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Meta-Analysis

Effect of enhanced recovery after surgery protocols on postoperative length of stay and complication rates in elective colorectal surgery: a systematic review and meta-analysis of randomized controlled trials

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ABSTRACT

Enhanced recovery after surgery (ERAS) protocols are standardized multimodal perioperative care pathways designed to reduce surgical stress, accelerate recovery, and improve outcomes. Originally developed for colorectal surgery, ERAS has been associated with shorter hospital stays and fewer complications, but evolving evidence and protocol variations warrant updated synthesis of high-quality randomized controlled trials. This systematic review and meta-analysis, conducted according to PRISMA guidelines and registered in PROSPERO (ID: 1038955), included randomized controlled trials published since 2010 comparing ERAS protocols (≥12 elements per ERAS® Society guidelines) with conventional care in elective colorectal surgery. The primary and secondary outcomes were postoperative length of stay and complications, respectively. Five trials met the eligibility criteria. Pooled analysis showed ERAS was associated with a non-significant reduction in length of stay (mean difference= –2.68 days; 95% CI: –5.70 to 0.34; p=0.082; I^2=96.66%), with sensitivity analysis excluding estimated data yielding a similar non-significant effect (mean difference = –3.89 days; 95% CI: –8.54 to 0.77; p=0.102). For complications, the pooled log odds ratio was –0.58 (95% CI: –1.22 to 0.06; p=0.078; I^2 = 86.63%), and sensitivity analysis restricted to low risk of bias studies also showed no significant difference (log OR= –0.56; 95% CI: –1.56 to 0.43; p=0.264). In conclusion, ERAS protocols showed trends toward reducing hospital stay and complications after elective colorectal surgery, but the results were not statistically significant, highlighting the need for further high-quality RCTs with standardized implementation.

Keywords: Enhanced recovery after surgery, ERAS, Colorectal surgery, Randomized controlled trials, Postoperative complications

INTRODUCTION

ERAS is a standardized, multimodal perioperative care protocol designed to attenuate surgical stress, optimize physiological function, and promote faster postoperative recovery.[1] Initially developed for colorectal surgery in the late 1990s, ERAS has since been adopted across various surgical specialties due to its association with improved clinical outcomes, particularly reductions in postoperative complications and hospital length of stay.[2] The ERAS approach integrates evidence-based practices across preoperative, intraoperative, and postoperative phases of care. Key elements include preoperative counseling and nutritional assessment, minimized preoperative fasting and bowel preparation, standardized opioid-sparing analgesia and anesthetic strategies, and early postoperative feeding and mobilization.[3] These interventions collectively aim to reduce perioperative morbidity, enhance functional recovery, and shorten hospitalization without increasing mortality risk.[4]

Postoperative complications occur in up to 50% of patients undergoing colorectal surgery and are closely related to factors such as preoperative functional capacity, nutritional status, psychological well-being, and smoking behavior, highlighting the importance of structured, multimodal perioperative interventions like those emphasized in ERAS protocols.[4]

While several meta-analyses have investigated the effect of ERAS protocols in colorectal surgery, we conducted this study to reassess the evidence using updated inclusion and exclusion criteria and to evaluate a slightly different set of clinical outcomes based on newly available randomized controlled trials.[5,6]

This systematic review and meta-analysis aims to address this gap by synthesizing current evidence from randomized controlled trials (RCTs) that compare ERAS protocols versus conventional perioperative care in patients undergoing elective colorectal surgery. The primary outcome is postoperative length of stay, and the secondary outcome is the overall rate of postoperative complications. Length of stay and postoperative complications were chosen as key outcomes due to their strong impact on patient recovery and healthcare resource use. Reducing both can improve safety, shorten hospitalization, and lower costs, making them essential metrics for evaluating ERAS protocols.

METHODS

Standard protocol approvals, registrations, and patient consent

The preferred items of reporting systematic reviews and meta-analyses (PRISMA) and the Cochrane Collaboration Handbook were used to conduct this study. This study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) (ID: 1038955). The Institutional Review Board (IRB) at the University of Jordan exempted our study protocol from review. The IRB waived the need for patient consent.

Eligibility criteria

Studies were included if they met the following criteria.

Design

Randomized controlled trials (RCTs)

Population

Adults (≥18 years) undergoing elective colorectal surgery.

Intervention

A standardized Enhanced Recovery After Surgery (ERAS) protocol, defined as implementing at least 12 core elements consistent with ERAS® Society guidelines.[7]

Comparator

Conventional (non-ERAS) perioperative care.

Primary outcome

Postoperative length of hospital stay (LOS), reported as mean±standard deviation (SD), or as median and interquartile range/range (convertible to mean ± SD)

Secondary outcome

Overall postoperative complication rate, defined as the number of patients experiencing ≥1 complication

Inclusion criteria

Full-text available in English, Human studies published from 2010 onward.

Exclusion criteria

Non-randomized studies, reviews, editorials, letters, protocols, or conference abstracts. Studies using ERAS protocols with <12 elements, or describing "fast-track" care not aligned with ERAS® Society standards. Emergency surgeries or pediatric populations. Studies not reporting LOS or complications in an analyzable format.

Literature search strategy

A comprehensive search of PubMed, Embase and Cochrane databases was performed covering literature published from January 1, 2010 to March 2025. Search strategies combined keywords and controlled vocabulary related to colorectal surgery, ERAS protocols, conventional care, length of stay, and randomized controlled trials. The search was done by AYA and RAO and any discrepancy was resolved by discussion until consensus was reached.

The search results were imported on Rayyan (https://rayyan.ai/), an artificial intelligence tool for systematic reviews, where the study selection was done. The study selection was done by AYA and RAO independently and any discrepancy was solved by discussion. All included studies received ethical approval and obtained informed consent from participants, as reported by the original trial authors. Full search strings for each database are available in Supplementary Material 1.

Study selection

A total of 58 records were identified: 4 from PubMed, 23 from Embase and 38 from Cochrane. After title and abstract screening, 3 PubMed ,4 Embase and 7 Cochrane

records were selected for full-text review. Following removal of 3 duplicates, 11 full-text articles were assessed for eligibility. Of these, 6 were excluded: 4 for implementing ERAS protocols with fewer than 12 elements, and one for not comparing ERAS with conventional treatment and one of missing primary or secondary outcome.[2,12-16] Five studies were included in the final meta-analysis.[1,3,9-11] All stages of screening and selection were conducted independently by AYA and RAO, with discrepancies resolved through discussion (Figure 1).

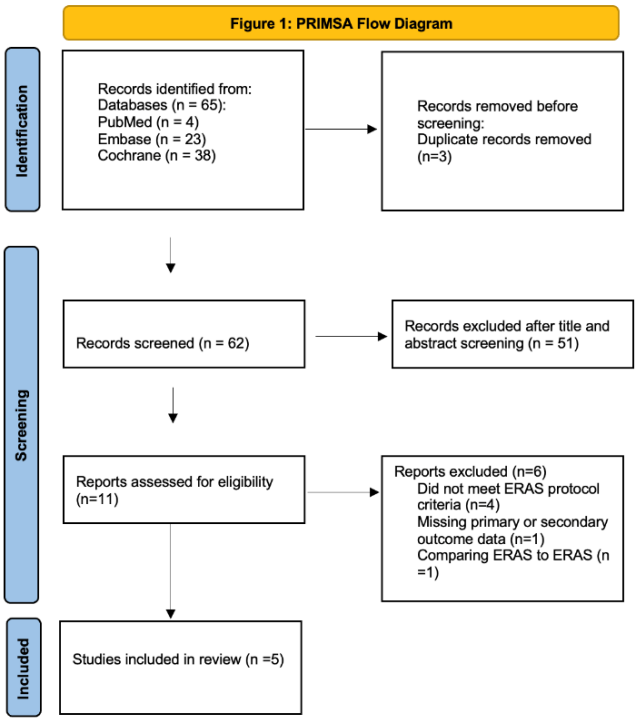

Figure 1: PRIMSA flow.

Data extraction

Data were extracted independently by AYA and RAO using a standardized form. The following data were recorded. Study characteristics (authors, year, country). Sample size for ERAS and control groups. Number of ERAS elements implemented. LOS (mean±SD or converted from median and range/IQR). Number of patients with ≥1 postoperative complication.

When LOS was reported as median with range or interquartile range, conversion to mean and SD was performed using the method proposed by Wan et al.[8]

Risk of bias assessment

The Cochrane risk of bias 2 (RoB 2) tool was used to assess methodological quality of each included RCT. AYA and RAO assessed the studies independently, and disagreements were resolved through discussion (Table 1).

Statistical analysis

All analyses were conducted using Stata software.

For LOS (a continuous outcome), pooled mean differences (MDs) and 95% confidence intervals (CIs) were calculated. For complication rates (a binary outcome), log odds ratios (log ORs) with 95% CIs were used. A random-effects model (REML method) was applied in both analyses due to expected heterogeneity across studies.

Heterogeneity was assessed using the I^2 statistic (to quantify inconsistency). Tau^2 (to estimate between-study variance). Chi^2 test (Q-test) to assess statistical significance. Publication bias was evaluated using visual inspection of funnel plots.

Sensitivity analyses

To assess the robustness of our findings, two sensitivity analyses were performed. For the primary outcome (length of stay), a subgroup analysis was conducted including only studies that reported LOS using mean and standard deviation directly, without data transformation. For the secondary outcome (postoperative complications), a sensitivity analysis was performed including only studies rated as having a low risk of bias based on the Cochrane Risk of Bias 2 (RoB 2) tool. In both cases, random-effects meta-analyses using the restricted maximum likelihood (REML) method were applied, and heterogeneity was assessed using the I^2 and Q statistics.

RESULTS

Effect of enhanced recovery after surgery protocols on length of stay

Five randomized controlled trials were included to assess the impact of ERAS protocols versus conventional care on postoperative length of stay (LOS) in elective colorectal surgery (Table 2 and 3).

A random-effects meta-analysis using the REML method revealed a pooled mean difference (MD) of –2.68 days in favor of ERAS (95% CI: –5.70 to 0.34), this did not reach statistical significance (p=0.082). A substantial degree of heterogeneity was observed (I^2=96.66%, τ^2=10.65, p<0.001), indicating high variability between study estimates.

The forest plot (Figure 2) visually reflects the findings, though the magnitude of effect varied notably, particularly with Shetiwy et al reporting a markedly larger benefit.[5]

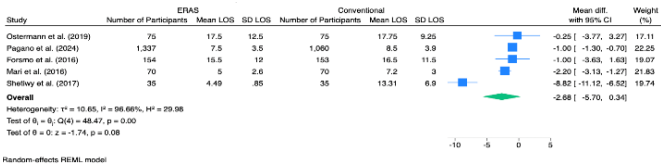

Figure 2: Forest plot on the effect of ERAS on LOS.

publication bias for the effect of enhanced recovery after surgery in length of stay

Visual inspection of the funnel plot (Figure 3) suggested asymmetry, raising the possibility of publication bias. The distribution of studies appears skewed, with fewer studies reporting smaller or null effects, especially on the right side of the plot. This asymmetry may reflect potential reporting bias, small-study effects, or true heterogeneity among studies. However, given the limited number of included studies (n=5), formal statistical tests for funnel plot asymmetry, such as Egger's regression test, were not performed, as they are underpowered and unreliable with fewer than 10 studies.

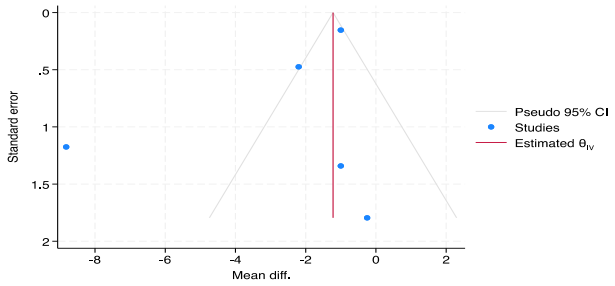

Figure 3: Funnel plot effect of ERAS on LOS.

Sensitivity/subgroup analysis for the effect of enhanced recovery after surgery on the length of stay

A sensitivity analysis was conducted by excluding Ostermann et al and Forsmo et al, as their postoperative LOS data were derived using the Wan et al method to estimate means and standard deviations.[1,3,16] The meta-analysis of the remaining three studies by Pagano et al, Mari et al, and Shetiwy et al yielded a slightly greater pooled reduction in LOS with ERAS protocols (mean difference= –3.89 days; 95% CI: –8.54 to 0.77), although statistical significance was still not reached (p=0.102). (Figure 4).[2,4,5] Substantial heterogeneity persisted (I^2=98.71%, τ^2=16.41) suggesting that variation in study effects is not solely attributable to the estimation method, but may reflect differences in patient selection, ERAS implementation fidelity, or surgical setting.

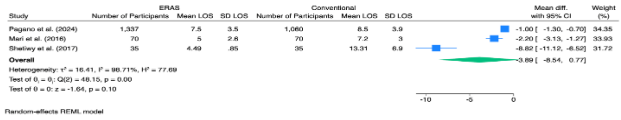

Figure 4: Sensitivity analysis on the effect of ERAS on LOS.

Effect of enhanced recovery after surgery protocols on postoperative complications

A total of five randomized controlled trials were included to evaluate the effect of ERAS protocols compared to conventional care on overall postoperative complications in patients undergoing colorectal surgery (Table 3). The pooled analysis demonstrated a log odds ratio (Log OR) of –0.58 (95% confidence interval (CI): –1.22 to 0.06), this difference did not reach statistical significance (p=0.078). Substantial heterogeneity was observed across studies, with an I^2 of 86.63% (τ^2=0.43, Q=22.69, p<0.001) (Figure 5).

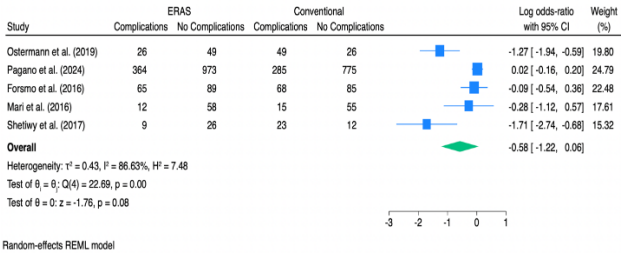

Figure 5: Forest plot on the effect of ERAS on post complication.

Funnel plot analysis

Visual inspection of the funnel plot revealed asymmetry. However, due to the small number of included studies (n =5), the ability to formally assess publication bias was limited, and interpretations should be made cautiously. (Figure 6).

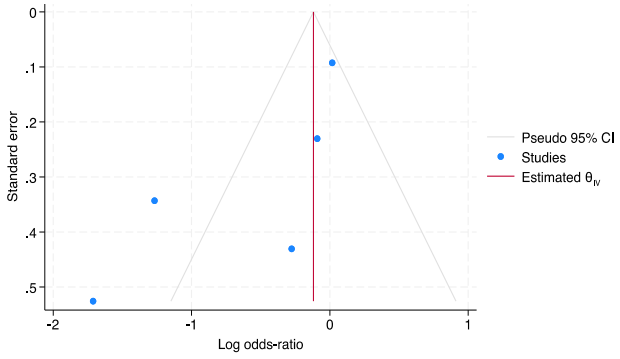

Figure 6: Funnel plot effect of ERAS on complications.

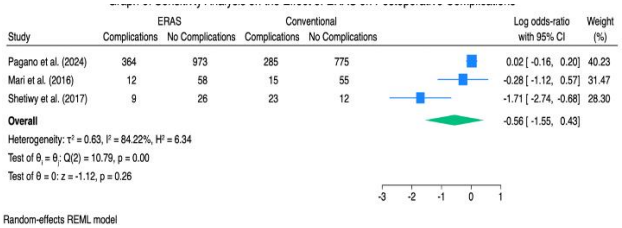

Figure 7: Sensitivity analysis on the effect of ERAS on postoperative complications.

Sensitivity/subgroup analysis for the effect of enhanced recovery after surgery on the postoperative complications

To assess the robustness of the findings, a sensitivity analysis was performed by excluding two studies, and that had "some concerns" in the risk of bias assessment according to the RoB 2 tool. This resulted in a reanalysis of the remaining three studies.[1,3,9-11] Following exclusion, the pooled log odds ratio was –0.56 (95% confidence interval (CI): –1.56 to 0.43), with the result remaining statistically non-significant (p=0.264) (Figure 7). Heterogeneity remained substantial, with an I^2 of 84.22% (τ^2=0.63, Q=10.79, p=0.0045), indicating persistent variability among the included studies. The sensitivity analysis did not materially alter the overall interpretation of the main analysis. These findings suggest that even after limiting the analysis to studies judged at low risk of bias, the evidence remains inconclusive regarding the effect of ERAS protocols on postoperative complications.

Table 1: Risk of bias 2 assessment for included RCTs.

Study	Randomization process	Deviations from intended interventions	Missing outcome data	Measurement of outcome	Selection of reported result	Overall, bias
Osterman n et al[1]	Low	Some concerns	Low	Low	Low	Some concerns
Forsmo et al[3]	Low	Some concerns	Low	Low	Low	Some concerns
Pagano et al[9]	Low	Low	Low	Low	Low	Low
Mari et al[10]	Low	Low	Low	Low	Low	Low
Shetiwy et al[11]	Low	Low	Low	Low	Low	Low

Table 2: ERAS elements implemented by study.

Study	ERAS elements implemented	Key ERAS elements
Ostermann et al[1]	16	Counselling, carb loading (x2), fasting limits, multimodal analgesia, GDT, lap approach, no drains, NGT out in OR, early fluids and solids, mobilization POD0–3, catheter out POD1, nutrition POD2–7, discharge criteria
Forsmo et al[3]	16	Counselling, carb drinks, no fasting, no premeds, laxatives, TIVA, warming, epidural (open), restricted fluids, early mobilization, early feeding, oral analgesia, catheter out POD2, discharge by milestones
Pagano et al[9]	23	Counselling, nutrition assessment, carb loading, no fasting, no premeds, PONV prevention, MIS, drain avoidance, epidural (open), warming, GDT, NGT removal, early feeding, opioid-sparing, mobilization, IV fluid stop POD1–2, follow-up
Mari et al[10]	13	No bowel prep, oral maltodextrin, fluid restriction, no NGT, no drains, spinal + NSAIDs, early feeding, mobilization <6h, solid food POD1, lap surgery, low IV fluids, milestone discharge
Shetiwy et al[11]	17	Counselling, carb drinks, selective bowel prep, no premeds, epidural (no opioids), NSAIDs, warming, early NGT/drain removal, early feeding, enforced mobilization, laxatives, transverse incision, discharge criteria

Table 3: Summary of included studies, LOS, complications.

Study	Sample size (ERAS/control)	Mean LOS–ERAS (days)	Mean LOS – conventional (days)	ERAS complications (n/%)	Conventional complications (n/%)
Ostermann et al[1]	75/75	17.50*	17.75*	26/34.7	49/65.3
Forsmo et al[3]	154/153	15.50*	16.50*	65/42.2	68/44.4
Pagano et al[9]	1337/1060	7.50	8.50	364/27.2	285/26.9
Mari et al[10]	70/70	6.00	8.00	14/20.0	26/37.1
Shetiwy et al[11]	35/35	4.49	13.31	9/25.7	23/65.7

Note: (*) Indicates that the Mean and Standard Deviations of the studies were calculated using the Wan et al's method.[16]

DISCUSSION

In this comprehensive meta-analysis of five randomized controlled trials, ERAS protocols were evaluated for their clinical impact in patients undergoing elective colorectal surgery. ERAS implementation was associated with a non-statistically significant reduction in hospital stay by approximately 2.7 days compared to conventional care. Similarly, the pooled analysis for postoperative complications showed no statistically significant difference between the ERAS and conventional care groups. Sensitivity analyses for both outcomes, after excluding studies with higher risk of bias, remained non-significant, reinforcing the uncertainty regarding the true effect of ERAS protocols on postoperative recovery. These findings indicate that, while ERAS protocols may offer clinical advantages, the current evidence remains inconclusive, and further high-quality trials are necessary to substantiate their effectiveness.

These findings differ from most previous evidence, notably the 2011 Cochrane meta-analysis, which reported a significant reduction in length of stay by approximately 2.9 days and a halving of complication risk when ERAS was compared with conventional strategies (RR 0.52; 95% CI 0.38 to 0.71).[5] Although that earlier review supported widespread ERAS adoption, the present meta-analysis did not find statistically significant reductions in either postoperative length of stay or complication rates.

This discrepancy may be attributable to differences in inclusion criteria, stricter standardization of ERAS protocols in the current analysis, variability in study design and patient populations, or insufficient statistical power. Importantly, by applying updated ERAS Society guidelines and stricter methodological standards, our study provides a more cautious and updated perspective, highlighting that the evidence supporting ERAS benefits may not be as definitive as previously believed. This distinction emphasizes the uniqueness and relevance of our findings within the evolving ERAS literature. Recent literature further supports the potential benefits of ERAS protocols. A meta-analysis of 12 randomized controlled trials demonstrated that ERAS protocols significantly reduce postoperative complications, surgical site infections, and hospital stay duration in patients undergoing colorectal surgery.[6] A contemporary systematic review confirmed that ERAS protocols consistently reduce LOS, accelerate recovery of gastrointestinal and nutritional function, and lower complication rates compared to conventional care.[17]

These findings are corroborated by a prospective randomized trial, which showed shorter hospital stays, fewer complications, and reductions in both readmission and mortality among colorectal cancer patients managed under an ERAS-based protocol.[18] Additionally, a prospective cohort study demonstrated that ERAS patients achieved higher postoperative protein intake and experienced fewer complications and shorter hospitalizations, emphasizing the role of nutrition-focused ERAS elements.[19] A large multi-institutional controlled study also reported a 5.5-day reduction in hospital stay with ERAS, without a corresponding increase in complications.[20] Similarly, a prospective controlled study found that fast-track protocols significantly reduced postoperative fatigue and improved functional recovery after major colonic surgery.[21] Beyond clinical outcomes, a randomized trial found that ERAS protocols significantly suppressed postoperative inflammation and preserved immune function compared to traditional care.[22] Several additional studies have also reported significantly lower postoperative complication rates in ERAS groups compared to conventional care groups.[23-25]

Other evidence also emerges from studies in related colorectal procedures. A randomized trial evaluating ERAS in elective stoma reversal reported a nearly two-day reduction in LOS, improved functional recovery, and no increase in complications.[26] A systematic review and meta-analysis focusing on ERAS during ileostomy reversal similarly demonstrated significant reductions in LOS without increases in complications or readmissions.[27] Although this meta-analysis focuses on colorectal surgery, different findings have been observed in other major abdominal procedures. A meta-analysis on gastric cancer surgery found a 1.78-day mean LOS reduction and improvements in recovery metrics.[28] Furthermore, a systematic review of accelerated ERAS protocols allowing discharge within 24 hours after colorectal cancer surgery demonstrated feasibility and safety in carefully selected patients.[29] Importantly, ERAS protocols have also shown safety and efficacy in patients with chronic comorbidities. For example, in individuals with type 2 diabetes mellitus undergoing colorectal surgery within an ERAS framework, no increases in LOS or complications were observed when glycemic control was optimized.[30]

In contrast to these largely positive findings in the broader literature, our meta-analysis presents a more cautious view. By focusing on standardized ERAS interventions and high-quality randomized evidence, we highlight that the purported benefits of ERAS protocols may not be as consistent or universally applicable as previously thought. This underscores the importance of critical appraisal of existing studies and the need for continued rigorous research. Altogether, this meta-analysis suggests that, although ERAS protocols may improve perioperative recovery, the evidence from randomized controlled trials included in this review did not demonstrate statistically significant reductions in postoperative length of stay or complication rates. Healthcare institutions are encouraged to continue implementing ERAS protocols, given the broader supportive literature, while recognizing the need for ongoing research to strengthen the evidence base, optimize protocol elements, and assess long-term and patient-centered outcomes.

Strengths

This meta-analysis has several notable strengths. It is among the first to include only randomized controlled trials that adhered to a standardized ERAS protocol comprising at least 12 core elements, as defined by the ERAS® Society. This methodological consistency enhances the comparability of interventions and strengthens the internal validity of the findings. Furthermore, the analysis focused on both clinical effectiveness (length of stay) and safety (postoperative complications). However, sensitivity analyses for both outcomes demonstrated non-significant results, suggesting that the observed reductions in LOS and complication rates could be influenced by methodological variability, limited study numbers, and heterogeneity between studies.

Limitations

Nevertheless, limitations must be acknowledged. The number of included studies was relatively small, and substantial heterogeneity was observed in length of stay outcomes, likely due to differences in patient selection, institutional practices, surgical techniques, and protocol adherence. Additionally, visual funnel plot asymmetry suggests the potential for publication bias, and not all studies provided detailed data on ERAS adherence or complication severity, which may have influenced outcome interpretation.

CONCLUSION

This meta-analysis of randomized controlled trials found that ERAS protocols were associated with reductions in postoperative length of stay and complication rates among patients undergoing elective colorectal surgery; however, these reductions did not achieve statistical significance. While ERAS protocols remain a promising strategy for optimizing perioperative care, the current evidence does not definitively establish their superiority over conventional care. Our findings differ from most prior systematic reviews and highlight the need for cautious interpretation of ERAS benefits. Future research should focus on long-term recovery, patient-centered outcomes, protocol adherence, and conducting large-scale randomized controlled trials with standardized reporting to confirm the true impact of ERAS protocols.

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Ethical approval: Not required

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