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Single-Center Evidence that ERAS Reduces Length of Stay and Hospital Costs after Laparoscopic Colectomy for Colon Cancer

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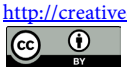

Abstract

Enhanced recovery after surgery (ERAS) pathways integrate evidence-based perioperative practices to attenuate surgical stress and accelerate functional recovery; however, their real-world impact on length of stay and hospital cost after laparoscopic colectomy remains of practical interest. To evaluate the clinical and economic value of enhanced recovery after surgery (ERAS) in laparoscopic colectomy for colon cancer, focusing on postoperative length of stay (LOS) and total hospital cost, and to interpret these outcomes in light of recovery milestones. In this single-center controlled study, consecutive patients undergoing laparoscopic radical colectomy between September 2023 and October 2024 were managed either by an ERAS pathway (n = 53) or conventional perioperative care (n = 47). The primary outcomes were postoperative LOS and total hospital cost. Secondary outcomes included time to first semi-liquid diet, time to first flatus, time to first bowel movement, and time to first ambulation. Group comparisons used t-tests or Wilcoxon rank-sum tests as appropriate; mean differences with 95% confidence intervals and standardized effect sizes (Hedges g) were calculated. Compared with conventional care, the ERAS group had a shorter LOS ((7.94 ± 1.73) days vs (10.72 ± 2.72) days; mean difference −2.78 days, 95% CI −3.70 to −1.86; g ≈ −1.23) and lower total hospital cost ((5.16 ± 0.69) × 10,000 RMB vs (5.57 ± 0.99) × 10,000 RMB; mean difference −0.41 × 10,000 RMB, 95% CI −0.75 to −0.07; g ≈ −0.48). Recovery milestones improved significantly with ERAS: first semi-liquid diet 4 (4, 5) vs 6 (5, 6) days; first flatus 2 (2, 3) vs 3 (3, 4) days; first bowel movement 5 (4, 5) vs 6 (6, 7) days; first ambulation 2 (1, 2) vs 3 (2, 3) days (all P < 0.001). ERAS for laparoscopic colectomy significantly shortens postoperative LOS and reduces

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hospital costs, while accelerating gastrointestinal and functional recovery. Routine implementation of ERAS with pathway adherence auditing is recommended for colorectal units. Protocol adherence. Prospective auditing confirmed broad adherence to core ERAS elements. Early oral intake and early ambulation targets were generally met, whereas occasional deviations were attributed to expected clinical considerations or patient preference. A composite adherence percentage was not calculated in this retrospective analysis. Protocol adherence auditing. ERAS adherence was prospectively audited using standardized perioperative order sets and a daily bedside nursing checklist that captured completion of core elements (early oral intake, early ambulation, multimodal opioid-sparing analgesia, goal-directed fluid therapy, and minimization/early removal of drains and catheters). Each element was recorded as completed or withheld, with clinical reasons when withheld.

Keywords

Enhanced Recovery after Surgery, Laparoscopy, Colon Cancer, Length of Stay, Hospital Cost, Perioperative Care

1. Introduction

Colorectal cancer is among the most common gastrointestinal malignancies. Surgery remains the cornerstone of curative treatment [1]. With the maturation of minimally invasive techniques, laparoscopic radical colectomy has become routine in many centers, providing an ideal scenario for implementing ERAS [2]. ERAS integrates multidisciplinary collaboration and evidence-based perioperative optimization to reduce surgical stress, promote recovery, mitigate complications, and control costs [3]. Key components include preoperative education and nutritional optimization, avoidance of routine mechanical bowel preparation and gastric decompression, goal-directed fluid therapy, early oral feeding, early ambulation, effective multimodal analgesia, and minimization of unnecessary drains and catheters [4]. In contemporary practice, patients and hospitals are primarily concerned with whether recovery is faster and less costly [5]. Thus, (Length of Stay, LOS) and hospital cost serve as practical indicators of pathway value, reflecting the aggregate quality of perioperative processes [6]. Although numerous studies suggest ERAS reduces LOS and complications, heterogeneity in protocols, implementation intensity, and patient mix can limit generalizability [7]. Using real-world data from our center, we focused on LOS and cost as core endpoints and interpreted them via recovery milestones to offer actionable, reproducible insights for clinical and operational management in colorectal surgery.

2. Materials and Methods

2.1. Study Design and Participants

Operators and teams. Procedures were performed by multiple attending colorec-

tal surgeons working on routine service teams. All surgeons were credentialed for laparoscopic colectomy and adhered to a standardized operative approach with harmonized anesthesia protocols and perioperative order sets across teams.

Group allocation. Patients were not randomized. During the study period at The First Affiliated Hospital of Yangtze University, consecutive eligible patients were managed according to the perioperative pathway routinely used by the admitting surgical team. Teams that had fully implemented ERAS delivered the ERAS pathway, whereas teams that maintained conventional practice delivered standard care. Patients were informed of the relevant pathway on admission and consented to follow it. No allocation concealment was applied.

This single-center controlled study enrolled 100 consecutive patients who underwent laparoscopic radical colectomy at a tertiary hospital between September 2023 and October 2024. Patients were managed either by an ERAS pathway (n = 53) or conventional perioperative care (n = 47). Baseline characteristics were comparable between groups, including sex distribution (male/female 27/26 vs 23/24), age ((66.66 ± 5.65) years vs (67.70 ± 6.52) years), and body mass index ((24.04 ± 2.58) kg/m^2 vs (24.18 ± 2.59) kg/m^2).

As summarized in **Table S1**, age, sex, and BMI did not differ significantly between groups; additional baseline variables are provided to facilitate assessment of potential confounding.

2.2. Inclusion and Exclusion Criteria

Inclusion criteria were: age < 80 years; histologically confirmed colon cancer; no distant metastasis on imaging (TNM stage ≤ III); planned laparoscopic radical colectomy; and complete clinical data. Exclusion criteria included: emergency surgery or preoperative intestinal obstruction; severe organ dysfunction, severe anemia, or marked malnutrition; prior abdominal surgery or neoadjuvant chemoradiation; preadmission nasogastric tube placement or prolonged fasting requiring nutritional support; conversion to open surgery, postoperative ICU admission, or inability to comply with pathway management.

2.3. ERAS Pathway and Conventional Care

The ERAS pathway comprised: preoperative counseling with expectation management and shortened fasting, avoidance of routine mechanical bowel preparation; intraoperative temperature and fluid optimization with short-acting anesthetics and opioid-sparing techniques [8], and avoidance of routine nasogastric and abdominal drains; postoperative early oral feeding (progressing from clear fluids to semi-liquid diet). Early ambulation, adequate analgesia and antiemetic prophylaxis, and early removal of urinary catheters and drains [9]. Conventional care followed traditional practices with longer fasting, more conservative postoperative feeding strategies, greater reliance on tubes and drains, and restricted ambulation.

2.4. Outcomes

Primary outcomes were postoperative LOS (days) and total hospital cost (10,000

RMB). Secondary outcomes were recovery milestones: time to first semi-liquid diet, first flatus, first bowel movement, and first ambulation (days).

2.5. Data Collection and Quality Assurance

Clinical and cost data were retrieved from the electronic medical record and hospital information systems and verified independently by two researchers. An ERAS team (surgeons, anesthesiologists, nurses, and dietitians) standardized patient education materials, daily diet and activity schedules, and pain assessment forms. Cases with missing key variables were excluded before the database lock.

2.6. Statistical Analysis

Baseline socio-demographic and clinical variables (age, sex, BMI, ASA class, tumor site/stage, common comorbidities) are summarized in Table S1. Continuous variables are reported as mean ± SD and categorical variables as n (%); between-group comparisons used the t-test or χ^2/Fisher's exact test as appropriate.

Analysis population. We conducted a per-protocol analysis. Patients who required intraoperative conversion to open surgery were excluded a priori because conversion substantially alters postoperative recovery and deviates from the intended laparoscopic ERAS pathway. Primary outcomes were compared between groups using the same tests described above.

Continuous variables were expressed as mean ± standard deviation or median (interquartile range), and categorical variables as counts (%). Between-group comparisons used the independent-samples t-test or the Wilcoxon rank-sum test as appropriate. We report mean differences with 95% confidence intervals and Hedges' g standardized effect sizes to facilitate cross-study comparison.

3. Results

3.1. Baseline Characteristics

There were no statistically significant differences between groups in age, sex, or BMI, indicating baseline comparability. All patients underwent laparoscopic radical colectomy; no major sources of bias were identified at baseline. See Table S1.

3.2. Primary Outcomes (LOS and Hospital Cost)

LOS was significantly shorter in the ERAS group than in conventional care ((7.94 ± 1.73) days vs (10.72 ± 2.72) days; mean difference −2.78 days, 95% CI −3.70 to −1.86; Hedges g ≈ −1.23), representing an approximate 25.9% relative reduction. Total cost was also lower with ERAS ((5.16 ± 0.69) × 10,000 (RMB) vs (5.57 ± 0.99) × 10,000 (RMB); mean difference −0.41 × 10,000 (RMB), 95% CI −0.75 to −0.07; Hedges g ≈ −0.48), corresponding to a relative decrease of about 7.4%. (Table 1)

3.3. Secondary Outcomes (Recovery Milestones)

These improvements likely reflect synergistic effects of early feeding and ambulation, opioid-sparing analgesia, and goal-directed fluid therapy. (Table 2)

3.4. Clinical Interpretation

The combination of faster functional recovery with shorter LOS and lower cost suggests a coherent pathway effect: "faster recovery → shorter LOS → lower cost."

Table 1. Primary outcomes comparing ERAS versus conventional care.

Outcome	ERAS (n = 53)	Conventional care (n = 47)	Test	Statistic	P-value
Postoperative length of stay (days)	7.94 ± 1.73	10.72 ± 2.72	t	−6.824	<0.001
Total hospital cost (10,000 RMB)	5.16 ± 0.69	5.57 ± 0.99	t	−2.337	0.022

Note: Data are mean ± standard deviation; t denotes the independent-samples t-test statistic.

Table 2. Recovery milestones comparing ERAS versus conventional care.

Recovery milestone	ERAS (n = 53)	Conventional care (n = 47)	Test	Statistic	P-value
Time to first semi-liquid diet (days)	4 (4, 5)	6 (5, 6)	Z	−7.717	<0.001
Time to first flatus (days)	2 (2, 3)	3 (3, 4)	Z	−6.407	<0.001
Time to first bowel movement (days)	5 (4, 5)	6 (6, 7)	Z	−7.939	<0.001
Time to first ambulation (days)	2 (1, 2)	3 (2, 3)	Z	−6.373	<0.001

Note: Data are median (interquartile range); Z denotes the Wilcoxon rank-sum test statistic.

4. Discussion

Although element-level adherence was prospectively audited, we did not compute a composite adherence metric; future work will quantify element-level compliance and examine its association with LOS and cost.

In our cohort, rates of ileus, surgical-site infection, pneumonia, and anastomotic leak were numerically lower with ERAS without statistically significant differences, consistent with the overall safety statement for ERAS in laparoscopic colectomy.

ERAS links evidence-based practices across the perioperative continuum to attenuate physiologic and psychological stress and accelerate recovery. Early oral feeding maintains mucosal integrity and reduces parenteral nutrition requirements; early ambulation improves ventilation, reduces venous thromboembolism risk, and stimulates gut motility; goal-directed fluid therapy limits tissue edema and hastens bowel function; multimodal, opioid-sparing analgesia mitigates postoperative ileus and nausea; and minimizing unnecessary tubes and drains improves comfort and reduces infection risk [10]. Together, these mechanisms plausibly explain the observed improvements in milestones, LOS, and cost [11].

From a hospital management perspective, saving approximately 2.8 inpatient days per case can meaningfully increase annual bed turnover and throughput [10]. A ~7.4% reduction in cost aligns with payer-driven value-based care and provides measurable levers for quality improvement [12]. We recommend incorporating LOS, cost, complication rates, and readmissions into unit-level (Key Performance

Indicators, KPIs) and monitoring pathway adherence with an electronic audit dashboard.

The reproducibility of ERAS hinges on nursing execution and patient education. Standardized preoperative counseling, daily recovery goal cards, systematic pain and (Postoperative Nausea and Vomiting, PONV) management, and multidisciplinary coordination enable early feeding and ambulation to occur on schedule—key drivers of LOS and cost reduction [13].

While our analysis centers on time and cost, prior literature and center experience suggest that when applied appropriately, ERAS does not increase major complications. For colorectal surgery, vigilance regarding anastomotic safety and infection control remains essential; early warning systems for pain, fever, distension, and inflammatory markers should be embedded in routine care [14].

This single-center controlled design lacks randomization and blinding and may be subject to residual confounding [15]. The modest sample size precluded subgroup analyses by tumor location, specific techniques, or comorbidities. Economic evaluation was not cost-utility–based and did not partition direct and indirect costs. Future multicenter prospective cohorts or randomized trials should include patient-reported outcomes, longer-term readmissions and healthcare utilization, and the influence of DRG/DIP payment reforms to provide a comprehensive clinical-economic-managerial assessment [16].

5. Conclusions

Because allocation was non-random and based on routine practice (admitting team's pathway in use), selection bias cannot be fully excluded despite consecutive enrollment and baseline comparability. Moreover, unmeasured surgeon- and team-level factors may persist and confound outcomes even under standardized protocols.

In laparoscopic colectomy for colon cancer, ERAS significantly shortens postoperative LOS and reduces total hospital cost while accelerating functional recovery. Routine adoption with robust pathway adherence auditing is warranted in colorectal surgical practice.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Appendix

Table S1. Baseline socio-demographic and clinical characteristics.

Variable	ERAS (n = 53)	Conventional (n = 47)	Test	P-value
Age (years), mean ± SD	66.66 ± 5.65	67.70 ± 6.52	t	0.788
Sex: Male, n (%)	27 (50.9%)	23 (48.9%)	χ^2	0.841
Sex: Female, n (%)	26 (49.1%)	24 (51.1%)	χ^2	0.841
BMI (kg/m^2), mean ± SD	24.04 ± 2.58	24.18 ± 2.59	t	0.399