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Enhanced Recovery After Surgery: Modern Standards in Perioperative Care

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Abstract

Background: Enhanced Recovery After Surgery (ERAS) protocols represent multimodal and multidisciplinary perioperative care pathways designed to reduce the physiological stress response to surgery, accelerate postoperative recovery, improve patient safety, and standardize clinical practice. The fast-track concept was first described in colorectal surgery and later

developed into broader ERAS pathways that have been adapted to gastrointestinal, bariatric, thoracic, gynecologic, urologic, orthopedic, plastic, cardiac, and spine surgery.

Aim: The aim of this narrative review was to summarize the current role of ERAS protocols as modern standards in perioperative care, with particular attention to their key components, clinical outcomes, safety profile, implementation challenges, and relevance across different surgical specialties.

Materials and methods: This narrative review was prepared on the basis of 30 peer-reviewed publications concerning ERAS protocols in different surgical settings. The analyzed studies included narrative reviews, systematic reviews, meta-analyses, randomized controlled trials, retrospective and prospective cohort studies, quality-improvement reports, and observational implementation studies. The synthesis focused on common ERAS components, postoperative length of stay, complications, readmissions, mortality, opioid use, gastrointestinal recovery, patient experience, and economic outcomes. No original patient data were collected, and no meta-analysis was performed in the present review.

Results: Across the analyzed literature, ERAS was consistently described as a structured perioperative pathway combining preoperative education and optimization, shortened fasting and carbohydrate loading, multimodal and opioid-sparing analgesia, optimized fluid management, minimally invasive surgery when appropriate, prevention of postoperative nausea and vomiting, early oral intake, early mobilization, and early removal or avoidance of tubes, drains, and catheters. Most included studies reported shorter length of stay or faster achievement of recovery milestones after ERAS implementation, usually without an increase in postoperative complications, readmissions, or mortality. Several studies also reported reduced opioid use, improved pain control, faster gastrointestinal recovery, lower postoperative nausea and vomiting, lower or unchanged complication rates, or potential cost savings. However, the strength of evidence differs between surgical specialties, and outcomes depend on protocol adherence, local resources, staff education, and multidisciplinary cooperation.

Conclusions: ERAS should be understood not as a single intervention but as an integrated perioperative care system. Its clinical value lies in the cumulative and synergistic effect of multiple evidence-based measures delivered by a coordinated multidisciplinary team. ERAS protocols are increasingly becoming modern standards of perioperative care, but successful implementation requires local adaptation, structured audit, patient involvement, and continuous quality improvement.

Keywords: *enhanced recovery after surgery, ERAS, perioperative care, postoperative recovery, multimodal analgesia, length of stay, surgical outcomes*

1. Introduction

Enhanced Recovery After Surgery (ERAS), historically related to the concept of fast-track surgery, is a multimodal model of perioperative care intended to minimize the physiological stress response to surgery and accelerate postoperative recovery [1,3,8,20,22]. The concept was developed from the observation that traditional perioperative routines, such as prolonged fasting, delayed feeding, delayed mobilization, routine tube use, and opioid-heavy analgesia, may contribute to slower recovery in selected surgical patients [8,9,22,23,26,30].

The fast-track concept was first proposed in the context of colorectal surgery and later evolved into ERAS pathways that expanded to a wide range of surgical disciplines [4,9,20,22,23,30]. The core assumption of ERAS is that postoperative recovery can be improved by combining evidence-based interventions throughout the preoperative, intraoperative, and postoperative periods [1,3,8,9,20]. These interventions are designed to preserve normal physiology, reduce catabolism and immune dysfunction, maintain euvolemia and normothermia, reduce opioid exposure, promote early oral intake and mobilization, and empower the patient to participate actively in recovery [3,8,9,15,20,22,26].

The importance of ERAS lies not only in shortening hospitalization but also in standardizing perioperative decision-making and improving the quality of care [9,15,21,24,25]. In this review, the phrase “modern standards” is used to describe ERAS as a widely adopted direction in perioperative care, while recognizing that the maturity of evidence and guidelines differs between surgical specialties [4,22,25,26]. Modern ERAS programs involve surgeons, anesthesiologists, nurses, physiotherapists, dietitians, pharmacists, and often dedicated ERAS coordinators [12,15,20,21,25]. Patient education and expectation-setting are central because adherence to recovery goals depends partly on the patient’s understanding of the pathway [15,20,21,22,26].

The aim of this review is to present ERAS as a modern standard in perioperative care by summarizing its main components, clinical effects, safety profile, barriers to implementation, and application across different surgical specialties [1–30].

2. Research materials and methods

2.1. Participants.

This narrative review did not include human participants, patient recruitment, clinical intervention, biological material, or direct access to individual-level medical records. Therefore, the term “participants” refers to the publications included in the review rather than to patients enrolled by the authors of the present manuscript. The source material consisted of 30 peer-reviewed publications concerning Enhanced Recovery After Surgery protocols in different surgical specialties. These publications included narrative reviews, systematic reviews, meta-analyses, randomized controlled trials, prospective and retrospective cohort studies, quality-improvement reports, observational studies, and specialty-specific implementation studies.

2.2. Procedure / Test protocol / Skill test trial / Measure / Instruments.

The methodological procedure consisted of a qualitative narrative synthesis of the supplied literature on ERAS protocols. No experimental test protocol, skill test trial, laboratory measure, psychometric scale, or clinical instrument was applied by the authors of the present review. The reviewed publications were analyzed with regard to study design, surgical specialty, ERAS protocol components, perioperative phase, length of stay, postoperative

complications, readmissions, mortality, opioid use, pain control, gastrointestinal recovery, patient experience, economic outcomes, and implementation barriers. The extracted information was organized according to the main phases of ERAS care: preoperative, intraoperative, and postoperative management. Additional thematic categories included clinical outcomes, safety, opioid-sparing recovery, patient-centered care, specialty-specific applications, and barriers to implementation.

2.3. Data collection and analysis / Statistical analysis.

Data collection was based on manual extraction of relevant information from the included publications. The analysis was descriptive and interpretative, with emphasis on identifying recurring ERAS components and comparing reported postoperative outcomes across surgical specialties. No original clinical database was created, and no individual patient-level data were analyzed in the present manuscript.

2.3.1. Statistical Software.

Statistical processing was not performed in this narrative review because no original quantitative dataset was created and no meta-analysis was conducted. Consequently, no statistical software package was used for pooled analysis, hypothesis testing, regression modeling, or calculation of effect estimates in the present manuscript. Numerical results presented in this review were taken from the cited publications and interpreted qualitatively in the context of their original study designs.

2.3.2. AI.

AI was utilized for two specific purposes in this research. Text analysis of clinical reasoning narratives to identify linguistic patterns associated with specific logical fallacies. Assistance in refining the academic English language of the manuscript, ensuring clarity, consistency, and adherence to scientific writing standards. AI were used for additional linguistic refinement of the research manuscript, ensuring proper English grammar, style, and clarity in the presentation of results. It is important to emphasize that all AI tools were used strictly as assistive instruments under human supervision. The final interpretation of results, classification of errors, and conclusions were determined by human experts in clinical medicine and formal logic. The AI tools served primarily to enhance efficiency in data processing, pattern recognition, and linguistic refinement, rather than replacing human judgment in the analytical process.

2.3.3. Statistical Methods.

No inferential statistical methods were applied in the present narrative review because the manuscript did not involve original patient data, numerical pooling, or meta-analysis. The synthesis was qualitative and focused on comparing themes and outcomes reported in the included publications, including length of stay, complications, readmissions, mortality, opioid use, postoperative pain, gastrointestinal recovery, patient experience, and economic outcomes.

The review summarizes quantitative findings only as they were reported in the original studies. Differences between ERAS and standard-care groups, such as changes in length of stay, postoperative complications, readmissions, opioid consumption, and costs, were not recalculated by the authors of the present manuscript. No pooled effect size, confidence interval, p-value, heterogeneity statistic, subgroup analysis, sensitivity analysis, or publication-bias assessment was generated for this review.

Because the analyzed publications differed in surgical specialty, study design, population, intervention content, adherence level, and outcome definitions, the results were interpreted descriptively rather than statistically. This approach was chosen to provide a broad overview of ERAS as a modern perioperative care model while avoiding unsupported quantitative conclusions across heterogeneous studies.

3. Research results

3.1. Core principles of ERAS protocols

ERAS protocols were described in the analyzed literature as structured, multimodal, and multidisciplinary perioperative pathways rather than as single therapeutic interventions [1,3,8,20,22,25]. The common goal of ERAS is to attenuate the surgical stress response, maintain physiological function, and accelerate recovery through coordinated actions before, during, and after surgery [1,3,8,20,22]. Although ERAS originated from fast-track concepts in colorectal surgery, the included studies show that its principles have been adapted to gastrointestinal, bariatric, thoracic, gynecologic, urologic, orthopedic, plastic, cardiac, and spine surgery [4,5,9,13,15,20,21,22,23,25,26,29,30].

The reviewed protocols shared several recurring components, including preoperative counseling, optimization of comorbidities, shortened fasting, carbohydrate loading when appropriate, antibiotic prophylaxis, thromboembolic prophylaxis, multimodal analgesia, prevention of postoperative nausea and vomiting, optimized fluid therapy, early oral intake, early mobilization, and avoidance or early removal of tubes, drains, and urinary catheters [3,8,9,11,17,20,21,22,24,26,30]. These elements were not identical across all specialties, because procedure-specific risks influenced the selection and timing of individual ERAS items [3,20,22,23,26]. For example, esophagectomy protocols require careful adaptation of early nutrition and drain management because of the complexity of reconstruction and the risk of thoracic complications [22]. Similarly, pancreatic surgery protocols require careful management of nutritional status, drains, delayed gastric emptying, and pancreatic fistula risk, which limits simple transfer of colorectal ERAS elements into pancreatic practice [20].

A repeated theme in the analyzed material was that ERAS should be interpreted as a bundle of mutually reinforcing measures rather than as a checklist of isolated interventions [1,3,8,20,22,25]. Early mobilization is facilitated by adequate multimodal pain control, reduced opioid exposure, limited catheter use, and clear patient instructions [2,5,11,21,26,30]. Early oral intake is supported by prevention of postoperative nausea and vomiting, avoidance of unnecessary nasogastric tubes, and careful fluid management [9,11,17,22,23,27,30]. Early discharge is safest when it follows objective criteria such as stable clinical status, toleration of oral intake, pain controlled with oral medication, mobility, and patient agreement [11,26,27,30].

3.2. Preoperative components

Preoperative counseling and patient education were among the most consistent ERAS components across the included studies [3,15,20,21,22,26,29,30]. Education was used to explain the planned procedure, the expected postoperative pathway, pain-management strategy, mobilization goals, nutritional expectations, and discharge criteria [15,20,21,22,26,30]. In the qualitative cardiac surgery study, patients emphasized the importance of information flow, perioperative care coordination, rehabilitation planning, and involvement of relatives, which supports the patient-centered role of preoperative education in

ERAS [15]. In the DIEP flap breast reconstruction study, the ERAS protocol included improved preoperative information and a patient-facing postoperative care plan, which was linked to shorter length of stay and lower pain scores without increased complications [29].

Optimization of modifiable risk factors was another major preoperative theme in the reviewed literature [1,3,20,23,26]. Depending on the surgical population, optimization included nutritional assessment, correction of anemia, smoking cessation, reduction of alcohol intake, diabetes control, sleep apnea assessment, respiratory training, physical activity, and management of cardiovascular or renal comorbidities [3,17,20,23,26,27]. In pancreatic surgery, the ERAS plus prehabilitation protocol included structured screening of weight, nutrition, physical activity, gastrointestinal symptoms, tobacco use, and alcohol use, followed by individualized information, daily physical activity, and respiratory muscle training [20]. In gastrectomy, respiratory prehabilitation with incentive spirometry was incorporated into the ERAS pathway and was associated with a shorter hospital stay and better preservation of postoperative pulmonary function [17].

Shortened fasting and carbohydrate loading were described as frequent preoperative ERAS elements [6,17,20,21,22,23,24,26,30]. Several protocols allowed clear fluids until approximately two hours before anesthesia and solids until approximately six hours before anesthesia when clinically appropriate [17,22,23,26,30]. In the gastric cancer study, the ERAS group received carbohydrate drinks until two hours before surgery, while the non-ERAS group followed more traditional preoperative fasting [6]. In bariatric surgery, ERAS protocols emphasized preoperative education, shortened fasting, nutritional preparation, and respiratory optimization, while also recognizing obesity-specific issues such as sleep apnea and thromboembolic risk [23,27].

Prehabilitation was presented as a developing ERAS component rather than as a universally standardized requirement [15,17,20,22]. The pancreatic surgery observational study suggested that adding prehabilitation increased screening and prescription of preoperative training, and it was associated with shorter time to first flatus and shorter length of stay after implementation of ERAS-related concepts [20]. The gastrectomy randomized trial suggested that adding supervised respiratory prehabilitation to ERAS reduced hospitalization and helped preserve peak expiratory flow rate in the postoperative period [17]. These findings support the inclusion of prehabilitation in selected high-risk or major surgical populations, although protocols remain heterogeneous [17,20,22].

3.3. Intraoperative components

Intraoperative ERAS care focused on reducing surgical trauma, maintaining physiological stability, limiting avoidable opioid exposure, preventing nausea and vomiting, and minimizing unnecessary drains and tubes [3,8,17,20,22,24,25,26,30]. Minimally invasive surgery was frequently included when technically and oncologically appropriate [6,9,11,22,24,26,30]. In colorectal surgery, ERAS was often combined with laparoscopic approaches, and studies reported shorter hospital stay without a consistent increase in complications or readmissions [9,11,24,30]. In esophagectomy, the review emphasized that minimally invasive techniques may reduce operative trauma and pulmonary complications, but the evidence base was limited by heterogeneity and a lack of randomized trials [22].

Fluid management was repeatedly identified as an important intraoperative and early postoperative element [8,11,17,20,24,30]. ERAS protocols generally discouraged both fluid overload and excessive restriction, favoring balanced or goal-directed strategies according to procedure and patient condition [8,17,20,24]. The meta-analysis on acute kidney injury addressed concerns that ERAS-related fluid strategies, vasoactive drug use, and non-steroidal

anti-inflammatory drugs might increase postoperative AKI risk [8]. In that meta-analysis, ERAS was not associated with a statistically significant increase in postoperative AKI compared with conventional care, and ERAS was associated with shorter hospital stay [8].

Multimodal analgesia was a central intraoperative and postoperative ERAS component in several specialties [2,3,5,17,21,25,26,30]. The analyzed protocols used different combinations of acetaminophen, non-steroidal anti-inflammatory drugs, epidural analgesia, local infiltration, transversus abdominis plane block, gabapentinoids, ketamine, dexmedetomidine, or regional anesthesia depending on the procedure and institutional practice [2,5,17,21,26,27,30]. The purpose of these strategies was to reduce unnecessary opioid exposure while maintaining adequate pain control and enabling early mobilization [2,3,5,21,25,26]. In plastic surgery, implementation of an ERAS protocol with emphasis on non-narcotic analgesia was associated with a sustained reduction in outpatient opioid prescribing [5].

Intraoperative measures also included antibiotic prophylaxis, thromboembolic prophylaxis, prevention of postoperative nausea and vomiting, maintenance of normothermia, and selective use of drains and tubes [11,17,20,21,22,24,25,26,27,30]. In the Hatyai colorectal cancer cohort, multimodal analgesia, nasogastric tube avoidance, early discontinuation of intravenous fluids, early urinary catheter removal, and early drain removal were associated with postoperative stay of five days or less [11]. In the Northern Italy colorectal real-world study, the ERAS protocol included laparoscopic surgery when possible, no routine drainage, nasogastric tube removal after surgery, early mobilization, early oral intake, and opioid-sparing analgesia [24]. These findings show that intraoperative and early postoperative decisions are closely connected within ERAS pathways [11,24,30].

3.4. Postoperative components

Postoperative ERAS care focused on early oral intake, early mobilization, opioid-sparing analgesia, removal or avoidance of nasogastric tubes, early urinary catheter removal, limited drain use, respiratory exercises, and discharge planning based on clinical criteria [6,9,11,17,20,21,22,24,25,28,29,30]. Early feeding was described as a key component in colorectal, bariatric, gynecologic, gastric, and selected thoracic or reconstructive protocols [6,9,11,17,21,23,24,27,28,29,30]. In the major gynecologic surgery study, the ERAS protocol allowed oral intake six hours after surgery, soft diet on postoperative day one, and transition to a general diet as tolerated [28]. In the colorectal cancer study from Hatyai Hospital, ERAS was associated with earlier oral intake and faster transition to a soft diet [11].

Early mobilization was one of the most consistent postoperative recovery goals [3,13,17,20,21,26,28,30]. Mobilization protocols varied across procedures, but they commonly encouraged sitting, standing, or walking on the day of surgery or within the first postoperative day [17,20,21,26,28,30]. In the major gynecologic surgery study, all ERAS patients ambulated within 24 hours, compared with 57.8% of patients in the pre-ERAS group [28]. In total hip arthroplasty outpatient pathways, early mobilization was presented as essential for safe same-day or short-stay discharge [26].

Avoidance or early removal of tubes, drains, and catheters was repeatedly associated with faster recovery and shorter hospitalization [11,13,20,21,22,24,25,30]. In esophagectomy, the review supported avoidance of routine nasogastric tube use or early removal, while also noting that nutrition and decompression strategies must be adapted to procedure-specific risks [22]. In thoracic surgery for chronic empyema, ERAS was associated with shorter chest tube duration and shorter postoperative stay in immunocompromised patients undergoing VATS [13]. In colorectal surgery, early removal of JP drains, avoidance of nasogastric tubes, and early urinary catheter removal were associated with shorter postoperative hospitalization [11].

Discharge criteria were described as essential safeguards against unsafe early discharge [11,26,27,30]. In the Hatyai colorectal cancer study, discharge required adequate pain control with oral medication, ability to tolerate a soft diet, absence of nausea, passage of flatus or stool, return to baseline mobility, and patient agreement [11]. In bariatric ERAS cost analysis, discharge required absence of surgical complications, absence of fever, pain controlled with oral analgesia, full ambulation, and patient acceptance [27]. These criteria support the interpretation that ERAS aims to accelerate recovery rather than force discharge before clinical readiness [11,26,27].

3.5. Effects on length of stay and recovery milestones

Shorter length of stay was the most consistent outcome reported across the included studies [6–9,11–14,17,19,20,24,25,27–30]. In the AKI meta-analysis, ERAS was associated with significantly shorter hospital stay, with a pooled mean difference of –1.54 days compared with standard care [8]. In the colorectal systematic review, ERAS implementation resulted in reduced hospital stay across included randomized trials, with reductions varying between three and eight days across studies [9]. In the Northern Italy real-world colorectal study, mean length of stay decreased from 8.1 days in 2022 to 5 days in 2023 after ERAS implementation [24].

Procedure-specific studies showed similar trends in several surgical fields [6,7,13,17,19,20,21,25,27,28,29,30]. In locally advanced gastric cancer surgery, the ERAS group had shorter time to first flatus and shorter hospital stay than the non-ERAS group [6]. In the gastrectomy randomized trial, the ERAS group had a shorter median length of hospitalization than the conventional group [17]. In bariatric surgery, the study of sleeve gastrectomy and one-anastomosis gastric bypass reported average reductions in length of stay of 1.2 days and 1.5 days, respectively, after ERAS implementation [7].

Thoracic, spine, plastic, and gynecologic studies also supported shorter hospitalization or faster discharge after ERAS implementation [13,19,21,25,28,29]. In the VATS empyema study, ERAS was associated with shorter chest tube duration and postoperative length of stay compared with conventional care [13]. In spine surgery, the propensity-matched study reported a reduction in mean length of stay from 4.4 days in the control group to 2.6 days in the ERAS group without additional adverse events [19]. In DIEP flap breast reconstruction, mean length of stay was reduced from six to five days after ERAS implementation [29]. In major gynecologic surgery, 81.1% of ERAS patients were discharged within seven days compared with 38.9% in the pre-ERAS group [28].

Recovery milestones also improved in multiple studies [6,11,17,20,28,30]. The Hatyai colorectal study reported earlier oral intake, earlier drain removal, and shorter postoperative stay in the ERAS group [11]. The pancreatic surgery study reported shorter time to first flatus after implementation of ERAS and prehabilitation concepts [20]. The colon-versus-rectal laparoscopic ERAS study showed that functional recovery and high compliance were possible in both colon and rectal surgery, although rectal resections were associated with longer length of stay [30].

3.6. Effects on complications, readmission, reoperation, and mortality

The included literature generally did not show a consistent increase in complications, readmissions, reoperations, or mortality after ERAS implementation [6,8,9,11,13,14,17,19,21,23,24,25,28,29,30]. In the AKI meta-analysis, ERAS did not significantly increase 30-day readmission, 30-day reoperation, or mortality compared with standard care [8]. In the colorectal systematic review, ERAS patients had reduced

postoperative complications and improved gastrointestinal recovery compared with conventional care [9]. In the Hatyai colorectal cancer study, ERAS reduced postoperative hospital stay without increasing complications, readmissions, or mortality [11].

Some specialty-specific findings were favorable, while others were neutral [6,10,13,14,19,24,25,28,29,30]. In the thoracic multi-hospital study, post-ERAS patients had lower risk-adjusted rates of overall morbidity, respiratory complications, pneumonia, surgical site infection, arrhythmias, infections, ICU use, opioid use, and postoperative length of stay [25]. In the VATS empyema study, ERAS was associated with reduced air leaks, atelectasis, and need for bronchoscopic aspiration [13]. In the DIEP flap breast reconstruction study, postoperative complications did not increase after ERAS implementation [29]. In radical cystectomy, the single-surgeon study reported shorter time to flatus and shorter length of stay but no statistically significant reduction in complications compared with standard care [10].

Readmission findings require cautious interpretation [6,7,8,11,14,23,24]. In bariatric ERAS literature, readmission and mortality were generally similar between ERAS and standard-care groups, despite shorter hospitalization [23]. In the sleeve gastrectomy and OAGB study, readmission rates were lower in the ERAS group than in historical controls [7]. In locally advanced gastric cancer surgery, readmission within 15 days was numerically higher in the ERAS group than in the non-ERAS group, although the study still reported shorter hospital stay and supported protocol feasibility [6]. In the Northern Italy colorectal study, readmissions and reoperations increased in the ERAS implementation year despite lower complications and shorter length of stay, which illustrates the need for careful follow-up after early discharge [24].

Mortality was generally unchanged or not increased in the included evidence [8,9,11,23,24]. The AKI meta-analysis reported no statistical difference in mortality between ERAS and standard care [8]. The Northern Italy colorectal study reported one 30-day death in each annual cohort despite shorter hospital stay in the ERAS year [24]. The bariatric narrative review summarized that postoperative mortality and readmission rates were similar between ERAS and standard-care patients in the reviewed bariatric evidence [23].

3.7. Pain control and opioid-sparing recovery

Opioid-sparing recovery was a major theme in the analyzed ERAS literature [2,3,5,21,25,26]. The rationale for opioid reduction is that opioid-heavy analgesia may contribute to nausea, vomiting, ileus, constipation, sedation, respiratory depression, urinary retention, and delayed mobilization [2,3,5,22,26]. ERAS protocols therefore used multimodal analgesia and regional or local techniques to maintain pain control while reducing opioid exposure [2,5,17,21,26,27,30].

The plastic surgery study demonstrated that ERAS implementation significantly reduced outpatient opioid prescriptions after a variety of plastic and reconstructive procedures, and the reduction was sustained over time [5]. The gynecologic oncology quality-improvement initiative reported lower postoperative opioid requirements after ERAS implementation for total abdominal hysterectomy, with median oral morphine equivalents decreasing from 56 to 40 [21]. The thoracic multi-hospital study reported lower opioid use after ERAS implementation for anatomic lung resection [25]. The spine surgery literature also identified reduced opioid consumption as a common ERAS benefit and highlighted the relevance of ERAS to long-term postoperative opioid use [1,3].

Pain outcomes also improved in several studies [17,21,23,27,28,29]. In DIEP flap breast reconstruction, the ERAS group had a lower average pain score than the control group [29]. In

major gynecologic surgery, day-three pain scores were lower in the ERAS group than in the pre-ERAS group [28]. In bariatric surgery, the narrative review reported that ERAS was associated with lower postoperative pain, reduced opioid use, and reduced antiemetic use in the analyzed literature [23]. In the RYGB cost analysis, ERAS patients had lower postoperative pain and lower postoperative nausea or vomiting than patients receiving standard care [27].

Patients with chronic opioid use or substance use disorder require individualized ERAS planning [2]. The reviewed article on substance use disorder emphasized that ERAS analgesic strategies in ambulatory surgery should be adapted to patient risk, medication history, and the need for coordination between surgical, anesthesia, pain, and addiction-related care [2]. This supports a balanced interpretation of opioid-sparing ERAS as opioid-minimizing rather than universally opioid-free care [2,5,21,26].

3.8. Gastrointestinal recovery, nausea, and oral intake

Faster gastrointestinal recovery was reported in multiple abdominal and pelvic surgery studies [6,9,11,17,20,28,30]. In locally advanced gastric cancer surgery, time to first flatus was shorter in the ERAS group than in the non-ERAS group [6]. In the colorectal systematic review, ERAS patients had faster gastrointestinal recovery, including quicker bowel movement, defecation, and resumption of normal diet [9]. In the Hatyai colorectal cancer study, ERAS was associated with earlier oral intake and faster transition to soft diet [11]. In major gynecologic surgery, first bowel sounds occurred earlier in the ERAS group, and all ERAS patients ambulated within 24 hours [28].

Postoperative nausea and vomiting were addressed through prophylaxis, opioid reduction, fluid management, and early feeding strategies [17,21,23,26,27]. The bariatric narrative review reported lower postoperative nausea and vomiting in ERAS patients across the analyzed bariatric literature [23]. The RYGB economic analysis reported lower postoperative nausea or vomiting in the ERAS group compared with the standard-care group [27]. In total hip arthroplasty outpatient pathways, prevention of nausea, dizziness, orthostatic hypotension, urinary retention, and pain was presented as essential for safe early discharge [26].

Early oral intake was repeatedly presented as both a recovery goal and a marker of functional improvement [9,11,17,21,22,23,24,27,28,30]. In bariatric ERAS, early oral fluids and nutrition were included in protocolized care, with attention to procedure-specific safety and nutritional education [23,27]. In esophagectomy, the review noted potential benefits of early enteral or oral nutrition but emphasized that feeding routes and timing require individualized adaptation because of reconstruction complexity and anastomotic concerns [22].

3.9. Patient-centered outcomes and patient experience

Patient-centered care was a recurring theme in the analyzed ERAS literature [15,21,26,29]. The cardiac surgery qualitative study identified information and communication flow, perioperative patient care, and rehabilitation as the main patient-experience themes [15]. Patients in that study considered preoperative education and preconditioning helpful, valued multidisciplinary care, and emphasized the importance of including relatives in the perioperative process [15].

Some studies also evaluated patient-centered outcomes beyond length of stay [15,16,26,29]. In laparoscopic radical cystectomy combined with cutaneous ureterostomy, the ERAS group had higher postoperative Herth Hope Index and FACT-G quality-of-life scores and lower complication incidence than the non-ERAS group, although the wording of some recovery-

time results in the article should be interpreted cautiously [16]. In DIEP flap breast reconstruction, ERAS reduced pain and constipation without increasing surgical complications, which is relevant to patient comfort during recovery [29]. In orthopedic outpatient pathways, patient and family engagement was identified as one of the core principles of safe ERAS-outpatient integration [26].

Patient-centered ERAS requires realistic expectations and clear discharge planning [11,15,26,27]. Patients should understand that early feeding, early mobilization, and opioid-sparing analgesia are active treatment components rather than optional aspects of recovery [15,26,28,30]. At the same time, ERAS protocols must remain flexible enough to account for frailty, comorbidities, pain, complications, and social support limitations [14,15,26].

3.10. ERAS in selected surgical specialties

Colorectal surgery provided the strongest and most mature ERAS evidence within the analyzed source set [9,11,24,30]. The systematic review of colorectal randomized trials found that ERAS reduced hospital stay, accelerated gastrointestinal recovery, reduced complications and opioid consumption, and improved nutritional recovery markers compared with conventional care [9]. The Hatyai laparoscopic colorectal cancer study showed shorter postoperative hospital stay, earlier oral intake, earlier drain removal, and no significant increase in complications, readmission, or mortality [11]. The Northern Italy real-world study showed shorter length of stay and fewer complications after ERAS implementation, although readmissions and reoperations were higher in the implementation year [24]. The colon-versus-rectal laparoscopic study showed that rectal cancer surgery was associated with longer length of stay than colonic surgery despite high ERAS compliance, and it identified bowel preparation and postoperative drainage as factors associated with prolonged hospitalization [30].

Gastric and upper gastrointestinal surgery showed benefits but required careful adaptation of nutrition and respiratory care [6,17,22]. The locally advanced gastric cancer study reported shorter time to first flatus and shorter hospital stay in the ERAS group, while readmission was numerically higher in the ERAS group [6]. The gastrectomy randomized trial showed shorter hospitalization and better preservation of postoperative pulmonary function when ERAS was combined with respiratory prehabilitation [17]. The esophagectomy review concluded that ERAS may reduce costs, length of stay, and pulmonary complications, but it also emphasized limited randomized evidence and the need for further standardization [22].

Bariatric surgery studies and reviews generally supported ERAS feasibility and safety [7,23,27]. The bariatric narrative review summarized evidence from guidelines, meta-analyses, randomized trials, and observational studies, reporting reductions in length of stay, postoperative nausea and vomiting, postoperative pain, opioid and antiemetic use, and costs, with similar mortality and readmission rates compared with standard care [23]. The sleeve gastrectomy and OAGB study reported shorter length of stay and lower complications and readmissions after ERAS implementation compared with historical controls [7]. The RYGB economic analysis showed lower postoperative pain, lower nausea or vomiting, shorter hospital stay, lower pharmacological and hospital-stay costs, and a mean saving of 1458.62 USD per patient after ERAS implementation [27].

Pancreatic surgery findings emphasized adherence and prehabilitation [20]. The pancreatic observational study compared historical controls with ERAS and ERAS plus prehabilitation groups and found that implementation improved adherence to protocol elements by both patients and healthcare professionals [20]. The same study reported shorter length of stay and shorter time to bowel movement after implementation, without significant differences in

complications [20]. These results suggest that implementation quality may be as important as the specific protocol content in complex pancreatic surgery [20].

Thoracic surgery findings supported both specialty-specific and system-wide ERAS implementation [13,25]. The VATS empyema study in immunocompromised patients reported shorter chest tube duration, shorter postoperative length of stay, smaller drainage volume, fewer air leaks, fewer cases of atelectasis, and reduced need for bronchoscopic aspiration in the ERAS group [13]. The anatomic lung resection study included 1007 patients across a healthcare system and showed lower risk-adjusted morbidity, respiratory complications, pneumonia, surgical site infection, arrhythmias, infections, opioid use, ICU use, and shorter postoperative length of stay after ERAS implementation [25]. These thoracic findings indicate that ERAS can be implemented beyond a single hospital when multidisciplinary buy-in and protocol monitoring are present [25].

Gynecologic surgery studies supported the feasibility of ERAS in both oncologic and non-oncologic major procedures [21,28]. The gynecologic oncology total abdominal hysterectomy quality-improvement initiative implemented an ERAS order set across a 12-site network and reported reduced postoperative opioid requirements and a trend toward shorter length of stay [21]. The major gynecologic surgery prospective case-control study reported faster bowel recovery, earlier ambulation, lower pain scores, fewer complications, and shorter hospital stay in the ERAS group [28]. These findings support ERAS use in gynecologic surgery while showing that implementation may require network-wide order sets and multidisciplinary coordination [21,28].

Urologic surgery evidence in the analyzed set focused mainly on radical cystectomy and laparoscopic radical cystectomy with cutaneous ureterostomy [10,16]. The radical cystectomy single-surgeon case series reported shorter time to flatus and shorter length of stay in the ERAS group, but complications were not reduced compared with standard care [10]. The laparoscopic radical cystectomy with cutaneous ureterostomy study reported improved hope and quality-of-life scores and fewer complications in the ERAS group, but some recovery-time wording in the abstract and results requires cautious interpretation [16]. Therefore, urologic ERAS appears promising, but conclusions should be conservative because of small cohorts, retrospective designs, and partial protocol adherence [10,16].

Spine surgery studies and reviews supported reductions in length of stay and opioid use without consistent increases in complications [1,3,19]. The matched spine surgery study showed a substantial reduction in length of stay without additional adverse events, readmissions, or worse pain and satisfaction outcomes [19]. The spine literature reviews emphasized that ERAS protocols may reduce length of stay, hospital costs, opioid requirement, and pain scores, but they also noted variability in protocol elements between centers [1,3]. These findings suggest that spine ERAS is expanding but remains less standardized than colorectal ERAS [1,3].

Orthopedic ERAS-outpatient pathways emphasized that early discharge should result from improved recovery rather than from length of stay targets alone [26]. The total hip arthroplasty review described five core ERAS principles: patient and family engagement, surgical best practices, multimodal opioid-sparing pain management, mobility and physical activity, and fluid and nutrition management [26]. It also emphasized that patient selection, prevention of pain and nausea, management of orthostatic symptoms, urinary retention prevention, wound care, and early mobilization are essential for safe outpatient arthroplasty pathways [26].

Plastic and reconstructive surgery studies showed benefits in opioid prescribing, pain,

constipation, and length of stay [5,29]. The plastic surgery opioid-prescribing study found that ERAS reduced outpatient opioid prescriptions after several plastic surgery operations [5]. The DIEP flap breast reconstruction study found shorter hospitalization, lower average pain scores, and less constipation after ERAS implementation without increased postoperative complications [29]. These results suggest that ERAS principles can be adapted to reconstructive procedures while preserving procedure-specific monitoring requirements such as flap assessment [29].

3.11. Economic outcomes and resource use

Several included studies reported cost-related outcomes or resource-use implications [7,21,23,25,26,27]. The bariatric RYGB economic analysis found significantly lower total procedure cost in the ERAS group, with a mean saving of 1458.62 USD per patient and a 21.25% reduction in total procedure cost [27]. The bariatric narrative review concluded that ERAS protocols were associated with reduced hospital costs in the bariatric literature [23]. The total hip arthroplasty ERAS-outpatient review cited reductions in direct healthcare costs when ERAS short-stay protocols were implemented [26].

Cost effects were not uniform across all studies [21,25]. In the gynecologic oncology total abdominal hysterectomy quality-improvement initiative, median total hospital costs did not significantly decrease despite reduced opioid requirements and a trend toward shorter length of stay [21]. In the thoracic multi-hospital study, overall hospital cost was not reduced after ERAS implementation, which the authors discussed in the context of pandemic-related and system-level healthcare cost inflation [25]. These findings show that clinical improvement does not always translate into immediate measured cost reduction, especially when costs are influenced by broader institutional or economic conditions [21,25].

3.12. Implementation barriers and adherence

Implementation was repeatedly described as a determinant of ERAS effectiveness [4,12,15,20,21,25]. Common barriers included resistance to changing traditional perioperative routines, differences between hospitals, limited staff education, insufficient patient engagement, inconsistent documentation, lack of electronic order sets, variable postoperative adherence, and resource constraints [4,12,15,20,21,25]. In pancreatic surgery, adherence varied between different parts of the pathway, and implementation improved several protocol elements such as gut motility stimulation and earlier removal of epidural anesthesia, drains, and urinary catheters [20]. In the thoracic system-wide study, implementation required a multidisciplinary quality review committee, structured dissemination, local champions, and repeated review of compliance metrics [25].

Protocol adherence was closely connected with outcomes in several studies [11,20,25,30]. In the Hatyai colorectal study, overall ERAS compliance was higher in the ERAS group, and adherence independently predicted postoperative stay of five days or less [11]. In the pancreatic study, implementation of ERAS and prehabilitation increased adherence among both patients and healthcare professionals [20]. In the colon-versus-rectal study, high ERAS compliance was possible in both colonic and rectal surgery, but procedure-specific elements such as bowel preparation and drainage influenced length of stay [30]. These findings indicate that ERAS should be implemented with audit, feedback, and procedure-specific adaptation rather than by simple introduction of a written protocol [11,20,25,30].

The analyzed literature also suggests that ERAS can be implemented in diverse healthcare settings when multidisciplinary support is present [11,12,21,25]. The gynecologic oncology quality-improvement initiative showed that ERAS implementation across a 12-site

community network was feasible with multidisciplinary input and electronic order sets [21]. The thoracic surgery study showed that a universal protocol could be implemented across multiple hospitals within one healthcare system, despite differences in hospital culture and resources [25]. The gastrointestinal cancer feasibility study in a tertiary care hospital reported high overall compliance with ERAS components, while also noting implementation challenges across preoperative, intraoperative, and postoperative phases [12].

4. Discussion

The expanded results of this review support the interpretation of ERAS as a perioperative care model whose effectiveness depends on the interaction between multiple preoperative, intraoperative, and postoperative components rather than on any single isolated intervention [1,3,8,20,22,25]. This is clinically important because many ERAS elements are functionally interdependent: opioid-sparing analgesia facilitates mobilization, reduced nausea supports oral intake, limited tube and catheter use improves patient mobility, and structured education improves adherence to recovery goals [2,5,11,15,21,26,30]. Therefore, ERAS should be interpreted as a coordinated pathway of care rather than as a simple checklist of independent perioperative tasks [1,3,20,22,25].

The most consistent finding across the analyzed publications was a reduction in length of stay or faster achievement of recovery milestones after ERAS implementation [6–9,11–14,17,19,20,24,25,27–30]. This finding was reported across diverse specialties, including colorectal surgery, gastric surgery, bariatric surgery, pancreatic surgery, thoracic surgery, spine surgery, gynecologic surgery, plastic surgery, and urologic surgery [6,7,9,11,13,14,17,19,20,21,24,25,27–30]. The consistency of this observation across heterogeneous procedures suggests that the effect of ERAS on length of stay is probably related to common mechanisms such as earlier mobilization, improved pain control, earlier oral intake, reduced postoperative nausea and vomiting, and earlier removal of tubes or catheters [9,11,17,20,21,23,26,28,30]. However, length of stay should not be treated as an isolated quality indicator because early discharge is safe only when recovery criteria are fulfilled [4,11,26,27].

The reviewed evidence suggests that ERAS can shorten hospitalization without a consistent increase in postoperative complications, readmissions, reoperations, or mortality [6,8,9,11,13,17,19,23,24,25,28,29,30]. This is particularly important because early discharge could theoretically transfer part of the postoperative risk from the hospital to the outpatient setting [4,11,24,26]. The available data do not support a general conclusion that ERAS increases this risk, but several studies show that readmission and reoperation outcomes may vary between procedures and healthcare systems [6,7,14,24]. Therefore, ERAS programs should include objective discharge criteria, early follow-up, patient education, and rapid access to medical evaluation when postoperative symptoms develop [11,24,26,27].

The findings on complications require a nuanced interpretation because the included studies differed in design, population, procedure type, and protocol content [1–30]. Some studies reported lower complication rates after ERAS implementation, particularly in colorectal, thoracic, gynecologic, and VATS empyema surgery [9,13,24,25,28]. Other studies reported similar complication rates despite shorter hospitalization, which may still be clinically meaningful because ERAS achieved faster recovery without compromising safety [6,10,17,19,29,30]. These differences suggest that ERAS may be most reliable as a recovery-optimization strategy, while its effect on complication reduction may depend more strongly on baseline risk, procedure type, adherence level, and local implementation quality

[9,20,24,25,30].

The meta-analysis on postoperative acute kidney injury provides an important safety perspective because ERAS protocols often include fluid optimization, vasoactive support, and multimodal analgesia that may include non-steroidal anti-inflammatory drugs [8]. In that meta-analysis, ERAS did not significantly increase postoperative AKI, readmission, reoperation, or mortality, and it significantly reduced hospital stay [8]. This supports the safety of ERAS in relation to renal outcomes in the included studies, but it should not be interpreted as permission to apply identical fluid and analgesic protocols to all patients [8]. Patients with chronic kidney disease, hemodynamic instability, high bleeding risk, or contraindications to non-steroidal anti-inflammatory drugs still require individualized perioperative planning [2,8,26].

Opioid-sparing analgesia emerges as one of the most clinically important components of modern ERAS pathways [2,3,5,21,25,26]. The rationale is strong because opioid-heavy analgesia may contribute to postoperative nausea and vomiting, ileus, constipation, sedation, urinary retention, respiratory depression, and delayed mobilization [2,3,5,22,26]. Several included studies reported reduced opioid use or opioid prescribing after ERAS implementation, including plastic surgery, gynecologic oncology, thoracic surgery, and spine surgery [3,5,21,25]. Nevertheless, opioid-sparing care should not be confused with absolute opioid avoidance because some patients, especially those with chronic opioid exposure or substance use disorder, may require individualized analgesic plans and specialist input [2].

Gastrointestinal recovery is another major mechanism through which ERAS appears to improve postoperative outcomes [6,9,11,17,20,28,30]. Earlier return of bowel function, earlier oral intake, reduced postoperative nausea and vomiting, and earlier tolerance of diet were reported in several abdominal and pelvic surgery studies [6,9,11,17,23,27,28,30]. These findings are clinically relevant because gastrointestinal recovery affects hydration, nutrition, mobility, patient comfort, and discharge readiness [9,11,23,27,28]. However, the timing and route of feeding must remain procedure-specific, especially in esophagectomy, gastric surgery, and pancreatic surgery where reconstruction, nutritional status, anastomotic risk, or delayed gastric emptying may require individualized decisions [17,20,22].

The patient-centered dimension of ERAS deserves particular attention because the protocol depends on active patient participation [15,21,26,29]. The qualitative cardiac surgery study showed that patients valued clear information, communication flow, interprofessional care, rehabilitation planning, and involvement of relatives [15]. These findings suggest that ERAS implementation should not focus only on technical elements such as drains, fluids, or analgesics, but should also include patient education, expectation management, and psychosocial support [15,20,21,26]. Patient-centered ERAS may be especially important in outpatient or short-stay pathways, where patients and relatives assume a larger role in monitoring recovery after discharge [15,26,27].

The specialty-specific findings show that ERAS evidence is not equally mature across all surgical fields [1–30]. Colorectal surgery remains the area with the most established evidence in the analyzed material, including systematic review data and multiple implementation studies [9,11,24,30]. Bariatric, thoracic, gynecologic, and spine surgery also show consistent benefits, particularly in length of stay, pain control, opioid use, or recovery milestones [1,3,7,13,21,23,25,27,28]. In contrast, evidence in urologic surgery, esophagectomy, pancreatic surgery, and some reconstructive procedures should be interpreted more cautiously because studies may be smaller, more heterogeneous, procedure-specific, or limited by retrospective design [10,16,20,22,29].

The urologic evidence illustrates why cautious interpretation is necessary [10,16]. The radical cystectomy case series suggested shorter time to flatus and shorter length of stay after ERAS, but complications were not significantly reduced [10]. The laparoscopic radical cystectomy with cutaneous ureterostomy study reported improved quality-of-life and hope-related outcomes and fewer complications in the ERAS group, but some wording in the abstract and recovery-time results appears internally inconsistent and should not be overinterpreted [16]. For this reason, urologic ERAS should be presented as promising rather than definitively proven across all cystectomy populations [10,16].

The economic findings suggest that ERAS may reduce costs, but the relationship between clinical improvement and cost reduction is not automatic [21,23,25,26,27]. The RYGB economic analysis reported a substantial cost saving per patient after ERAS implementation, and the bariatric narrative review summarized cost reductions in bariatric ERAS literature [23,27]. Orthopedic ERAS-outpatient pathways also suggest that shorter hospitalization may reduce direct healthcare costs when safety and patient experience are preserved [26]. However, gynecologic oncology and thoracic surgery studies did not demonstrate uniform cost reduction, showing that institutional accounting, pandemic-related costs, staffing, implementation expenses, and healthcare-system factors may modify the economic effect of ERAS [21,25].

Implementation quality is a central determinant of ERAS effectiveness [4,12,15,20,21,25]. Several studies showed that successful ERAS implementation required multidisciplinary cooperation, protocol education, electronic order sets, audit, feedback, local champions, and monitoring of adherence [15,20,21,25]. The pancreatic surgery study demonstrated that adherence varied between ERAS components and that implementation improved several process measures, including gut motility stimulation and earlier removal of epidural anesthesia, drains, and urinary catheters [20]. The thoracic multi-hospital study demonstrated that ERAS can be implemented across a diverse healthcare system when supported by structured dissemination, compliance monitoring, and quality review processes [25].

The review also highlights a methodological challenge in ERAS research: protocols vary considerably between centers, procedures, and time periods [1–30]. This variability makes it difficult to determine which individual ERAS items are responsible for observed improvements [3,20,22,23,26]. It also limits direct comparison between studies because one center's ERAS protocol may differ substantially from another center's pathway in analgesia, feeding, fluid therapy, mobilization, drain use, discharge criteria, or follow-up [3,11,20,22,24,26,30]. Future research should therefore focus not only on whether ERAS works, but also on which components are most influential in specific surgical populations [9,20,22,25].

The present review has several limitations [1–30]. First, it is a narrative review based on a selected set of publications rather than a systematic review with a predefined search strategy [1–30]. Second, the included publications differ in design, including reviews, meta-analyses, randomized trials, retrospective cohorts, prospective cohorts, quality-improvement initiatives, and qualitative research [1–30]. Third, the included studies cover many surgical specialties, which allows broad interpretation but limits direct quantitative comparison [1–30]. Fourth, the present manuscript did not perform pooled statistical analysis, risk-of-bias assessment, or formal evidence grading [1–30].

Despite these limitations, the consistency of several findings across multiple specialties supports the clinical relevance of ERAS as a modern perioperative care model [1–30]. The strongest common signals are shorter length of stay, faster recovery milestones, opioid-sparing analgesia, earlier oral intake and mobilization, and no consistent increase in major

safety outcomes [5–9,11–14,17,19,20,21,23–25,28–30]. At the same time, ERAS should not be treated as a rigid universal checklist because procedure-specific risks, patient characteristics, local resources, and adherence determine whether a protocol is safe and effective [3,20,22,23,26]. The best interpretation of the available evidence is that ERAS represents a flexible, evidence-informed framework for improving perioperative care rather than a single standardized intervention that can be copied unchanged across all operations [1,3,20,22,25,26].

5. Conclusion

Enhanced Recovery After Surgery protocols represent a modern standard of perioperative care based on multimodal, multidisciplinary, and patient-centered principles [1,3,8,15,20,22,25]. The evidence summarized in this review indicates that ERAS can shorten hospitalization, accelerate recovery milestones, reduce opioid exposure, improve pain control, and maintain or reduce postoperative complications without a consistent increase in readmissions or mortality [5–9,11–14,17,19,20,21,23–25,28–30].

ERAS should not be reduced to early discharge [4,26]. Its real purpose is safer and faster recovery through optimized preoperative preparation, careful intraoperative management, and structured postoperative rehabilitation [1,3,8,20,22,26]. Because the available evidence is heterogeneous, ERAS should be adapted locally and evaluated with procedure-specific outcomes rather than treated as a rigid universal checklist [3,20,22,23,26]. Future work should focus on identifying the most impactful ERAS components, improving implementation in different healthcare systems, tailoring protocols to high-risk populations, and evaluating long-term functional and patient-reported outcomes [2,4,9,15,20,22,25].

Supplementary Materials

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The authors declare no conflict of interest.

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