



# The enhanced recovery after surgery (ERAS) protocol implementation in a national tertiary-level hospital: a prospective cohort study

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**Introduction:** Successful colorectal surgery is determined based on postoperative mortality and morbidity rates, complication rates, and cost-effectiveness. One of the methods to obtain an excellent postoperative outcome is the enhanced recovery after surgery (ERAS) protocol. This study aims to see the effects of implementing an ERAS protocol in colorectal surgery patients.

**Methods:** Eighty-four patients who underwent elective colorectal surgery at National Tertiary-level Hospital were included between January 2021 and July 2022. Patients were then placed into ERAS (42) and control groups (42) according to the criteria. The Patients in the ERAS group underwent a customized 18-component ERAS protocol and were assessed for adherence. Postoperatively, both groups were monitored for up to 30 days and assessed for complications and readmission. The authors then analyzed the length of stay and total patient costs in both groups.

**Results:** The length of stay in the ERAS group was shorter than the control group [median (interquartile range) 6 (5–7) vs. 13 (11–19),  $P < 0.001$ ], with a lower total cost of [USD 1875 (1234–3722) vs. USD 3063 (2251–4907),  $P < 0.001$ ]. Patients in the ERAS group had a lower incidence of complications, 10% vs. 21%, and readmission 5% vs. 10%, within 30 days after discharge than patients in the control group; however, the differences were not statistically significant. The adherence to the ERAS protocol within the ERAS group was 97%.

**Conclusion:** Implementing the ERAS protocol in colorectal patients reduces the length of stay and total costs.

**Keyword:** Colorectal surgery, enhanced recovery after surgery (ERAS) protocol, outcome

## Introduction

Colorectal surgery (CRC) is one of the most commonly performed surgeries worldwide<sup>[1]</sup>. Among the many indications for CRC, such as ulcerative colitis, Crohn's disease, mechanical obstruction, and recurrent diverticulitis<sup>[1,2]</sup>, colorectal malignancy is the most common<sup>[1]</sup>. In 2018, the International Agency for Research on Cancer reported 1 096 000 new cases of colon cancer and estimated 704 000 new cases of rectal cancer, with a focus on geographic variability across 20 world regions<sup>[3]</sup>. Meanwhile, in Indonesia, there were 30 017 new cases of

colorectal cancer in 2019<sup>[4]</sup>. Colorectal surgery is a high-risk surgery, with mortality and morbidity rates of 1–16% and 35%, respectively<sup>[2,5]</sup>. The incidence of postoperative complications can be up to 38%, with 5-year and 8-year survival rates of 71% and 61%<sup>[1,4]</sup>. In Indonesia, the survival rate of colorectal cancer after CRC was only 43%<sup>[4]</sup>.

A successful colorectal surgery is defined by its outcomes, such as post-surgery mortality and morbidity rate, complication rate, and cost-effectiveness<sup>[6]</sup>. Higher postoperative complications, prolonged treatment periods, and higher readmission rates can

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increase total treatment costs, eventually devastating and harmful for patients and medical facilities<sup>[7,8]</sup>. Even though the burden of this problem is quite significant, there has been no standardization of preoperative colorectal surgery until now. In the last two decades, many methods and procedures have been developed to overcome this problem, including minimally invasive surgery, preoperative carbohydrate loading, utilization of regional anaesthesia, perioperative oral nutrition, limited use of the nasogastric tube, and selective bowel preparation before surgery. These methods were assembled into an established protocol: the enhanced recovery after surgery (ERAS)<sup>[8,9]</sup>.

ERAS is a guideline proposed by the ERAS Society based on evidence, trials, and extensive cohort studies to optimize surgical outcomes throughout different medical specialties<sup>[10]</sup>. ERAS is a well-established multidisciplinary surgical protocol consisting of preoperative, intraoperative, and postoperative strategies<sup>[8,9]</sup>. Despite these benefits, several studies assessing ERAS application reported a higher rate of complications and readmissions, which can disadvantage patients and health facilities<sup>[11–13]</sup>. In a previous Indonesian study, the reported compliance of ERAS protocol among patients with colorectal surgery was 67%, significantly reducing the postoperative length of stay by up to 5 days<sup>[14]</sup>. However, this study was conducted retrospectively and evaluated only 11 components of the ERAS protocol. Thus requiring a study with a prospective design that evaluates more components of the ERAS protocol

We aimed to determine whether applying the ERAS protocol to patients undergoing colorectal surgery could improve surgical outcomes (length of stay, complications, readmission, and total costs) in the National Tertiary Hospital clinical setting.

## Methods

### Study design and setting

This prospective cohort study analyzed the implementation of ERAS protocol in colorectal patients and its effect on length of stay, readmission rate, complications, and costs in Hospital, an Indonesian tertiary-level hospital, from January 2021 to July 2022. ERAS protocol used in our study was arranged based on the guidelines of the ERAS Society. The sampling process was performed for all patients undergoing elective colorectal surgeries in The Central Surgery Room during the study period, who continued their medical care at Integrated Medical Ward Unit and fulfilled all inclusion and exclusion criteria. In this study, we also used a multidisciplinary team approach that carried out various protocol points in all phases, according to their areas of expertise. This team comprised surgeons, anesthesiologists, physical medicine, internists, rehabilitation specialists, general physicians, dietitians, nurses, pharmacists, surgery admission staff, medical record staff, and hospital administration staff.

### Study participants

We evaluated patients in two different groups: ERAS and non-ERAS. In both groups, we included patients who underwent elective/non-emergency colorectal surgery above 18 years of age, with a maximum of two different comorbidities to minimize postoperative complications, a body mass index above 18.5 kg/m<sup>2</sup>, and an ASA below 2. Patients were first evaluated for eligibility for the ERAS protocol and their willingness to follow a

## HIGHLIGHTS

- The length of stay in the enhanced recovery after surgery group was shorter than the control group [median (interquartile range) 6 (5–7) vs. 13 (11–19),  $P < 0.001$ ], with a lower total cost of [USD 1875 (1234–3722) vs. USD 3063 (2251–4907),  $P < 0.001$ ].
- Patients in the ERAS group had a lower incidence of complications, 4 (10%) vs. 9 (21%), and readmission 2 (5%) vs. 4 (10%), within 30 days after discharge.
- Implementing the enhanced recovery after surgery protocol in colorectal patients reduces the length of stay and total costs.

series of ERAS protocols at the outpatient clinic. The Patients registered in the ERAS group followed the protocol of our ERAS research team. For the control group, patients selected through examination in the outpatient clinic would undergo conventional/traditional surgery.

The sample size was calculated using an unpaired numerical, analytical research sample size formula, with an alpha of 5%, a beta of 10%, a combined standard deviation of four based on previous studies, and an assumed mean outcome difference of 3<sup>[15]</sup>. To obtain a minimum sample size for each group of 37 subjects.

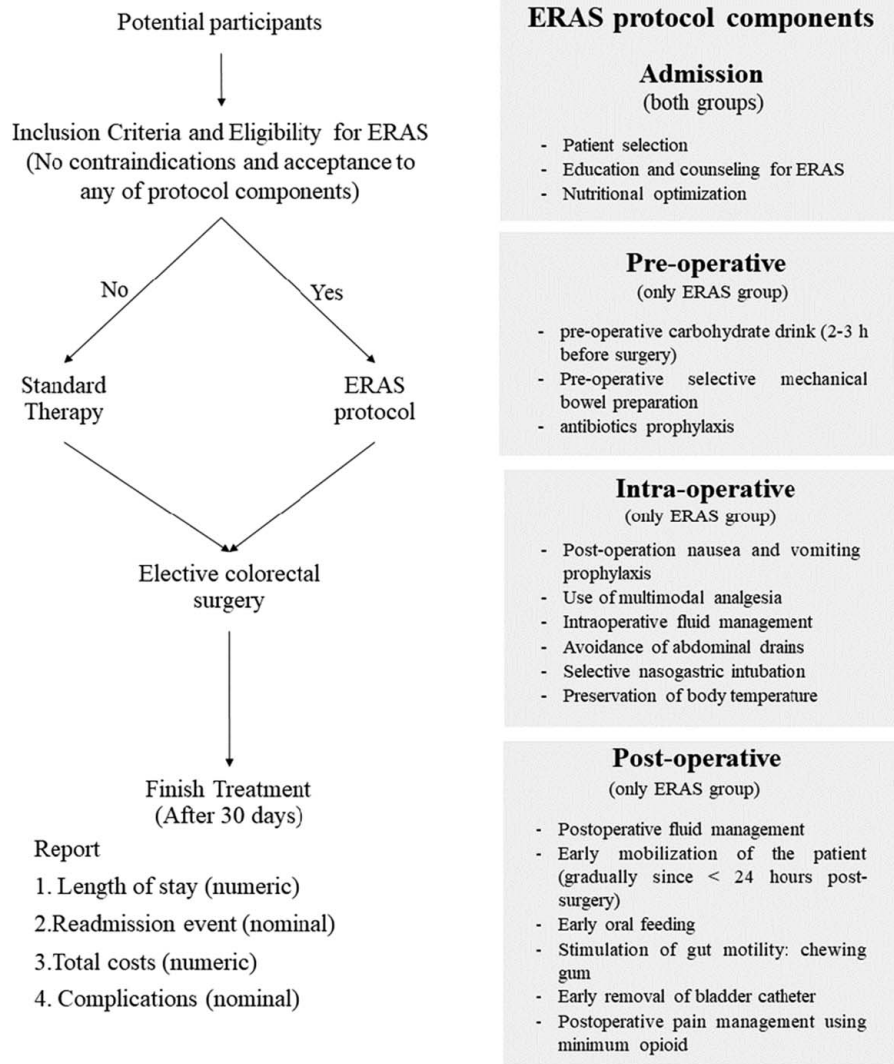
### Outcomes

The primary outcomes of this study were: (1) the length of hospitalization, (2) postoperative complications, (3) readmission rate, and (4) total medical costs. The length of hospitalization was calculated from the day of admission to the hospital ward until the discharge. Postoperative complications were defined as infection on the surgical site or systemic infection, wound dehiscence, and other complications found after surgery. The readmission rate was calculated from discharge to one month after surgery. Total medical costs were calculated based on direct medical costs recorded in the hospital billing data. The currency was converted from Indonesian Rupiah (IDR) to US dollars (USD) based on the 1 September 2022, conversion rate of USD 1 = IDR 14,200.

In addition, we assessed the adherence of patients in the ERAS group to the ERAS protocol (Fig. 1). Each implemented protocol component was recorded, and the number of protocols that could be implemented for each patient was calculated. The adherence to the eighteen ERAS protocols was grouped into: less than 90%, 90–95%, 96–100% for readmission, complications, length of stay less than 7 days, and costs less than USD 3000 for patients in the ERAS group based on a previous study<sup>[16–18]</sup>. The controlled price of USD 3000 is determined based on our hospital's average cost of the non-ERAS group.

### Data analysis

The data collected from the outcomes were cleaned and validated before data analysis using IBM SPSS version 24.0. The length of hospitalization and medical cost data are presented on a numerical scale, while readmission and complications are nominal data. We checked the normality distribution of numerical data before further inferential statistical analysis. Non-normally distributed data were analyzed using Mann–Whitney tests to compare the length of hospital stay between the two groups; the complications and readmissions were analyzed with the chi-



**Figure 1.** Preoperative, intraoperative, and postoperative ERAS protocol components. ERAS, enhanced recovery after surgery.

Square test or Fisher’s test according to the feasibility of the data. A linear regression test was performed to compare the cost of treatment between the two groups. Statistically significant when the *P* value is less than 0.05.

**Ethical approval**

The Health Research Ethics Committee approved this study and has been registered on ClinicalTrials.gov. We provided oral explanations to potential participants and ensured they voluntarily participated in the study. Participants were allowed to withdraw from the study without any consequences. Only those patients who provided consent were included in this study. This work has been reported in line with the STROCCS criteria<sup>[19]</sup>.

**Results**

Of the 84 colorectal surgeries that met our study criteria, 42 underwent surgeries with the ERAS protocol, and 42 underwent surgery with a traditional, non-ERAS protocol (Table 1). The

majority of patients were male (60%), diagnosed with malignancies (70%), and underwent laparotomy surgical procedures (84%).

ERAS group patients had a shorter hospital stay than those in the control group [median (interquartile range) 6 (5–7) vs. 13 (11–19), *P* < 0.001] and lower total costs [USD 1875 (1234–3722) vs. USD 3063 (2251–4907) *P* < 0.001]. Furthermore, the ERAS group also had lower readmission and complication rates, but the differences were not statistically significant (Table 2).

We also assessed the compliance rate of the ERAS protocol implemented in the ERAS patients group. The data show a total mean of 97% throughout all 18 components, including the admission, preoperative, intraoperative, and postoperative phases. Eleven components were executed for all subjects of ERAS group. In contrast, seven others could not be implemented, primarily because of the patient’s perioperative conditions (Fig. 2). Based on the calculations for every patient, 26 patients completed 100% of the ERAS protocol, with the lowest compliance rate of 83%. We found that two patients were readmitted to the hospital, four patients had postoperative complications, and most had a

**Table 1**  
Demographic characteristics of subjects implementing ERAS protocol and control group.

	ERAS (n=42)	Control (n=42)	Total (n=84)
Age (years), mean ± SD	49.6 ± 14.6	48.5 ± 12.1	49.1 ± 13.4
Sex, n (%)			
Male	23 (55)	27 (64)	50 (60)
Female	19 (45)	15 (36)	34 (40)
Surgery approach, n (%)			
Laparotomy	38 (90)	33 (79)	71 (84)
Laparoscopy	4 (10)	9 (21)	13 (16)
Surgical procedure, n (%)			
Colostomy closure	18 (43)	2 (5)	20 (24)
Low anterior resection	5 (12)	4 (10)	9 (11)
Abdominoperineal resection	4 (10)	2 (5)	6 (7)
Hartmann procedure	1 (2)	4 (10)	5 (6)
Reverse hartmann procedure	4 (10)	1 (2)	5 (6)
Hemicolectomy	4 (10)	9 (21)	13 (16)
Laparotomy biopsy	0 (0)	3 (7)	3 (7)
Others	6 (14)	17 (40)	23 (27)
Diagnosis, n (%)			
Malignancy	27 (64)	32 (88)	59 (70)
Non-malignancy	15 (36)	10 (12)	25 (30)
Location, n (%)			
Colon	28 (67)	29 (69)	57 (68)
Rectal	14 (33)	13 (31)	27 (32)
Body mass index (kg/m <sup>2</sup> ), mean ± SD	22.7 ± 2.8	22.2 ± 2.3	22.4 ± 2.6
ASA Score, n (%)			
ASA 1	6 (14)	2 (5)	8 (10)
ASA 2	36 (86)	40 (95)	76 (90)

ASA, American Society of Anaesthesiologists; ERAS, enhanced recovery after surgery.

length of stay duration below seven days (90%), and required costs of under USD 3000 (83%). Patients readmitted to the hospital had a compliance rate of 100% (Fig. 3).

## Discussion

Until recently, this study was Indonesia's first comprehensive assessment of implementation outcomes. This study complements the previous Indonesian study using a multidisciplinary team approach to conduct ERAS protocol in actual clinical settings in a National Tertiary Hospital in Indonesia<sup>[14]</sup>. This study suggests that ERAS for colorectal surgery reduces the length of stay, total hospital costs, complications, and readmission rates compared to those colorectal surgeries without ERAS. This study also found that adherence to each component of the ERAS

protocol was high, even higher than the previous Indonesian study.

The higher adherence to the ERAS protocol was due to the different study methods. The previous Indonesian study was conducted retrospectively and only included 11 components of the ERAS protocol, which may be due to the limited data available in medical records<sup>[14]</sup>. However, despite the high adherence, there were still protocol components with less than 90% adherence, including using abdominal drain and prolonged nasogastric tube postoperative. Those were due to more advanced intraoperative findings, more complex surgery, and preventing postoperative ileus. The other component was not complete bowel preparation; the cause was that the patients came to the hospital one day before operations, and we could not control the patient bowel preparation.

We found that implementing ERAS protocol in patients undergoing colorectal surgery at our facilities could reduce the length of stay to 50%. Our study follows a study conducted in Korea by Choi *et al.*<sup>[20]</sup>, who concluded that the implementation of the ERAS protocol from 2017 to 2019 at St. Mary's Hospital in patients undergoing colon surgery showed significant results at a shorter length of stay with an average of 5.1 days. This study evaluated more ERAS protocol components than our study. The difference in the number of protocol components is due to the adjustments in each component's performance. However, in that study, the compliance rate for the protocol components in 2019 was only 67.3%, which is far below the compliance rate we found at our facility, which was 97%. Our findings are supported by previous studies at our facility by Wifanto and colleagues and a study in Spain by Ripolles-Melchor and colleagues which concluded that the more ERAS protocols that are fulfilled, the shorter the length of stay<sup>[16,17]</sup>.

Additionally, almost 86% of our ERAS group patients had an ASA score of 2, whereas the remaining patients had a score of 1. Patients' conditions in the admission and preoperative phase played an essential role in this outcome since it determines the recovery period of patients individually during treatment in the hospital ward. The patient's nutritional status also participated in preoperative conditions examination, in which our ERAS and control group overall had an average BMI score of 22.4 (healthy weight range).

Consequently, we also found that ERAS protocol implementation significantly reduces total cost by 40% (USD 1200) more than the control groups. This result is consistent with a study in New Zealand by Sammour and colleagues, who concluded that ERAS protocol implementation in Manukau Surgical Centre significantly reduced costs by up to 6%<sup>[21]</sup>. Most of the costs were reduced due to shorter stay duration and reduced postoperative complication costs. With the potency of reducing

**Table 2**  
Comparison of outcomes between ERAS and control group.

	ERAS (n=42)	Control (n=42)	B or RR (95% CI)	P
Length of stay (LOS), days	6 (5–7)	13 (11–19)	3.4 (95% CI, 0.1–2.6)	< 0.001*
Readmission	2 (5%)	4 (10%)	0.5 (95% CI, 0.1–2.6)	0.7**
Complication	4 (10%)	9 (21%)	0.4 (95% CI, 0.1–1.3)	0.1**
Costs	USD 1875 (USD 1234–3722)	USD 3063 (USD 2251–4907)	6.6 (95% CI, –0.6 to 0.9)	< 0.001***

ERAS, enhanced recovery after surgery; RR, risk ratio.

\*Significance values of LOS tested with Mann–Whitney.

\*\*Significance values of readmission tested with Fisher test, Complication with  $\chi^2$ .

\*\*\*Significance values tested with unpaired t-test.

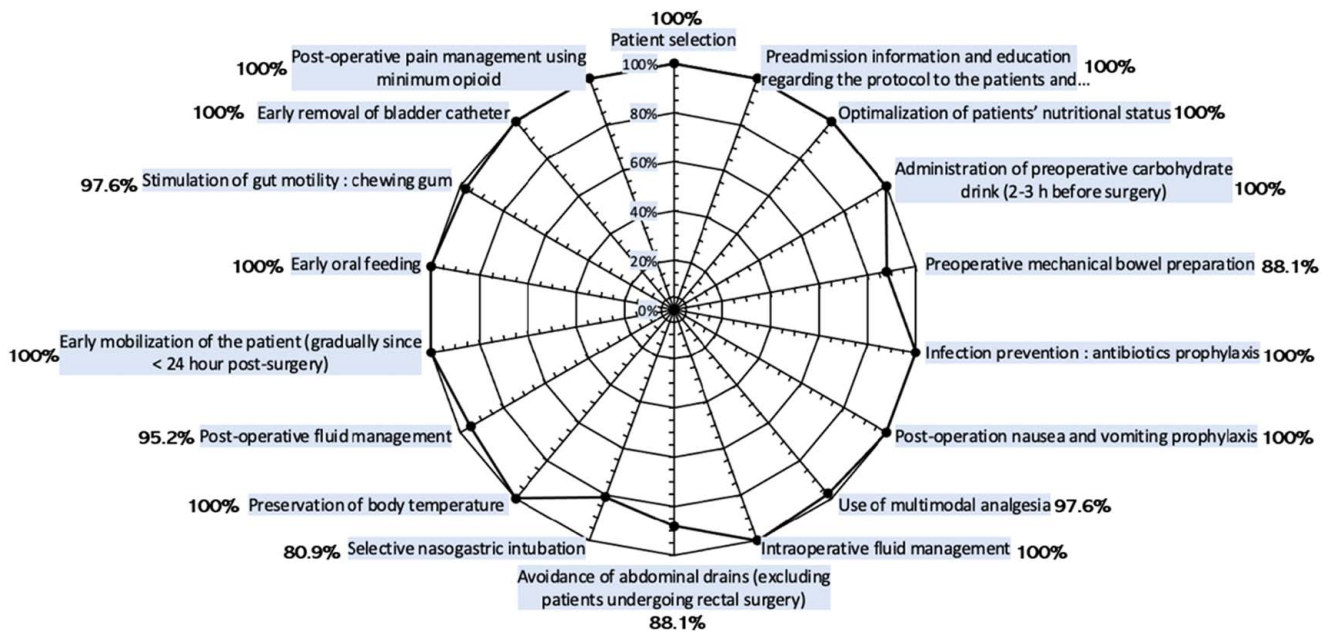


Figure 2. Compliance distribution throughout protocol items of patients implementing enhanced recovery after surgery protocol.

patients' total costs, ERAS may become the appropriate solution to Indonesia's Universal Healthcare Coverage System, which demands optimum outcomes by utilizing limited resources and prioritizes cost-effectiveness as proven in a study in Alberta by Nguyen and colleagues who concluded that implementing the ERAS protocol in colorectal surgery could save 73–83% (USD 1768) per patient<sup>[22]</sup>. Therefore, It is vital to see its cost-effectiveness in Indonesia and scalability to other facilities for broader implementation.

In addition, our study's lower number of complications and readmission rates did not show a significant difference. In contrast to the findings of the Ripolles-Melchor and colleagues study,

which concluded the complication rate was lower in the ERAS group (25.2% vs. 30.3%). This result differs from our study mainly due to the differences in population characteristics and the number of samples involved. Furthermore, almost 70% of our total samples involved malignancy cases, which may also affect complications and readmission rates for patients, depending on their respective progression or stages<sup>[23]</sup>.

However, on the contrary, different compliance rates of patients undergoing ERAS in our study did not show significant differences in patient outcomes<sup>[20,24]</sup>. Seow-En *et al.*<sup>[25]</sup> conducted a study on 315 patients which compared the outcomes between patients with greater than 70% and less than 70%

### Compliance of ERAS Protocol

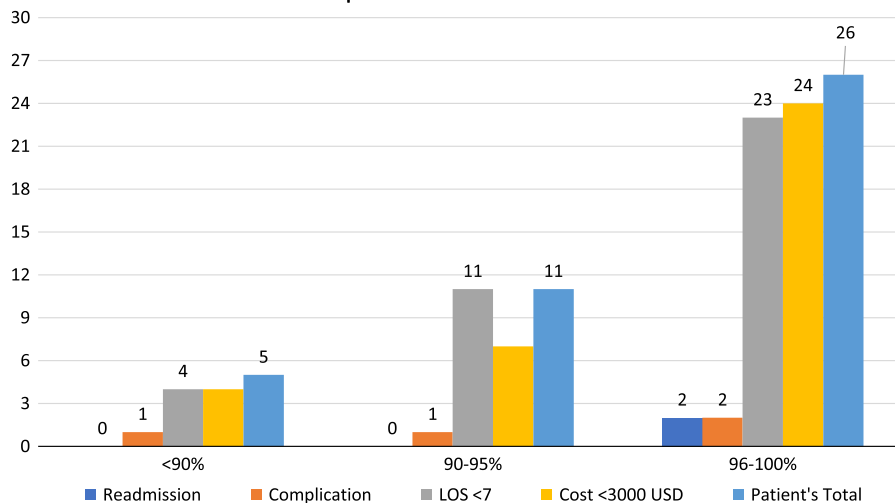


Figure 3. Compliance rate distribution of ERAS protocol against readmission, complication, length of stay, and costs in ERAS group patients. ERAS, enhanced recovery after surgery; LOS, length of stay.

compliance rates of ERAS components, resulting in a shorter length of stay of up to 1 day, lower readmission rate of 4% vs. 5% and lower complication rate of 15% vs. 22% favoring to patients with a compliance rate of greater than 70%. These discrepancies may result from different models of study, different numbers of protocols, and different operational definitions of ERAS components used. Reinforcing and checking the compliance of all ERAS protocols in each patient are challenging in actual clinical practice due to limited resources available but result in optimum outcomes if done correctly.

The limitation of this study was that it did not evaluate other prognostic factors that may influence postoperative patient morbidity, such as laboratory findings (leucocytes, neutrophils, monocytes, platelets, haemoglobin, RDW-CV, MCV, etc.) and the Charlson Comorbidity Index (CCI). Additionally, another limitation of this study was did not an assessment of patient comfort factors during the implementation of the ERAS protocol. So this could become an opportunity for further research.

## Conclusion

This study shows that implementing the ERAS protocol among colorectal patients has the potential to result in a reduction in hospital stay duration and overall expenses. Furthermore, the ERAS protocol may also lead to decreased rates of readmission and complications, although statistical significance was not observed when compared to the control group.

## Ethics approval and consent to participate

This study received ethical approval from the Institutional Review Board (IRB) (No KET-1433/UN2.F1/ETIK/PPM.00.02/2020) from the Ethic Research Committee of the Faculty of Medicine Universitas Indonesia.

## Consent

Written informed consent was obtained from the patients for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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## Author contribution

Y.M.: conception and design, critical revision of the article. R.A.S.: conception and design, critical revision of the article. F.I.: conception and design, data collection. W.S.J.: conception and design, data collection. A.S.P.: data collection. L.S.: data collection. V.M.: data collection. A.N.L.: data collection. R.P.: data collection. R.M.N.: data collection. S.S.: data collection. A.M.N.: data collection. N.R.M.M.: data collection. V.H.: data collection. E.N.S.: data collection. E.W.: data collection. R.M.: data collection. R.K.W.: critical revision of the article, analysis and interpretation. L.D.L.: critical revision of the article, analysis and interpretation. T.J.M.L.: critical revision of the article, analysis

and interpretation. All authors in this paper contributed according to their expertise. All authors of this paper have read and approved the final version submitted.

## Conflicts of interest disclosure

The authors declare that they have no competing interests.

## Research registration unique identifying number (UIN)

This study has been registered on ClinicalTrials.gov with the number NCT06010225.

## Guarantor

Ridho Ardhi Syaiful. Yarman Mazni.

## Data availability statement

Data are available, but not widely published.

## Provenance and peer review

Not commissioned, externally peer-reviewed.

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