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Enhanced Recovery After Surgery (Eras) In Gi Surgery: Evidence And Implementation

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ABSTRACT

Enhanced Recovery After Surgery (ERAS) represents a paradigm shift in perioperative care, integrating evidence-based, multidisciplinary strategies designed to optimize surgical outcomes and accelerate patient recovery. Originally developed for colorectal procedures, ERAS protocols have since been adapted to various gastrointestinal (GI) surgeries, including esophagectomy, gastrectomy, and hepatopancreatobiliary (HPB) operations. These protocols focus on minimizing surgical stress, maintaining physiological balance, and promoting early mobilization, oral intake, and patient engagement. Implementation across different phases preoperative, intraoperative, and postoperative has been shown to reduce postoperative morbidity, hospital stay, and overall healthcare costs without compromising safety or oncological outcomes. Globally, ERAS has achieved high compliance and institutional acceptance through structured training, continuous audits, and multidisciplinary teamwork. In India, while the adoption of ERAS principles is growing, challenges such as limited resources, inconsistent compliance, and resistance to traditional practices remain significant barriers. Nonetheless, successful outcomes from tertiary centers highlight its potential for broader application. Future directions involve digital integration, individualized recovery pathways, and expansion into resource-limited settings. Continued research is needed to address regional variations, strengthen evidence on long-term outcomes, and establish national guidelines for standardized implementation. ERAS has redefined the postoperative recovery process, offering a patient-centered, efficient, and sustainable model for modern surgical care in gastrointestinal practice..

Keywords: Enhanced Recovery After Surgery, Gastrointestinal Surgery, ERAS Implementation, Perioperative Care, Postoperative Recovery

INTRODUCTION

Surgery is one of the most crucial interventions in modern medicine, yet it imposes significant physiological, metabolic, and psychological stress on the human body. In recent decades, advancements in surgical techniques have been accompanied by innovations in perioperative care, particularly the concept of Enhanced Recovery After Surgery (ERAS). The ERAS protocol represents a paradigm shift in surgical management, emphasizing evidence-based, multidisciplinary strategies to optimize recovery, minimize complications, and enhance patient satisfaction [1]. The concept of ERAS was first introduced in the 1990s by Professor Henrik Kehlet, a Danish surgeon who demonstrated that perioperative optimization could significantly reduce morbidity and hospital stay in colorectal surgery. His work laid the foundation for a structured, multimodal approach to surgical care addressing preoperative preparation, intraoperative management, and postoperative recovery as a unified continuum [2].

Since then, the ERAS Society, established in Sweden in 2010, has played a key role in globalizing and standardizing these evidence-based pathways across surgical specialties. The core philosophy of ERAS is to reduce the surgical stress response, maintain normal physiological function, and facilitate early return to baseline activities. Traditional surgical care practices such as prolonged fasting, routine nasogastric intubation, delayed feeding, and excessive bed rest have gradually been replaced with ERAS-guided practices like early oral intake, multimodal analgesia, and early ambulation [3]. Over time, ERAS protocols have evolved to become multidisciplinary care models, integrating the expertise of surgeons, anesthesiologists, nurses, dietitians, physiotherapists, and psychologists. Each component of the pathway from preoperative patient education and carbohydrate loading to postoperative early feeding and mobilization works

synergistically to optimize recovery. Studies consistently demonstrate that hospitals with ERAS compliance rates exceeding 70% experience up to 50% reductions in complication rates and 30–50% shorter hospital stays [1].

In gastrointestinal (GI) surgery, ERAS has been particularly transformative. From colorectal and gastric resections to hepatopancreatobiliary (HPB) and minimally invasive surgeries, ERAS principles have been adapted and validated. Multiple randomized controlled trials and meta-analyses have shown that ERAS significantly decreases postoperative morbidity, reduces ileus incidence, and promotes faster return of bowel function [4]. In colorectal surgery, which was the pioneering field for ERAS implementation, outcomes are the most robustly studied. Evidence shows reductions in postoperative pain, faster ambulation, and improved patient-reported outcomes without increasing readmission or mortality rates [5]. Similarly, in upper GI surgeries such as gastrectomy and esophagectomy, ERAS has shown feasibility and safety, with enhanced tolerance to early oral feeding and reduced hospital stays. ERAS has also extended into hepatopancreatobiliary surgery, where enhanced perioperative care reduces complications such as bile leak and delayed gastric emptying. Despite the complexity of HPB procedures, results indicate that structured ERAS pathways can standardize recovery and improve patient outcomes [6]. The evidence base for ERAS is extensive and growing. The study also highlighted the effectiveness of ERAS in high-risk populations and urgent surgeries, showcasing its adaptability and resilience in diverse clinical contexts [7].

The implementation of ERAS in clinical settings, however, varies widely. Successful adoption requires not just protocol development but cultural change, interdisciplinary collaboration, and continuous auditing. Studies underscore that mere protocol existence is insufficient without proper adherence and education among healthcare providers [8]. In India, the concept of ERAS is gaining momentum, but widespread implementation remains limited. Institutional experiences from tertiary centers such as AIIMS, PGIMER, and CMC Vellore have shown encouraging results, yet barriers such as resource limitations, traditional surgical mindsets, and lack of standardized training persist. The Indian healthcare landscape, with its diverse patient demographics and variable infrastructure, presents both challenges and opportunities for ERAS adoption [9].Global evidence suggests that ERAS implementation success correlates strongly with compliance auditing, dedicated coordinators, and multidisciplinary teamwork [10]. Hospitals that incorporate continuous feedback mechanisms into ERAS programs demonstrate sustained improvements in outcomes, lower costs, and higher patient satisfaction rates.

Moreover, ERAS aligns with the principles of value-based healthcare, focusing on quality, cost-effectiveness, and patient-centered outcomes. By integrating prehabilitation, multimodal pain control, and individualized nutrition strategies, ERAS enhances both clinical and functional recovery while minimizing hospital burden [11]. Despite the growing evidence, several challenges persist in the Indian context: variability in compliance, limited ERAS training programs, and the need for local guidelines tailored to Indian dietary patterns and postoperative care environments. Additionally, patient education and counseling remain underemphasized in many centers, affecting adherence and outcomes [12].

Future perspectives in ERAS research emphasize integration of digital health tools, AI-based patient monitoring, and personalized risk assessment models, which could further optimize perioperative care. These innovations, combined with nurse-led audits and multidisciplinary education, can bridge the gap between evidence and practice [13]. Overall, the evolution of ERAS represents not just a protocol change, but a cultural transformation in surgery. It redefines the surgical journey from passive recovery to active participation focusing on patient empowerment, standardization, and outcome-driven care. As ERAS principles continue to mature, they hold promise to revolutionize perioperative care in India and globally, improving safety, efficiency, and sustainability in surgical practice [14]. The aim of this review paper is to critically evaluate the evidence and implementation of Enhanced Recovery After Surgery (ERAS) in gastrointestinal surgery, with special emphasis on its clinical effectiveness, multidisciplinary framework, and challenges in Indian healthcare settings. The paper seeks to consolidate current research findings, analyze barriers and facilitators to ERAS adoption, and propose strategies for optimized, context-specific implementation to enhance patient recovery and outcomes in GI surgery [15].

Historical Evolution and Concept of Enhanced Recovery After Surgery (ERAS)

Surgical recovery has long been a critical determinant of postoperative outcomes, influencing morbidity, mortality, and patient satisfaction. The evolution of perioperative care from conventional methods to evidence-based multimodal strategies has culminated in the concept known as Enhanced Recovery After Surgery (ERAS). This approach emphasizes optimization of physiological function and reduction of surgical stress through standardized, multidisciplinary protocols designed to enhance patient outcomes and accelerate recovery [16]. The origins of ERAS date back to the early 1990s, when surgeons began to challenge traditional postoperative practices such as prolonged fasting, delayed mobilization, and routine nasogastric decompression. These methods were found to contribute to increased catabolism, insulin resistance, and delayed gastrointestinal recovery. The ERAS framework emerged as a response to these shortcomings, integrating perioperative interventions that collectively minimize surgical trauma and maintain homeostasis [17]. This concept was initially developed in colorectal surgery, where high complication rates and extended hospital stays prompted innovation in perioperative management. Early clinical results demonstrated that patients managed with structured ERAS protocols experienced reduced morbidity, earlier return of bowel function, and significantly shorter hospital stays compared to conventional care [18].

The fundamental principle underlying ERAS is the attenuation of the surgical stress response, a cascade involving neuroendocrine and inflammatory pathways that disrupt normal metabolism and immune function. ERAS strategies counter this by combining preoperative optimization, intraoperative precision, and postoperative rehabilitation. For instance, preoperative carbohydrate loading preserves insulin sensitivity; multimodal, opioid-sparing analgesia reduces nausea and

ileus; and early ambulation prevents thromboembolic events and muscle atrophy [19]. By addressing multiple physiological domains simultaneously, ERAS protocols ensure a faster and safer return to baseline function. Unlike traditional perioperative management, which often relied on surgeon preference and institution-specific habits, ERAS introduced a standardized, evidence-based methodology supported by continuous audit and multidisciplinary collaboration. This holistic model emphasizes the integration of surgeons, anesthesiologists, nurses, physiotherapists, nutritionists, and patients as active participants in recovery. The inclusion of preoperative education empowers patients to understand their role, improving adherence to postoperative milestones and overall satisfaction [20]. The shift from a passive to an active recovery paradigm represented a cultural transformation in surgery, emphasizing patient-centered care rather than procedure-centered outcomes.

As ERAS protocols gained international recognition, formal societies and expert groups were established to refine and disseminate best practices. These organizations created structured guidelines outlining optimal perioperative management for specific surgical specialties, beginning with colorectal surgery and expanding to gastrointestinal, urological, gynecologic, orthopedic, and cardiothoracic operations [21]. Each guideline incorporated the latest evidence to ensure consistent outcomes across healthcare systems. The ERAS Society, established in the 2000s, played a pivotal role in developing and updating these recommendations, emphasizing audit, compliance monitoring, and continuous quality improvement. Central to ERAS is the principle of multimodal synergy the idea that combining small evidence-based improvements across multiple aspects of care produces substantial cumulative benefits. The protocol encompasses three core phases: preoperative, intraoperative, and postoperative. The preoperative phase involves patient counseling, optimization of comorbidities, cessation of smoking and alcohol, and carbohydrate-rich fluids up to two hours before anesthesia. The intraoperative phase focuses on minimally invasive techniques, normothermia maintenance, balanced fluid therapy, and use of regional anesthesia to minimize opioid requirements. The postoperative phase emphasizes early oral feeding, mobilization within 24 hours, avoidance of unnecessary tubes or drains, and multimodal analgesia [22]. Together, these steps maintain physiological equilibrium, minimize complications, and shorten convalescence. Global implementation studies have consistently demonstrated the superiority of ERAS over traditional care. Across gastrointestinal surgery, ERAS has been associated with a 30–50% reduction in hospital stay, decreased complication rates, and improved functional recovery without increasing readmissions or mortality [23]. These outcomes have been replicated in multiple randomized controlled trials and meta-analyses, confirming the reproducibility of results across different populations and healthcare settings. Moreover, ERAS contributes to cost efficiency by reducing postoperative resource utilization, enhancing bed turnover, and lowering overall treatment expenditure.

Principles and Core Components of ERAS Protocols

Enhanced Recovery After Surgery (ERAS) represents a structured, evidence-based framework designed to optimize perioperative care and enhance postoperative recovery through a combination of multidisciplinary interventions. Its principles rest on maintaining physiological function, reducing surgical stress, and promoting rapid rehabilitation after gastrointestinal (GI) surgery. Rather than focusing solely on the surgical act, ERAS emphasizes the entire perioperative journey — preoperative, intraoperative, and postoperative to achieve faster recovery, reduced complications, and improved patient satisfaction [24]. The first fundamental principle of ERAS is the attenuation of the surgical stress response. Surgery triggers hormonal, inflammatory, and metabolic disturbances that impair recovery. These include elevated cortisol levels, insulin resistance, increased protein catabolism, and reduced immune function. ERAS protocols aim to minimize these changes through prehabilitation, optimal anesthesia, and early postoperative mobilization. The goal is to preserve normal physiology as much as possible. This approach differs from traditional postoperative care, which historically emphasized prolonged rest, fasting, and narcotic-based pain control all of which exacerbate metabolic dysfunction. Through ERAS, the body's recovery mechanisms are supported rather than suppressed, ensuring faster functional restoration [25]. A second core principle involves multimodal optimization, where several evidence-based interventions are applied concurrently to produce synergistic benefits. The philosophy of ERAS recognizes that no single measure alone can significantly improve recovery; rather, it is the combined effect of multiple small changes that leads to measurable outcomes. For example, early nutrition combined with opioid-sparing analgesia and early mobilization yields better outcomes than any one of these interventions alone. This multimodal strategy underpins the holistic and integrated nature of ERAS [26].

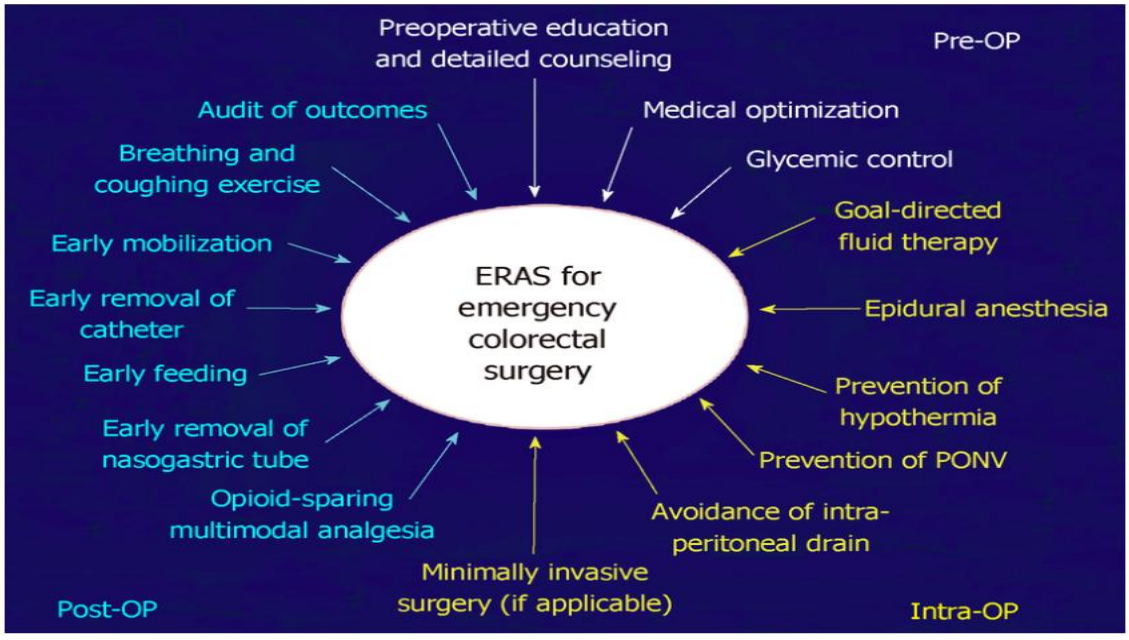
The preoperative phase is the first critical component of ERAS and begins well before the patient arrives in the operating theater. This stage focuses on patient education, risk assessment, and physiological optimization. Preoperative counseling ensures that patients understand the procedure, the recovery expectations, and their active role in the process. Evidence suggests that informed patients demonstrate greater adherence to mobilization and feeding schedules, resulting in fewer complications and higher satisfaction. Nutritional optimization forms another key aspect, as malnourished patients experience delayed wound healing and increased infection rates. Shortened fasting periods and carbohydrate-rich drinks administered two hours before anesthesia help reduce insulin resistance and maintain metabolic balance. Additionally, prehabilitation — including exercise, smoking cessation, and control of comorbidities such as diabetes or hypertension — strengthens physiological reserves, preparing the patient for surgical stress [27]. The intraoperative phase of ERAS is equally important, focusing on minimizing tissue trauma, maintaining hemodynamic stability, and preventing hypothermia. Minimally invasive surgical techniques, when appropriate, are preferred because they cause less inflammatory response and allow faster postoperative mobilization. Goal-directed fluid therapy ensures optimal tissue perfusion while preventing both fluid overload and hypovolemia. Maintaining normothermia through active warming devices prevents coagulopathy, wound

infections, and shivering-related metabolic stress. Anesthetic management also plays a pivotal role: balanced anesthesia with short-acting agents allows early extubation, while regional or epidural analgesia reduces the need for opioids, minimizing nausea, ileus, and respiratory complications. Intraoperative measures are guided by the principle of physiological balance — avoiding extremes that disrupt the body's homeostasis [28].

The postoperative phase in ERAS departs significantly from traditional surgical recovery models. Historically, patients were kept fasting until bowel sounds returned and restricted to bed rest for several days. ERAS challenges this approach by emphasizing early oral intake and mobilization as soon as safely possible. Early feeding stimulates gut motility, enhances mucosal integrity, and prevents bacterial translocation, thereby reducing postoperative ileus. Early mobilization — ideally within 24 hours — improves pulmonary function, reduces thromboembolic risks, and preserves muscle mass. Effective pain management through multimodal, opioid-sparing regimens ensures that patients can eat, move, and breathe deeply without sedation or respiratory compromise. Drains, catheters, and nasogastric tubes are avoided or removed early to facilitate movement and comfort. The use of standardized discharge criteria ensures that patients are safely transitioned from hospital to home when functional milestones are achieved rather than based on arbitrary time frames [29]. Another principle central to ERAS is standardization with flexibility. While ERAS protocols are structured and evidence-based, they are not rigid checklists. Instead, they allow adaptation based on patient-specific factors, surgical complexity, and institutional resources. The key is consistency in implementing core elements while accommodating individual variation. Regular auditing of compliance and outcomes is an essential feature of ERAS, as adherence directly correlates with success. Centers that maintain compliance above 70% consistently report reduced morbidity, shorter hospital stays, and better patient-reported outcomes [30].

Evidence of ERAS in Colorectal Surgery

Colorectal surgery has historically been associated with significant postoperative morbidity, prolonged hospital stays, and delayed return of bowel function. It was within this context that the Enhanced Recovery After Surgery (ERAS) concept was first implemented and scientifically validated. The colorectal field served as the experimental foundation upon which ERAS principles were developed, tested, and refined. The earliest applications of ERAS in colorectal surgery demonstrated that coordinated perioperative care could drastically improve outcomes without compromising safety [31]. This section presents a detailed overview of the evidence supporting ERAS in colorectal surgery, examining clinical outcomes, physiological benefits, and long-term impacts. ERAS protocols in colorectal procedures encompass all perioperative phases preoperative preparation, intraoperative management, and postoperative rehabilitation. Traditional practices in colorectal surgery, such as mechanical bowel preparation, routine nasogastric intubation, and delayed feeding, were gradually challenged and replaced with evidence-based interventions. Studies consistently showed that early oral intake, opioid-sparing analgesia, and early mobilization led to faster recovery of gastrointestinal motility and a shorter duration of postoperative ileus [32]. The elimination of unnecessary fasting and nasogastric decompression not only improved comfort but also reduced pulmonary complications and wound infections.



Enhanced recovery after surgery protocol in emergency colorectal surgery. ERAS: Enhanced recovery after surgery; PONV: Postoperative nausea and vomiting.

Figure 1: Enhanced recovery after surgery protocol in emergency colorectal surgery [32]

A substantial body of evidence supports the safety and efficacy of ERAS in colorectal surgery. Randomized controlled trials and meta-analyses involving thousands of patients have demonstrated that ERAS reduces hospital stay by 30–50% compared to traditional care while simultaneously lowering postoperative morbidity rates. Importantly, these benefits are achieved without increasing readmission or mortality rates [33]. Patients undergoing colorectal resections under ERAS protocols typically experience earlier bowel movements, less postoperative pain, reduced reliance on opioids, and greater satisfaction with care. These outcomes stem from the synergistic effects of multiple ERAS interventions rather than any single measure. The physiological rationale behind ERAS's success in colorectal surgery lies in the control of surgical stress and maintenance of metabolic homeostasis. Surgical trauma triggers a systemic inflammatory response characterized by hormonal, metabolic, and immunological disturbances. ERAS strategies including preoperative carbohydrate loading, normothermia maintenance, and multimodal analgesia mitigate these responses, preserving muscle mass, insulin sensitivity, and immune function [34]. Early feeding plays a particularly important role by maintaining intestinal mucosal integrity and preventing bacterial translocation, which reduces the risk of sepsis and anastomotic leakage.

Clinical studies comparing traditional care with ERAS pathways in colorectal surgery consistently reveal significant improvements in measurable outcomes. Patients treated under ERAS protocols often have a median hospital stay of four to six days, compared to seven to ten days with conventional management. Complication rates, including pulmonary infections, wound dehiscence, and venous thromboembolism, are markedly lower. In addition, the incidence of postoperative ileus is significantly reduced, owing to early mobilization and enteral nutrition. The combination of epidural analgesia, non-opioid medications, and avoidance of excessive intravenous fluids minimizes bowel edema and supports faster gut recovery [35]. Beyond physiological outcomes, ERAS has demonstrated clear economic advantages. Shorter hospital stays and lower complication rates translate to substantial cost savings for both healthcare institutions and patients. Studies evaluating cost-effectiveness consistently report reductions in direct hospital expenses of up to 25–30% per patient without compromising quality of care. These savings are primarily attributed to reduced postoperative complications, earlier discharge, and fewer unplanned readmissions. Additionally, ERAS fosters more efficient resource utilization, allowing hospitals to manage higher surgical volumes with existing infrastructure [36]. Another major finding in colorectal ERAS research is the relationship between protocol compliance and clinical outcomes. Evidence shows that the success of ERAS is directly correlated with adherence to its components. Institutions achieving compliance levels above 70% report significantly better results, including shorter length of stay and fewer postoperative complications. Conversely, partial implementation yields less pronounced benefits. This highlights the importance of standardized team training, auditing, and multidisciplinary cooperation to ensure consistency in care delivery. The introduction of ERAS compliance registries has further facilitated benchmarking across hospitals and promoted continuous improvement [37].

ERAS in Upper Gastrointestinal Surgery (Esophagectomy and Gastrectomy)

Upper gastrointestinal (GI) surgeries such as esophagectomy and gastrectomy represent some of the most complex and physiologically demanding procedures in modern surgical practice. These operations are associated with significant morbidity, prolonged recovery times, and considerable metabolic stress due to their invasiveness and the disruption of normal gastrointestinal continuity. Consequently, the application of Enhanced Recovery After Surgery (ERAS) principles in upper GI surgery has been a major step forward in improving outcomes, optimizing patient care, and redefining perioperative management. The growing body of evidence demonstrates that ERAS protocols, when effectively implemented, enhance postoperative recovery, reduce complications, and maintain safety without compromising oncological or surgical outcomes [38]. The physiological rationale for ERAS in upper GI surgery mirrors its foundation in other surgical specialties reduction of surgical stress, maintenance of homeostasis, and promotion of early recovery. However, in procedures like esophagectomy and gastrectomy, the physiological challenges are greater due to factors such as major fluid shifts, nutritional depletion, and the need for anastomotic integrity. Traditionally, these patients were managed with prolonged fasting, nasogastric decompression, delayed feeding, and extended bed rest. Such practices often led to postoperative ileus, pulmonary infections, and muscle wasting. ERAS challenges these long-standing traditions by advocating for early oral or enteral feeding, multimodal analgesia, and early mobilization, all supported by meticulous perioperative planning and teamwork [39].

The preoperative phase of ERAS in upper GI surgery emphasizes optimization of nutrition, respiratory function, and psychological preparedness. Many patients undergoing esophagectomy or gastrectomy have preexisting malnutrition or cachexia due to underlying malignancy. Nutritional screening and prehabilitation, including protein supplementation and exercise programs, improve functional reserves and tolerance to surgical stress. Preoperative counseling plays an equally vital role by educating patients about the surgery, expected milestones, and the importance of participation in recovery activities. Smoking and alcohol cessation are encouraged to minimize postoperative pulmonary and wound complications. Furthermore, reduced fasting times and preoperative carbohydrate loading maintain insulin sensitivity and mitigate catabolic stress responses [40]. During the intraoperative phase, ERAS principles focus on minimizing physiological disturbance while ensuring surgical precision. Minimally invasive techniques such as laparoscopic and thoracoscopic esophagectomy or gastrectomy have become integral to the ERAS model because they reduce tissue trauma and postoperative pain. Goal-directed fluid therapy helps maintain perfusion while avoiding overload, thereby reducing the risk of pulmonary edema and anastomotic complications. Maintenance of normothermia prevents coagulopathy and infection, while regional anesthesia techniques — including epidural or paravertebral blocks contribute to effective pain management with minimal opioid reliance. The emphasis on balanced anesthesia and hemodynamic stability helps reduce systemic inflammation and supports

faster extubation, shorter intensive care unit (ICU) stays, and early mobilization [41].

The postoperative phase of ERAS in upper GI surgery represents one of the most significant paradigm shifts in perioperative management. Conventional practice delayed oral or enteral feeding until the return of bowel sounds or after contrast studies confirmed anastomotic integrity. However, evidence now supports early enteral nutrition, even within the first 24 hours, as safe and beneficial in most cases. Early feeding maintains gut integrity, reduces bacterial translocation, and stimulates peristalsis. It also supports immune function and decreases infectious complications. Patients managed under ERAS protocols typically resume oral or jejunal feeding earlier, experience fewer pulmonary infections, and demonstrate faster gastrointestinal recovery compared to those managed with traditional care [42]. Pain control in ERAS for upper GI surgery relies heavily on multimodal analgesia rather than opioids alone. Excessive opioid use can depress respiration, delay gastric emptying, and increase the risk of postoperative nausea and vomiting. Non-opioid agents such as acetaminophen, nonsteroidal anti-inflammatory drugs (NSAIDs), and regional blocks are used to provide effective analgesia while preserving gut motility. This approach reduces the incidence of respiratory complications and facilitates early mobilization. Furthermore, the avoidance of routine nasogastric tubes and drains under ERAS protocols reduces discomfort and promotes spontaneous breathing and coughing, thereby preventing pulmonary complications [43]. arly mobilization is another cornerstone of ERAS in esophagectomy and gastrectomy. Patients are encouraged to sit up and ambulate within 24 hours of surgery, depending on their condition. Early mobilization enhances pulmonary ventilation, prevents deep vein thrombosis, and preserves muscle strength. It also has psychological benefits, as patients report greater independence and motivation during recovery. Close coordination among nursing, physiotherapy, and surgical teams ensures that mobilization is safe and progressive, with milestones tailored to the individual's tolerance and operative complexity [44].

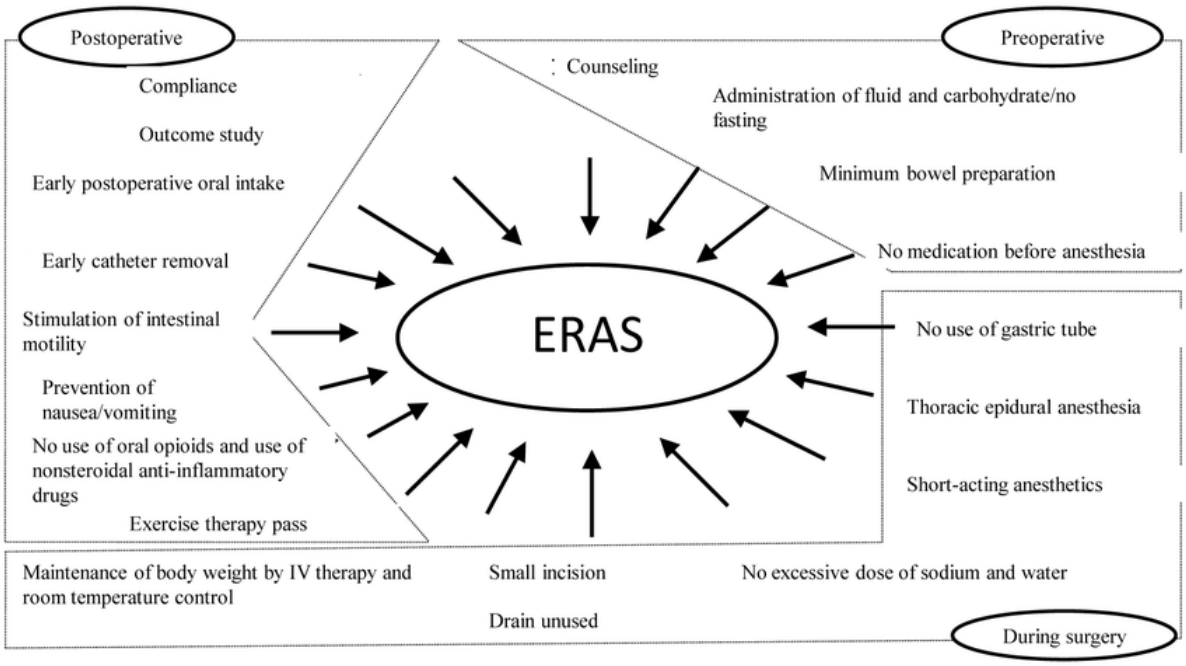


Figure 2: Outline of ERAS protocol. ERAS, enhanced recovery after surgery [44]

ERAS in Hepatopancreatobiliary (HPB) and Minimally Invasive Surgery

Hepatopancreatobiliary (HPB) surgery encompasses complex operations such as liver resections, pancreaticoduodenectomy, and biliary reconstructions — all associated with high morbidity, prolonged hospital stays, and significant physiological stress. The integration of Enhanced Recovery After Surgery (ERAS) principles into HPB surgery has redefined postoperative management by emphasizing evidence-based perioperative optimization. Although these procedures pose unique challenges due to their complexity and potential for major blood loss or organ dysfunction, studies have shown that ERAS protocols can be effectively adapted to HPB surgery, leading to improved clinical outcomes, faster recovery, and reduced healthcare costs [45]. The physiological stress associated with HPB surgery is profound, as these procedures involve large incisions, extended operative durations, and major metabolic shifts. ERAS protocols mitigate these effects through preoperative nutritional optimization, meticulous fluid management, and early mobilization. The central goal is to maintain homeostasis and support hepatic and pancreatic function during the recovery process. Preoperative patient counseling, carbohydrate loading, and cessation of fasting are standard ERAS components that minimize catabolic responses and preserve insulin sensitivity. These measures, when combined with intraoperative precision and postoperative rehabilitation, result in fewer complications and quicker convalescence [46]. In the intraoperative phase, ERAS in HPB surgery emphasizes minimally invasive techniques such as laparoscopic and robotic approaches whenever feasible. These methods reduce surgical trauma, blood loss, and postoperative pain while facilitating faster mobilization. Controlled fluid therapy and maintenance of

normothermia are crucial, as both overhydration and hypothermia can negatively impact liver regeneration and wound healing. Regional anesthesia and multimodal analgesia are employed to minimize opioid dependence, which is particularly important because opioids can delay gastric emptying and impair respiratory function in the immediate postoperative period [47]. The postoperative phase focuses on early enteral nutrition, effective pain management, and early ambulation. Early feeding after liver or pancreatic surgery supports gastrointestinal function and prevents muscle wasting. In pancreatic resections, early oral or jejunal feeding is encouraged as soon as bowel motility returns, helping to prevent catabolism and infectious complications. Drain management is also an important consideration; selective use and early removal of surgical drains reduce infection risk and discomfort without compromising safety. Encouraging patients to mobilize within 24 hours after surgery improves pulmonary function, reduces thromboembolic risk, and accelerates recovery [48].

Clinical evidence supports the safety and effectiveness of ERAS protocols in HPB surgery. Studies have shown reductions in postoperative complications, including bile leaks, delayed gastric emptying, and infections. Hospital stay is reduced by an average of two to four days without any increase in readmissions or mortality rates. Moreover, ERAS does not compromise oncological outcomes, making it suitable for hepatic and pancreatic malignancies. The combination of minimally invasive techniques and ERAS care pathways has demonstrated additive benefits, with shorter recovery times and fewer complications compared to conventional open surgery under traditional care models [49]. The implementation of ERAS in HPB surgery, however, requires careful adaptation due to the complexity and variability of these procedures. Multidisciplinary coordination between surgeons, anesthesiologists, hepatologists, nutritionists, and physiotherapists is vital to achieve protocol compliance. Audit systems and adherence tracking are equally important, as compliance levels above 70% are consistently associated with superior outcomes. Patient education also plays a central role, ensuring that individuals understand their active participation in recovery and are psychologically prepared for early mobilization and nutritional intake [50].

Minimally invasive approaches, including laparoscopic liver resection and robotic pancreatic surgery, have further enhanced the effectiveness of ERAS protocols. These techniques reduce surgical trauma, inflammatory responses, and postoperative pain while allowing quicker discharge and return to normal activities. When integrated with ERAS pathways, minimally invasive HPB surgery yields optimal outcomes, demonstrating that surgical innovation and perioperative optimization are complementary rather than independent advancements [51]. The integration of Enhanced Recovery After Surgery principles into hepatopancreatobiliary and minimally invasive surgery represents a major advancement in modern perioperative care. Through a structured, multidisciplinary, and patient-centered approach, ERAS reduces complications, accelerates recovery, and enhances the overall quality of life for patients undergoing complex abdominal operations. Its success in HPB surgery demonstrates the flexibility and universality of the ERAS model, confirming that even the most intricate surgical procedures benefit from evidence-based recovery optimization and coordinated care [52].

Implementation and Compliance: Global versus Indian Perspective

The implementation of Enhanced Recovery After Surgery (ERAS) protocols worldwide has transformed perioperative care, yet the degree of compliance and success varies significantly between healthcare systems. Globally, ERAS has evolved into a standardized and evidence-driven framework supported by multidisciplinary collaboration and institutional commitment. Its adoption in developed nations has been facilitated by structured training programs, audit systems, and policy integration. In contrast, while ERAS has gained recognition in India, implementation remains inconsistent and often limited to tertiary care centers. Understanding the global and Indian perspectives on ERAS implementation and compliance provides valuable insight into the challenges, achievements, and future directions of this transformative surgical approach [53]. On the global scale, ERAS implementation has been driven by robust institutional support and adherence to standardized protocols. Many hospitals in Europe and North America have established ERAS committees that monitor compliance, conduct audits, and train staff. Regular feedback mechanisms ensure that deviations from protocol are identified and corrected promptly. Studies have shown that compliance rates above 70% yield the best outcomes, including shorter hospital stays, fewer complications, and reduced costs. In these regions, compliance is maintained through integration into hospital policies, electronic medical records, and multidisciplinary care pathways that link surgeons, anesthesiologists, nurses, physiotherapists, and nutritionists into a cohesive team [54]. Education and continuous professional training play a pivotal role in sustaining ERAS adherence globally. Structured workshops, simulation-based learning, and inclusion of ERAS principles in surgical curricula ensure that every member of the perioperative team understands their responsibilities. Moreover, regular outcome audits and benchmarking against national ERAS registries promote a culture of accountability and continuous improvement. These data-driven feedback systems not only enhance compliance but also identify best practices that can be shared across institutions. Such systemic integration has made ERAS an essential component of quality improvement and patient safety programs in many high-income countries [55].

In contrast, implementation of ERAS in India faces a distinct set of challenges. While awareness of ERAS is increasing, especially in academic and urban tertiary centers, widespread adoption remains limited. The diversity of healthcare infrastructure across India — from well-equipped private hospitals to resource-constrained public institutions — poses significant barriers to uniform implementation. In many hospitals, traditional perioperative practices such as prolonged fasting, delayed feeding, and routine nasogastric decompression persist due to a lack of awareness and training. Additionally, limited access to specialized personnel such as dietitians, physiotherapists, and ERAS coordinators impedes comprehensive

protocol execution [56]. Resource constraints further complicate implementation in Indian settings. ERAS requires coordinated teamwork, access to advanced anesthesia monitoring, and postoperative rehabilitation facilities, which may not be available in smaller centers. Variability in staffing levels and inconsistent documentation practices also hinder compliance monitoring. Despite these obstacles, several Indian tertiary care centers have successfully implemented ERAS protocols, reporting shorter hospital stays, reduced complications, and high patient satisfaction. However, these successes remain isolated examples rather than widespread practices due to limited dissemination and absence of national-level coordination [57]. Cultural and behavioral factors also play an important role in ERAS compliance in India. Patients and families often equate longer hospital stays with better care, creating resistance to early discharge even when clinically appropriate. Similarly, surgeons trained under traditional models may be hesitant to deviate from long-established practices. Overcoming such resistance requires education, demonstration of clinical safety, and visible success stories that can build confidence among both healthcare providers and patients. Multidisciplinary team meetings and institutional workshops have proven effective in gradually shifting attitudes toward ERAS-based care [58]. To improve compliance, Indian healthcare systems must focus on developing context-specific ERAS pathways adapted to local resources and patient populations. National surgical societies could play a crucial role in establishing standardized protocols, promoting research, and creating regional training centers. Incorporating ERAS training into postgraduate medical education would ensure long-term sustainability and uniform understanding among future practitioners. Furthermore, digital tools such as mobile-based audit systems can facilitate real-time monitoring and compliance tracking even in resource-limited settings. Collaboration between public and private sectors can help extend ERAS implementation beyond major urban centers, ensuring broader accessibility and equity in surgical recovery practices [59].

Barriers, Facilitators, and Quality Improvement Measures in ERAS

The successful implementation of Enhanced Recovery After Surgery (ERAS) protocols depends on the coordinated effort of multidisciplinary teams and adherence to standardized practices. However, several barriers hinder full compliance and sustainability. One of the most significant challenges is the resistance to change among healthcare professionals accustomed to traditional perioperative routines. Longstanding habits such as extended fasting, delayed feeding, and prolonged immobilization persist despite evidence supporting early recovery strategies. This reluctance often stems from concerns about patient safety, lack of familiarity with ERAS principles, and insufficient institutional support [60]. Another major barrier is limited infrastructure and resource availability, particularly in low- and middle-income settings. Effective ERAS implementation requires adequate staffing, anesthesia monitoring, postoperative rehabilitation, and nutrition services. In many centers, the absence of specialized personnel such as dietitians, physiotherapists, and ERAS coordinators restricts full protocol execution. In addition, inadequate documentation and audit systems make it difficult to track compliance or outcomes accurately. Without data-driven evaluation, continuous improvement and accountability are compromised [61]. Patient-related factors also play a role. Low health literacy, cultural beliefs about prolonged rest after surgery, and anxiety regarding early discharge can impede adherence. These challenges highlight the importance of patient education and engagement as core components of ERAS. Preoperative counseling and shared decision-making empower patients to take an active role in recovery, improving compliance with mobilization and nutritional goals [62].

Facilitators of ERAS include strong institutional leadership, multidisciplinary teamwork, and continuous training. Hospitals that establish dedicated ERAS committees and conduct regular audits demonstrate higher compliance and better outcomes. Quality improvement measures such as feedback sessions, performance dashboards, and recognition of staff compliance foster motivation and accountability. Incorporating ERAS into hospital policy and electronic health records ensures consistency and long-term sustainability [63]. Overcoming the barriers to ERAS implementation requires a strategic focus on education, resource allocation, and continuous quality monitoring. By strengthening multidisciplinary collaboration and embedding ERAS principles into institutional culture, healthcare systems can achieve sustained improvements in surgical outcomes and patient satisfaction [64].

Table 1: Future Directions and Research Gaps in ERAS Implementation

Focus Area	Description / Key Points	Expected Outcome	References
1. Personalization of ERAS Protocols	Transition from standardized to individualized recovery pathways based on patient comorbidities, risk profiles, and surgical complexity. Predictive analytics to tailor interventions such as fluid balance, analgesia, and nutrition.	More precise, patient-centered recovery with optimized outcomes.	[65]
2. Digital Health Integration	Utilization of mobile apps, wearable sensors, and telemonitoring systems for real-time tracking of postoperative recovery (mobility, pain, nutrition).	Early detection of complications, improved adherence, enhanced patient engagement.	[66]

3. Artificial Intelligence and Machine Learning	Development of predictive algorithms to anticipate complications and support dynamic, data-driven clinical decisions.	Standardized care, reduced variability among teams, proactive management.	[66]
4. Research Expansion and Global Applicability	Need for multicentric, long-term studies assessing quality of life, cost-effectiveness, and oncological outcomes. Emphasis on data from low- and middle-income countries.	Strengthened evidence base and adaptability of ERAS across diverse healthcare systems.	[67]
5. Education and Training	Establishment of national ERAS registries, specialized training centers, and continuous medical education programs.	Improved compliance, sustainability, and inter-hospital collaboration.	[68]
6. Implementation Science and Sustainability	Focus on audit systems, outcome monitoring, and institutional leadership to maintain protocol fidelity.	Continuous improvement and long-term ERAS integration into hospital systems.	[69]
7. Future Integration with Value-Based Healthcare	Alignment of ERAS with healthcare models emphasizing quality, efficiency, and patient outcomes. Integration of technology and multidisciplinary cooperation.	Equitable, efficient, and technology-driven surgical recovery worldwide.	[70]

Conclusion

Enhanced Recovery After Surgery (ERAS) has revolutionized gastrointestinal surgical care by replacing conventional, prolonged recovery models with structured, evidence-based pathways that prioritize patient safety, comfort, and efficiency. Through its multidisciplinary and multimodal approach, ERAS minimizes physiological disruption, shortens hospital stays, and reduces postoperative complications across colorectal, upper gastrointestinal, and hepatopancreatobiliary procedures. Global experience confirms its success, particularly where compliance is high and supported by audit systems and teamwork. In the Indian context, ERAS remains at a developmental stage, facing challenges such as limited resources, variable awareness, and traditional resistance. However, growing institutional successes demonstrate that with training, leadership, and digital innovation, widespread ERAS integration is achievable. Future priorities include developing India-specific guidelines, incorporating ERAS principles into medical education, and expanding research on long-term and quality-of-life outcomes. Overall, ERAS represents not merely a protocol but a holistic transformation in surgical philosophy one that harmonizes science, technology, and patient participation to deliver safer and faster recovery in gastrointestinal surgery.

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