

## Original Article



# Effects of the Enhanced Recovery After Surgery (ERAS) Program for Colorectal Cancer Patients Undergoing Laparoscopic Surgery

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## OPEN ACCESS

Received: Apr 17, 2022

Revised: Apr 25, 2022

Accepted: Apr 25, 2022

Published online: Apr 27, 2022

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### Conflict of Interest

The authors declare that they have no competing interests.

### Author Contributions

Conceptualization: Yeom J, Lim HS; Data curation: Yeom J, Lim HS; Formal analysis: Yeom J, Lim HS; Investigation: Yeom J, Lim HS; Methodology: Yeom J, Lim HS; Project administration: Yeom J, Lim HS; Resources:

## ABSTRACT

This study sought to investigate the effects of the enhanced recovery after surgery (ERAS) program on postoperative recovery and nutritional status in patients with colorectal cancer undergoing laparoscopic surgery. A total of 37 patients were included: 19 in the experimental group and 18 in the control group. The experimental group was supplemented with carbohydrate drinks before and after surgery, and the control group was maintained with fasting and water intake in the traditional method. Both care management and nutrition education were implemented for both groups. Patients were evaluated for physical condition, clinical indicators, blood tests, pain, length of stay, nutritional status, and nutrient intake. Use of the ERAS program for the experimental group resulted in shorter length of stay ( $p = 0.006$ ), less pain ( $p < 0.001$ ), and a lower rate of malnutrition ( $p = 0.014$ ) compared with controls. In conclusion, carbohydrate drinks provide great advantages by reducing discomfort, such as pain or thirst, during fasting in patients after colon cancer surgery, helping patients to eat comfortably and actively, minimizing insulin resistance, maintaining nitrogen balance, and reducing infection and anastomosis leakage. For use of ERAS as a standardized program, repeated and expanded research is needed, and a Korean-style ERAS should be prepared by using this approach for various diseases.

**Keywords:** Colon cancer; Enhanced postsurgical recovery; Perioperative care; Nutritional status

## INTRODUCTION

In 2019, Korea ranked 4th in the incidence of colorectal cancer, and among 184 countries globally, the rate of colorectal cancer was the highest in Korea at 45 people per 100,000 people [1]. The known primary causes of colorectal cancer are genetic factors, as well as the lifestyle effects and changes, such as aging of the population, westernized eating habits, smoking, drinking, obesity, and a lack of physical activity [2,3]. As a treatment method for colorectal cancer, surgical therapy, chemotherapy, and radiation therapy are performed alone or in combination [4]. A combination of auxiliary chemotherapy and radiation therapy before and after surgery is typically performed [4,5]. With this treatment approach, however, colorectal cancer patients experience many health-related quality of life declines, such as psychological shock from the diagnosis of cancer and

Yeom J, Lim HS; Supervision: Lim HS; Writing - original draft: Yeom J, Lim HS; Writing - review & editing: Lim HS.

treatment that limits daily life because of pain and feeling socially alienated due to placement of a permanent stoma [6]. Preparation for colorectal cancer surgery is removal of gastric residues to reduce the risk of aspiration; usually fasting and intestinal washing are performed for about 8 h, and fasting is continued long-term even after surgery [7]. During the treatment process, patients often feel discomfort, including dry mouth and thirst, acute pain, nausea and vomiting, discomfort in urination, and abdominal discomfort [7,8].

An enhanced recovery after surgery (ERAS) program has been developed to reduce discomfort by optimizing pre- and postoperative care and to reduce repetitive processes, such as fast meal adaptation, repeat surgery, and readmission [9]. The ERAS program is a multidisciplinary program consisting of several medical staff participating in the treatment and management of patients before, during, and after surgery for 'evidence-oriented' individual medical practices to improve post-operative recovery by reducing the body's stress response [9]. It is a new concept in surgical patient care and management that 'multidisciplinary team' provides 'multimodal.' When the ERAS program was discussed, the term 'fast-track surgery' was used interchangeably, but the key goal is quality, not speed, of recovery. Implementation of the ERAS program prevents cellular function deterioration, alleviates loss of muscle mass and strength, and alleviates disturbance of metabolic homeostasis by reducing insulin resistance, which increases due to catecholamine secretion and inflammatory response during and after surgery [8-10]. In international studies, supplementation of carbohydrate drinks before surgery reduced discomfort in patients after colon cancer surgery, who showed rapid resilience with this approach [9,10]. National studies in Korea have also announced the effect of ERAS programs in increasing quality of life and reducing medical expenses [11]. In Korea, a safe carbohydrate supplement drink has been developed for patients before surgery. This drink has little residue remaining in the stomach 2 hours after consumption and thus has little effect on anesthesia for surgery, leading to its use for management in various surgical populations.

This study aimed to investigate the effects of the ERAS program on postoperative recovery and nutritional status in patients with colorectal cancer undergoing laparoscopic surgery.

## MATERIALS AND METHODS

### Patients

This study was conducted in patients admitted to a university hospital in Gyeonggi-do, Korea, for colorectal cancer surgery. The inclusion criteria were as follows: age 20 years or older, histologically confirmed colon cancer, and clinical stage (cTanyN0-2), corresponding to Eastern Cooperative Oncology Group performance status 0-2, and American Society of Anesthesiology (ASA) classification  $\leq 3$ . The exclusion criteria were as follows: previous treatment for colorectal cancer or malignant tumors of other tissues within the past 5 years, confirmed metastasis on imaging and histologic analysis (cTanyNanyM1), planned surgery for intestinal fistula, active gastrointestinal bleeding, and previous low anterior resection surgery. A total of 40 participants were recruited, with randomization of 20 patients each to the experimental and control groups. After 3 patients discontinued the study, they were excluded from the final analysis, which assessed the remaining 37 participants.

### Study design

At our research institution, the traditional dietary progress of patients after colorectal cancer surgery is the same as that for the control group. In our study, a soft diet was the post-op diet

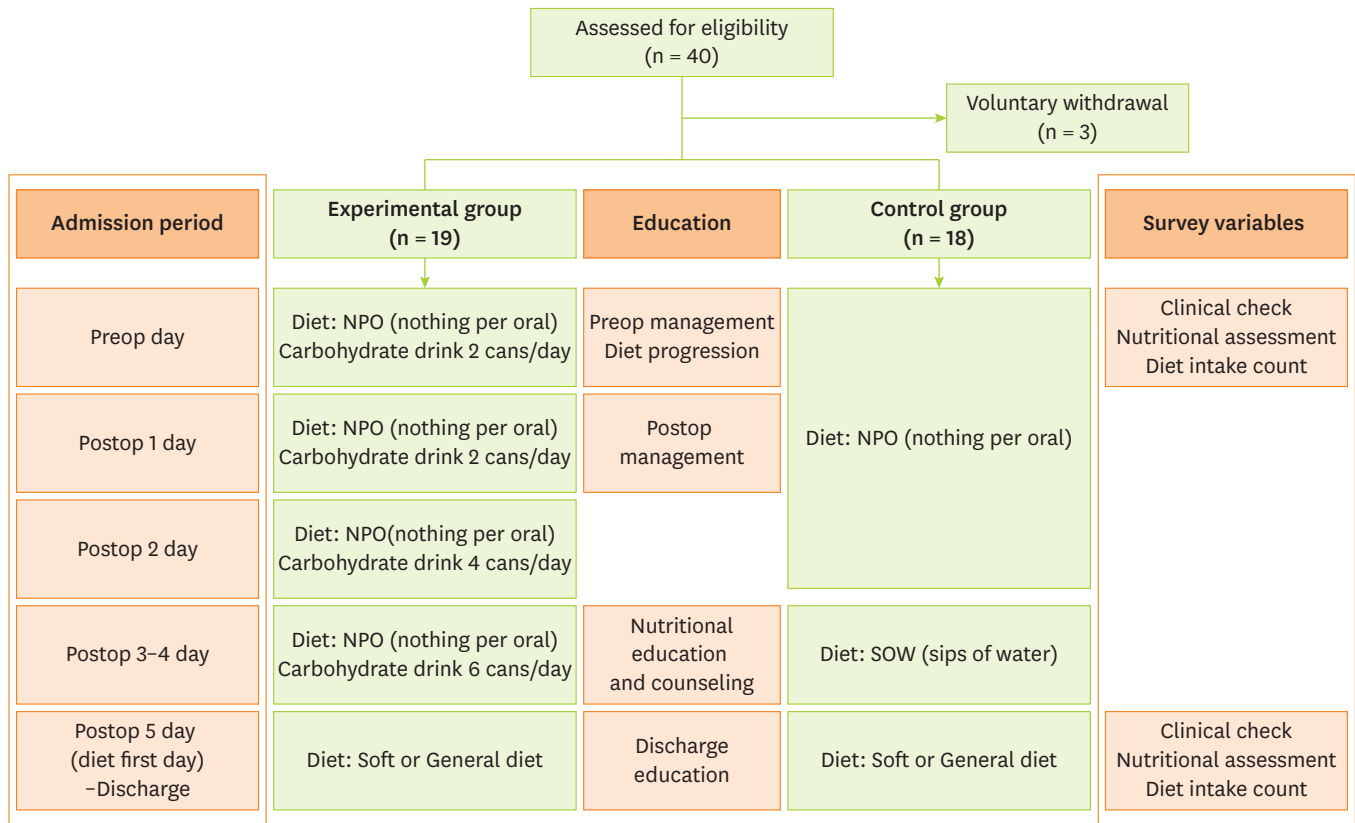


Figure 1. Flow of study progress.

fasting until day 5 for both the experimental and control groups. The ERAS program used in the experimental group ordered carbohydrate drinks from before surgery to postoperative day 4. Care management and nutrition education were conducted in the same way in both groups. The dietary content was investigated for the first meal before and after surgery and at discharge (Figure 1). The carbohydrate drinks used in the ERAS program are products only sold in Korea. They contain carbohydrates and some electrolytes, and the specific nutritional ingredients are shown in Table 1.

### Variables

The patient data collected were general characteristics, physical condition (height, weight, and weight loss after surgery), colorectal cancer location, comorbid disease, ASA classification, and length of hospital stay. The ASA categories used in this study were normal health (ASA I), mild systematic disorder (ASA II), and severe systematic disorder (ASA III) [12].

Table 1. Information of carbohydrate drink

Name: No-NPO	Contents
Volume (mL)	200
Energy (kcal)	100
Carbohydrate (g)	25.6
Sugar (g)	4
Fat (g)	0
Protein (g)	0
Sodium (mg)	104
Potassium (mg)	96

NPO, nil per os.

Changes in hematologic indicators were confirmed by examining patients' medical records for white blood cell count and concentrations of albumin, lymphocytes, hemoglobin, and hematocrit on the day 7 before surgery and postoperative day 7. Postoperative complications were judged by surgical site inspection. Postoperative pain evaluation was performed using the numeric rating scale, by which patients can select a pain score ranging from 1 to 10 points, and is divided into mild pain (1–3 points), moderate pain (4–6 points), and severe pain (7–10 points).

The energy intake was analyzed based on the usual dietary intake before admission, on postoperative day 5, and on discharge by a clinical dietitian. The nutritional status was evaluated using the Patient-Generated Subjective Global Assessment (PG-SGA) before surgery and at discharge.

### Statistical analysis

The collected data were analyzed using SPSS, version 25.0 (IBM, Armonk, NY, USA). A homogeneity test was performed by comparing differences between treatment groups using the independent two-sample t-test for continuous variables and the  $\chi^2$  test for categorical data. The relationship between the length of hospital stays and dietary intake at discharge was analyzed by the Pearson correlation and expressed as a scatterplot. All results confirmed the significance at  $p < 0.05$ .

### Ethics approval and informed consent

The purpose and content of the surgery were explained, and consent was obtained, and approval was obtained from the Institutional Review Board of Soonchunhyang University Bucheon Hospital (IRB No. 2017-05-012).

## RESULTS

### Homogeneity test between experimental and control groups

The average age (years) of the study patients was  $60.68 \pm 8.1$  and  $62.83 \pm 11.09$  years in the experimental and control group, respectively. The sex distribution of male and female patients was similar between groups. No differences were noted between groups for patient height and weight. The postoperative weight loss was  $1.49 \pm 1.35$  and  $1.65 \pm 1.67$  kg in the experimental and control group, respectively, which showed more weight loss; however, this difference was not significant. The location of colon cancer was more colon, and comorbidities were mainly diabetes and hypertension. The ASA score of normal health (ASA I) accounted for the largest proportion of ASA scored in both the experimental and control groups with 10 (52.6%) and 8 (44.4%) patients, respectively. No significant between-group differences were found in general characteristics, so the 2 groups were considered to be homogeneous (**Table 2**).

### Comparison of perioperative hematologic data

Before the experimental treatment, no statistically significant differences were found between groups on blood test results for white blood cell counts and concentrations of albumin, lymphocyte, hemoglobin, and hematocrit, indicating homogeneity for the 2 groups. After surgery, the white blood cell value slightly increased in the experimental group, with a significant difference in the change in this value between the 2 groups. Surgical site infection, a postoperative complication observation item, was identified in one control group patient. A significant difference was shown between 2 groups for postoperative pain ( $p < 0.001$ ), with

**Table 2.** Clinical features in patients

Characteristics	Experimental group (n = 19)	Control group (n = 18)	p value
Sex			0.433
Male	9 (47.4)	10 (55.6)	
Female	10 (52.6)	8 (44.4)	
Age (yr)	60.68 ± 8.81	62.83 ± 11.09	0.520
Height (cm)	161.58 ± 7.57	160.86 ± 8.94	0.793
Preoperative weight (kg)	65.48 ± 8.54	64.51 ± 8.56	0.731
Postoperative weight (kg)	63.98 ± 8.16	62.85 ± 8.35	0.679
Weight loss in hospitalization (kg)	1.49 ± 1.35	1.65 ± 1.67	0.750
Location			0.560
Colon	10 (52.6)	10 (55.6)	
Sigmoid	9 (47.4)	8 (44.4)	
Comorbidity			0.499
No	11 (57.9)	10 (55.6)	
Yes	9 (47.4)	8 (44.4)	
ASA classification			0.532
I	10 (52.6)	8 (44.4)	
II	8 (42.1)	7 (38.9)	
III	1 (5.3)	3 (16.7)	

Data represented as mean ± standard deviation and number (%). The p value by  $\chi^2$  test (categorical variables) and independent t-test (continuous variables).  
ASA, American Society of Anesthesiology.

**Table 3.** Comparison of perioperative hematologic examination in patients

Variables	Experimental group (n = 19)	Control group (n = 18)	p value
Albumin change	1.15 ± 0.62	1.17 ± 0.48	0.892
Preop albumin (mg/dL)	4.25 ± 0.25	4.32 ± 0.53	0.639
Postop albumin (mg/dL)	3.11 ± 0.66	3.14 ± 0.66	0.857
White blood cell change ( $\mu$ L)	-0.23 ± 2.24	1.34 ± 1.54	0.017
Preop white blood cell ( $\mu$ L)	6.10 ± 1.06	7.02 ± 1.72	0.058
Postop white blood cell ( $\mu$ L)	6.33 ± 2.02	5.44 ± 1.93	0.179
Lymphocyte change (%)	10.11 ± 9.57	7.37 ± 10.71	0.419
Preop lymphocyte (%)	32.29 ± 9.12	30.39 ± 10.10	0.552
Postop lymphocyte (%)	22.18 ± 7.30	23.02 ± 7.75	0.737
Hemoglobin change (g/dL)	1.15 ± 0.77	1.32 ± 1.08	0.585
Preop hemoglobin (g/dL)	12.70 ± 1.67	13.18 ± 1.84	0.414
Postop hemoglobin (g/dL)	11.55 ± 1.69	11.86 ± 1.24	0.530
Hematocrit change (%)	3.68 ± 2.13	4.01 ± 3.04	0.706
Preop hematocrit (%)	38.19 ± 3.99	39.01 ± 4.45	0.560
Postop hematocrit (%)	34.51 ± 4.22	35.00 ± 3.19	0.694
SSI status			0.486
Yes	0 (0.0)	1 (5.6)	
No	19 (100.0)	17 (94.4)	
Postoperative pain status (points)	3.78 ± 1.32	5.67 ± 1.14	< 0.001
Length of hospital stay (days)	7.16 ± 2.06	9.28 ± 1.56	< 0.006
Readmission	0 (0.0)	0 (0.0)	1.000

Data represented as mean ± standard deviation and number (%). The p value by  $\chi^2$  test (categorical variables) and independent t-test (continuous variables).  
SSI, surgical site infection.

3.78 ± 1.32 points in the experimental group, which was lower in pain than 5.67 ± 1.14 points in the control group. The hospitalization period (days) also showed a significant difference in the 2 groups ( $p = 0.006$ ), and the experimental group (7.16 ± 2.06) had a shorter hospitalization period than the control group (9.28 ± 1.56) (**Table 3**).

### Comparison of perioperative nutritional indicators

Before the experimental treatment, energy intake was 1,815.00 ± 186.66 and 1,830.44 ± 152.92 kcal in the experimental and control group, respectively. Preoperative PG-SGA assessment

**Table 4.** Comparison of perioperative diet intake and nutritional status in patients

Variables	Experimental group (n = 19)	Control group (n = 18)	p value
Preop energy intake (kcal)	1,815.00 ± 186.66	1,830.44 ± 152.92	0.785
Diet first day energy intake (kcal)	638.26 ± 194.07	415.11 ± 183.71	0.001
Discharge energy intake (kcal)	1,714.26 ± 172.22	1,591.89 ± 174.34	0.039
Preop PG-SGA			0.969
Normal	17 (94.7)	17 (94.4)	
Mild-moderate malnutrition	1 (5.3)	1 (5.6)	
Severe malnutrition	0 (0.0)	0 (0.0)	
Discharge PG-SGA			0.491
Normal	15 (78.9)	11 (61.1)	
Mild-moderate malnutrition	3 (15.8)	5 (27.8)	
Severe malnutrition	1 (5.3)	2 (11.1)	

Data represented as mean ± standard deviation and number (%). The p value by  $\chi^2$  test (categorical variables) and independent t-test (continuous variables).

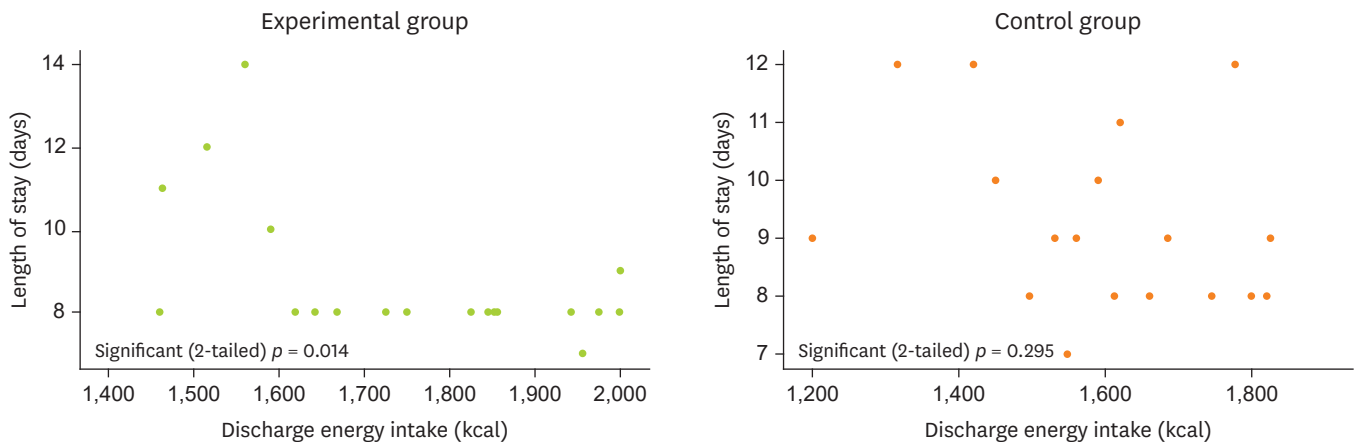
PG-SGA, Patient Generated-Subjective Global Assessment.

showed normal nutritional status for most patients, with 17 (94.7%) patients in each group, and thus no significant differences in nutritional characteristics.

The energy intake of the first diet after surgery and the diet on discharge were analyzed. The energy intake of the first meal was 638.26 ± 194.07 and 415.11 ± 183.71 kcal in the experimental and control group, respectively, with higher intakes in the experimental group ( $p = 0.001$ ). The energy intake on the discharge day also showed a significant difference between the 2 groups ( $p < 0.039$ ), with the experimental group (1,714.26 ± 172.22 kcal) having higher intake than the control group (1,591.89 ± 172.34 kcal). For postoperative nutritional status, the mild-to-moderate malnutrition ratio was higher in the control group at 15.8% versus 27.8% for the experimental group, and the severe malnutrition ratio was 5.3% and 11.1%, respectively, although these differences were not statistically significant (**Table 4**).

### Relationship between length of hospital stay and diet intake

No between-group differences were observed for the occurrence of postoperative complications, so the correlation between the number of days of hospital stay and the energy intake at discharge was analyzed as an effect variable. In the experimental group, a linear correlation with the length of hospital stay and energy intake was found as a significant result ( $p = 0.014$ ), but this correlation was not found for the control group ( $p = 0.295$ ) (**Figure 2**).


**Figure 2.** The Correlation analysis between length of stay and discharge energy intake in 2 groups.

## DISCUSSION

In the overall treatment process, the concept of the ERAS program has emerged as one of the multifaceted approaches, rather than being limited to only surgical techniques. Since it was first proposed in the late 1990s, the ERAS program has now been used for surgical patients in many fields [13]. In hospitals, cooperation and systematic support between multidisciplinary teams is essential, and the ERAS program can be safely implemented to the extent that it is mainly used based on standardized surgical guidelines (Critical Pathway). However, according to a report by Kim et al. [14] in Korea, only 29 respondents answered that they used the ERAS program as medical staff working at university hospitals and that the program was mainly used for patients with digestive diseases. This result was very meaningful in that the reasons for not using the ERAS program were the lack of program recognition and the difficulty of implementing this type of detailed program [14]. In contrast, the ERAS program is actively used in surgeries, such as treatment of biliary pancreatic acid, thyroid disease, pediatric surgery, and vascular surgery. However, the ERAS program is only used in very limited fields in Korea, with no recent research [15,16]. Therefore, this study was conducted as a pilot study to develop a standardized ERAS program for colon cancer surgical patients and to improve patient recovery. The effect of the ERAS program was evaluated by supplementing patients with a carbohydrate diet during fasting and using standard education programs.

The experimental and control group patients were compared for the presence of complications and blood test results, which showed no significant differences; most of the blood tests were within the normal range before and after surgery. This finding was the same as the conclusion reached by in the study of Kim et al. [17], which showed that the frequency of complications and readmission rate did not differ between the experimental and control groups. However, the experimental group experienced a shorter length of stay and significantly less pain. In another previous study [18], the actual gas-out time was faster, so the meals could be advanced, and as a result, the length of stay was interpreted as a shorter period. Previous studies have decreased the length of stay until the progression to a soft diet by using the ERAS program. In this study, the length of stay in the experimental group was shorter even though the start date of the soft diet was the same in both groups. The reason for this finding was thought to be because postoperative carbohydrate drinks have reduced discomfort such as pain and thirst during fasting and helped patients to eat comfortably and actively. In addition, analysis showed that the average length of stay was 2–4 days earlier than in previous studies because the postoperative management education program was concurrently provided to relieve anxiety and fear of postoperative complications. Based on these findings, use of the ERAS program is desirable as a complex program that includes evaluation indicators and tools, diet progression, education, and counseling for various surgical approaches to treat disease.

The strength of this study is that the nutritional status was compared and evaluated. Most previous studies analyzed length of stay and patient pain or satisfaction to indicate early recovery; in contrast, this study presented results of the analysis of the patient's actual nutritional intake status. In other words, in the experimental group, the energy intake at discharge was higher, the number of malnourished patients was lower, and a significant relationship between energy intake and length of stay was observed. In general, it is known that the poorer the patient's nutritional status, the higher the incidence and mortality of complications, delayed wound recovery, and increased medical costs [19]. Malnutrition is common in gastrointestinal cancer patients because it causes both nutrient malabsorption and metabolic disorders. In previous studies, the malnutrition rate of the patients of this

study was low at 21.1% in the experimental group and 38.9% in the control group, compared with 62.6% [20] and 47.0% [21] after colon cancer surgery, respectively. During the period when the control group maintained fasting through traditional management methods, the experimental group was supplied with sugar and water by nutritional supplementation with carbohydrate drinks. Postoperative carbohydrate supplementation may be related to great benefits in minimizing insulin resistance, maintaining nitrogen balance, and reducing infection and anastomotic leakage [22].

Most of the ERAS programs for surgical patients in Korea did not include all of the guidelines, and some cases of self-modification occurred, which may be attributed to different circumstances for each hospital and lack of agreement between medical staff. Limitations of this study include the small number of patients, and that the dietary intervention of carbohydrate drink supplementation was the main rather than the application of the program through a multidisciplinary agreement. Verification of the effectiveness of this approach was insufficient in that strict early recovery standards, such as the use of drainage tube and early walking time, were not applied. For future studies, it is necessary to evaluate various factors such as patient adherence, satisfaction, and quality of life and to further evaluate medical expenses for an ERAS program.

## CONCLUSION

Use of an ERAS program in colorectal cancer patients showed that the experimental group had shorter length of stay, reduced pain, and low malnutritional status than the control group. To develop into a more standardized program, expanded iterative studies are needed, and a Korean-style ERAS program should be created by applying this approach to various diseases.

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