several limitations. First, the inclusion of only one randomized controlled trial and limited observational study samples reduces the robustness of conclusions. Second, significant heterogeneity exists across studies: (1) unreported prior stoma creation methods (open/laparoscopic) may confound laparoscopic advantages; (2) divergent preoperative diagnoses (colorectal neoplasia/diverticular disease/IBD) could modulate complication risks, yet disease-stratified data were absent; (3) open surgery cohorts lacked granular reporting on anastomotic techniques (handsewn/stapled), introducing potential methodological bias; (4) original studies universally omitted long-term outcomes and diagnosis-specific complications. These limitations underscore the need for large-scale prospective studies with standardized reporting protocols.

This study substantiates the clinical advantages of laparoscopic-assisted ileostomy reversal, demonstrating significant benefits in reducing postoperative morbidity, decreasing hospitalization duration, and enhancing recovery outcomes. However, the widespread application of this technique requires further support from randomized controlled trials to validate its efficacy across different patient populations. With ongoing technical advancements and the accumulation of surgical experience, the efficiency and safety of laparoscopic surgery are expected to improve further.

Conclusion

Current clinical evidence suggests that laparoscopic-assisted ileostomy closure demonstrates significant advantages in reducing postoperative complications, shortening hospital stays, and accelerating recovery. With advancements in technique and accumulation of surgical experience, the procedure is expected to achieve further optimization.

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Author contribution All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Xiao-Qiang Zhang and Run-Xi Tang. Quality assessments was finished by Xiao-Qiang Zhang, Dong-Hao Pan and Run-Xi Tang. The first draft of the manuscript was written by Xiao-Qiang Zhang and Run-Xi Tang. Review and editing were performed by Guang-Yan Ji, Hua Tang, and Lei-Yuan Shuai. The chart production was completed by Xiao-Qiang Zhang, Run-xi Tang, Ming-Yang Xia and Chao-Fu Zhang. Xiao-Qiang Zhang and Run-Xi Tang contributed equally to this study. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

Data availability All research data can be found in our figures and tables.

Declarations

Ethics approval Not applicable.

Consent to participate Not applicable.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

References

1. Wu SW, Ma CC, Yang Y (2014) Role of protective stoma in low anterior resection for rectal cancer: a meta-analysis. World J Gastroenterol 20:18031–18037. https://doi.org/10.3748/wjg.v20.i47.18031
2. Karanjia ND, Corder AP, Bearn P, Heald RJ (1994) Leakage from stapled low anastomosis after total mesorectal excision for carcinoma of the rectum. Br J Surg 81:1224–1226. https://doi.org/10.1002/bjs.1800810850
3. Choi DH, Hwang JK, Ko YT et al (2010) Risk factors for anastomotic leakage after laparoscopic rectal resection. Journal of the Korean Society of Coloproctology 26:265–273. https://doi.org/10.3393/jksc.2010.26.4.265
4. García-Botello SA, García-Armengol J, García-Granero E et al (2004) A prospective audit of the complications of loop ileostomy construction and takedown. Dig Surg 21:440–446. https://doi.org/10.1159/000083471
5. Chow A, Tilney HS, Paraskeva P et al (2009) The morbidity surrounding reversal of defunctioning ileostomies: a systematic review of 48 studies including 6,107 cases. Int J Colorectal Dis 24:711–723. https://doi.org/10.1007/s00384-009-0660-z
6. Bain IM, Patel R, Keighley MR (1996) Comparison of sutured and stapled closure of loop ileostomy after restorative proctocolectomy. Ann R Coll Surg Engl 78:555–556
7. Gatt M, Reddy BS, Mainprize KS (2007) Day-case stoma surgery: is it feasible? Surgeon 5:143–147. https://doi.org/10.1016/s1479-666x(07)80041-2
8. Hull TL, Kobe I, Fazio VW (1996) Comparison of handsewn with stapled loop ileostomy closures. Dis Colon Rectum 39:1086–1089. https://doi.org/10.1007/bf02081405
9. Young MT, Hwang GS, Menon G et al (2015) Laparoscopic versus open loop ileostomy reversal: is there an advantage to a minimally invasive approach? World J Surg 39:2805–2811. https://doi.org/10.1007/s00268-015-3186-2
10 Milone M, Elmore U, Di Salvo E et al (2015) Intracorporeal versus extracorporeal anastomosis. Results from a multicentre comparative study on 512 right-sided colorectal cancers. Surg Endoscopy 29:2314–2320. https://doi.org/10.1007/s00464-014-3950-7
11. Kennedy GD, Heise C, Rajamanickam V, Harms B, Foley EF (2009) Laparoscopy decreases postoperative complication rates after abdominal colectomy: results from the national surgical quality improvement program. Ann Surg 249:596–601. https://doi.org/10.1097/SLA.0b013e31819ec903
12. Veldkamp R, Kuhry E, Hop WC et al (2005) Laparoscopic surgery versus open surgery for colon cancer: short-term outcomes of a randomised trial. Lancet Oncol 6:477–484. https://doi.org/10.1016/s1470-2045(05)70221-7
13. Abeles A, Kwasnicki RM, Darzi A (2017) Enhanced recovery after surgery: current research insights and future direction. World J Gastrointestinal Surg 9:37–45. https://doi.org/10.4240/wjgs.v9.i2.37
14. Laudicella M, Walsh B, Munasinghe A, Faiz O (2016) Impact of laparoscopic versus open surgery on hospital costs for colon cancer: a population-based retrospective cohort study. BMJ Open 6:e012977. https://doi.org/10.1136/bmjopen-2016-012977
15. Sujatha-Bhaskar S, Whealon M, Inaba CS et al (2019) Laparoscopic loop ileostomy reversal with intracorporeal anastomosis is associated with shorter length of stay without increased direct cost. Surg Endosc 33:644–650. https://doi.org/10.1007/s00464-018-6518-0
16. Su H, Luo S, Xu Z et al (2021) Satisfactory short-term outcome of total laparoscopic loop ileostomy reversal in obese patients: a comparative study with open techniques. Updat Surg 73:561–567. https://doi.org/10.1007/s13304-020-00890-8
17. Royds J, O'Riordan JM, Mansour E, Eguare E, Neary P (2013) Randomized clinical trial of the benefit of laparoscopy with closure of loop ileostomy. Br J Surg 100:1295–1301. https://doi.org/10.1002/bjs.9183
18. Russek K, George JM, Zafar N, Cuevas-Estandia P, Franklin M (2011) Laparoscopic loop ileostomy reversal: reducing morbidity while improving functional outcomes. JSLS : J Soc Laparoendoscopic Surg 15:475–479. https://doi.org/10.4293/108680811x13176785203950
19. Wan X, Wang W, Liu J, Tong T (2014) Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol 14:135. https://doi.org/10.1186/1471-2288-14-135
20. Hozo SP, Djulbegovic B, Hozo I (2005) Estimating the mean and variance from the median, range, and the size of a sample. BMC Med Res Methodol 5:13. https://doi.org/10.1186/1471-2288-5-13
21. Yellinek S, Krizzuk D, Gilshtein H et al (2021) Early postoperative outcomes of diverting loop ileostomy closure surgery following laparoscopic versus open colorectal surgery. Surg Endosc 35:2509–2514. https://doi.org/10.1007/s00464-020-07662-w
22. Xu Z, Luo S, Su H et al (2022) Satisfactory short-term outcomes of totally laparoscopic ileostomy reversal compared to open surgery in colorectal cancer patients. Front Surg 9:1076874. https://doi.org/10.3389/fsurg.2022.1076874
23. Y. J. Wang, K. H. Lin, J. C. Kang, et al. Benefits of laparoscopy-assisted ileostomy in colorectal cancer patients with bowel obstruction. World J Clin Cases. 2023; 11: 5660–5665 https://doi.org/10.12998/wjcc.v11.i24.5660
24. Wang G, Yao X, Gao J (2024) The therapeutic experience of laparoscopic end ileostomy reversal surgery for Crohn′s disease. Chinese J Inflamm Bowel Dis 8:293–295. https://doi.org/10.3760/cma.j.cn101480-20230811-00007
25. Wan J, Yuan XQ, Wu TQ et al (2021) Laparoscopic vs open surgery in ileostomy reversal in Crohn's disease: a retrospective study. World J Gastroint Surg 13:1414–1422. https://doi.org/10.4240/wjgs.v13.i11.1414
26. Y. Xiao-bo, Z. En-lin , L. Jian 2020 Comparative study of completely laparoscopic and open single lumen ileostomy reversal J Laparoscopic Surg 2020;25 603–607 https://doi.org/10.13499/j.cnki.fqjwkzz.2020.08.603
27. N. Wu, M. F. -qiang ,W. W. -yue. Comparative study of the efficacy between laparoscopic loop ileostomy reversal and standard loop ileostomy reversal. J China-Japan Friendship Hospital. 2016; 30: 331–334
28. Shou L, Hao S, Zheng X et al (2021) Retrospective analysis of short-term curative effect of total laparoscopic and open loop ileostomy reversal. Chin J Colorec Dis (Electronic Edition) 10:357–361
29. L. Guogang, Z. Yunpeng, W. Longhui, et al. Clinical effectiveness analysis of laparoscopic loop ileostom closure: a single-center retrospective study. J Colorectal Anal Surg. 2024; 30: 557–561 https://doi.org/10.19668/j.cnki.issn1674-0491.2024.05.008
30. S. Szomstein, E. Lo Menzo, C. Simpfendorfer, N. Zundel and R. J. Rosenthal. Laparoscopic lysis of adhesions. World J Surg. 2006; 30: 535–540 https://doi.org/10.1007/s00268-005-7778-0
31. Burns EM, Currie A, Bottle A et al (2013) Minimal-access colorectal surgery is associated with fewer adhesion-related

admissions than open surgery. Br J Surg 100:152–159. https://doi.org/10.1002/bjs.8964
32. Poskus E, Kildusis E, Smolskas E, Ambrazevicius M, Strupas K (2014) Complications after loop ileostomy closure: a retrospective analysis of 132 patients. Viszeralmedizin 30:276–280. https://doi.org/10.1159/000366218
33. Xu Z, Luo S, Su H et al (2023) Application of laparoscopic surgery in ileostomy reversal. Cancer Res Prev Treat 50:334–337. https://doi.org/10.3971/j.issn.1000-8578.2023.22.1257
34. Suh YJ, Park JW, Kim YS, Park SC, Oh JH (2014) A beneficial effect of purse-string skin closure after ileostomy takedown: a retrospective cohort study. Int J Surg (London, England) 12:615–620. https://doi.org/10.1016/j.ijsu.2014.04.008
35. Klink CD, Wünschmann M, Binnebösel M et al (2013) Influence of skin closure technique on surgical site infection after loop ileostomy reversal: retrospective cohort study. Int J Surg (London, England) 11:1123–1125. https://doi.org/10.1016/j.ijsu.2013.09.003
36. Dusch N, Goranova D, Herrle F, Niedergethmann M, Kienle P (2013) Randomized controlled trial: comparison of two surgical techniques for closing the wound following ileostomy closure: purse string vs direct suture. Colorectal Dis 15:1033–1040. https://doi.org/10.1111/codi.12211
37. Obi M, Beffa L, Melland-Smith M et al (2024) The rate of ileostomy site incisional hernias: more common than we think? Hernia 28:2311–2320. https://doi.org/10.1007/s10029-024-03163-0
38. Mari GM, Crippa J, Costanzi ATM et al (2018) Intracorporeal anastomosis reduces surgical stress response in laparoscopic right hemicolectomy: a prospective randomized trial. Surg Laparosc, Endosc Percutaneous Tech 28:77–81. https://doi.org/10.1097/sle.0000000000000506
39. Lancaster GA, Dodd S, Williamson PR (2004) Design and analysis of pilot studies: recommendations for good practice. J Eval Clin Pract 10:307–312. https://doi.org/10.1111/j.2002.384.doc.x
40. Crawshaw BP, Chien HL, Augestad KM, Delaney CP (2015) Effect of laparoscopic surgery on health care utilization and costs in patients who undergo colectomy. JAMA Surg 150:410–415. https://doi.org/10.1001/jamasurg.2014.3171
41. F. Rondelli, A. Gemini, S. Cerasari, et al. Laparoscopic vs. open loop ileostomy reversal: a meta-analysis of randomized and non-randomized studies. Langenbecks Arch Surg. 2023; 408: 329 https://doi.org/10.1007/s00423-023-03075-0
42. McKechnie T, Tessier L, Anpalagan T et al (2023) Laparoscopic versus open loop ileostomy reversal: a systematic review and meta-analysis. Surg Pract Sci 13:100161. https://doi.org/10.1016/j.sipas.2023.100161
43. ten Broek RP, van den Beukel BA, van Goor H (2013) Comparison of operative notes with real-time observation of adhesiolysis-related complications during surgery. Br J Surg 100:426–432. https://doi.org/10.1002/bjs.8994