DOI: 10.7860/JCDR/2026/85528.23501

Review Article

Surgery Section

Enhanced Recovery after Bowel Surgery: A Narrative Review of Current Concepts, Implementation Challenges, and Future Directions

YASHASVI TRIVEDI[1], RAJESH GATTANI[2], AMIT BOSE[3], SHAILABH[4], BHAGYESH SAPKALE[5]

ABSTRACT

Enhanced Recovery After Surgery (ERAS) is a transformative, evidence-based multimodal approach which is aimed at minimising surgical stress, optimising perioperative physiology, and accelerating recovery in bowel surgery. This narrative review article highlights current evidence on the core components, physiological foundations, implementation patterns, along with outcome benefits of ERAS protocol in various bowel surgical procedures. Preoperative strategies such as patient counselling, risk optimisation and carbohydrate loading can help to reduce anxiety, insulin resistance, as well as postoperative catabolism. Intraoperative elements like minimally invasive surgery, Goal-Directed Fluid Therapy (GDFT), multimodal analgesia, regulation of temperature, and avoidance of routine tubes and drains can help further to prevent inflammatory and neuroendocrine stress responses. Postoperative measures, including early feeding, early mobilisation, opioid-sparing analgesia and meticulous fluid and glycaemic management, facilitate faster functional bowel recovery and reduced morbidity. The narrative review also highlights adaptation of ERAS across specific surgical procedures like Low Anterior Resection (LAR), emergency bowel surgery, Inflammatory Bowel Disease (IBD), as well as geriatric populations. Despite available robust evidence, some barriers like compliance variability, resource limitations, along with cultural factors can disturb overall widespread implementation of ERAS, particularly in low and middle-income countries such as India. Emerging technologies, namely robotic surgery, digital ERAS tracking, artificial intelligence-guided perioperative surgical procedures, and personalised recovery pathways can offer promising results thus enhancing adherence and outcomes. Overall, ERAS protocols can further improve recovery of patient, reduce complications, and enhance the quality and efficiency of various bowel surgeries.

Keywords: Carbohydrate loading, Goal-directed fluid therapy, Minimally invasive surgery, Multimodal analgesia, Postoperative mobilisation

INTRODUCTION

The ERAS programmes, also known as a fast-track surgery is a paradigm shift in the way of perioperative care for colorectal and other major surgeries [1]. Instead of using single intervention, ERAS is an evidence-based, multimodal intervention that emphasises the physiological state of stress response to surgery through preoperative optimisation, opioid-sparing analgesia, GDFT, minimally invasive techniques when possible, early feeding and mobilisation [1]. Combined, the effects of these factors are to ensure homeostasis, minimise postoperative catabolism and complications, accelerate functional recovery following bowel surgery and thereby contribute to reduced postoperative mortality through lower rates of infection, cardiopulmonary complications, and organ dysfunction [2].

Since ERAS bundles simultaneously address a number of perioperative factors, they consistently reduce length of stay, postoperative morbidity, and healthcare costs in colorectal surgery compared to traditional care [2]. Such advantages resulted in the ERAS® Society developing consensus guidelines on elective colorectal surgery, which provides graded recommendations for each element of the pathway and multidisciplinary implementation along with compliance measurement are placed in focus [3]. Notably, in the resource-limited settings such as India, ERAS is not only feasible, but also safe in these environments and that the increase of protocol implementation level is positively associated with better results, which is why ERAS can be considered a viable way to enhance the quality and efficiency of colorectal care in all parts of the world [4].

The adoption of ERAS in colorectal and gastrointestinal surgery in Indian scenario has developed in various aspects in recent years [5]. Given the infrastructural and cultural challenges, a survey among the Indian anaesthesiologists indicates that most (≈ 89%) are familiar with ERAS, although compliance with the main aspects of postoperative elements, including early removal of nasogastric tubes, early oral feeding, and prompt discontinuation of intravenous (i.v.) fluid, is inconsistent [5]. In a prospective interventional study at an Indian tertiary cancer centre, Theja S et al., described a very high overall compliance rate of ERAS (≈ 88.5%), in gastrointestinal cancer surgeries, with a median duration of hospitalisation (6.5 days) [6]. A more recent Indian study by Ahmad N et al., in colorectal resections (IGIMS, Patna) introduced a 16-item ERAS protocol, with a compliance rate of approximately 78.6 on average and found that those patients who complied with the ERAS protocol (more than 80-percent) had a much shorter hospital stay (mean 5.2 days vs. 7.6 days) and fewer complications [7]. One audit of 215 colorectal surgery patients in a regional cancer institute in India revealed some variation in adherence to the elements of ERAS with only a few items (e.g., preoperative counselling, selective bowel prep) achieving >80% compliance [8]. This narrative review article aims to highlight current concepts, implementation challenges, and future directions of ERAS protocols in bowel surgery, also emphasises evidence-based components along with required procedure-specific adaptations.

Core Components of Enhanced Recovery after Bowel Surgery

Preoperative Patient Preparation in ERAS for Bowel Surgery: The fundamental preoperative measures as part of the ERAS of

bowel (colorectal) surgery are based on the principles of physical and mental conditioning of the patient to endure surgery with minimum stress and faster recovery [9]. Key elements in preoperative-ERAS are preoperative counselling (structured, often prior to surgery), shared decision-making (setting of expectations regarding pain management, nutrition, mobilisation and discharge), systematic medical optimisation of comorbidities (anaemia correction, glycaemic control, smoking/alcohol cessation), functional preoperative prehabilitation (exercise and physiotherapy where feasible) [9,10]. These are accompanied by protocolised risk assessment, thromboprophylaxis planning and minimisation of sedative premedication all which are aimed at reducing surgical stress, physiological reserves and shorten length of stay [10].

The most evidence-based preoperative interventions in ERAS of bowel surgery include nutritional strategies and fasting/feeding guidelines [11]. Routine prolonged fasting is discouraged: clear carbohydrate beverages until two hours prior to anaesthesia and targeted nutritional optimisation is suggested to reduce insulin resistance and sooner recovery of bowel function; it helps reducing length of stay and faster recovery when carbohydrates are given before operations [11]. Meanwhile, few elements, like independent benefit of mechanical bowel preparation, drains, or nasogastric tubes lack more coherent evidence and should be utilised selectively according to the current ERAS society guidance and local practice [12]. Overall, the combination of patient education, medical optimisation, carbohydrate-based preoperative nutrition, and a clear, multidisciplinary plan (anaesthesia, surgery, nursing, physiotherapy) is the key to the preoperative package that ensures the positive outcome in elective bowel surgery [12]. Preoperative ERAS measures for bowel surgery are mentioned in [Table/Fig-1] [9-12].

Category	Key elements	Purpose/expected benefit	References
Patient counselling & shared decision-making	• Structured preoperative counselling • Discussion about expectations: pain management, nutrition, mobilisation, discharge	• Reduces anxiety • Improves patient participation and compliance • Enhances recovery	[9]
Medical optimisation	• Correction of anaemia • Glycaemic control • Smoking and alcohol cessation	• Reduces postoperative complications • Improves overall surgical outcome	[9,10]
Functional prehabilitation	• Exercise programmes • Physiotherapy (where feasible)	• Improves physical conditioning • Enhances functional reserve and faster recovery	[9,10]
Risk assessment & perioperative planning	• Protocolised assessment of surgical risk • Thromboprophylaxis planning • Avoidance/ minimisation of sedative premedication	• Reduces surgical stress • Maintains physiological stability • Shortens hospital stay	[10]
Nutritional strategies	• Avoid prolonged fasting • Clear carbohydrate drinks up to 2 hours before anaesthesia • Targeted nutritional optimisation	• Reduces insulin resistance • Promotes earlier return of bowel function • Reduces length of stay	[11]
Bowel preparation & devices (selective use)	• MBP only when indicated • Selective use of drains and nasogastric tubes	• Prevents unnecessary interventions • Aligns with current ERAS guidelines and evidence	[12]
Multidisciplinary care coordination	• Collaborative planning between surgery, anaesthesia, nursing, physiotherapy teams	• Ensures consistency, reduces complications, and supports fast-track recovery	[12]

[Table/Fig-1]: Preoperative ERAS measures for bowel surgery [9-12].
Legend: ERAS: Enhanced recovery after surgery; MBP: Mechanical bowel preparation

Essential Intraoperative Practices in ERAS for Bowel Surgery

The aim of the intraoperative phase of ERAS in bowel surgery is to reduce the occurrence of physiological stress, homeostasis maintenance, and early recovery, after the surgery [13]. One of these is the incorporation of minimally invasive surgery, laparoscopic or robotic; which is consistently linked with reduced tissue trauma, lower inflammatory response, decreased postoperative pain and earlier bowel recovery relative to open surgery [13]. Intraoperative normothermia by forced-air warming, warmed i.v. fluids, and maintaining operating room temperature are also vital in controlling hypothermia that promotes surgical site infections, coagulopathy, and length of stay [14]. GDFT is also a focus of ERAS guidelines where fluid responsiveness indicators are dynamic and not fixed-volume strategies to fluid administration [14,15]. GDFT is helpful in reducing postoperative complications, ileus, and cardiopulmonary events by preventing fluid overload and hypovolaemia [15].

Another fundamental ERAS measure is multimodal intraoperative analgesia, which tries to minimise consumption of opioids and the related ileus, nausea, and delayed mobilisation [9,16]. In laparoscopic colorectal surgery, Transverse Abdominis Plane (TAP) blocks and quadratus lumborum blocks, among other regional blocks, are growing in popularity, whereas in open colorectal surgery, better pain control, and reduced ileus have been demonstrated as a result of epidural analgesia [17,18]. ERAS protocols also promote the avoidance of unwarranted nasogastric tubes and intra-abdominal drains, which was evidenced by the fact that they increase complications and delay bowel recovery in case they are routinely used [9]. The multimodal antiemetic prophylaxis (dexamethasone, 5-HT3 antagonists, and volatile-sparing anaesthesia) is applied to prevent Postoperative Nausea and Vomiting (PONV) since it delays the initiation of early oral intake and oral mobilisation [7,19]. Thus, these intraoperative measures such as minimally invasive surgery, physiologic optimisation, goal-directed fluids, regional analgesia, tubes-drains avoidance, and structured PONV prevention constitute the evidence-based ERAS framework that will greatly enhance the outcomes of bowel surgery [7,9]. Intraoperative components of ERAS protocol in bowel surgery are depicted in [Table/Fig-2] [7,9,13-19].

Category	Key elements	Purpose/Benefits	Ref
Minimally invasive surgical approach	• Laparoscopic surgery • Robotic surgery	• Reduced tissue trauma • Lower inflammatory response • Less postoperative pain • Earlier bowel recovery	[13]
Intraoperative temperature management	• Forced-air warming • Warmed i.v. fluids • Maintaining operating room temperature	• Prevents hypothermia • Reduces surgical site infections • Lowers coagulopathy risk • Decreases length of stay	[14]
Goal-Directed Fluid Therapy (GDFT)	• Dynamic fluid responsiveness indicators • Avoids fixed-volume strategies	• Prevents fluid overload & hypovolaemia • Reduces postoperative complications • Lowers ileus & cardiopulmonary events	[14,15]
Multimodal intraoperative analgesia	• Opioid-sparing strategies • TAP block, QL block (laparoscopic cases) • Epidural analgesia (open cases)	• Minimises opioid side effects (ileus, nausea) • Enhances mobilisation • Better pain control & reduced ileus (epidural)	[16-18]
Avoidance of routine tubes & drains	• Avoid routine nasogastric tubes • Avoid routine intra-abdominal drains	• Reduces complications • Prevents delayed bowel recovery	[17]
PONV prophylaxis	• Dexamethasone • 5-HT3 antagonists • Volatile-sparing anaesthesia	• Prevents postoperative nausea & vomiting • Enables early feeding • Enables early mobilisation	[7,19]

Overall intraoperative ERAS framework	• Minimally invasive techniques • Physiologic optimisation • GDFT • Regional analgesia • Avoid tubes/drains • Structured PONV prevention	• Evidence-based improvements in bowel surgery outcomes	[7,9]

[Table/Fig-2]: Intraoperative components of ERAS protocol in bowel surgery [7,9,13-19].
Legend: ERAS: Enhanced recovery after surgery; i.v.: Intravenous; GDFT: Goal-directed fluid therapy; TAP Block- Transversus abdominis plane block; QL Block: Quadratus lumborum block; PONV: Postoperative nausea and vomiting; 5-HT3 Antagonists: 5-hydroxytryptamine Type-3 receptor antagonists

Postoperative Optimisation Measures in ERAS for Bowel Surgery

Early oral feeding and earliest mobilisation are major components of ERAS protocols that improve recovery in the postoperative period in colorectal surgery [16]. Early resumption of diet, commonly within 24 hours, reduces the period of recovery of bowel functioning and postoperative ileus [20]. Early mobilisation (as soon as it is done safely), reduces the risks of muscle deconditioning, venous thromboembolism, and lung complications, and aids gastrointestinal recovery [21]. These are supplemented by opioid-sparing multimodal analgesia, in which non-opioid drug systemic agents and regional/neuraxial techniques are employed, which will allow reducing opioid-related side effects such as ileus, nausea, and sedation, thereby facilitating faster mobilisation and oral intake [21].

Another critical area in the postoperative ERAS pathway is fluid management, early removal of catheters/drains, glycaemic control, and prevention of ileus [22]. Reduction of fluid overload and the prompt discontinuation of i.v. fluids (e.g., by day 1 of the postoperative period) is closely linked with the fewer complications and shorter hospital stay [22]. Meanwhile, the catheterisation of the urine (usually in the first 24 hours) has proved to be safe and associated with less urinary tract infections and earlier mobilisation [23]. ERAS protocols can incorporate alvimopan, a peripherally acting μ-opioid receptor antagonist, in patients of postoperative ileus risk to expedite the healing of the gastrointestinal tract and decrease the incidence of ileus [24]. Finally, for diabetic colorectal surgery patients, tight glycaemic monitoring and control (for example with continuous glucose monitoring) has been shown to improve anastomotic healing and reduce length of stay in the context of ERAS [25].

ERAS protocols are known to be consistently playing role in translating perioperative optimisation strategies into meaningful clinical outcome benefits in colorectal surgery [26]. In a randomised controlled trial, Forsmo HM et al., showed that higher compliance with ERAS criteria usually structured preoperative, postoperative counseling was independently associated having significant reduction in length of hospital stay without an increase in postoperative complications [26]. Thereby underscoring central role of patient engagement and protocol adherence [26]. These findings were further validated through the RecoverMI trial, where Bednarski BK et al., showed that an accelerated ERAS pathway following minimally invasive colorectal cancer surgery resulted in faster functional recovery of patient as well as earlier discharge compared to standard care, while maintaining comparable morbidity, readmission rates [27]. Similar advantages are also been reported across both laparoscopic, open colorectal procedures along with fast-track or ERAS-based approaches consistently showing reduced postoperative ileus, shorter hospitalisation as well as lower overall morbidity when it is compared to conventional perioperative care [28,29].

Evidence from low and middle-income settings further supports these benefits as ERAS implementation in elective open colorectal surgery has been shown to significantly shorten the period of hospital stay as well as improve early postoperative outcomes without compromising safety [30]. Contemporary data further continues to reaffirm all of these findings with recent comparative analyses reporting superior recovery metrics in patients, shorter length of stay in ERAS cohorts when compared to traditional care [30,31]. Collectively, all these studies provide robust clinical evidence that ERAS protocols reliably enhance postoperative recovery as well as reduce hospitalisation across diverse colorectal surgical populations, healthcare settings [30,31].

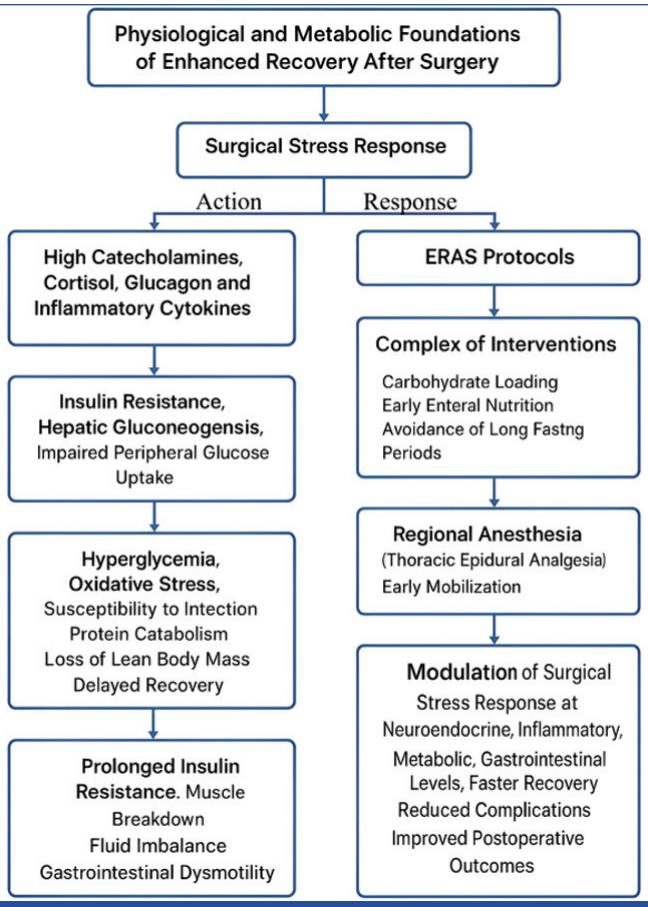
Physiological and Metabolic Foundations of Enhanced Recovery After Surgery (ERAS)

The surgical stress response is known as physiological response to significant changes in the abdomen and bowel after surgery that is characterised by a combination of neuroendocrine and inflammatory cascades involving sympathetic nervous system and hypothalamic-pituitary-adrenal axis activation [32]. This results in high catecholamines, cortisol, glucagon and inflammatory cytokines, including Interleukin-6 (IL-6) and Tumour Necrosis Factor-alpha (TNF-α) [32]. These mediators induce systemic inflammation, endothelial dysfunction, hypercoagulability, and fluid retention besides disrupting immune function [32]. Bowel surgery at a metabolic level induces a high level of insulin resistance, hepatic gluconeogenesis, and the impairment of peripheral glucose uptake [32]. The resultant hyperglycaemia increases the level of oxidative stress and susceptibility to infection [32]. At the same time, protein catabolism increases as a part of the stress-induced transition to the catabolic hormonal state, and leads to the loss of lean body mass and delayed recovery [32].

Bowel surgery also exacerbates the metabolic disturbances caused by manipulation of intestines, peritoneum and mesentery, which enhances inflammatory signalling and aggravates postoperative ileus [32]. Splanchnic hypoperfusion, cytokine release and sympathetic overactivity disrupt gut motility and mucosal barrier integrity [32]. Combined with prolonged preoperative fasting, immobility, and opioid administration, the patients often develop prolonged insulin resistance, muscle breakdown, fluid imbalance, and gastrointestinal dysmotility, which are the factors responsible for postoperative morbidity [32].

ERAS protocols are designed to reduce these pathophysiological imbalances with a complex of interventions that are highly effective in the existing perioperative literature [33]. Carbohydrate loading, early enteral nutrition and avoidance of long fasting periods, enhances perioperative insulin sensitivity and decrease the breakdown of proteins [33]. Opioid-sparing multimodal analgesia, GDFT and minimal invasive surgical methods reduce inflammatory processes and prevent fluid overload and gut hypoperfusion [33]. The regional anaesthesia approaches, such as thoracic epidural analgesia, reduce sympathetic drive and cortisol secretion, therefore, inhibiting neuroendocrine stress response [13,34]. Early mobilisation increases muscle metabolism, decreases insulin resistance and improves pulmonary mechanics [13,34]. All these ERAS components bring about the modulation of the surgical stress response at several levels; the neuroendocrine, inflammatory, metabolic, and gastrointestinal levels leading to a faster recovery, reduction in complications, and better postoperative outcomes [33,34]. Physiological and metabolic foundations of ERAS is depicted through [Table/Fig-3].

The ERAS protocols exert their beneficial effects through attenuating postoperative inflammatory as well as immune stress responses that are associated with colorectal surgery [35]. In a randomised clinical trial, Mari G et al., showed that patients managed under an ERAS protocol during laparoscopic colorectal surgery exhibited lower postoperative IL-6 levels as compared to those receiving conventional perioperative care thereby reflecting a reduced systemic inflammatory response as well as diminished surgical stress burden [35]. Complementing all of these findings, Feng J et al., also reported that fast-track surgical pathways were related to



[Table/Fig-3]: Physiological and metabolic foundations of Enhanced Recovery After Surgery (ERAS).
Legend: References- [13,32-34]; Source- Made by Authors

improved postoperative immune function inclusive of preservation of cellular immunity, reduction in pro-inflammatory cytokine release, when compared to traditional care in colorectal surgery patients [36]. The observed modulation of inflammatory mediators, immune responses is likely mediated through multiple ERAS components such as minimisation of surgical trauma by minimally invasive techniques, opioid-sparing multimodal analgesia, optimised fluid therapy as well as early enteral nutrition [36]. These biological effects further provide a mechanistic explanation for reduced postoperative morbidity, faster gastrointestinal recovery, shorter length of hospital stay which is consistently observed with ERAS implementation in colorectal surgery [35,36].

ERAS Protocol Adaptations Across Different Types of Bowel Surgery

The same multimodal principles form the basis of ERAS pathways in colorectal surgery (right hemicolectomy, left colectomy, and LAR); but they need operation-specific adjustments [37]. Right and left colectomies are generally associated with early oral feeding, opioid-sparing regional analgesia, along with minimal fluid shifts [37]. LAR surgeries are mainly related with a greater need of attention to pelvic autonomic preservation, selective urinary catheter duration, and avoiding routine pelvic drains, due to increased risks of pelvic sepsis and delayed bowel functionality [38]. Laparoscopic colectomy with adherence to strict protocols leads to a decrease in ileus, infections, and hospitalisation in all segments of the colon, and the maximum benefits occur when compliance reaches 70 to 80% of the elements of the pathways [39]. In addition, colorectal ERAS bundles are always superior to the conventional perioperative care despite the colorectal segment affected, especially when there is focus on intraoperative haemodynamic optimisation and early mobilisation [37,39].

In the case of small-bowel surgery, there is limited evidence about ERAS, but it suggests that the conventional principles of early enteral nutrition, restrictive yet GDFT, and early mobilisation can be applied without causing anastomotic or infectious complications [40]. Small-bowel resection cases demonstrate that these patients usually respond to early feeding and early catheter/drain removal [40]. Prolonged preoperative optimisation, counselling or carbohydrate loading is usually not possible in emergency bowel surgery, and ERAS is modified with key deliverable elements like opioid-sparing analgesia, judicious fluids, active temperature management, early postoperative feeding when tolerated and aggressive pulmonary physiotherapy [41]. The modified ERAS in the emergency still reduces the morbidity and length of stay in comparison to the traditional care, though the results are still lower than those of elective ERAS, owing to the severity of underlying illnesses [41].

In the case of surgeries of IBD, the ERAS needs consideration of disease-specific physiologic challenges, which include malnutrition, chronic corticosteroid, use anaemia, and disrupted immune responsivity [42]. In both Crohn diseases and ulcerative colitis surgeries, the ERAS protocols reduce the gastrointestinal recovery time and length of stay with no addition to the increase in anastomotic leaks and readmission when preoperative nutrition and steroid-management strategies are considered as a part of the pathway [42]. Similarly, geriatric patients have better outcomes with frailty-focused geriatrics ERAS, which includes prehabilitation, delirium-prevention bundles, early mobilisation of patient under physiotherapy oversight, and personalised opioid minimisation [43,44]. Frail elderly individuals are able to attain the same level of ERAS outcomes as younger patients with such customised interventions, which underscores the versatility and security of ERAS in physiologically susceptible groups [44]. ERAS protocol adaptations across different types of bowel surgery is mentioned in [Table/Fig-4] [37-44].

Beyond individual components of ERAS, growing evidence further supports that standardisation of ERAS protocols is an essential aspect for achieving consistent, reproducible improvements in outcomes

Surgery type	Key ERAS modifications/ considerations	Rationale/expected benefit	References
Right & Left Colectomy	• Early oral feeding • Opioid-sparing regional analgesia • Minimal fluid shifts	• Faster bowel recovery • Lower complications	[37]
Low Anterior Resection (LAR)	• Pelvic autonomic nerve preservation • Selective urinary catheter duration • Avoid routine pelvic drains	• Reduces pelvic sepsis risk • Prevents delayed bowel function	[38]
Laparoscopic colectomy (all segments)	• Strict ERAS adherence (70-80% compliance)	• Reduced ileus, infections, hospital stay	[39]
Small-bowel surgery	• Early enteral nutrition • Restrictive but GDFT-based fluids • Early mobilisation • Early catheter/drain removal	• Safe recovery without increased anastomotic or infectious complications	[40]
Emergency bowel surgery	• Modified ERAS: opioid-sparing analgesia, judicious fluids, temperature control, early feeding when tolerated, pulmonary physiotherapy	• Reduced morbidity and LOS despite inability to implement full elective ERAS	[41]
Inflammatory Bowel Disease (IBD) Surgery	• Preoperative nutritional optimisation • Steroid-management strategies	• Shorter GI recovery time • No increase in leaks or readmissions	[42]
Geriatric/Frail Patients	• Frailty-focused ERAS: prehabilitation, delirium-prevention, early mobilisation with physiotherapy, personalised opioid minimisation	• Outcomes comparable to younger patients • Safe in physiologically vulnerable groups	[43,44]

[Table/Fig-4]: ERAS protocol adaptations across different types of bowel surgery [37-44].

of the colorectal surgery patients. Shetiwy M et al., showed that implementing a standardised, multidisciplinary ERAS pathway for colorectal cancer surgery significantly improved recovery parameters in patients as well as reduced variability in perioperative care thus highlighting that fragmented, selective adoption of ERAS elements diminishes its overall effectiveness [45]. All of these findings reinforce about structured protocols, rather than isolated interventions, are very important for realising full benefits of enhanced recovery programmes [45]. Importantly, it concerns regarding safety of ERAS in elderly patients who usually present having frailty, comorbidities, reduced physiological reserve [45]. In a randomised controlled trial, which was done for specifically targeting older adults undergoing colorectal surgery, Ostermann S et al., demonstrated that an ERAS program tailored to elderly patients significantly reduced length of hospital stay and postoperative complications without increasing morbidity or compromising safety [46]. Together, all of these studies highlight that ERAS protocols are not only useful when standardised but are also adaptable as well as safe across age groups, provided that patient-specific modifications, multidisciplinary coordination are maintained properly [46].

Barriers and Challenges to Effective ERAS Implementation in Bowel Surgery

System-level, provider-level, and patient-level barriers to the successful implementation of ERAS protocol in bowel surgery are common [47]. One of the most significant issues is the lack of adherence to multidisciplinary protocols especially in cases when surgeons, anaesthesiologists, nurses, and physiotherapists do not align with the protocol in a unified way [47]. The inconsistency in clinical practice, the unwillingness to leave the traditional perioperative habits, and a lack of knowledge about the evidence behind the use of ERAS factors makes it a significant contributor to non-compliance [47]. Research into the colorectal ERAS process has continuously demonstrated that such minor deviations as excessive administration of perioperative fluids, prolonging of the starving period, and use of a nasogastric tube that was not required can reduce protocol effectiveness and delay the recovery process [47,48].

Limitation of resources is also very essential. This is because in many hospitals, particularly in the Low-Middle Income Countries (LMICs), there are limitations associated with staffs, infrastructure, and perioperative monitoring which disrupts the standardisation of ERAS protocol [49]. The unavailability of carbohydrate loading beverages, thoracic epidural analgesia equipment, multimodal analgesic medications, or minimal invasive surgery platforms restrict the achievement of full ERAS adherence [49]. Moreover, the lack of electronic tracking systems and the absence of ERAS coordinators complicate the protocol audits, which results in the lack of data-driven quality improvement [49].

Patient-related challenges which includes low health literacy, anxiety regarding early feeding or mobilisation, and cultural expectations of prolonged rest after surgery can also cause difficulties in adoption of ERAS protocol [50]. Comorbid issues such as weakness, malnutrition, along with uncontrolled diabetes mellitus limits early mobilisation and feeding in patients [47]. In addition, postoperative pain, unless controlled with optimum analgesia, becomes a significant hindrance to the prompt ambulation [47]. The patient engagement, preoperative counselling, and setting clear expectations is important to enhance ERAS adherence [47,50]. In this way, the evidence-based and highly efficient ERAS protocols require an organised education, institution-wide support, regular auditing, and effective and multidisciplinary coordination [47,49]. Barriers and challenges to effective ERAS implementation in bowel surgery and proposed rectification strategies are depicted in [Table/Fig-5] [47-50].

Barrier level	Specific barriers/ challenges	Impact on ERAS implementation	Proposed rectification strategies	References
System-level	Limited resources in LMIC settings (staffing, infrastructure, monitoring facilities)	Inconsistent protocol application and inability to standardise ERAS pathways	Phased ERAS implementation, prioritisation of high-impact low-cost elements, institutional administrative support	[49]
	Lack of ERAS coordinators and electronic data-tracking systems	Poor protocol auditing, lack of feedback and quality improvement	Appointment of ERAS coordinators, development of basic electronic audit tools and registries	[49]
	Limited availability of ERAS-specific resources (carbohydrate drinks, multimodal analgesics, MIS platforms)	Partial adherence to ERAS components	Adaptation of protocols to locally available resources, substitution with cost-effective alternatives	[49]
Provider-level	Poor multidisciplinary coordination among surgeons, anaesthesiologists, nurses, physiotherapists	Fragmented care delivery and reduced protocol compliance	Regular multidisciplinary meetings, standardised care pathways, team-based accountability	[47]
	Resistance to change from traditional perioperative practices	Delayed adoption and inconsistent implementation	Continuous medical education, dissemination of evidence-based benefits of ERAS	[47]
	Knowledge gaps regarding ERAS evidence and outcomes	Non-compliance with protocol elements	Structured ERAS training programmes and workshops	[47]
	Minor protocol deviations (excessive fluids, prolonged fasting, unnecessary nasogastric tubes)	Reduced protocol effectiveness and delayed recovery	Use of standardised checklists, real-time compliance monitoring	[47,48]
Patient-level	Low health literacy and poor understanding of ERAS principles	Reduced cooperation with early feeding and mobilisation	Comprehensive preoperative counseling, patient education materials	[50]
	Anxiety and cultural beliefs favoring prolonged postoperative rest	Delayed mobilisation and functional recovery	Preoperative expectation-setting and reassurance	[50]
	Comorbidities (malnutrition, frailty, uncontrolled diabetes)	Limited early mobilisation and feeding	Prehabilitation programmes, nutritional optimisation, glycemic control	[47]
	Inadequate postoperative pain control	Impaired ambulation and delayed recovery	Multimodal, opioid-sparing analgesia strategies	[47]

[Table/Fig-5]: Barriers and challenges to effective ERAS implementation in bowel surgery and proposed rectification strategies [47-50]; Source- Made by Authors.

Future Directions and Technological Advancements in ERAS for Bowel Surgery

Future directions for ERAS in bowel surgery should focus on integration of technological, personalised, and oncologic aspects for enhancing perioperative outcomes in patient [51,52]. The usage of ERAS protocol into robotic colorectal surgery has shown benefits, as robotic platforms thereby provide superior visualisation

along with reduced trauma of tissue, helping earlier mobilisation, reduced postoperative pain, and shorter hospital stays [52]. AI-supported perioperative pathways are also emerging as powerful tools for prediction of complications, adequate fluid management, and individualising analgesia, thus reduces variability in compliance of ERAS accordingly [51].

In oncological bowel surgery, ERAS protocols are developing for inclusion of tailored prehabilitation, optimised nutrition, and coordination along with neoadjuvant treatments for supporting complex cancer-related pathways [51,53]. Additionally, shifting toward personalised ERAS protocols, which is guided by biomarkers like inflammatory and microbiome profiles, sarcopenia indices, nutritional markers is necessary to allow risk-stratified perioperative planning and more precise implementation of ERAS [51]. Collectively, integration of robotics, artificial intelligence, digital health monitoring devices, and biomarker-based stratification represents future aspects of ERAS, which thus aims for delivering more individualised, efficient, also outcome-driven perioperative care in bowel surgery [51].

CONCLUSION(S)

The ERAS is known as a transformative, evidence-based protocol which is used for optimisation of perioperative care in bowel surgery through multimodal strategies targeting surgical stress, metabolic stability, and functional recovery. Across elective, emergency, minimally invasive, small-bowel, colorectal, and high-risk populations, ERAS is known for reducing various type of complications, such as ileus, length of stay, and healthcare costs. Although there are many challenges in its implementation, particularly in resource-limited settings; improving multidisciplinary coordination, proper auditing, and patient engagement can help in improvement of outcomes. Further, integration of technological advancements and personalised perioperative pathways can enhance effectiveness of ERAS thus leading to advancement of global standards in bowel surgery.

REFERENCES

[1] Gillis C, Ljungqvist O, Carli F. Prehabilitation, enhanced recovery after surgery, or both? A narrative review. Br J Anaesth. 2022;128(3):434-48.
[2] Lau CSM, Chamberlain RS. Enhanced recovery after surgery programs improve patient outcomes and recovery: A meta-analysis. World J Surg. 2017;41(4):899-913.
[3] Gustafsson UO, Scott MJ, Hubner M, Nygren J, Demartines N, Francis N, et al. Guidelines for perioperative care in elective colorectal surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations: 2018. World J Surg. 2019;43(3):659-95.
[4] Slim N, Teng WH, Shakweh E, Sylvester HC, Awad M, Schembri R, et al. Enhanced recovery programme after colorectal surgery in high-income and low-middle income countries: A systematic review and meta-analysis. Int J Surg Lond Engl. 2023;109(11):3609-16.
[5] Singh R, Gupta A, Gupta N, Kumar V. Enhanced recovery after surgery (ERAS): Are anaesthesiologists prepared for the paradigm shift in perioperative care? A prospective cross-sectional survey in India. Indian J Anaesth. 2021;(Suppl 3):S127-S138.
[6] Theja S, Mishra S, Bhoriwal S, Garg R, Bharati SJ, Kumar V, et al. Feasibility of the ERAS (Enhanced Recovery After Surgery) Protocol in Patients Undergoing Gastrointestinal Cancer Surgeries in a Tertiary Care Hospital-A Prospective Interventional Study. Indian J Surg Oncol. 2024;15(2):304-11.
[7] Ahmad N, Baitha KSL, Pawar SS, Mohsin F, Prakash P, Raj R, et al. Enhanced Recovery After Surgery (ERAS®) protocol in colorectal resections: A prospective observational study of implementation and outcomes at a tertiary referral center. Cureus. 2025;17(7):e88664.
[8] Pal AR, Mitra S, Aich S, Goswami J. Existing practice of perioperative management of colorectal surgeries in a regional cancer institute and compliance with ERAS guidelines. Indian J Anaesth. 2019;63(1):26-30.
[9] Jain SN, Lamture Y, Krishna M. Enhanced recovery after surgery: Exploring the advances and strategies. Cureus. 2023;15(10):e47237.
[10] Schwenk W. Optimized perioperative management (fast-track, ERAS) to enhance postoperative recovery in elective colorectal surgery. GMS Hyg Infect Control. 2022;17:Doc10.
[11] Bredefeld C, Patel A, Islam S, Peragallo-Dittko V. Enhanced recovery after surgery: Preoperative carbohydrate loading and insulin management in type 2 diabetes. Surg Open Sci. 2024;18:107-10.
[12] Watt DG, McSorley ST, Horgan PG, McMillan DC. Enhanced recovery after surgery: Which components, if any, impact on the systemic inflammatory response following colorectal surgery?: A systematic review. Medicine (Baltimore). 2015;94(36):e1286.
[13] Elias KM, Brindle ME, Nelson G. Enhanced recovery after surgery - Evidence and practice. NEJM Evid. 2025;4(3):EVIDra2400012.
[14] Simmons JW, Dobyns JB, Paiste J. Enhanced recovery after surgery: Intraoperative fluid management strategies. Surg Clin North Am. 2018;98(6):1185-200.
[15] McLain N, Parks S, Collins MJ. Perioperative goal-directed fluid therapy: A prime component of enhanced recovery after surgery. AANA J. 2021;89(4):351-57.
[16] Wright RM, Nelson G. Applying principles of enhanced recovery after surgery. Br J Surg. 2025;112(9):znaf194.
[17] Peltrini R, Cantoni V, Green R, Greco PA, Calabria M, Bucci L, et al. Efficacy of transversus abdominis plane (TAP) block in colorectal surgery: A systematic review and meta-analysis. Tech Coloproctology. 2020;24(8):787-802.
[18] Elvir-Lazo OL, White PF, Yumul R, Cruz Eng H. Management strategies for the treatment and prevention of postoperative/postdischarge nausea and vomiting: An updated review. F1000Research. 2020;9:F1000 Faculty Rev-983.
[19] Emile SH, Horesh N, Garoufalia Z, Gefen R, Ray-Offor E, Wexner SD. Strategies to reduce ileus after colorectal surgery: A qualitative umbrella review of the collective evidence. Surgery. 2024;175(2):280-88.
[20] Scott MJ, Aggarwal G, Aitken RJ, Anderson ID, Balfour A, Foss NB, et al. Consensus guidelines for perioperative care for emergency laparotomy Enhanced Recovery After Surgery (ERAS®) society recommendations part 2-emergency laparotomy: Intra- and postoperative care. World J Surg [Internet]. 2023 Aug [cited 2025 Nov 17];47(8):1850-80. Available from: https://pubmed.ncbi.nlm.nih.gov/37277507/
[21] Sato H, Ota H, Munakata K, Matsuura Y, Fujii M, Wada N, et al. Perioperative fluid management influences complication rates and length of hospital stay in the enhanced recovery after surgery (ERAS) protocol for patients with colorectal cancer. Surg Today. 2023;53(2):242-51.
[22] Kim IK, Lee CS, Bae JH, Han SR, Lee DS, Lee IK, et al. Immediate urinary catheter removal after colorectal surgery with the enhanced recovery after surgery protocol. Int J Colorectal Dis. 2023 Jun 7;38(1):162.
[23] Adam MA, Lee LM, Kim J, Shenoi M, Mallipeddi M, Aziz H, et al. Alvimopan provides additional improvement in outcomes and cost savings in enhanced recovery colorectal surgery. Ann Surg. 2016;264(1):141-46.
[24] Wang Q, Zhou Y, Wang W, Ou Y, Wu X, Chen J, et al. Effects of continuous glucose monitoring in enhanced recovery after colorectal cancer patient surgery with type 2 diabetes (application of CGM in the ERAS process of CRC patient with diabetes). Front Med. 2025;12:1464071.
[25] Forsmo HM, Pfeffer F, Rasdal A, Østgaard G, Mohn AC, Körner H, et al. Compliance with enhanced recovery after surgery criteria and preoperative and postoperative counselling reduces length of hospital stay in colorectal surgery: Results of a randomized controlled trial. Colorectal Dis Off J Assoc Coloproctology G B Irel. 2016;18(6):603-11.
[26] Bednarski BK, Nickerson TP, You YN, Messick CA, Speer B, Gottumukkala V, et al. Randomized clinical trial of accelerated enhanced recovery after minimally invasive colorectal cancer surgery (RecoverMI trial). Br J Surg. 2019;106(10):1311-18.
[27] Li Q, Du L, Lu L, Tong Y, Wu S, Yang Y, et al. Clinical application of enhanced recovery after surgery in perioperative period of laparoscopic colorectal cancer surgery. J Laparoendosc Adv Surg Tech A. 2019;29(2):178-83.
[28] Taupyk Y, Cao X, Zhao Y, Wang C, Wang Q. Fast-track laparoscopic surgery: A better option for treating colorectal cancer than conventional laparoscopic surgery. Oncol Lett. 2015;10(1):443-48.
[29] Abd ElRahman EM, Kharoub MS, Shora A, Emara NA, Balbaa MA. Early outcome of enhanced recovery programs versus conventional perioperative care in elective open left side colonic carcinoma surgery: Analysis of 80 cases. Indian J Surg Oncol. 2020;11(3):372-77.
[30] Iqbal MT, Jutt AU, Arbi FM. Comparison of the outcomes of enhanced recovery after surgery (eras) vs conventional care in elective colorectal surgery. J Ayub Med Coll Abbottabad JAMC. 2024;36(1):19-24.
[31] Scott MJ, Urman RD. Concepts in physiology and pathophysiology of enhanced recovery after surgery. Int Anesthesiol Clin. 2017;55(4):38-50.
[32] Scott MJ, Baldini G, Fearon KCH, Feldheiser A, Feldman LS, Gan TJ, et al. Enhanced Recovery After Surgery (ERAS) for gastrointestinal surgery, part 1: Pathophysiological considerations. Acta Anaesthesiol Scand. 2015;59(10):1212-31.
[33] Kehlet H, Joshi GP. Enhanced recovery after surgery: Current controversies and concerns. Anesth Analg. 2017;125(6):2154-55.
[34] Mari G, Crippa J, Costanzi A, Mazzola M, Rossi M, Maggioni D. ERAS protocol reduces IL-6 secretion in colorectal laparoscopic surgery: Results from a randomized clinical trial. Surg Laparosc Endosc Percutan Tech. 2016;26(6):444-48.
[35] Feng J, Li K, Li L, Wang X, Huang M, Yang J, et al. The effects of fast-track surgery on inflammation and immunity in patients undergoing colorectal surgery. Int J Colorectal Dis. 2016;31(10):1675-82.
[36] Turaga AH. Enhanced Recovery After Surgery (ERAS) protocols for improving outcomes for patients undergoing major colorectal surgery. Cureus. 2023;15(7):e41755.
[37] D'Souza N, Robinson PD, Branagan G, Chave H. Enhanced recovery after anterior resection: Earlier leak diagnosis and low mortality in a case series. Ann R Coll Surg Engl. 2019;101(7):495-500.
[38] Garmpis N, Dimitroulis D, Garmpi A, Diamantis E, Spartalis E, Schizas D, et al. Enhanced recovery after surgery: Is it time to change our strategy regarding laparoscopic colectomy? Vivo Athens Greece. 2019;33(3):669-74.
[39] Ghufran S, Janjua AA, Chaudary SM, Munawwar F, Hassan M, Changazi SH. Outcome of enhanced recovery after surgery protocols in patients undergoing small bowel surgery. Cureus. 2020;12(10):e11073.

[40] Mac Curtain BM, O'Mahony A, Temperley HC, Ng ZQ. Enhanced recovery after surgery protocols and emergency surgery: A systematic review and meta-analysis of randomized controlled trials. ANZ J Surg. 2023;93(7-8):1780-86.
[41] Lin V, Poulsen JK, Juvik AF, Roikjær O, Gögenur I, Fransgaard T. The implementation of an inflammatory bowel disease-specific enhanced recovery after surgery protocol: An observational cohort study. Tech Coloproctology. 2024;28(1):58.
[42] Tan JKH, Ang JJ, Chan DKH. Enhanced recovery program versus conventional care after colorectal surgery in the geriatric population: A systematic review and meta-analysis. Surg Endosc. 2021;35(6):3166-74.
[43] Studniarek A, Borsuk DJ, Marecik SJ, Park JJ, Kochar K. Enhanced recovery after surgery protocols. does frailty play a role? Am Surg. 2021;87(7):1054-61.
[44] Shetiwy M, Fady T, Shahatto F, Setit A. Standardizing the protocols for enhanced recovery from colorectal cancer surgery: Are we a step closer to ideal recovery? Ann Coloproctology. 2017;33(3):86-92.
[45] Ostermann S, Morel P, Chalé JJ, Bucher P, Konrad B, Meier RPH, et al. Randomized controlled trial of enhanced recovery program dedicated to elderly patients after colorectal surgery. Dis Colon Rectum. 2019;62(9):1105-16.
[46] Alawadi ZM, Leal I, Phatak UR, Flores-Gonzalez JR, Holihan JL, Karanjawala BE, et al. Facilitators and barriers of implementing enhanced recovery in colorectal surgery at a safety net hospital: A provider and patient perspective. Surgery. 2016;159(3):700-12.
[47] Ayinde BO, Chokshi P, Adhikari S, Jaimalani A, Yeritsyan A, Surve AV, et al. Challenges and elements hindering the adoption of Enhanced Recovery After Surgery (ERAS) protocols in colorectal surgery and their resolutions: A systematic review. Cureus. 2024;16(6):e63222.
[48] Oodit R, Biccard BM, Panieri E, Alvarez AO, Sioson MRS, Maswime S, et al. Guidelines for perioperative care in elective abdominal and pelvic surgery at primary and secondary hospitals in Low-Middle-Income Countries (LMIC's): Enhanced Recovery After Surgery (ERAS) society recommendation. World J Surg. 2022;46(8):1826-43.
[49] Besson AJ, Kei C, Djordjevic A, Carter V, Deftereos I, Yeung J. Does implementation of and adherence to enhanced recovery after surgery improve perioperative nutritional management in colorectal cancer surgery? ANZ J Surg. 2022;92(6):1382-87.
[50] Abosheisha M, Nasr E, Abdellatif M, Swealem A, Ammar A, Hasan MAS, et al. The future of enhanced recovery after surgery in general surgery: Integrating artificial intelligence, personalized care, and technological advances. Cureus. 2025;17(9):e91528.
[51] Slim K, Mattevi C. Robotic surgery or enhanced recovery programs or both? And in which order? Surgery. 2018;164(5):937-38.
[52] Nelson G, Bakkum-Gamez J, Kalogera E, Glaser G, Altman A, Meyer LA, et al. Guidelines for perioperative care in gynecologic/oncology: Enhanced Recovery After Surgery (ERAS) Society recommendations-2019 update. Int J Gynecol Cancer Off J Int Gynecol Cancer Soc. 2019;29(4):651-68.

PARTICULARS OF CONTRIBUTORS:
1. Junior Resident, Department of General Surgery, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.
2. Professor, Department of General Surgery, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.
3. Professor, Department of General Surgery, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.
4. Junior Resident, Department of General Surgery, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.
5. Undergraduate Student, Department of Medicine, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Wardha, Maharashtra, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Yashasvi Trivedi,
Junior Resident, Jawaharlal Nehru Medical College, Datta Meghe Institute of Higher Education and Research, Wardha-442001, Maharashtra, India.
E-mail: yashasvitrivedi16@gmail.com

PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Dec 10, 2025
- Manual Googling: Mar 03, 2026
- iThenticate Software: Mar 05, 2026 (1%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? No
- Was informed consent obtained from the subjects involved in the study? No
- For any images presented appropriate consent has been obtained from the subjects. No

Date of Submission: **Nov 24, 2025**
Date of Peer Review: **Dec 22, 2025**
Date of Acceptance: **Mar 07, 2026**
Date of Publishing: **Jun 01, 2026**