Review

Clinical outcomes and future directions of enhanced recovery after surgery in colorectal surgery: a narrative review

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Abstract

Enhanced recovery after surgery (ERAS) protocols are designed to minimize surgical stress, preserve physiological function, and expedite recovery through standardized perioperative care for primary colorectal surgery patients. This narrative review explores the benefits of current ERAS protocols in improving outcomes for these patients and provides insights into future advancements. Numerous studies have shown that ERAS protocols significantly reduce the length of hospital stays by several days compared to conventional care. Additionally, the implementation of ERAS is linked to a reduction in postoperative complications, including lower incidences of surgical site infections, anastomotic leaks, and

postoperative ileus. Patients adhering to ERAS protocols also benefit from quicker gastrointestinal recovery, marked by an earlier return of bowel function. Some research indicates that colorectal cancer patients undergoing surgery with ERAS protocols may experience improved overall survival rates. High compliance with ERAS protocols leads to better outcomes, yet achieving full adherence continues to be a challenge. Despite these advantages, implementation challenges persist, with compliance rates affected by varying clinical practices and resource availability. However, the future of ERAS looks promising with the incorporation of prehabilitation strategies and technologies such as wearable devices and telemedicine. These innovations provide real-time monitoring, enhance patient engagement, and improve postoperative follow-up, potentially transforming perioperative care in colorectal surgery and offering new avenues for enhanced patient outcomes.

Keywords: Colorectal neoplasms; Colorectal surgery; Enhanced recovery after surgery; Postoperative complications; Preoperative care

Introduction

Background

Enhanced recovery after surgery (ERAS) protocols were developed to reduce perioperative surgical stress, maintain postoperative physiological function, and accelerate recovery through a standardized approach to perioperative care for patients undergoing major colorectal surgery [1-5]. Since the introduction of "fast-track surgery," the ERAS society has rapidly expanded, influencing changes in surgical and anesthesia protocols across multiple disciplines with a focus on improving the quality of recovery [6,7]. The ERAS concept involves a multidisciplinary and multimodal approach, integrating evidence-based interventions and management changes through interactive audits [1,2]. The ERAS Society first published guidelines for elective colorectal surgery in 2005, which have been updated to the fourth edition [1,3]. Previous studies have shown that ERAS protocols reduce the length of hospital stay (LOS), decreases postoperative morbidities, and enhance gastrointestinal functional recovery [3,5,8].

Despite the benefits of ERAS, implementing new practices remains challenging. Evidence indicates that changes in clinical practice often take up to 15 years to align with clear evidence [9]. There is a need to support a team-based approach to quickly implement new and improved care [2]. The compliance rate for ERAS protocols is generally reported to be above 60% and can reach over 90%, even in elderly patients who have undergone colorectal surgery [8,10-14]. In addition, ERAS is a continuously evolving framework, built upon the most reliable current evidence in perioperative care [6]. It is important to adopt the latest ERAS protocols and implement further changes based on new, clear evidence [2].

Objectives

The purpose of this review is to present an overview of the available evidence on the advantages of current ERAS protocols in improving outcomes for patients undergoing major colorectal surgery, while also offering guidance for future developments.

Ethics statement

This is a literature-based study; therefore, neither approval by the institutional review board nor obtainment of informed consent was required.

Elements of ERAS protocols

The ERAS Society guidelines for elective colorectal surgery are shown in Table 1 [1].

Table 1. Enhanced recovery after surgery protocol for elective colorectal surgery

Preadmission items
Preadmission information, education and counseling
Preoperative optimization
Smoking cessation

Avoiding alcohol abuse
Prehabilitation
Preoperative nutritional care
Management of anemia
Oral or intravenous iron therapy
Preoperative items
Prevention of nausea and vomiting
Preanesthetic medication
Antimicrobial prophylaxis and skin preparation
Bowel preparation
Preoperative fluid and electrolyte therapy
Preoperative fasting and carbohydrate loading
Intraoperative items
Standard anesthetic protocol
Intraoperative fluid therapy
Avoiding fluid excess and organ hypoperfusion
Preventing intraoperative hypothermia
Minimally invasive surgery
No drainage catheter of the peritoneal cavity and pelvis
Postoperative items
No nasogastric intubation
Postoperative multimodal analgesia
Epidural blockade
Spinal anesthesia/analgesia
Lidocaine infusions
Abdominal wall blocks
Thromboprophylaxis
Postoperative near-zero fluid and electrolyte balance
Early removal of urinary drainage catheter
Prevention of postoperative ileus
Postoperative glycemic control
Postoperative nutritional care
Early oral feeding
Immunonutrition
Early mobilization

ERAS protocols are designed to minimize stress and enhance the response to stress [2,6,15]. By preserving homeostasis, it helps patients avoid catabolism, thereby preventing the loss of protein, muscle

strength, and cellular dysfunction [2,3]. The reduction of insulin resistance promotes proper cellular function during tissue injury [16,17]. ERAS protocols include several components to support these objectives: providing preoperative nutritional support to malnourished patients, administering carbohydrates before surgery to minimize postoperative insulin resistance, using epidural or spinal analgesia to reduce the endocrine stress response, employing anti-inflammatory drugs to control inflammation, encouraging early postoperative feeding to ensure adequate energy intake, and optimizing pain control to prevent stress and insulin resistance [1,2,15,17,18]. In addition, ERAS protocols aim to maintain fluid and electrolyte balance. Insufficient fluid can lead to reduced perfusion and organ dysfunction, while excessive intravenous salt and fluid administration is a recognized cause of postoperative ileus and related complications [19]. It is essential to maintain euvolemia, cardiac output, and the delivery of oxygen and nutrients to tissues to preserve cellular function, especially during tissue repair. Once euvolemia is achieved, vasopressors may be administered as necessary to maintain mean arterial blood pressure. A common recommendation is to target minimal weight change, typically maintaining a net intake of intravenous fluid around 30 mL/kg and limiting weight gain to within 2 kg [2,20-22]. Postoperative intravenous fluids are generally discontinued approximately 24 hours after surgery. A patient on an ERAS pathway should be drinking, eating, mobilizing, and sleeping on the day after surgery. ERAS protocols also avoid several traditional care practices that have been proven harmful, such as the routine use of nasogastric tubes, prolonged urinary catheterization, and prolonged or inappropriate use of abdominal drains [1,2,8,13,14].

The implementation of ERAS protocols in clinical settings varies by country and hospital. Adhering to all items of ERAS protocols is essential, yet often challenging to accomplish [10]. A systematic review and meta-analysis reported that several components, including preadmission information, education and counseling, preanesthetic medication, bowel preparation, preoperative fluid and electrolyte therapy, minimally invasive surgery, multimodal analgesia, avoidance of nasogastric intubation, early removal of urinary drainage catheters, and early mobilization, were effectively implemented. However, other elements such as preoperative optimization, anemia management, and postoperative glycemic control were less

frequently applied [23].

Analysis of the outcomes of ERAS protocols

The outcomes of implementing ERAS protocols are summarized in Table 2.

Table 2. Outcomes of ERAS protocols compared with conventional treatment

Author	Study design	Study population	Patients (n)	Outcomes	*p*-value
Length of stay (days)					
Quiram et al. [31]	Multicenter Retrospective	Elective RC, MIS	600	3 vs. 5	<0.001
Meillat et al. [29]	Retrospective	Elective CRC	320	5.8 vs. 8.2	<0.001
Wang et al. [30]	Retrospective	Elective CRC	542	7.73 vs. 10.96	<0.001
Vignali et al. [32]	Retrospective	Elective RC, MIS	297	8.9 vs. 12.1	<0.001
Cristóbal et al. [33]	Prospective	Elective RC, MIS	300	5 vs. 7	<0.001
Simpson et al. [24]	Retrospective	Elective colectomy	4,363	6 vs. 7	<0.001
Pędziwiatr et al. [10 or 26]	Prospective	Elective colectomy	92	3 vs 5	0.014
Liu et al. [25]	Multicenter Retrospective	Elective colectomy	3,768	4.2 vs. 5.1	<0.001
Tampo et al. [8]	Retrospective	Elective colectomy	267	5.8 vs. 7.9	<0.001
Toh et al. [14]	Retrospective	Elective colectomy	171	7.0 vs. 10.8	0.024
Kim et al. [15 or 40]	Retrospective	Elective stoma reversal	108	2.3 vs. 4.1	<0.001
Dag et al. [27]	RCT	Elective colectomy	199	5.5 vs. 9.0	<0.001
Lau et al. [28]	RCT	Elective colectomy	111	5.0 vs. 7.0	0.01
Complication rate (%)					
Quiram et al. [31]	Multicenter Retrospective	Elective RC, MIS	600	34.7 vs. 54.3	<0.001
Meillat et al. [29]	Retrospective	Elective CRC	320	21.3 vs. 34.4	0.002
Cristóbal et al. [33]	Prospective	Elective CRC, MIS	300	28.0 vs. 46.0	0.002
Pędziwiatr et al. [10 or 26]	Prospective	Elective colectomy	92	9.4 vs. 56.0	0.014
Liu et al. [25]	Multicenter Retrospective	Elective colectomy	2,406	14.7 vs. 18.1	0.02
Barberan-Garcia et al. [36]	RCT	Elective abdominal surgery	144	31.0 vs. 62.0	0.001

Garfinkle et al. [34]	Retrospective	Elective colectomy	40,446	14.9 vs. 20.3	<0.001
Ripollés-Melchor et al. [35]	Multicenter Prospective	Elective colectomy	2,084	25.2 vs. 30.3	0.01
Flatus resumption time (days)					
Wang et al. [30]	Retrospective	Elective CRC	542	2.3 vs. 2.9	<0.001
Vignali et al. [32]	Retrospective	Elective RC, MIS	297	2.1 vs. 3.3	<0.001
Lau et al. [28]	RCT	Elective colectomy	111	3.7 vs. 4.8	0.04
Overall survival rate (%)					
Quiram et al. [31]	Multicenter Retrospective	Elective RC, MIS	600	91.4 vs. 81.7	<0.001
Tidadini et al. [37 or 38]	Retrospective	Elective CRC	1,001	76.1 vs. 69.2	0.017
Tidadini et al. [37 or 38]	Retrospective	Elective CRC	661	73.1 vs. 64.4	0.016

RCT, randomized controlled trial; RC, rectal cancer; MIS, minimally invasive surgery; CRC, colorectal cancer

Length of hospital stay

Several studies have reported a reduction in the length of stay (LOS) with the implementation of ERAS protocols. Simpson et al. analyzed 4,363 patients who underwent elective colorectal surgery and found that ERAS protocols significantly reduced LOS [24]. Tampo et al. reported a significant impact of ERAS protocols on reducing LOS in elective colectomy patients [8]. Toh et al. demonstrated that the reduction in LOS was influenced by the implementation of ERAS protocols and the absence of complications [14]. Liu et al. analyzed 3,768 patients who underwent elective colectomy in 20 medical centers and found that the implementation of ERAS protocols was associated with significant decreases in LOS [25]. Pędziwiatr et al. conducted a prospective cohort study and found that the implementation of ERAS protocols in elective colectomy significantly reduced LOS [26]. These studies also showed that good compliance was associated with a significantly shorter LOS [8,24,26]. Two randomized controlled trials showed that the implementation of ERAS protocols was associated with shorter LOS in elective colectomy. Dag et al. enrolled 199 patients and found that early feeding was associated with a significantly shorter LOS [27]. Lau et al. enrolled 111 patients and reported that the early use of a low-residue diet was associated with a reduction in LOS [28]. Some studies reported that the implementation of ERAS protocols in patients

with colorectal cancer undergoing elective surgery was associated with a reduction in LOS [29,30]. Several studies reported that the impact of ERAS protocols on shorter LOS in patients with colorectal cancer undergoing elective minimally invasive surgery. Quiram et al. analyzed 600 patients with rectal cancer who underwent elective minimally invasive surgery, and Vignali et al. analyzed 320 patients, finding that the implementation of ERAS protocols was associated with a significantly shorter LOS [31,32]. Cristóbal et al. prospectively enrolled 300 patients and reported that the implementation of ERAS protocols reduced the LOS in patients with colorectal cancer undergoing robotic surgery [33]. In one study, a multimodal pain management protocol for loop ileostomy reversal was associated with a significantly shorter LOS [15]. Another study showed no differences in LOS despite the implementation of ERAS protocols in elderly patients with colorectal cancer [13].

Complication rate

Several studies have reported a reduction in postoperative complication rates following the implementation of ERAS protocols. Liu et al. analyzed 2,406 patients who underwent elective colectomy and found that the implementation of ERAS protocols resulted in lower complication rates compared to conventional treatment [25]. Garfinkle et al. studied 40,446 patients undergoing elective colectomy and discovered that oral antibiotic preparation alone significantly reduced surgical site infections, anastomotic leaks, postoperative ileus, and major morbidity [34]. Pędziwiatr et al. conducted a prospective cohort study and determined that ERAS protocols significantly reduced complication rates in elective colectomy surgery [26]. Ripollés-Melchor et al. carried out a multicenter, prospective study and reported significantly fewer moderate to severe complications after elective colorectal surgery in the ERAS group compared to the conventional treatment group. An increase in ERAS adherence was also associated with a decrease in postoperative complications [35]. Barberan-Garcia et al. conducted a randomized controlled trial with 144 patients undergoing elective major abdominal surgery, including colectomy, and found that personalized prehabilitation reduced complication rates [36]. Several studies have highlighted the impact of ERAS protocols on reducing complication rates in patients with colorectal cancer undergoing elective surgery. Meillat et al. reported that the implementation of an ERAS protocol reduced complication rates after

elective colorectal cancer surgery [29]. Quiram et al. analyzed 600 patients with rectal cancer who underwent elective minimally invasive surgery and found that the implementation of ERAS protocols was associated with a significantly lower complication rate [31]. Cristóbal et al. prospectively enrolled 300 patients and reported that the implementation of ERAS protocols reduced the complication rates in patients with colorectal cancer who underwent robotic surgery [33]. However, several other studies found that the implementation of ERAS protocols was not associated with changes in postoperative complication rates [13,15,27,30,32]. Additionally, one study reported higher postoperative complication rates in the ERAS group compared to conventional treatment after elective colectomy [8].

Gastrointestinal functional recovery

Several studies have reported a reduction in gastrointestinal functional recovery time with the implementation of ERAS protocols. Wang et al. analyzed 542 patients with colorectal cancer who underwent elective surgery, while Vignali et al. studied 297 patients with rectal cancer who underwent minimally invasive surgery. Both studies found that the implementation of ERAS protocols was associated with a significantly shorter time to first flatus resumption. Lau et al. conducted a randomized controlled trial with 111 patients undergoing elective colectomy and found that the early use of a low residue diet was associated with a faster return of bowel function [28].

Overall survival rates

Multiple studies have reported an association between the implementation of ERAS protocols and improved overall survival rates in patients with colorectal cancer who underwent elective surgery. Quiram et al. analyzed 600 patients with rectal cancer who underwent elective minimally invasive surgery and found that the implementation of ERAS protocols was associated with a significantly higher overall survival rate [31]. Tidadini et al. conducted two retrospective studies and reported that the implementation of ERAS protocols improved overall survival rates in patients with colorectal cancer who underwent elective surgery [37,38].

Future directions of ERAS protocols

Prehabilitation

Emerging evidence suggests that prehabilitation is beneficial in the treatment of colorectal cancer [39,40]. ERAS protocols should focus on the impact of prehabilitation, especially given the growing interest in its potential to reduce LOS and postoperative complications [6,41]. Prehabilitation, which involves preoperative exercise, nutritional support, and psychological interventions, aims to improve a patient's functional capacity before surgery, thereby reducing the impact of surgical stress [42]. However, the benefits of prehabilitation remain uncertain due to conflicting evidence in the literature. Valkenet et al. reported that preoperative inspiratory muscle training reduced postoperative pulmonary complications in cardiac and abdominal aortic aneurysm surgeries. Conversely, no significant differences were observed in postoperative complications and LOS in orthopedic surgery [43]. Lemanu et al. reported that poor adherence to prehabilitation was associated with limited improvement in clinical outcomes [44]. These findings may be influenced by the heterogeneity of the studies, including differences in prehabilitation protocols and surgical specialties [45]. Despite these challenges, another review focusing on total body exercise as a prehabilitation intervention reported improvements in postoperative pain, LOS, and physical function [46]. Moreover, a randomized controlled trial involving colorectal surgery patients demonstrated that a multimodal prehabilitation program, including exercise, nutritional counseling, and stress reduction, led to increased functional walking capacity both preoperatively and postoperatively compared to standard rehabilitation [47]. Therefore, prehabilitation may offer significant benefits, particularly when applied in a structured and comprehensive manner. As the evidence for prehabilitation is still in its early stages, further high-quality, randomized controlled trials are needed to better understand its role in ERAS protocols. Future research should aim to establish standardized and structured prehabilitation interventions and identify the specific patient populations that could most benefit from them [41,45].

Use of technology

As ERAS protocols continue to evolve, there is a growing interest in utilizing new technologies to improve patients' outcomes [3]. The integration of wearable devices and telemedicine could enhance existing ERAS protocols [41,45]. Wearable sensors are proving to be valuable for monitoring patients' physical activity and recovery [48]. These devices can track and transmit data on body movement and vital signs, both in-hospital and post-discharge [49,50]. Several studies have demonstrated a correlation between early postoperative physical activity, such as daily step counts, and improved recovery outcomes, including shorter LOS and better functional recovery [51-53]. Real-time monitoring of patient activity provides healthcare providers with essential insights into recovery progress and aids in the early identification of complications [54]. Additionally, providing patients with feedback on their activity levels can motivate them to engage more actively in their recovery process [55,56]. In addition to wearable sensors, telemedicine holds the potential to transform both preoperative and postoperative care [41]. Telemedicine can facilitate remote consultations, monitor postoperative recovery, and reduce the need for unnecessary hospital visits [57]. Some studies have shown that virtual visits and the use of mobile applications for patient self-reporting are promising, with approximately 30% to 70% of patients reporting enhanced care through virtual follow-ups [58-60]. Telemedicine also improves access to healthcare in underserved areas, facilitating better preoperative assessment and preparation [45]. By providing continuous monitoring and feedback, wearable devices and telemedicine can support improved recovery outcomes and enhance overall patient satisfaction. Future research should focus on optimizing these technologies for broader adoption and developing standardized protocols to ensure their effectiveness across various surgical specialties [41,45].

Discussion

ERAS protocols have been established as a highly effective, evidence-based strategy for optimizing surgical recovery, particularly in the field of colorectal surgery. Characterized by its multidisciplinary and multimodal approach, ERAS aims to minimize surgical stress, preserve physiological function, and

promote a more rapid recovery. Numerous studies have shown that implementing ERAS protocols reduces LOS, lowers complication rates, and improves gastrointestinal recovery, especially with high compliance to protocol elements. Despite these successes, challenges remain in the widespread implementation of ERAS protocols in various clinical settings. Future efforts should concentrate on integrating prehabilitation, which emphasizes preoperative exercise, nutrition, and psychological support, and on incorporating emerging technologies such as wearable sensors and telemedicine. These innovations have the potential to further enhance patient outcomes by enabling real-time monitoring and fostering greater patient involvement in their recovery process.

Conclusion

While ERAS protocols have transformed perioperative care, ongoing research, technological advancements, and the integration of prehabilitation remain crucial for optimizing outcomes and enhancing patient care across various surgical disciplines.

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