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REVIEW ARTICLE

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Enhanced Recovery After Surgery (ERAS) Protocols in Colorectal Cancer Surgery: Impact on Postoperative Outcomes

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ABSTRACT

Aim: This literature review evaluates current evidence regarding the impact of ERAS implementation on postoperative outcomes in patients undergoing colorectal cancer resections. **Methods:** A narrative literature review was conducted using recent studies published within the last 10 years. Studies evaluating ERAS implementation in colorectal cancer resections and reporting outcomes such as post-operative complications, length of stay, and patient's functional recovery were included. **Results:** Across the reviewed literature, ERAS protocols consistently demonstrated improvements in multiple postoperative outcomes. Most studies reported a significant reduction in over 90% for minimal and moderate complications. ERAS also consistently shortens hospital length of stay, particularly through early nasogastric tube removal and optimized perioperative fluid and dietary management. Early mobilization and structured recovery components improve postoperative functional recovery, supporting a faster return to preoperative activity levels. **Conclusion:** The ERAS protocol integrates multiple evidence-based interventions that collectively reduce operative stress and enhance patient recovery. Current evidence demonstrates that ERAS implementation significantly decreases postoperative complications and shortens hospital length of stay, while also offering a cost-effective approach to perioperative management.

Keywords: Enhanced Recovery After Surgery (ERAS), Colorectal cancer surgery, Postoperative outcomes
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INTRODUCTION

Colorectal cancer (CRC) represents a major gastrointestinal malignancy whose biological behavior and clinical outcomes vary according to tumor stage and molecular characteristics.[1] According to the International Agency for Research on Cancer (IARC), CRC is the third most frequently diagnosed cancer globally, accounting for approximately 9.6% of all cases, with an estimated 1.1 million new cases each year.[2,3] It is also the second leading cause of cancer-related mortality, responsible for approximately 9.3% of cancer deaths worldwide.[3] Surgical intervention constitutes the primary therapeutic modality for CRC and are often combined with systemic chemotherapy and other adjunctive treatments.[4] However, colorectal surgery carries a substantial risk of postoperative complications, including technical complications, surgical-site infections, and other adverse events that may compromise patient safety and overall clinical outcomes.[5]

Enhanced Recovery After Surgery (ERAS) is a multimodal and multidisciplinary perioperative care strategy designed to attenuate surgical stress responses, preserve organ function, and optimize postoperative outcomes.[6] ERAS protocols have gained prominence in colorectal surgery, where postoperative morbidity significantly influences recovery trajectories.[7] Evidence indicates that ERAS implementation in colorectal procedures shortens hospital length

of stay and facilitates earlier mobilization and resumption of enteral nutrition, without increasing postoperative complication rates.[8]

This review synthesizes current evidence on the application of ERAS protocols in colorectal cancer surgery, examining core components of ERAS pathways and their impact on postoperative outcomes. Additionally, challenges associated with ERAS implementation are discussed, and potential future directions for optimizing perioperative care are outlined.

METHODS

This narrative literature review was conducted by searching major electronic databases, including PubMed, ScienceDirect, SpringerLink, and Google Scholar, for articles published in the last 10 years related to Enhanced Recovery After Surgery (ERAS) protocols in colorectal cancer surgery. The search used keywords such as "ERAS," "colorectal cancer," "colorectal surgery," "postoperative outcomes". Eligible studies included randomized controlled trials, cohort studies, systematic reviews, and clinical guidelines evaluating the impact of ERAS on postoperative outcomes such as complications, length of stay, morbidity, and recovery parameters. Articles not available in English, unrelated to colorectal cancer, or lacking outcome data were excluded. The selected literature was analysed and synthesized to provide a comprehensive understanding of current evidence regarding the effectiveness of ERAS in colorectal cancer surgery.

RESULTS

Overview of ERAS in Colorectal Surgery

Enhanced Recovery After Surgery (ERAS) protocols have been established as a standardized perioperative care strategy for patients undergoing major colorectal procedures.[9] Although specific elements may vary among institutions, ERAS pathways typically include preoperative patient education, carbohydrate loading, minimization of preoperative fasting, early postoperative mobilization, timely removal of urinary catheters, and multimodal analgesia. Successful implementation requires coordinated multidisciplinary involvement, including surgeons, anesthesiologists, nursing staff, and other healthcare professionals.[6]

An ERAS program typically comprises multiple interventions spanning the preoperative, intraoperative, and postoperative phases of care. Because these measures are implemented concurrently, isolating the specific contribution of each component can be challenging. However, a retrospective evaluation of ERAS compliance over an eight-year period identified key predictors of reduced length of stay, including early patient mobilization, utilization of non-opioid analgesia, initiation of early oral intake (with prompt discontinuation of intravenous fluids), avoidance of nasogastric tube use, and early removal of epidural catheters and urinary catheters.[10]

Pre-Operative ERAS Components

The Enhanced Recovery After Surgery (ERAS) protocols rely on an evidence-based, multidisciplinary framework to optimize perioperative care. Although ERAS spans the entire surgical continuum, the preoperative phase is particularly critical, as it enables risk modification, patient education, and physiological optimization prior to surgery. Effective implementation of preoperative ERAS measures has been associated with reduced postoperative morbidity, enhanced patient satisfaction, and accelerated recovery.[11] The pre-operative ERAS components recommendations are as follows in Table 1.

Table 1. ERAS pre-operative protocol recommendations for Colorectal Cancer Surgery

Pre-Operative Components	Recommendation	Recommendation Grade
Preadmission education and information	Tailored information for patients with rectal cancer reduced anxiety and improved satisfaction, especially 6 months after surgery	Strong
Pre-operative optimization	Predictive tools should be used to identify high-risk patients before colorectal surgery to optimize perioperative planning and preparation	Strong
	Comorbidities should be optimized before surgery and identified for postoperative planning	Strong
	Patients with high rates of alcohol consumption should stop drinking 4 weeks before surgery	Weak
	Cigarette smokers should stop smoking and undergo behavioral intervention, with nicotine replacement, at least 4 weeks before surgery	Strong
	All patients should undergo routine screening and correction of anemia	Strong
Pre-operative nutrition care	Patients should undergo routine nutritional screening using a validated tool to detect malnutrition	Strong
PONV prophylaxis	Using medications such as dexamethasone, ondansetron, granisetron, ramosetron, and aprepitant should be undertaken	Strong
Preanesthetic sedation/anxiolytics	Routine use of anxiolytic pre-medication	Weak
Prophylaxis against thromboembolism	Receive multimodal thromboembolism prevention using both mechanical and pharmacological modalities	Strong
Bowel Preparation	Mechanical Bowel Preparation should not be used routinely in colonic surgery but may be considered in rectal surgery with diverting stomas. If MBP is used, adding oral antibiotic is recommended.	Avoidance of MBP Alone: Weak Use of combined MBP and OA preparation: Strong
Preoperative fasting and carbohydrate loading	Short preoperative fasting (Solids for 6 hours, clear liquids for 2 hours before anesthesia) is recommended	Strong
Antibiotic prophylaxis and skin preparation	IV Antibiotic prophylaxis must be administered within 60 minutes before incision as a single dose	Strong
	Chlorhexidine preparations for skin disinfection should be used	Strong
Pre-operative Fluids	Remain well hydrated by drinking clear fluids up to 2 hours before going to the operating room	Strong

Intraoperative ERAS Components

Intraoperative components of the Enhanced Recovery After Surgery (ERAS) protocol measures focus on minimizing surgical stress, maintaining physiological homeostasis, and reducing perioperative complications through evidence-based anesthetic and surgical strategies. Successful ERAS implementation requires close coordination between anesthesia and surgical teams.[12]

1. Standard Anesthetic Protocol

The primary anesthetic objective within the ERAS framework is to minimize the physiological stress response to surgery and facilitate early postoperative recovery. The use of short-acting anesthetic agents is recommended, with individualized titration of anesthetic depth guided by EEG-based monitoring to reduce hemodynamic instability, postoperative cognitive dysfunction, delirium, and intraoperative awareness. Maintenance of hemodynamic

stability and application of lung-protective ventilation strategies are essential. Quantitative neuromuscular monitoring is advised, with full reversal ensured prior to extubation, defined as a train-of-four (TOF) ratio greater than 0.9.[12]

2. Normothermia
   Maintaining normothermia intraoperatively is essential, as it reduces the risk of surgical site infection, coagulopathy, blood transfusion requirements, cardiopulmonary complications, prolonged hospitalization, andoverall healthcare costs. Active surface warming techniques should be employed routinely to preserve thermal stability throughout the procedure.[13]
3. Intraoperative Fluid Management
   Both inadequate hydration and excessive fluid administration have been associated with increased risks of postoperative complications, including renal impairment, respiratory complications, and surgical site infections. Goal-directed fluid therapy is recommended, with the aim of achieving a modestly positive perioperative fluid balance to optimize tissue perfusion while minimizing adverse outcomes.[13]
4. Surgical Technique
   Minimally invasive surgery (MIS) is preferable when surgical expertise and resources are available, as it is associated with shorter recovery times and reduced length of hospitalization. The advantages of ERAS are maximized when MIS is implemented in conjunction with standardized perioperative care pathways.[13]
5. Abdominal Drains
   Routine placement of drains following colorectal surgery has not been shown to reduce the risk of anastomotic leakage or postoperative infection and may, in fact, increase the incidence of surgical site infections and prolong hospitalization. Consequently, routine drainage is not recommended after colon or rectal resection.[13]

Post-Operative ERAS Components

Postoperative ERAS components in colorectal surgery focus on promoting early recovery through optimized pain control, early mobilization, and rapid return of gastrointestinal function. These strategies aim to reduce complications, shorten hospital stay, and improve overall patient outcomes.

1. Nasogastric tube
   Nasogastric tube (NGT) placement may assist gastric decompression during colorectal surgery, especially in minimally invasive procedures. While prophylactic intraoperative NGT use may be considered, routine postoperative use is not recommended. Re-insertion of an NGT may be warranted in patients presenting with postoperative vomiting.[13]
2. Normoglycemia
   Both intraoperative hypo- and hyperglycemia should be avoided through targeted glycemic management. Intraoperative glycemia should be maintained within physiologic range, and postoperative glucose levels should be controlled between 140–180 mg/dL (7.8–10.0 mmol/L) with careful monitoring to prevent hypoglycemia.[13]
3. Postoperative fluid
   Postoperative fluid therapy should aim for a modestly positive fluid balance while avoiding excessive fluid administration that results in weight gain greater than 2.5 kg. Balanced crystalloid solutions are recommended for maintenance therapy. Sodium- and chloride-rich solutions (e.g., 0.9% NaCl) should be avoided for replacement therapy, with balanced alternatives preferred.[13]

4. Urinary drainage
   In uncomplicated minimally invasive colectomy (without epidural analgesia), urinary catheters should be removed within 24 hours. For minimally invasive rectal surgery without additional risk factors for urinary retention, removal within 48 hours is advised.[13]
5. Prevention of ileus
   Postoperative paralytic ileus (POI) remains a frequent complication following colorectal surgery, characterized by delayed bowel motility resulting in abdominal distention, pain, nausea, and vomiting. POI contributes to prolonged hospitalization, patient discomfort, and increased healthcare costs. Although often self-limiting, prolonged ileus may increase morbidity. A multimodal strategy is recommended to reduce POI risk.[13]
6. Postoperative analgesia
   Effective postoperative analgesia is essential to minimize pain and stress responses, facilitate early mobilization, and reduce risks of complications such as deep vein thrombosis, respiratory impairment, and chronic pain. A multimodal approach should be employed after both open and minimally invasive colorectal surgeries. Analgesic strategies may include acetaminophen, NSAIDs, and transversus abdominis plane (TAP) blocks for colonic surgery, with consideration of intrathecal morphine when appropriate.[13]
7. Postoperative nutritional care
   Oral nutrition is preferred over parenteral nutrition in patients with a functioning gastrointestinal tract. Early initiation of oral or enteral feeding, ideally with oral nutritional supplements (ONS), is recommended within 24 hours postoperatively to support bowel function and shorten hospitalization. Oral intake should resume within hours of colorectal surgery. Malnourished patients should continue ONS providing at least 500 kcal daily for 8–12 weeks postoperatively, accompanied by exercise, to limit muscle loss. After discharge, ONS should be continued for at least 10 days. Daily nutritional monitoring is advised to identify insufficient intake. Specialized nutrition therapy (enteral or parenteral when indicated) should be initiated within 24 hours in malnourished patients or those unable to tolerate adequate oral intake by postoperative day five.[13]
8. Mobilization
   Early mobilization is a fundamental element of perioperative recovery. Mobilization or physiotherapy should begin on the day of surgery—initially placing the patient in a sitting position, followed by ambulation for two 30-minute sessions. From postoperative day one until discharge, patients should achieve at least three hours of mobilization daily.[13]

DISCUSSION

Impact on Post-Operative Outcomes in Colorectal Cancer Surgery

The implementation of ERAS protocols facilitates rapid restoration of physiological homeostasis following colorectal surgery. Patients are encouraged to ambulate early, resume oral intake promptly, and discontinue intravenous fluid support as soon as feasible. This coordinated perioperative strategy enhances physiologic recovery, shortens the time to functional restoration, and contributes to a reduction in postoperative complications.[14]

Reduction in post-operative complications

ERAS protocol for patients undergoing colorectal surgery was reported to be capable of reducing the risk of postoperative complications.[15] The ERAS protocol was found to reduce the systemic inflammatory

response after colorectal surgery and documented better immune profiles[25,26], yet few studies have proven the relationship between the ERAS protocol and inflammatory markers (C-reactive protein, interleukin-6, neutrophil-lymphocyte ratio, etc.).[16]

In the findings reported by Ostermann et al., there were fewer infection complications and a 47% decrease in 30-day morbidity.[26] A study by Naseer et al. showed the decreased post-operative complication rate in the ERAS group was 14.3% in comparison with the traditional group at 33.3%, providing an added strength to this protocol.[17] Han *et al*. also documented higher percentage of postoperative complications without ERAS protocol than the ERAS group in elderly patients who underwent colorectal cancer surgery (29.0% vs 12.1%).[27] A high compliance to the ERAS protocol were found to be associated with lower risk of in-hospital complications, in which post-operative ileus and infectious complications were most frequent in patients non-compliant to the ERAS protocol.[28] ERAS protocol was also noted to significantly reduce postoperative pain and nausea/vomiting ($p<0.001$) without an increase in readmissions.[29]

Decrease in the length of stay

Multiple studies have demonstrated that ERAS protocols consistently shorten postoperative hospitalization across a range of surgical procedures, including gastrectomy, colorectal resection, prostatectomy, and bariatric surgery.[7] A pooled analysis of 1,454 patients from five clinical trials revealed a significantly reduced length of hospital stay among patients managed with ERAS compared to conventional care. The mean difference in hospitalization duration was –2.87 days, with a 95% confidence interval of –3.33 to –2.36 days. This reduction was statistically significant ($p<0.0001$), and heterogeneity between studies was low (I^2 = 13%, P = .21), indicating consistent findings across the included trials.[18]

Patients who underwent colorectal cancer surgery managed under ERAS protocols experienced a markedly shorter hospitalization, with a mean duration of approximately 4 days, compared to nearly 7 days in the conventional care group. Two components of the protocol were identified as key contributors to a reduction of approximately 2 days in hospital stay: (1) early removal of nasogastric tubes and (2) optimized management of postoperative fluids and diet.[17] High-quality evidence demonstrated that early cessation of nasogastric decompression alone reduced hospitalization by an average of 1.37 days, and when combined with initiation of both solid and liquid oral intake by postoperative day one, the reduction increased to 1.46 days.[15]

Improvement in functional recovery and quality of life

Improvement in muscle strength can be achieved within two weeks of structured resistance training. Consequently, early restoration of preoperative physical function may contribute to a reduced period of postoperative disability. Studies examining creatine kinase (CK) gene expression after muscle surgery demonstrated that pain is transient, with a return to baseline muscle activity that may be mildly aggravated by movement but is not indicative of significant tissue injury. Furthermore, several investigations have shown that the intensity of muscular pain does not necessarily correlate with CK levels, pathological changes, or overall muscle performance. Notably, anticipation of pain may amplify its perception during the early postoperative period. Comprehensive evaluation of physiological disturbances involving surgical serositis,

cardiopulmonary impairment, and gastrointestinal dysregulation is essential for anticipating the need for hospitalization.[19]

The present study evaluated the impact of Enhanced Recovery After Surgery (ERAS) protocols on postoperative outcomes in patients undergoing colorectal cancer surgery. Using Centers for Disease Control and Prevention (CDC) grading criteria, complication severity decreased from severe to moderate with strict adherence to ERAS recommendations. Increased compliance with the ERAS pathway was associated with a significant reduction in postoperative complications, hospital readmissions, reoperations, and overall length of hospital stay.[20]

ERAS vs Traditional Care

Multiple studies have consistently demonstrated a marked reduction in hospital stay duration for colorectal surgery patients treated within an ERAS framework. Forsmo et al. reported a median length of stay (LOS) of 5 days in ERAS patients compared with 8 days under conventional care.[30] Bednarski et al. similarly observed shorter hospitalization among patients managed with the RecoverMI strategy, which integrates minimally invasive techniques with ERAS principles.[31] Shetiwy et al. documented a significant reduction in LOS, with ERAS patients averaging 4.49 days versus 13.31 days receiving traditional management.[32] Comparable findings were reported by Taupyk et al. and Mari et al., where LOS decreased from 10.9 to 5.9 days and from 7.2 to 5 days, respectively, with ERAS implementation.[24,33] Collectively, these data highlight the capacity of ERAS protocols to accelerate postoperative recovery while promoting more efficient healthcare resource utilization, including reduced hospital costs and improved bed availability.[21]

Although the overall incidence of postoperative complications was lower in the ERAS cohort compared to the conventional group (50% vs. 60%), this difference did not reach statistical significance (p=0.238). Notably, among patients managed under the ERAS protocol, those undergoing open surgery had a significantly higher likelihood of developing postoperative complications relative to those treated laparoscopically (69.23% vs. 14.29%, p=0.015), corresponding to a 4.846-fold increased risk.[22]

Early mobilization represents a key element of postoperative care and demonstrates a clear distinction between ERAS and conventional management strategies. Within ERAS pathways, patients are encouraged to ambulate as early as possible, often within 24 hours following surgery. Early mobilization has been shown to reduce the incidence of major complications, including deep vein thrombosis, pulmonary embolism, and pneumonia. Additionally, it facilitates a quicker return to baseline activity levels, supports preservation and recovery of muscle strength, and enhances overall functional outcomes. Consequently, patients who ambulate early typically experience shorter hospitalization durations and accelerated recovery trajectories compared to those managed under traditional postoperative protocols.[22]

Colorectal surgery frequently presents multiple postoperative challenges, including infectious complications, anastomotic leakage, difficulties in pain control, and delayed functional recovery. Conventional postoperative care pathways are often associated with prolonged hospital stays and increased morbidity. In contrast, implementation of ERAS protocols has been consistently shown to improve postoperative outcomes. Specifically, ERAS reduces postoperative hospital stay (PHS) by an

average of 2.00 days, accelerates return of bowel function as evidenced by a reduction in time to first flatus by approximately 12.18 hours, and shortens the time to first defecation by about 32.93 hours when compared with traditional postoperative care (95% CI).[7]

Additionally, ERAS protocol was proven to be more cost effective than traditional perioperative care. A study conducted by Zamora et al in a Philippine Government Hospital found that hospital expenses for open colorectal procedures can be decreased by high compliance to ERAS protocol. However, potential savings from ERAS adherence may be countered by the greater costs of minimally invasive surgery procedures, which are driven by equipment-related charges.[34] Lee et al. also noted lower overall societal costs in colorectal surgery patients in ERAS group was more than 99% likely to be cost-effective, thus showing ERAS protocol is more of an economical option compared to conventional perioperative management for elective colorectal resection.[35]

Future Prospect of ERAS in Colorectal Cancer Surgery

Emerging evidence highlights the clinical value of prehabilitation in patients undergoing colorectal cancer surgery. Given increasing interest in its potential to reduce length of stay and postoperative complications, ERAS pathways should incorporate structured prehabilitation strategies. Prehabilitation—consisting of preoperative physical conditioning, nutritional optimization, and psychological support—aims to enhance functional reserves and improve resilience to surgical stress. Future research is warranted to develop standardized prehabilitation protocols and determine which patient subgroups derive the greatest benefit.[23]

As ERAS protocols continue to advance, growing attention has been directed toward leveraging emerging technologies to further optimize patient outcomes. The incorporation of wearable devices and telemedicine platforms into perioperative pathways represents a promising extension of current practice. Wearable sensors, in particular, offer valuable real-time monitoring of patient activity and physiological parameters, enabling continuous assessment of recovery both during hospitalization and following discharge. This integration has the potential to enhance clinical decision-making, support individualized postoperative care, and ultimately improve recovery trajectories.[23]

Several studies have demonstrated promising outcomes with the use of virtual postoperative consultations and mobile health applications for patient self-reporting, with approximately 30–70% of patients indicating improved care experiences through virtual follow-ups. Telemedicine further enhances access to perioperative care, particularly in underserved regions, by enabling more efficient preoperative evaluation and optimization. The combination of telemedicine and wearable monitoring systems allows for continuous patient surveillance and timely clinical feedback, contributing to improved recovery trajectories and higher patient satisfaction. Future investigations should aim to standardize these digital approaches, determine optimal implementation strategies, and evaluate their applicability across different surgical disciplines to support broader integration into ERAS pathways.[23]

This narrative review has several limitations. The absence of a systematic search strategy and quantitative synthesis may introduce selection bias. Variability in study design, patient characteristics, ERAS adherence, and outcome definitions limits comparability across studies. In addition, most evidence is derived from observational

studies, and the individual effects of specific ERAS components could not be independently assessed.

CONCLUSION

The ERAS protocol integrates multiple evidence-based interventions that collectively reduce operative stress and enhance patient recovery. Current evidence demonstrates that ERAS implementation significantly decreases postoperative complications and shortens hospital length of stay, while also offering a cost-effective approach to perioperative management.

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DISCLOSURE

The authors declare no conflict of interest in this study.

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