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Impact of Enhanced Recovery after Surgery Program Implementation. Our Results

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Abbreviations:
ASA: American Society of Anesthesiologists (Physical Status Classification);
BMI: Body Mass Index;
CDC: Clavien-Dindo Classification;
CRP: C-reactive Protein;
ERAS: Enhanced Recovery After Surgery;
LOS: Length Of Stay;
MIS: Minimally Invasive Surgery;
SD: Standard Deviation;
SPSS: Statistical Package for the Social Sciences;
SSI: Surgical Site Infection;
TNM: Tumor Node Metastasis.

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Rezumat

Impactul implementării programului Enhanced Recovery After Surgery. Rezultatele noastre

Context: Programul Enhanced Recovery After Surgery (ERAS) este o cale de îngrijire perioperatorie multimodală, bazată pe dovezi, destinată îmbunătățirii recuperării postoperatorii. Acest studiu evaluează impactul implementării ERAS asupra rezultatelor clinice, concentrându-se pe durata spitalizării (LOS) şi complicațiile postoperatorii la pacienții supuşi chirurgiei colorectale.
Metode: Am efectuat un studiu de cohortă retrospectiv-prospectiv, incluzând 231 de pacienți care au suferit intervenții chirurgicale colorectale elective între 2016 şi 2023. Pacienții au fost împărțiți în două grupuri: grupul pre-ERAS (n=84, 2016–2019) şi grupul ERAS (n=147, 2020–2023). Rezultatul primar analizat a fost durata spitalizării (LOS), iar rezultatele secundare au inclus complicațiile postoperatorii şi necesitatea de transfuzie de sânge. Comparațiile statistice au fost realizate utilizând testul t Student şi testul chi-pătrat, considerând p<0,05 ca nivel de semnificație.
Rezultate: Implementarea ERAS a fost asociată cu o reducere semnificativă a duratei spitalizării — de la 10,3 zile la 5,5 zile (p<0,01). Deşi rata globală a complicațiilor nu a prezentat diferențe semnificative (p=0,15), mai puțini pacienți din grupul ERAS au prezentat complicații (10,5% față de 18,1%). Nu au existat diferențe semnificative privind ratele fistulelor anastomotice, infecțiilor plăgii chirurgicale sau necesității de transfuzie postoperatorie.
Concluzie: Protocolul ERAS a redus semnificativ durata spitalizării fără a creşte morbiditatea postoperatorie la pacienții operați de chirurgie colorectală. Aceste constatări susțin valoarea clinică şi fezabilitatea implementării protocolului ERAS. Sunt necesare studii prospective multicentrice suplimentare pentru a evalua impactul pe termen lung al ERAS asupra rezultatelor funcționale, calității vieții şi eficienței costurilor în sistemul de sănătate.

Cuvinte cheie: recuperare accelerată după chirurgie, chirurgie colorectală, durata spitalizării, complicații post-operatorii, chirurgie minim invazivă

Abstract

Background: The Enhanced Recovery After Surgery (ERAS) program is a multimodal, evidence-based perioperative care pathway to improve postoperative recovery. This study evaluates the impact of ERAS implementation on clinical outcomes, with a focus on length of stay (LOS) and postoperative complications in patients undergoing colorectal surgery.

Methods: We conducted a retrospective-prospective cohort study involving 231 patients who underwent elective colorectal surgery between 2016 and 2023. Patients were divided into two groups: pre-ERAS (n=84, 2016–2019) and ERAS (n=147, 2020–2023). The primary outcome was LOS, while secondary outcomes included postoperative complications and blood transfusion requirements. Statistical comparisons were made using the Student's t-test and the chi-square test, with significance defined as $p<0.05$.

Results: ERAS implementation was associated with a significant reduction in LOS - from 10.3 days to 5.5 days ($p<0.01$). Although the overall complication rate did not differ significantly ($p=0.15$), fewer patients in the ERAS group experienced complications (10.5% vs 18.1%). No significant differences were found in rates of anastomotic leaks, surgical site infections, or postoperative transfusion.

Conclusion: The ERAS protocol significantly reduced hospital stays without increasing postoperative morbidity in colorectal surgery patients. These findings support the clinical value and feasibility of the protocol.

Keywords: enhanced recovery after Ssurgery, colorectal surgery, length of stay, postoperative complications, minimally invasive surgery

Introduction

The Enhanced Recovery After Surgery (ERAS) program offers a research-based strategy focused on optimizing and accelerating recovery during the perioperative period (1). High compliance with ERAS elements is strongly correlated with improved outcomes, underscoring the need for strict adherence throughout all perioperative stages. From preadmission to postoperative care, successful implementation depends not only on clinical resources but also on multidisciplinary cooperation and individualized patient management. However, due to the resources of each clinic, implementation can sometimes be more difficult for some items than others.

ERAS has become a cornerstone of perioperative care in colorectal surgery. Multiple studies have shown its ability to reduce postoperative complications, expedite recovery, and shorten hospital stays without compromising safety. The ERAS Society's updated 2018 guidelines for elective colonic surgery emphasize key aspects such as prehabilitation, minimally invasive techniques, multimodal analgesia, and early mobilization (1). Recent meta-analyses have reinforced the clinical feasibility and benefits of ERAS in colorectal surgery, including reduced hospital stay and postoperative complications (2).

Although standardization has improved, ERAS elements are often tailored to institutional resources and patient populations, making local evaluation of outcomes essential. This study analyzes the clinical impact of ERAS protocol implementation within a single institution by comparing outcomes in patients treated before and after protocol adoption. We analyzed key perioperative variables - including length of stay, complication rates, and blood transfusion requirements - and examined adherence to protocol components and any modifications made for individualized care.

Methods

A retrospective-prospective cohort study was conducted, including 231 patients who underwent elective colorectal surgery between January 2016 and December 2023. Patients were divided into two groups: a pre-ERAS group (n=84), receiving

standard perioperative care, and an ERAS group (n=147), managed according to standardized enhanced recovery protocols.

The ERAS protocol incorporated preoperative counseling, prehabilitation, carbohydrate loading, antimicrobial and thrombo-prophylaxis, minimally invasive surgery techniques, multimodal analgesia, early oral feeding and mobilization, early removal of urinary catheters, and discharge based on functional criteria.

Certain items were adapted: bowel preparation was used only in resections in need for transanal stapled anastomosis; surgical drains were selectively used in patients deemed to have a high bleeding risk.

Primary endpoints: (1) postoperative complications, (2) hospital stay, and (3) hemoglobin drop. Secondary endpoints: (1) adherence per ERAS item, (2) readmissions, (3) CRP, albumin, protein levels, (4) impact of the minimally invasive approach.

Demographic and perioperative variables collected included: age, sex, ASA classification, BMI, TNM stage, comorbidities, and surgical procedure type. Postoperative complications were classified using the Clavien-Dindo scale. Continuous variables were reported as mean ± SD and compared with Student's t-test. Categorical data were compared using the chi-square test. A p-value < 0.05 was considered statistically significant.

The institutional review board granted ethical approval. All patients provided written informed consent before inclusion.

Results

A total of 231 patients were included in the study, divided into the pre-ERAS group (n=84; surgery performed from January 1st 2016 to December 31st 2019) and the ERAS (n=147; surgeries performed from January 1st 2020 – December 31st 2023).

Fig. 1 graphically compares the two groups in terms of sample size, mean age, and male gender distribution, showing no statistically significant differences.

In *Table 1*, we observe the demographic characteristics of the two groups. There were no statistically significant differences between the two groups regarding age (65.64 ± 11.74 vs. 66.3±11.83 years, p=0.129) or sex distribution (70.2% vs. 62.6% male, p=0.302), with males comprising approximately 66.1% of the overall cohort. Significant differences were found in ASA classification and diabetes prevalence: ASA II was more frequent in the ERAS group (69.4 % vs. 46.4 %, p=0.001), ASA III was more common in the pre-ERAS group (50 % vs. 30.6 %, p=0.005), and diabetes mellitus was significantly more prevalent in the pre-ERAS group (15.5 % vs. 0.7 %, p<0.001). Other comorbidities such as cardiovascular disease and chronic kidney disease did not differ significantly between groups.

Surgical Approach and Procedures

Fig. 2 summarizes the surgical procedures per-

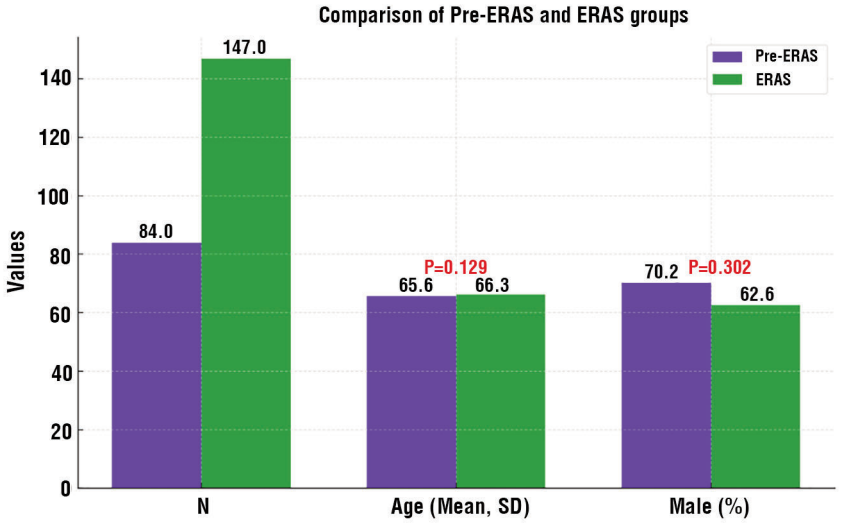

Figure 1. Demographic characteristics of the studied groups

(ERAS – Enhanced Recovery After Surgery, SD – Standard Deviation).

Table 1. Demographic data, ASA score, and comorbidities (e.g., diabetes, cardiovascular disease), highlighting statistically relevant differences between groups where applicable.

Variable	Pre-ERAS group (n=84)	ERAS group (n=147)	p-value
Number of patients	84	147	-
Mean age (years)	65.64 ± 11.74	66.3 ± 11.83	0.129
Male sex (%)	70.2%	62.6%	0.302
ASA I (%)	1.2%	0 %	0.776
ASA II (%)	46.4%	69.4%	0.1
ASA III (%)	50.0%	30.6%	0.5
ASA IV (%)	2.4%	0 %	0.254
Diabetes mellitus (%)	15.5%	0.7%	<0.001
Cardiovascular disease (%)	54.8%	56.5%	0.910
Chronic kidney disease (%)	0 %	3.4%	0.215

formed, including right colectomy, left colectomies, and rectal resection. For clarity, the localization of tumors was simplified as right colon, left colon, or rectum.

As illustrated in *Fig. 2* and *Table 2*, notable differences were observed between the ERAS and pre-ERAS groups regarding the type of resection performed and the surgical approach utilized. While right colectomy was performed with equal frequency in both groups (19.1%), left colectomies were more common in the pre-ERAS group (50.0% vs. 37.4 %, p=0.033) while rectal resections were more frequently performed during the ERAS period (43.5 % vs. 31.0 %, p=0.109). A dramatic

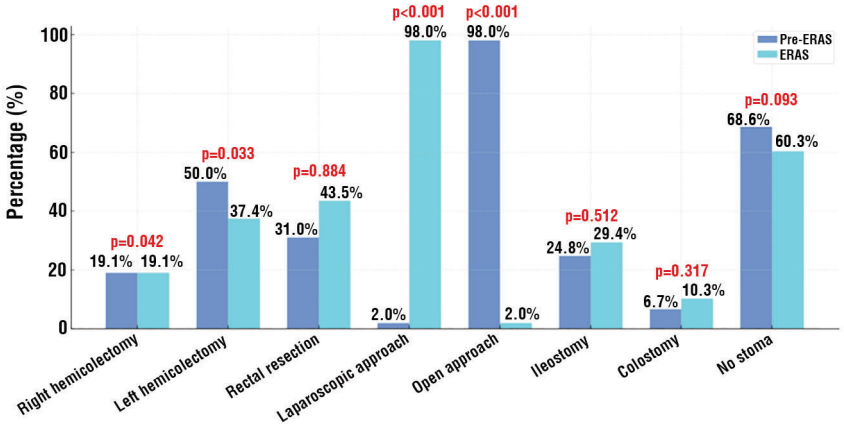

Figure 2. Surgical procedures and tumor localization: Pre-ERAS vs ERAS

Table 2. Comparison of surgical procedures and tumor localization (right colon, left colon, rectum) in pre-ERAS and ERAS groups

Surgical Variable	Pre-ERAS group (n=84)	ERAS group (n=147)	p-value
Right colectomy (%)	19.1	19.1	1.000
Left colectomy (%)	50.0	37.4	0.033
Rectal resection (%)	31.0	43.5	0.109
Laparoscopic approach (%)	42.9	98.6	<0.001
Open approach (%)	57.1	1.4	<0.001
Ileostomy (%)	1.2	0.7	0.512
Colostomy (%)	3.6	2.0	0.317
No stoma (%)	95.2	96.6	0.093

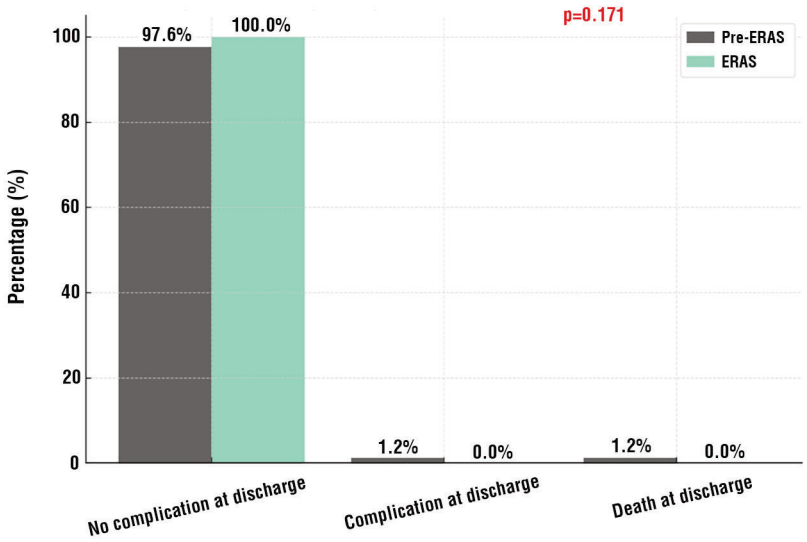

Figure 3. Distribution of discharge complications and mortality according to protocol group

shift was observed in the surgical approach: laparoscopic surgery was increased from 42.9% o in the pre-ERAS group (n=48) to 98.6% in the ERAS group (n =145) (p< 0.001). No statistically significant difference was observed between the two groups in terms of operative time, with a mean duration of 260.90 minutes in the pre-ERAS group and 262.12 minutes in the ERAS group (p=0.917), the length of surgery was adapted according to the particularities of each case and the complexity of the procedure. Given the surgical team's solid experience in laparoscopic techniques, the similar operative times likely reflect the individualized adaptation of each procedure to the patient's specific clinical context.

Table 2 summarizes the types of surgical procedures performed. The use of protective stomas was infrequent in both groups, with no statistically significant differences in the rates of ileostomy (0.7% ERAS vs. 1.2% pre-ERAS, p=0.512) or colostomy (2.0% ERAS vs. 3.6% pre-ERAS, p=0.317). The proportion of patients not requiring a stoma was high in both groups, slightly higher in the ERAS group (96.6% vs. 95.2%, p=0.093). Protective ileostomies were performed selectively in cases with mid and low-rectal tumors.

Postoperative Complications

Fig. 3 illustrates the distribution of discharge-related complications and mortality, which were rare and occurred only in the pre-ERAS group, without reaching statistical significance (p=0.171).

Complications were categorized according to the Clavien-Dindo classification. The distribution of postoperative complications according to the Clavien-Dindo classification is summarized in *Table 3*. Among the 231 patients included in the study, the vast majority (87.9%) experienced no postoperative or discharge-related complications. Most complications were minor, with Grade I (e.g., transient postoperative ileus) and Grade II (e.g., Clostridium difficile infection, superficial wound abscesses) representing 1.3% and 2.6% of cases, respectively. More severe complications were rare: Grade III (requiring surgical or radiological intervention) occurred in 2.6% of patients, while life-threatening events (Grade IV) and post-operative deaths (Grade V) were each recorded in 0.4% of cases.

Most were grade I-II, with no statistically significant difference between the groups. Readmission rates were slightly lower in the ERAS group (2 % vs. 4.7%, p = 0.33). The overall trend favored better outcomes with ERAS.

Table 3. Classification of postoperative complications according to Clavien-Dindo (all patients - percentages calculated from the total number of patients, n = 231)

Clavien-Dindo Grade	Number of patients (%)	Percentage (n)
No complications	203	87.9
Grade I (minor, self-limiting)	5	2.2
Grade II (requiring medical treatment)	18	7.8
Grade III (requiring surgical intervention)	3	1.3
Grade IV (life-threatening complication)	2	0.9
Grade V (death)	0	0.0

Length of Stay and Transfusions

A significant reduction difference is observed regarding the length of stay in the ERAS group (5.5 days vs. 10.3 days, p<0.001). Discharge decisions were based on predefined functional recovery criteria, not a fixed number of days.

Although the overall postoperative transfusion rate did not reach statistical significance between the two groups (p = 0.071), ERAS implementation was associated with a clear reduction in transfusion requirements. On postoperative day 2, the transfusion rate was lower in the ERAS group compared to the non-ERAS group (4.8% vs. 13.1%), without reaching statistical significance (p=0.071), but suggesting a favorable trend. By postoperative day 4, the difference became statistically significant, with a transfusion rate of 2.0% in the ERAS group versus 10.7% in the non-ERAS group (p=0.007), supporting the effectiveness of the protocol in minimizing perioperative blood loss and enhancing hematologic recovery. These laboratory differences between groups, particularly in hemoglobin and albumin levels, are summarized in *Fig. 4*.

Regarding several laboratory findings:

- Postoperative hemoglobin (day 2): The postoperative hemoglobin was slightly higher in the ERAS group (11.05 g/dl vs. 10.57 g/dl, p=0.004) although the difference did not reach statistical significance in this dataset. This difference is primarily due to the more rectal resections performed in the ERAS group. Due to the vascular anatomy of the pelvis and the complexity of these procedures, rectal resections are associated with an increased risk of intraoperative blood loss. Despite this, the ERAS protocol emphasizes careful perioperative management to minimize unnecessary transfusions.
- Preoperative albumin: The ERAS group had significantly higher preoperative albumin levels (3.99 g/dl vs. 3.58 g/dl, p=0.01), indicating better nutritional optimization in the preoperative period, as the protocol encourages.
- Postoperative iron administration (day 2): No significant difference was observed in postoperative iron administration (3.40% vs. 3.60%, p=0.946), reflecting similar management strategies for iron replacement between groups.
- Certain ERAS outcomes (e.g. time to first bowel movement, full mobilization, need for nasogastric aspiration, and postoperative analgesic consumption) were not systematically recorded. This represents a limitation and should be addressed in future prospective studies.

Discussion

Our study demonstrated a significant reduction in the length of hospital stay (LOS) following the implementation of the ERAS program, with a decrease from 10.3 days in the pre-ERAS group to 5.5 days in the ERAS group. This reduction further supports the clinical benefit of implementing ERAS protocols in colorectal surgery.

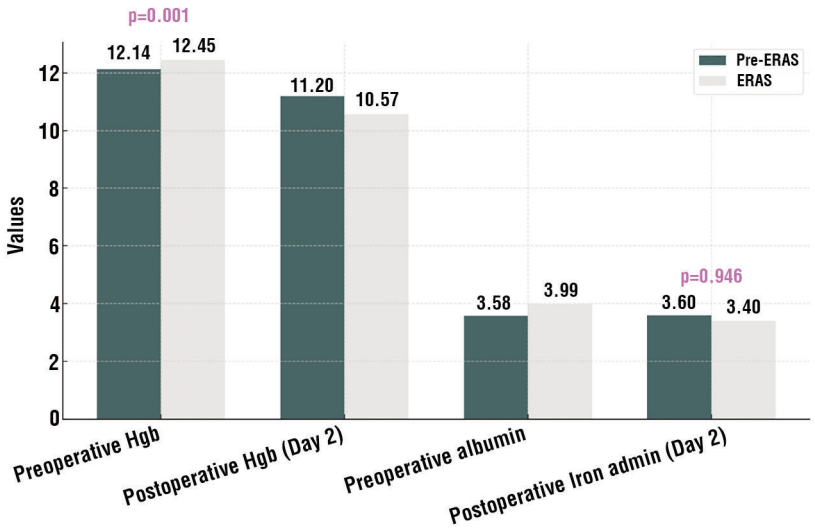

Figure 4. Laboratory findings for the two groups

(ERAS – Enhanced Recovery After Surgery, SD – Standard Deviation).

A critical condition for these results is good adherence, which can sometimes be challenging to maintain (3). A study by Bakker et al. from the Netherlands emphasized that length of stay (LOS) is significantly influenced by adherence, with lower adherence resulting in a longer LOS (4). Adherence depends on multiple factors, one of the most significant being the quality of multi-disciplinary communication. ERAS program should be well known and integrated by the multidisciplinary team working on a case. Additionally, communication with the patient is key to adherence; clearly explaining the peri-operative steps fosters better collaboration, trust, and recovery outcomes.

Our findings also revealed a non-significant but favorable trend toward reduced complication rates in the ERAS group (10.5 % vs. 18.1 5%). A study by Yarman Mazni and colleagues reported that the complication rate did not show statistically significant differences. Moreover, the same applies to the 30-day readmission rate (5).

No statistically significant difference was observed regarding the need for postoperative blood transfusions on day 2 between the groups (4.1% in the ERAS group vs. 11.9% in the Pre-ERAS group, p=0.071). Another important conside-ration is the potential variation in estimated intraoperative blood loss. In their study involving 3,000 patients, Iris H. Wei and colleagues reported that no significant differences in blood loss were observed among the groups analyzed (6).

Additional findings from our study include demographics, tumor localization, and surgical approach, which complement the core results.

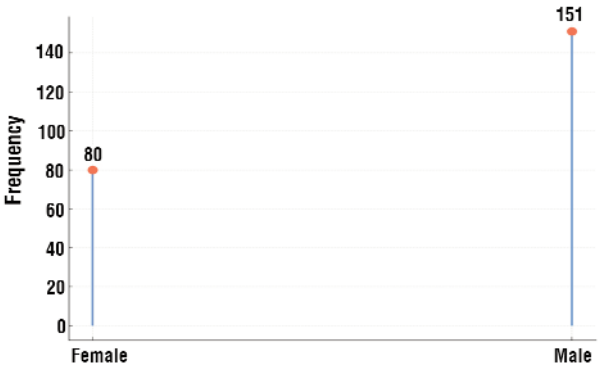

Figure 5. Gender distribution of patients in our study

Gender Distribution and Tumor Localization

Our study revealed a higher prevalence of colo-rectal cancer among men (65.4%) compared to women (34.6%). This distribution is illustrated in *Fig. 5*. In terms of tumor location, tumors were most frequently located in the rectum (39%), followed by the sigmoid colon (19.9%) and right colon (19.1%), as illustrated in *Fig. 6*, a distribution which consequently provides a clearer understanding of the demographic and pathological trends influencing surgical out-comes.

Hospital Stay Duration

The average length of stay was calculated as 10.3 days, highlighting the significance of ERAS protocols in reducing this to 5.5 days in the ERAS group. This reduction emphasizes the efficiency of

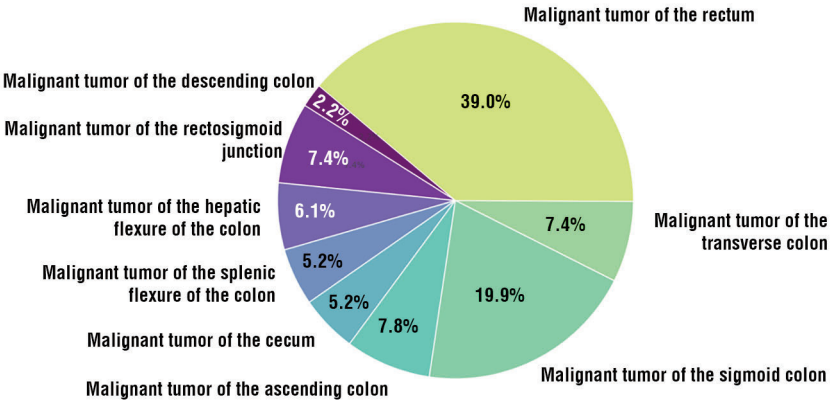

Figure 6. Distribution of malignant tumors by location in our study

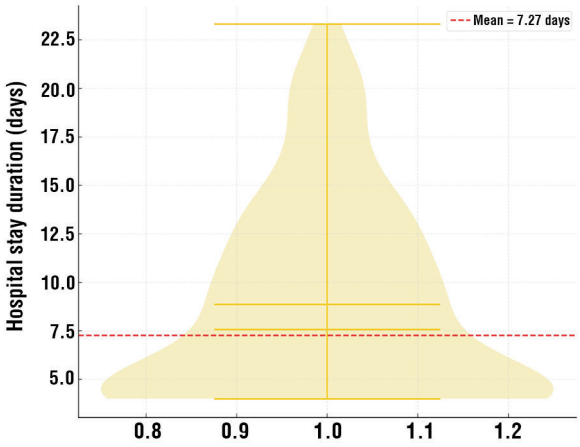

Figure 7. Distribution of hospital stay duration (violin plot)

structured perioperative interventions. *Fig. 7* provides a violin plot of overall hospital stay duration, highlighting a central concentration of cases around the general mean value.

Postoperative Complications

Our data indicated that 87.9% of patients did not experience postoperative complications. Among those who did, rates of fistula formation and wound infections were minimal, demonstrating the success of the program in minimizing adverse outcomes, and occasional, *Clostridium difficile* infections have also been described in similar colorectal surgery cohorts (7).

Nutritional and Preoperative Care

All patients received nutritional counseling and anemia management before surgery, improving hemoglobin and albumin levels. These optimizations helped to improve recovery and reduce LOS.

Surgical Approach

Laparoscopic techniques were employed in 98.6% of patients in the ERAS group, compared to only 42.9% in the pre-ERAS group, reflecting adherence to ERAS guidelines that promote minimally invasive surgery and contributing to faster recovery, reduced complication rates, and improved patient satisfaction. *Fig. 8* illustrates the overall predominance of laparoscopic surgery among all procedures performed, supporting the general trend toward minimally invasive approaches.

Implications for Future Applications

Integrating ERAS principles demonstrated measurable benefits, including shorter LOS and reduced complications. Adherence to these protocols and patient-specific adaptations is crucial for optimizing surgical outcomes. These findings encourage broader implementation and further research to refine these strategies.

The Critical Role of Pre-Admission Information, Education, and Counseling

The comprehensive integration of preoperative information, patient education and counseling within surgical care is fundamental in optimizing clinical outcomes. These preparatory measures are crucial in enhancing patient comprehension of the surgical process, mitigating preoperative anxiety and fostering efficient collaboration within the multidisciplinary healthcare team. Substantial evidence indicates that well-informed patients demonstrate higher adherence to postoperative recovery protocols, which correlates with improved clinical outcomes and a significant reduction in hospital length of stay.

In this study, all patients (100%) underwent standardized pre-admission counseling, education, and information sessions, underscoring the critical role of these interventions in the perioperative pathway. This systematic approach facilitated a more comprehensive understanding of surgical procedures and strengthened patient-provider communication, reinforcing trust and adherence to treatment plans.

Additionally, preadmission counseling facilitated the early identification of potential clinical or psychological challenges, enabling the develop-

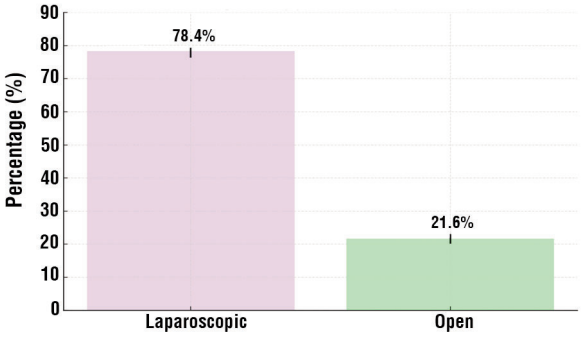

Figure 8. Overall distribution of surgical approach (laparoscopic vs. open)

ment of individualized management plans tailored to each patient's needs. Such personalization contributes to more effective care delivery and enhances patient satisfaction with their healthcare experience. As fundamental elements of Enhanced Recovery After Surgery (ERAS) protocols, these interventions are critical to streamlining the perioperative journey and promoting optimal recovery outcomes.

Adhering rigorously to the ERAS protocol significantly improves recovery rates and fewer postoperative complications (1). Additionally, implementing a structured method for preoperative patient education significantly alleviates perioperative anxiety and improves overall surgical outcomes (5).

Long-term oncological outcomes for laparoscopic colorectal cancer resections have been shown to match those of open surgery. The study highlighted the advantages of laparoscopic techniques, including minimized postoperative pain and accelerated recovery, particularly when integrated into ERAS protocols (8).

In a systematic review, Moloo et al. assessed the differences between hand-assisted and conventional laparoscopic surgical techniques in colorectal operations. The findings demonstrated equivalent safety and effectiveness, endorsing the inclusion of both approaches in ERAS protocols (9).

Enhanced recovery protocols for upper gastrointestinal and hepatopancreatic procedures have reduced hospital stays and minimized postoperative complications. Although colorectal surgery has been the primary area of focus for ERAS, this review underscores the increasing adoption of these methods in various surgical disciplines (10).

Chau et al. conducted an in-depth evaluation of perioperative enhanced recovery protocols for gynecological cancers, focusing on the collaborative nature of ERAS strategies and their ability to be tailored to diverse groups of patients (11).

The ERAS Society for Perioperative Management guidelines in elective colonic surgery offer a systematic framework to enhance recovery, utilizing evidence-based strategies like prehabilitation, minimally invasive procedures, and early patient mobilization (12-14).

All procedures included in this study were performed by an experienced colorectal and laparoscopic surgeon, as part of a multidisciplinary team with established experience in ERAS principles. Several core elements of the ERAS pathway - such as minimally invasive techniques, nutritional optimization, and multimodal analgesia - were already in practice before formal implementation. Regardless of the overall success of ERAS implementation, several challenges were encountered in our hospital, particularly resistance from some healthcare professionals who remained reluctant to embrace ERAS principles and the innovations introduced by the protocol, continuing to prefer traditional surgical techniques and conventional therapeutic gestures. Additionally, some patients were hesitant to accept preoperative and perioperative interventions that deviated from their conventional expectations.

Despite the significant findings of this study, certain limitations must be acknowledged. The single-center design (14-16) may limit the external validity of the results, as variations in institutional resources, surgical techniques (17,18), and patient demographics could influence outcomes. Moreover, the retrospective data collection in the pre-ERAS cohort introduces a potential selection and reporting bias risk. Although data were extracted from electronic medical records, the possibility of incomplete documentation cannot be excluded. Additionally, while this study demonstrates a significant reduction in length of stay (LOS) following ERAS implementation, long-term outcomes such as functional recovery, patient-reported quality of life and cost-effectiveness were not assessed (19-21). Future prospective multicenter studies with longer follow-up periods are warranted to validate these findings and explore further determinants of postoperative outcomes (21).

Conclusions

Implementing the ERAS program in colorectal surgical patients has demonstrated a significant reduction in LOS without an associated increase in postoperative morbidity. The findings suggest that adherence to ERAS protocols facilitates improved perioperative outcomes, highlighting the role of key multimodal components, including nutritional optimization, multimodal analgesia, and early mobilization in enhancing perioperative recovery. The adoption of minimally invasive surgical techniques was markedly increased in the ERAS group, reflecting alignment with protocol recommendations and contributing to enhanced postoperative recovery. Although differences in complication and readmission rates were not statistically significant, trends favoring the ERAS group support its clinical relevance. The results underline the feasibility and effectiveness of ERAS implementation in real-world settings, reinforcing

its value for future standardized surgical care.

It is important to emphasize that several principles and components of the ERAS protocol had already been selectively integrated into our clinical routine before the formal implementation of the program. This early familiarity with ERAS-based strategies, including aspects of minimally invasive surgery, perioperative optimization, and enhanced recovery measures, may have facilitated both the feasibility of full protocol adoption and the favorable clinical outcomes observed in this study.

Future multicenter prospective studies are needed to explore the long-term benefits of ERAS, including functional recovery, quality of life and healthcare cost-effectiveness. Greater efforts toward widespread adoption and adherence to ERAS principles will further enhance surgical care and patient outcomes.

Conflicts of Interest

The authors declare no conflicts of interest.

Funding

This research received no external funding.

Ethical Statement

This study was conducted by the Declaration of Helsinki and received approval from the Ethics Committee of the Central Military Emergency University Hospital Dr. Carol Davila in Bucharest, Romania. Patient confidentiality was maintained throughout, and all data were anonymized before analysis. (The protocol code and date of approval are 566/20.12.2022).

Informed Consent Statement

Written informed consent was obtained from all participants in this research.

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