



The Impact of ERAS and Multidisciplinary Teams on Perioperative Management in Colorectal Cancer

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ABSTRACT

Introduction: The Enhanced Recovery After Surgery (ERAS) protocol, a comprehensive multimodal approach, aims to mitigate surgical stress, expedite recovery, and improve postoperative outcomes. Its implementation has notably advanced perioperative care in colorectal cancer surgeries. Integrating ERAS with multidisciplinary collaboration, involving surgery, anesthesia, nursing, and nutrition, may further enhance patient outcomes, making it a significant focus in clinical practice.

Methods: This study assessed the effectiveness of integrating the ERAS model with multidisciplinary collaboration during the perioperative period in colorectal cancer patients. A total of 117 patients scheduled for elective surgery at Haiyan People's Hospital between August 2023 and April 2024 were randomly assigned to either a control group ($n=59$), receiving traditional care, or an experimental group ($n=58$),

receiving ERAS-based multidisciplinary care. Key outcomes related to postoperative rehabilitation were evaluated.

Results: Patients in the ERAS group demonstrated significantly shorter hospital stays, quicker catheter removal, and earlier mobilization compared to the control group ($P<0.0001$ for all). Additionally, the ERAS group exhibited reduced postoperative inflammatory responses, as indicated by significantly lower interleukin-6 levels on the first postoperative day ($P=0.0247$). The quality of life was significantly higher in the ERAS group ($P<0.05$). Furthermore, the ERAS group incurred lower total hospitalization expenses than the control group ($P=0.0011$).

Conclusion: These findings confirm the benefits of the ERAS protocol in enhancing postoperative recovery in colorectal cancer surgeries. The study highlights the importance of a multidisciplinary approach in optimizing patient outcomes and reducing the burden on hospital resources.

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Key Summary Points

Why carry out this study?

Colorectal cancer (CRC) is a significant global health issue, with increasing incidence and mortality rates, particularly in China, necessitating improved perioperative care.

Traditional surgical approaches for CRC often result in inadequate pain management, longer recovery times, and diminished quality of life, highlighting the need for better perioperative strategies.

This study hypothesized that integrating the Enhanced Recovery After Surgery (ERAS) protocol with multidisciplinary collaboration would improve pain management and overall perioperative outcomes for colorectal cancer patients compared to traditional care.

What was learned from the study?

The study found that the ERAS protocol, combined with multidisciplinary care, greatly improved pain management, significantly reduced hospital stays, accelerated recovery time (e.g., quicker catheter removal and earlier mobilization), and enhanced quality of life post-surgery compared to traditional care.

INTRODUCTION

Colorectal cancer (CRC) represents a significant and growing global health challenge, affecting both worldwide populations and China, where incidence and mortality rates are on the rise [1]. Surgical intervention remains the cornerstone of CRC treatment, often complemented by chemotherapy and other modalities [2]. However, traditional surgical approaches face numerous shortcomings, including inadequate preoperative preparation, insufficient emphasis on lifestyle modifications, such as diet, physical activity, smoking and alcohol consumption, and a lack of comprehensive perioperative care, including insufficient venous thromboembolism (VTE) prevention and attention to psychological care.

Additionally, open surgeries are often performed without considering adverse anesthetic reactions, noticeable postoperative discomfort, and shortened postoperative bed rest. These issues can lead to suboptimal recovery outcomes, extended hospital stays, and diminished quality of life for patients [3].

Enhanced Recovery After Surgery (ERAS) protocols have emerged as a transformative approach in surgical care, aiming to mitigate these issues through evidence-based practices [4–6]. ERAS protocols leverage multidisciplinary collaboration, integrating expertise from surgery, anesthesia, nursing, and nutrition to streamline perioperative care pathways [7]. This holistic approach seeks to minimize surgical stress responses, reduce postoperative complications, and expedite patient recovery.

In this study, we assess the implementation and effectiveness of the ERAS model combined with multidisciplinary collaboration in the perioperative management of 117 patients undergoing elective CRC surgery at Haiyan People's Hospital. In addition to the default ERAS guidelines, which provide a general framework for perioperative care, our approach emphasizes enhanced psychological and nutritional support, detailed follow-up plans, and innovative practices like chewing gum therapy to promote intestinal motility [8]. These improvements are expected to provide significant benefits by offering more personalized and comprehensive care, leading to better postoperative outcomes and quality of life. The novelty of our study lies in its detailed multidisciplinary integration, setting a new standard for patient-centered perioperative management, with significant clinical implications. We performed a comprehensive evaluation of different metrics, providing a foundation for the broader adoption of standardized perioperative management practices that prioritize patient-centered care and recovery.

METHODS

The study was approved by the Ethics Committee of the Health Bureau of Haiyan, Zhejiang Province (2023–41). Informed consent was

obtained from all patients or their families. Data privacy and confidentiality were maintained according to the Declaration of Helsinki. We are grateful to the World Health Organization (WHO) for their permission to use the WHO Quality of Life Assessment, Brief Version (WHO-QOL-BREF) questionnaire in this study.

Study Design

This study utilized a randomized controlled trial design. A total of 120 patients with CRC scheduled for elective surgery were selected through random sampling at Haiyan People's Hospital from August 2023 to April 2024. Three cases were excluded due to postoperative immunohistochemistry results indicating benign conditions, resulting in a final sample size of 117 cases. These cases were randomly allocated into two groups: a control group of 59 cases receiving traditional general surgical care, and an experimental group of 58 cases treated under the ERAS-based care model combined with multidisciplinary collaboration.

Patient Population and Eligibility Criteria

The study included patients who met the following inclusion criteria: (1) they had a pathological diagnosis of CRC, (2) were between the ages of 30 and 80, (3) voluntarily participated with informed consent, and (4) had cardiac function classified as grade 3 or above according to the New York Heart Association (NYHA) classification [9]. Patients were excluded if they (1) had malignant tumors in other parts of the body, (2) severe dysfunction of other organs, or (3) significant cognitive impairment or difficulty in communicating effectively, (4) were lost to follow-up, (5) were pregnant or lactating, or (6) had other endocrine-related complications.

Perioperative Protocols

The control group received traditional medical care from the Department of General Surgery, which included preoperative preparation, psychological support, dietary guidance, close monitoring of vital signs postoperatively, pulmonary

rehabilitation, and specialized nursing. The experimental group followed the ERAS model with multidisciplinary collaboration. Through surgery, stringent monitoring of blood pressure, heart rate, and respiratory conditions was maintained for all the patients to ensure clear airways. For a detailed comparison of procedures between the control group and the ERAS group, refer to Supplementary Table 4.

Control Group (Traditional Medical Care)

Preoperative Care

Preoperative preparations involved patients consuming a semi-liquid diet 1 day before surgery, receiving enemas 1 day before and on the day of surgery, fasting for 10 h, and abstaining from water for 10 h. Additionally, a gastric tube was inserted.

Intraoperative Care

Intraoperative care involved standard monitoring of blood pressure, heart rate, and respiratory conditions, and continuous monitoring of urine routine. General anesthesia was administered using short-acting sedatives (sufentanil, propofol), muscle relaxants (rocuronium), and nerve blocks (ropivacaine). Lung-protective ventilation strategies were employed, using small tidal volumes (6–8 mL/Kg) with individualized positive end-expiratory pressure (PEEP) settings (5–8 cm H₂O). The intra-abdominal pressure was maintained at a standard level of 12–15 mmHg during surgery. Standard laparoscopic surgery was performed with routine placement of a nasogastric tube, abdominal drainage tube, and urinary catheters. The left colic artery was not preserved in rectal-sigmoid surgeries, and Denonvilliers' fascia was not preserved in rectal surgeries. For the right colon, a mixed approach from the caudal was utilized. The control group followed a conventional rehydration protocol, with fluids administered at a rate of 1800–2500 mL/day.

Postoperative Care

Following surgery, urinary catheters remained in place for 2–3 days, and patients received intravenous fluid replacement at a rate of 25–30 mL/kg per day per day to maintain fluid balance. The control group received single-mode analgesia, which included the use of nonsteroidal anti-inflammatory drugs (NSAIDs) or opioids, in addition to intravenous patient-controlled analgesia (PCA) for pain management, and prophylactic antibiotics were given for 3 days to reduce the risk of postoperative infections. On the second day after surgery, patients commenced bed exercises. They were allowed to begin drinking water only after passing gas from the rectum, followed by a gradual transition to a normal diet. This traditional medical care approach aimed to ensure surgical safety, reduce infection risk, and promote postoperative recovery, with specific procedures varying depending on the individual patient's condition but typically adhering to a standardized medical care protocol.

Experimental Group (ERAS Model with Multidisciplinary Collaboration)

Management Committee and Multidisciplinary Team (MDT)

An accelerated recovery surgery management committee was established to set up a management system. An ERAS pilot department was designated, focusing on specific disease types and forming an ERAS-MDT team. This team is supervised by the medical and nursing departments and mainly comprises professionals from the gastrointestinal surgery, anesthesia, and nutrition departments. The director of the gastrointestinal surgery department acts as the team leader, coordinating team activities. Depending on the situation, additional departments such as psychology, information technology, and health management may be involved. The initial multidisciplinary meeting established the organizational structure, work responsibilities, and operating system of the ERAS-MDT. Treatment plans were adjusted according to patient

conditions, with follow-ups to observe efficacy, manage complications, and provide psychological counseling.

Development of Standardized Clinical Pathway

A standardized ERAS-MDT clinical pathway was developed as a guide and tool for the team. Expert group members, based on relevant medical literature and the specialty's actual situation, created a standardized clinical pathway and a flowchart for the implementation of specific ERAS measures.

Supervision and Feedback System

A supervision and feedback system was established, including an ERAS scoring table to accurately evaluate the patient's recovery status. Conventional methods such as meetings, telephone calls, and paper materials were used, supplemented by digital technology, such as mobile phone apps and online information systems, to achieve comprehensive monitoring. This system is crucial for the stable operation of the ERAS concept and helps improve compliance from both doctors and patients.

Preoperative Care

Upon admission, the first ERAS-MDT meeting was completed. The doctor assessed the patient's physical condition and integrated the patient into the clinical pathway, testing serum inflammatory factors. Changes in the patient's condition were closely monitored, and active and effective treatments were administered. Discharge standards were formulated at this stage. Gastrointestinal surgery nurses provided preoperative communication and health education, introducing the ERAS concept, its advantages, and main measures in detail. Patients received psychological care and basic treatments. Nurses guided patients on smoking cessation, alcohol cessation, breathing training, expectoration skills, VTE prevention education, and pulmonary rehabilitation, and structured aerobic exercise plans aimed at improving lung function and overall fitness levels before surgery. Additionally,

a comprehensive assessment of the patient's nutritional status was conducted, including interventions for anemia correction through dietary adjustments and supplementation, ensuring the patient was in optimal condition for surgery. Preoperative anemia correction is crucial in enhancing recovery and reducing the risk of complications associated with low hemoglobin levels during and after surgery. Strengthened communication with patients and their families aims to achieve the best results. Patients fasted for 6 h before surgery and stopped drinking fluids 2 h before anesthesia administration. Psychological counseling, dietary guidance, and postoperative analgesia are crucial for ensuring successful surgery. Routine gastric tube insertion was avoided; post-surgery, analgesics and sedatives were administered to improve sleep quality. A comprehensive assessment of the patient's nutritional status was conducted, along with preoperative anesthesia assessment and follow-up.

Intraoperative Care

Intraoperative care focuses on minimizing surgical trauma and stress through minimally invasive techniques and precise operations, adhering to the principles of minimally invasive, precise, and damage-controlled surgery. The anesthesia protocol included induction using short-acting sedatives (sufentanil, propofol), muscle relaxants (rocuronium), and nerve blocks (ropivacaine). This was followed by maintenance with remifentanyl, propofol, and rocuronium, adhering to the ERAS anesthesia protocol. Prophylactic antibiotics were administered before surgery to reduce the risk of infection. During surgery, airway management and lung-protective ventilation strategies were used and psychological support was emphasized. The anesthesia plan was optimized by combining general anesthesia with endotracheal intubation. Although continuous glucose monitoring is not a standard ERAS procedure, we implemented regular glucose checks to manage stress-induced hyperglycemia, particularly in elderly patients, to maintain normal physiological function and reduce the risk of complications. Continuous monitoring of urine routine, body temperature, blood

glucose, blood pressure, and other indicators was maintained. Lung-protective ventilation strategies were employed during surgery to minimize postoperative pulmonary complications, especially given the patient's head-down position and increased intra-abdominal pressure during laparoscopic procedures. This involved using small tidal volumes (6–8 mL/Kg) with individualized positive end-expiratory pressure (PEEP) settings (5–8 cm H₂O) to prevent lung collapse and improve respiratory compliance. The ERAS group also utilized lower intra-abdominal pressure (8–10 mmHg) than the control group (12–15 mmHg), reducing third-space fluid losses and the need for aggressive fluid replacement. ERAS guidelines emphasize a near-zero fluid balance during surgery to avoid both fluid overload and hypovolemia; thus, goal-directed therapy (GDT) was implemented in fluid management, with balanced fluid input typically controlled between 500 and 1000 mL unless special circumstances dictate otherwise. Temperature management measures were taken to prevent intraoperative hypothermia. For the right colon, a mixed approach from the head was utilized, aiming to reduce intraoperative bleeding and shorten the operation time. This method, combined with the ERAS protocol, emphasizes careful dissection and preservation of key anatomical structures to enhance postoperative recovery. Laparoscopic surgery in the ERAS group also included the preservation of the left colic artery during rectum-sigmoid surgeries to enhance blood supply and reduce anastomotic leakage. Denonvilliers' fascia and the pelvic plexus were preserved during rectal surgeries, which reduces the incidence of male sexual dysfunction and urinary dysfunction. Nasogastric tubes were not placed, and the number of tubes, including urinary catheters, was minimized. This approach is consistent with ERAS protocols, which aim to reduce patient discomfort and expedite recovery.

Postoperative Care

Postoperative care in the experimental group utilized a multimodal analgesia (MMA) approach. The regimen included the use of sufentanil administered intravenously for patient-controlled analgesia (PCA), along with a

subcutaneous injection of ropivacaine. The analgesia protocol was further supported by phloroglucinol injections and tramadol sustained-release tablets administered orally after meals. Additionally, traditional Chinese medicine auricular acupoint pressure was applied to both ears targeting specific points including Shenmen, rectum, endocrine, and subcortical regions until the pain was reduced to a visual analogue scale (VAS) score of 1–2. These strategies were complemented by regional and nerve blocks in combination with intravenous analgesics (PCA), ensuring comprehensive pain management. Two antiemetic drugs were used to reduce postoperative nausea and vomiting (PONV), and antibiotics were discontinued 48 h postoperatively. Routine care and psychological counseling, along with other rehabilitation support measures, were provided upon discharge. During hospitalization, the need for drain tube retention was assessed daily, and urinary catheters were removed within 48 h, with the removal of other drainage tubes as early as possible. Appropriate dietary care and rehabilitation treatment were given according to the patient's condition. On the first day after surgery, if no contraindications were found, VTE drugs were effectively administered. Chewing gum therapy as "sham feeding" was introduced postoperatively to promote intestinal motility recovery and reduce paralytic ileus duration. Once bowel sounds were audible, patients were allowed to start drinking water and transition to enteral nutrition powder after 24 h, with a gradual return to a regular diet. If oral intake was tolerated, intravenous fluids were discontinued as soon as possible. If intravenous fluids were necessary, they were administered at a rate of 25–30 mL/kg per day, with careful monitoring to avoid both fluid overload and dehydration. Patients could begin changing positions in bed with assistance as soon as they were awake after anesthesia. On the first postoperative day, with assistance from family members or health care professionals, patients stood at the bedside or got out of bed. During this time, serum inflammatory factors were also measured. On the second day after surgery, the patient got off the bed and engaged in indoor activities. They aimed for at least three activities while accumulating a total activity time of no less than

2 h. Professional nutritionists were responsible for providing dietary guidance to the patient. Between the sixth and seventh days after surgery, the patient completed a pre-discharge quality of life assessment and was discharged.

Post-discharge follow-up for the experimental group included a phone follow-up within 3 days of discharge, outpatient visits within 7 days postoperatively, and clinical follow-up continued for up to 30 days after surgery.

Data Collection

Quality of Life Assessment (WHOQOL-BREF)

The WHOQOL-BREF [10, 11] assessment tool covered physical health, psychological health, social relationships, surrounding environment, and overall health status. It includes a total of 26 items and uses a five-level rating scale, with a maximum score of 100 for each domain. Higher scores indicate better functional and overall health. The aggregated score was calculated as the average score of the four domains. Permission to use the WHOQOL-BREF was granted by WHO.

Inflammatory Factor Levels

Measurements of inflammatory factor levels were taken both preoperatively and on the first day postoperatively.

General Postoperative Recovery

This included recording the time of first gas passage, time to first off-bed ambulation, catheter removal time, time to initiate eating, time of bowel movement, length of hospital stays, total costs, and potential postoperative complications.

Statistical Analysis

Statistical analysis was performed using SPSS 27.0 software. Descriptive and inferential statistics were used to analyze quantitative data. Numerical data are expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$) and were analyzed using

unpaired two-tailed *t*-tests. Categorical data are presented as frequencies and percentages and analyzed using the chi-square test. Statistical significance was defined as a significance level (*P*-value) less than 0.05.

RESULTS

Patient Demographics and Baseline Characteristics

A total of 120 patients with CRC were initially enrolled in the study. However, three cases were excluded due to postoperative immunohistochemistry results indicating benign conditions, resulting in a final sample size of 117 cases. Of these, 59 patients were in the control group and 58 in the ERAS group. The baseline characteristics of the two groups were comparable, with no significant differences in age, body mass index (BMI), gender distribution, or American Society of Anesthesiologists (ASA) score (all *P*>0.05), as shown in Table 1.

Postoperative Recovery Outcomes

Patients in the ERAS group experienced significantly shorter postoperative hospital stays

compared to the control group (10.26 ± 1.09 days vs. 11.83 ± 1.51 days, *P*<0.0001). Additionally, the catheter removal time was significantly reduced in the ERAS group (2.36 ± 1.09 days vs. 5.24 ± 2.31 days, *P*<0.0001), as illustrated in Table 2. Similarly, patients in the ERAS group had significantly shorter time to first off-bed mobilization (1.12 ± 0.42 days vs. 2.58 ± 0.67 days, *P*<0.0001), passed first gas sooner (2.29 ± 0.77 days vs. 2.95 ± 0.97 days, *P*=0.000098), and started oral feeding earlier (2.24 ± 0.60 days vs. 3.20 ± 1.20 days, *P*<0.0001). There was no significant difference in defecation time between the two groups (*P*=0.993).

Quality of Life and Cost Analysis

The quality of life, assessed using the WHO-QOL-BREF questionnaire [10], was significantly higher in the ERAS group (79.69 ± 8.63) than in the control group (68.20 ± 9.02 , *P*<0.05), as illustrated in Table 2, suggesting that the ERAS protocol not only enhances physical recovery but also improves overall well-being. In addition, the total hospitalization expenses were significantly lower for the ERAS group ($34,634.86 \pm 4081.71$ RMB) compared to the control group ($38,221.48 \pm 7032.26$ RMB, *P*=0.0011),

Table 1 Baseline characteristics of the study participants

	ERAS group (<i>n</i> = 58)	Control group (<i>n</i> = 59)	<i>P</i>
Age (years), mean ± SD	64.68 ± 9.33	66.23 ± 8.44	0.348
BMI, mean ± SD	22.10 ± 2.57	20.98 ± 1.65	0.1104
Sex, <i>n</i> (%)			
Male	32 (55.17%)	31 (52.54%)	1
Female	26 (44.83%)	28 (47.46%)	
ASA score, <i>n</i> (%)			
I	32 (55.17%)	37 (62.71%)	0.407
II	26 (44.83%)	22 (37.29%)	

BMI body mass index, *ASA* American Society of Anesthesiologists

The unpaired two-tailed *t*-test was used to determine the *P*-values for age and BMI, while the chi-square test was used to determine the *P*-values for sex and ASA

Table 2 Effect of ERAS protocol on postoperative recovery and hospital stay

	ERAS group (<i>n</i> = 58)	Control group (<i>n</i> = 59)	<i>P</i>
Hospitalization expenses (RMB), mean ± SD	34,634.86 ± 4081.71	38,221.48 ± 7032.26	0.0011
Time to first off-bed ambulation (days), mean ± SD	1.12 ± 0.42	2.58 ± 0.67	< 0.0001
Postoperative intestinal exhaust time (days), mean ± SD	2.29 ± 0.77	2.95 ± 0.97	0.000098
Expected time (days), mean ± SD	2.36 ± 1.09	5.24 ± 2.31	< 0.0001
Defecation time (days), mean ± SD	4.84 ± 1.66	4.86 ± 1.58	0.993
Time of first feeding (days), mean ± SD	2.24 ± 0.60	3.20 ± 1.20	< 0.0001
Postoperative hospital stay (days), mean ± SD	10.26 ± 1.09	11.83 ± 1.51	< 0.0001
WHOQOL-BREF (score), mean ± SD	68.20 ± 9.02	79.69 ± 8.63	< 0.05

RMB renminbi, *WHOQOL-BREF* World Health Organization Quality of Life brief questionnaire

P-values were calculated using the unpaired two-tailed *t*-test

as shown in Table 2, reflecting the economic benefits of the ERAS protocol.

Inflammatory Response

In both the control group and the ERAS group, postoperative interleukin-6 (IL-6) levels increased significantly, but the magnitude of increase was much smaller in the ERAS group (9.73 ± 10.54 pg/mL) than in the control group (13.20 ± 5.04 pg/mL, $P = 0.0247$) (Table 3), suggesting reduced postoperative inflammation. Other cytokines including interleukin-2 (IL-2), interleukin-4 (IL-4), interleukin-10 (IL-10),

tumor necrosis factor (TNF), and interferon-gamma (IFN- γ) showed no significant differences between the groups.

Demographic and Clinical Factors Affecting Recovery

The demographic and clinical characteristics of the participants revealed that age, education level, primary diagnosis, and BMI significantly influenced postoperative outcomes, as shown in Table 4. In particular, the length of hospital stay varied significantly with age; younger patients (< 50 years) in the ERAS

Table 3 Impact of ERAS protocol on inflammatory cytokine levels post-colorectal surgery

	ERAS group (<i>n</i> = 58)	Control group (<i>n</i> = 59)	<i>P</i>
IL-2, mean ± SD (pg/mL)	0.138 ± 0.493	0.005 ± 0.521	0.157
IL-4, mean ± SD (pg/mL)	0.089 ± 0.746	0.300 ± 1.213	0.261
IL-6, mean ± SD (pg/mL)	9.73 ± 10.54	13.20 ± 5.04	0.0247
IL-10, mean ± SD (pg/mL)	0.783 ± 1.531	0.940 ± 2.016	0.603
TNF, mean ± SD (pg/mL)	0.288 ± 1.396	0.987 ± 3.886	0.197
IFN- γ , mean ± SD (pg/mL)	0.273 ± 1.441	0.222 ± 1.304	0.839

TNF tumor necrosis factor, IFN- γ interferon-gamma, IL-2, IL-4, IL-6, IL-10 interleukins 2, 4, 6, and 10, respectively

P-values were calculated using the unpaired two-tailed *t*-test

Table 4 Demographic and clinical characteristics of study participants

Outcome measure	Characteristic	Control group (<i>n</i> = 59)	ERAS group (<i>n</i> = 58)	<i>P</i>
Length of hospital stay (days)	Age group			
	< 50	12.0 ± 1.41 (4)	9.4 ± 0.8 (5)	0.0253
	50–70	11.92 ± 1.55 (39)	9.91 ± 2.45 (33)	0.00016
	> 70	11.56 ± 1.50 (16)	10.3 ± 0.81 (20)	0.0062
Quality of life score > 76 (%)	Education level (%)			
	Illiterate	4 (6.78%)	3 (5.17%)	1
	Elementary school	12 (20.34%)	26 (44.83%)	0.0085
	Middle school	1 (1.69%)	11 (18.97%)	0.0055
	High school	1 (1.69%)	1 (1.72%)	1
	Bachelor's degree	1 (1.69%)	1 (1.72%)	1
Time to mobilization (days)	Primary diagnosis			
	Colon cancer	2.46 ± 0.73 (31)	1.03 ± 0.2 (31)	< 0.0001
	Rectal cancer	2.72 ± 0.57 (28)	1.28 ± 0.54 (27)	< 0.0001
Time to tube removal (days)	BMI category			
	< 18.5	10.00 ± 2.82 (2)	9.50 ± 0.9 (4)	0.844
	18.5–22.9	10.94 ± 1.52 (51)	9.16 ± 0.92 (31)	< 0.0001
	> 22.9	10.50 ± 1.22 (6)	8.96 ± 0.43 (23)	< 0.0001

BMI body mass index

The *P*-values for length of hospital stay, time to mobilization, and time to tube removal were obtained using the unpaired two-tailed *t*-test; the *P*-values for education level and quality of life score were obtained using the chi-square test

group had a shorter stay (9.4 ± 0.8 days) than those in the control group (12.0 ± 1.41 days, $P = 0.0253$). In addition, ERAS patients with higher education levels, especially those with elementary or middle school education, more frequently had quality of life scores exceeding 76 ($P < 0.01$), and time to first off-bed mobilization was significantly shorter in the ERAS group for both colon and rectal cancer patients ($P < 0.0001$). Finally, BMI also affected the time to tube removal, with patients in the 18.5–22.9 and > 22.9 categories benefiting more from the ERAS protocol ($P < 0.0001$). These results underscore the importance of tailoring ERAS protocols to individual patient characteristics to optimize recovery outcomes.

Compliance with ERAS Measures and Outcomes

Reflecting the structured implementation of the ERAS protocol, the core ERAS measures had notably high adherence rates within the ERAS group (Supplemental Table 1), and the ERAS group showed significantly higher adherence across many measures compared to the control group, as shown in Table 5. In particular, 60.3% of patients in the ERAS group adhered to preoperative counseling, whereas only 30.5% in the control group did so ($P < 0.0001$). Nutritional optimization adherence was 36.2% in the ERAS group compared to 18.6% in the

Table 5 Compliance with ERAS

ERAS component	Control group		ERAS group		<i>P</i>
	Adherent (<i>n</i> = 59)	Non-adherent (<i>n</i> = 59)	Adherent (<i>n</i> = 58)	Non-adherent (<i>n</i> = 58)	
Preoperative counseling, <i>n</i> (%)	18 (30.5)	41 (69.5)	35 (60.3)	23 (39.7)	< 0.0001
Nutritional optimization, <i>n</i> (%)	11 (18.6)	48 (81.4)	21 (36.2)	37 (63.8)	< 0.0001
Postoperative mobilization, <i>n</i> (%)	24 (40.7)	35 (59.3)	53 (91.2)	5 (9.8)	< 0.0001
Pain management strategy, <i>n</i> (%)	27 (45.8)	32 (54.2)	58 (100)	0 (0)	< 0.0001

P-values were calculated using the chi-square test

control group ($P < 0.0001$). Postoperative mobilization saw a compliance rate of 91.2% in the ERAS group versus 40.7% in the control group ($P < 0.0001$). Furthermore, 100% of patients in the ERAS group adhered to pain management strategies, significantly higher than 45.8% in the control group ($P < 0.0001$). Of note, the pain scores of the control group were generally higher than those of the ERAS group throughout the observation period, especially in the first 2 weeks. This trend, though not statistically significant, suggests potential differences in pain management outcomes between the two groups, as illustrated in the time-series

analysis of patient recovery (Fig. 1). This reduction in pain scores up to 28 days post-surgery underscores the long-term effectiveness of ERAS. Taken together, these results validate the successful implementation of ERAS protocols, aimed at enhancing postoperative recovery.

Long-Term Prognostic Outcomes

One year postoperatively, there was no significant difference in the secondary rate of malignancy between the ERAS and control groups, as shown in Table 6. However, the ERAS group

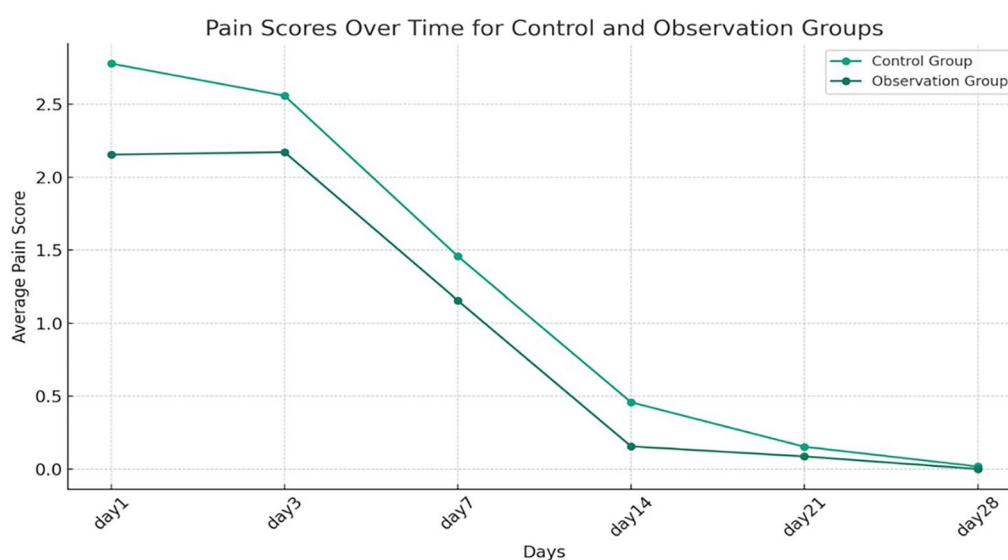


Fig. 1 Time-series analysis of patient recovery. Average pain score trends in control and ERAS (observation) groups, up to 28 days post-surgery

Table 6 Subgroup analysis of long-term prognostic outcomes 1 year post-surgery

Outcome measure	Control (<i>n</i> = 23)* At 1 year	ERAS (<i>n</i> = 19)	<i>P</i>
Secondary rate of malignancy, cases (%)	3 (1.87)	1 (5.26)	0.109
QLQ-CR29 score (75–100)	67.94 ± 4.82	71.56 ± 3.30	0.007
Activities of daily living (ADL) score (0–100)	84.13 ± 11.43	98.05 ± 3.72	0.001
AJCC pathological stage I, cases (%)	3 (13.04)	4 (21.05)	0.0374

QLQ-CR29 Quality of Life Questionnaire–Colorectal Cancer Module 29, *ADL* activities of daily living, *AJCC* American Joint Committee on Cancer

The *P*-values for the QLQ-CR29 score and ADL score were obtained using the unpaired two-tailed *t*-test; the *P*-values for the secondary rate of malignancy and AJCC pathological stage I were obtained using the chi-square test

*Some patients died or were lost during the follow-up period

scored significantly higher in the Quality of Life Questionnaire–Colorectal Cancer Module 29 (QLQ-CR29 [12]) than the control group (71.56 ± 3.30 vs. 67.94 ± 4.82, *P* = 0.007), indicating better quality of life, as shown in Table 6 and Supplementary Table 2. Additionally, the Activities of Daily Living (ADL [13, 14]) scores were significantly higher in the ERAS group (98.05 ± 3.72 vs. 84.13 ± 11.43; *P* = 0.001), demonstrating improved functional status. Finally, the American Joint Committee on Cancer (AJCC) pathological staging [15], a comprehensive classification system used to describe the extent of cancer spread, showed significant differences, particularly in stage I, less severe cases, where the ERAS group had a higher proportion of patients with better outcomes (21.05% vs. 13.04%; *P* = 0.0374), as shown in Table 6 and Supplementary Table 3.

DISCUSSION

Colorectal cancer is a significant health concern, with rising incidence and mortality rates, particularly in China. Traditional surgical management methods often lead to longer postoperative recovery periods and a higher risk of complications [16]. The ERAS protocol aims to address these issues by optimizing perioperative care through evidence-based practices and collaborative efforts among medical professionals

[6, 17, 18]. This study explores the effectiveness of the ERAS protocol combined with multidisciplinary collaboration in the perioperative treatment of patients with CRC.

Our findings underscore the substantial benefits of implementing the ERAS protocol in conjunction with multidisciplinary collaboration for patients undergoing CRC surgery. Patients in the ERAS group experienced significantly better outcomes, including reduced hospital stay duration, earlier catheter removal, and improved overall quality of life, compared to those receiving traditional care.

A notable difference in this study compared to the standard ERAS protocol is the integration of a multidisciplinary team comprising surgeons, anesthesiologists, nurses, and nutritionists, which ensured comprehensive preoperative education and psychological support, contributing to better patient outcomes. Enhanced communication and health education provided to patients and their families facilitated a smoother surgical experience and improved adherence to postoperative care instructions. Innovations like chewing gum therapy, which reduced the duration of paralytic ileus and hospital stays, also demonstrated clinical significance [8].

Shorter hospital stays in the ERAS group suggested quicker recovery and reduced medical resource utilization. Earlier catheter removal and lower postoperative pain scores further underscored the effectiveness of ERAS in enhancing recovery and mobility. Additionally, a slower

increase in interleukin-6 levels in the ERAS group may indicate a more controlled inflammatory response, contributing to smoother recovery. We also examined demographic factors like age, education level, and BMI, providing insights into their impact on postoperative recovery, with higher education levels correlating with better outcomes, possibly due to improved understanding and adherence to postoperative care instructions.

We assessed the feasibility of the multidisciplinary collaborative ERAS model using the Delphi method [19], involving a panel of experts who provided feedback and reached consensus through multiple rounds of questioning, combined with established guideline opinions [25]. We considered individual patient differences and provided targeted care. Video and oral education helped patients understand their conditions, reduce stress, and improve cooperation [21]. ERAS measures were optimized before, during, and after surgery, ensuring that patients were well informed and enhancing overall outcomes.

This study shows a significant reduction in hospital stay, associated with healthcare professionals and anesthesiologists incorporating ERAS principles into their protocols. The successful implementation of ERAS was linked to the willingness of healthcare professionals and anesthesiologists to adopt its principles. This reflects the medical field's openness to new concepts and the significant impact of ERAS on improving patient care [20, 22]. Our analysis confirmed the critical link between compliance with ERAS components and improved recovery outcomes. For example, pain scores in the ERAS group were consistently lower, especially in the first 2 weeks after surgery, indicating more effective pain management. However, this trend did not achieve statistical significance, which could be attributed to the limited sample size. In addition, our subgroup analysis revealed that ERAS patients had better outcomes, such as reduced frequent defecation, improved body mass management, and better perceptions of attractiveness. One year post-surgery, these patients faced fewer physical and psychological challenges, emphasizing the importance of comprehensive treatment, including diet management, rehabilitation, and psychological support. Although

there was no significant change in the secondary rate of malignant tumors, the findings highlight the clinical benefits of the ERAS protocol in long-term prognosis.

The study highlighted areas for improvement in nutritional optimization and resource limitations in the implementation of ERAS protocols. Compliance with nutritional guidelines was low, indicating the need for better strategies. The study also highlighted challenges in patient adaptation, coordination, and training of medical teams. Coordination and training of medical teams are crucial, as ERAS requires close cooperation among multidisciplinary teams, including surgeons, anesthesiologists, and nurses [23]. Resource and facility limitations, particularly in resource-constrained healthcare environments like primary care hospitals, may restrict the implementation of advanced nursing and monitoring as part of ERAS, including postoperative pain management, nutritional support, and early mobilization [24].

In the control group, there was one case of postoperative hemorrhage, one case of intestinal obstruction, and one case of anastomotic fistula. Patients with anastomotic fistula had long-term constipation and were instructed to take oral enteral nutrition powder for 1 week after admission. Anastomotic fistula was caused by high postoperative stool discharge pressure, highlighting the need for better preoperative intestinal preparation in the future. Postoperative bleeding was caused by improper hemostasis of the surgical wound, and the slow recovery of intestinal function after surgery is considered to be one of the factors causing intestinal obstruction [25]. Despite encouraging early eating in the ERAS protocol, some patients experienced bloating, likely due to incomplete recovery of bowel function [26].

CONCLUSIONS

In conclusion, the application of the ERAS protocol combined with multidisciplinary collaboration shows significant promise in enhancing postoperative recovery for patients with CRC. The study provides a strong foundation for

the continued development and implementation of ERAS protocols, aiming to standardize perioperative care and improve patient outcomes on a broader scale. Further research and refinement of these protocols will be essential in optimizing perioperative care and ensuring the best possible outcomes for patients.

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Data Availability. The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Conflict of Interest. Qianqian Zhang, Qinfeng Sun, Junfeng Li, Xing Fu, Yuhuan Wu, Jiawei Zhang, and Xia Jin declare no conflict of interest.

Ethical Approval. The study was approved by the Ethics Committee of the Health Bureau of Haiyan, Zhejiang Province (2023–41). Informed consent was obtained from all patients or their families. Data privacy and confidentiality were

maintained according to the Declaration of Helsinki.

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