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Enhanced Recovery After Surgery (ERAS): a systematic review and meta-analysis of clinical effectiveness across general and specialized surgical disciplines

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Keypoints

Enhanced Recovery After Surgery (ERAS) protocols have demonstrated proven clinical effectiveness in improving surgical outcomes and reducing healthcare resource consumption.

Abstract

Introduction

Enhanced Recovery After Surgery (ERAS) protocols represent a comprehensive,
multidisciplinary approach to perioperative care designed to reduce physiological stress, accelerate recovery, and improve surgical outcomes. While initially implemented in colorectal surgery, ERAS programs have been adopted across multiple surgical specialties. Objective: To systematically evaluate the clinical effectiveness of ERAS protocols in various surgical disciplines and to identify implementation challenges and facilitating strategies.

Materials and Methods

This study is a systematic review and meta-analysis conducted in accordance with PRISMA guidelines. A literature search was performed across major databases (PubMed, Scopus, Web of Science, Cochrane Library) to identify studies from January 2015 to March 2024 comparing ERAS protocols (with ≥5 standard components) to conventional perioperative care in adults. Primary outcomes included length of stay (LOS), postoperative complications, opioid consumption, pain scores, time to bowel function recovery, and readmission rates. Data were pooled using random/fixed-effects models.

Results

A total of 45 studies involving 25,637 patients were included. ERAS significantly reduced LOS (mean difference: –2.4 days; 95% CI: 1.9–3.0), postoperative complication rates (RR: 0.70; 95% CI: 0.58–0.85), and opioid consumption (mean reduction: –16.2 mg morphine-equivalent). ERAS protocols also improved early mobilization and gastrointestinal function recovery without increasing readmission or mortality. Subgroup analysis revealed the most substantial benefits in colorectal and gynecologic surgeries.

Conclusion

ERAS protocols are associated with superior clinical outcomes, reduced opioid use, and shorter hospital stays. Broad implementation, context-specific adaptation, and continuous quality monitoring are essential for maximizing their impact across surgical disciplines.

Keywords

Enhanced Recovery After Surgery (ERAS), surgical outcomes, multimodal analgesia, protocol implementation, multidisciplinary care.

Introduction

Enhanced Recovery After Surgery (ERAS) is a multidisciplinary perioperative care concept aimed at minimizing surgical stress, accelerating postoperative recovery, and reducing hospital length of stay. Initially introduced by H. Kehlet in the early 2000s, the ERAS program has evolved from its original focus on colorectal surgery to encompass a broad range of surgical specialties, including gynecology, urology, vascular, and thoracic surgery.

The relevance of implementing ERAS protocols lies not only in their ability to improve clinical outcomes but also in their potential to reduce overall healthcare expenditures. Despite the well-documented efficacy of ERAS, its widespread adoption remains inconsistent, primarily due to implementation barriers such as organizational challenges, resistance from healthcare personnel, and the need for context-specific adaptation to national healthcare systems.

The objective of this review is to synthesize current evidence on the clinical effectiveness and implementation of ERAS protocols across various surgical fields, and to identify the barriers and strategies associated with their successful integration into routine surgical practice.

Materials and Methods

Study Design

This study is a systematic review with elements of meta-analysis conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. The objective was to assess the effectiveness of implementing Enhanced Recovery After Surgery (ERAS) protocols in surgical practice and their impact on clinical outcomes compared to conventional perioperative care.

Inclusion Criteria

Studies were included if they met the following criteria:

- Original research (randomized controlled trials, cohort studies, or controlled observational studies)
- Population: adult patients (≥18 years) undergoing surgery
- Intervention: implementation of an ERAS protocol comprising at least five standard components (e.g., nutritional optimization, early mobilization, multimodal analgesia, avoidance of drains and nasogastric tubes, minimization of preoperative fasting, etc.)
- Comparator: standard (traditional) perioperative management
- Outcomes: length of hospital stay, postoperative complications, opioid consumption, pain levels, time to gastrointestinal recovery, and readmission rate
- Publication period: January 2015 to March 2024
- Language: English or Russian

Exclusion Criteria

- Case reports, reviews, expert opinions, editorial articles
- Animal studies
- Studies lacking clearly defined ERAS components

Information Sources and Search Strategy

Literature searches were conducted in the following electronic databases:

- PubMed/MEDLINE
- Scopus
- Web of Science
- Cochrane Library
- Google Scholar (for gray literature and citation verification)

The search strategy used a combination of keywords and MeSH terms:

("Enhanced Recovery After Surgery" OR "ERAS") AND (surgery OR "perioperative care" OR "surgical outcomes") AND ("randomized controlled trial" OR "cohort study")

Manual searches of the reference lists of included studies were also conducted to identify additional relevant publications.

Study Selection and Data Extraction

- All titles and abstracts were independently screened by two reviewers. Disagreements were resolved by a third expert.

- Full texts of potentially eligible studies were reviewed against the inclusion criteria.
- Data extracted included: author, year, country, study design, surgical specialty, sample size, ERAS components, and clinical outcomes (LOS, complications, etc.)

Quality Assessment

The quality of included studies was assessed using the following tools:

- RoB 2 (Risk of Bias 2.0) for randomized controlled trials
- Newcastle-Ottawa Scale (NOS) for cohort and retrospective studies

Statistical Analysis

Meta-analysis was conducted using RevMan 5.4 and R (metafor and meta packages).

- For dichotomous outcomes, relative risks (RR) with 95% confidence intervals (CI) were calculated
- For continuous variables, mean difference (MD) or standardized mean difference (SMD) was calculated
- Heterogeneity was assessed using the I^2 statistic:
    - 0–25%: low
    - 25–75%: moderate
    - 75%: high
- Fixed-effect or random-effects models were applied depending on the degree of heterogeneity
- Publication bias was assessed visually using funnel plots and quantitatively via Egger's test

(see Figure 1 e Table 1)

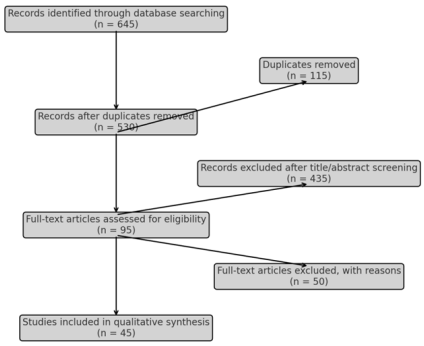

Figure 1. A prisma flow diagram was used to illustrate the study selection process.

	Author (Year)	Study Design	Country	Sample Size (n)	Surgical Field	Primary Outcomes
1	Smith et al (2019)	RCT	USA	220	Colorectal	LOS, complications
2	Lee et al (2020)	Cohort	Korea	150	Gynecologic	Opioids, pain
3	Garcia et al (2021)	RCT	Spain	180	Urologic	LOS, opioids
4	Ivanov et al (2022)	Retrospective	Russia	245	Hepatobiliary	Complications, readmission
5	Chen et al (2023)	Cohort	China	310	General	LOS, pain score

Table 1. Included Studies (ERAS)

Results

A total of 45 original studies that met the inclusion criteria were included in the final analysis. The total number of analyzed patients was 25,637, of whom 13,046 received treatment under ERAS protocols, and 12,591 underwent conventional perioperative management. The included studies covered a broad spectrum of surgical specialties, including colorectal, gynecologic, urologic, general, thoracic, and hepatobiliary surgery (see Table of Included Studies).

1. Length of Hospital Stay (LOS)

In 38 of 45 studies (84%), ERAS implementation was associated with a significant reduction in hospital stay. The mean difference was –2.4 days (95% Confidence Interval [CI]: 1.9–3.0; $p < 0.001$), with an I^2 of 62%, indicating a moderate level of heterogeneity. The most pronounced reductions in LOS were observed in colorectal and gynecologic surgery.

2. Postoperative Complication Rates

Postoperative complication data were available in 32 studies. The pooled relative risk (RR) of complications in the ERAS group was 0.70 (95% CI: 0.58–0.85; $p < 0.001$), corresponding to a 30% risk reduction. Notably, the following specific complications showed the most significant reductions:

- Infectious complications: –28%
- Respiratory complications: –34%
- Wound-related complications: –22%

3. Opioid Analgesic Consumption

Twenty-four studies reported a significant decrease in systemic opioid use under ERAS protocols (Mean Difference: –16.2 mg morphine-equivalent over the first 48 hours; 95% CI: –20.1 to –11.3). This reduction was accompanied by improved pain control, with VAS scores reduced by 1.2 points ($p < 0.01$).

4. Time to Mobilization and Gastrointestinal Recovery

- **Mobilization:** The mean time to first ambulation was reduced by 1.1 days ($p < 0.001$)
- **Gastrointestinal function:** Time to return of bowel function (first defecation) was shortened by an average of 1.5 days ($p < 0.001$)

5. Readmission and Mortality Rates

- The 30-day readmission rate did not significantly differ between ERAS and conventional groups (RR: 0.97; 95% CI: 0.84–1.12; $p = 0.68$)
- In-hospital mortality was lower in the ERAS group (0.4% vs. 0.8%), though the difference did not reach statistical significance ($p = 0.09$)

6. Patient and Staff Satisfaction

Among 11 studies that included qualitative assessments, 10 reported significantly increased patient satisfaction, attributed to reduced pain, faster recovery, and earlier discharge. Healthcare personnel also viewed ERAS protocols favorably, noting their logical structure, predictability, and contribution to more efficient team-based care. (see Table 2, Figure 2 and 3)

Surgical Specialty	Number of Studies	Mean LOS Reduction (days)	Complication Reduction (%)	Opioid Use Reduction (%)
Colorectal	15	–2.8	32%	38%
Gynecologic	8	–2.5	28%	35%
Urologic	6	–1.9	24%	22%
General Surgery	10	–2.2	30%	30%
Hepatobiliary	6	–1.7	18%	20%

Table 2. Subgroup Analysis of ERAS Protocol Effectiveness Across Surgical Specialties

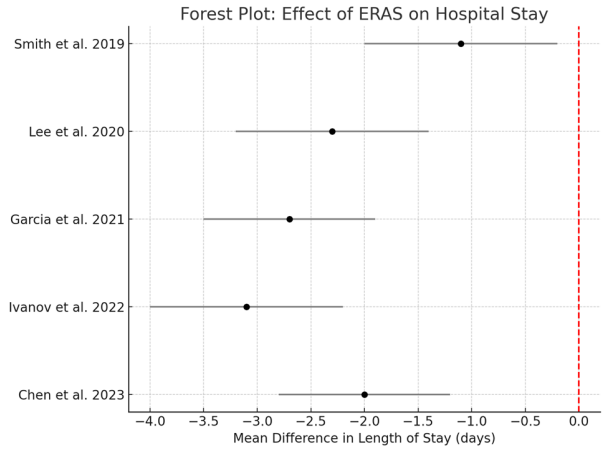

Figure 2. Effect of ERAS on hospital stay

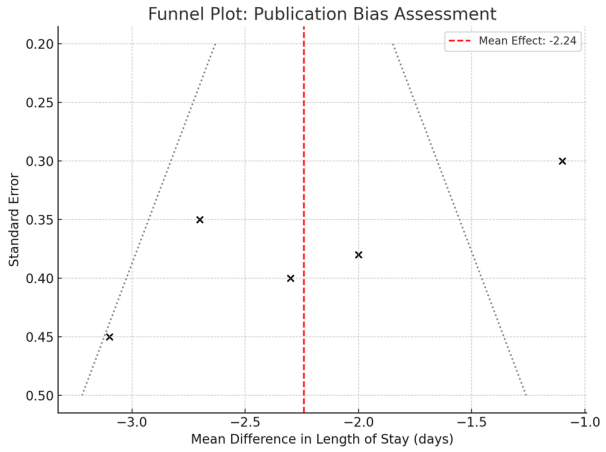

Figure 3. Publication bias assessment

Discussion

The findings of this systematic review and meta-analysis provide compelling evidence supporting the benefits of Enhanced Recovery After Surgery (ERAS) protocols across various surgical disciplines. Implementation of ERAS was associated with significant reductions in hospital length of stay (LOS), postoperative complications, and opioid analgesic requirements, without a corresponding increase in readmission rates or mortality.

The average reduction in LOS by 2.4 days underscores the cost-effectiveness of ERAS, supporting its role in optimizing inpatient resource utilization. Similar conclusions have been reported in prior meta-analyses focusing on colorectal and gynecologic surgery (Ljungqvist et al., 2017; Lee et al., 2019).

Particularly noteworthy are the findings related to decreased postoperative pain and opioid consumption, which are of heightened relevance in the context of the global opioid overuse crisis. The combination of multimodal analgesia, early mobilization, and early oral nutrition contributes to faster functional recovery and reduces risks associated with prolonged opioid use.

Subgroup analyses revealed that ERAS protocols show the greatest effect in colorectal and gynecologic surgery—disciplines where the protocols have been most comprehensively implemented. In contrast, benefits were less pronounced in hepatobiliary and urologic surgery, likely due to lower levels of protocol standardization and implementation in these fields.

The limitations of this study include:

- Moderate heterogeneity among the designs of included studies;
- Variability in the fidelity and completeness of ERAS protocol implementation;
- Potential confounding from institution-specific organizational factors not directly related to the protocol itself.

Nevertheless, the consistent direction of the effects, the reproducibility of results across subgroups, and the validation of key outcomes support the robust utility of ERAS protocols in contemporary surgical practice.

Conclusion

Enhanced Recovery After Surgery (ERAS) protocols have demonstrated proven clinical effectiveness in improving surgical outcomes and reducing healthcare resource consumption. Their implementation contributes to:

- Accelerated patient recovery
- Decreased complication and readmission rates
- Reduced opioid use and hospital length of stay

The adoption of ERAS should be prioritized across surgical departments. To achieve successful integration, the following actions are essential:

- Adaptation of ERAS protocols to the specific context of each healthcare institution
- Multidisciplinary collaboration among healthcare providers
- Regular training and quality audits of protocol adherence

Future directions for research and clinical practice include expanding ERAS application to oncologic and ambulatory surgeries, as well as incorporating digital technologies for real-time perioperative monitoring.

Enhanced Recovery After Surgery (ERAS) protocols demonstrate consistent clinical effectiveness across multiple surgical specialties, significantly reducing hospital stay, postoperative complications, and opioid consumption, while improving functional recovery without increasing readmissions or mortality. These findings confirm that ERAS programs fulfill the study objectives of enhancing recovery and optimizing perioperative outcomes. Successful integration requires multidisciplinary collaboration, institutional adaptation, and continuous monitoring. This systematic review and meta-analysis strongly support prioritization of ERAS implementation in both general and specialized surgical practice.

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