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ORIGINAL ARTICLE

Effects of a new perioperative enhanced recovery after surgery protocol in hepatectomy for hepatocellular carcinoma

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Abstract

Purpose Enhanced recovery after surgery (ERAS) protocols are becoming the standard of care in many surgical procedures, although data on their use following hepatectomy for hepatocellular carcinoma (HCC) are scarce. This study aimed to evaluate the effects of a new ERAS pathway in terms of the patient nutrition status after hepatectomy for HCC.
Methods This is a retrospective analysis of 97 consecutive patients treated with open or laparoscopic hepatectomy for HCC between January 2011 and August 2014. We compared the perioperative outcomes between patients whose treatment incorporated the ERAS pathway and control patients. The nutritional status was evaluated using the controlling nutritional status score.
Results The length of hospital stay (LOS) after both open and laparoscopic hepatectomy was shorter for the ERAS group than the control group. The days of ambulation and cessation of intravenous infusion were earlier and the postoperative nutrition status was statistically better in the ERAS group than in the control group. A multivariate analysis showed that being in the non-ERAS group was a risk factor of delayed discharge. There were no marked differences in the rate of severe complications between the two groups.
Conclusions The ERAS pathway seems feasible and safe and results in a faster recovery, reduced LOS, improved nutrition status, and fewer severe complications.

Keywords Enhanced recovery after surgery · Hepatectomy · Hepatocellular carcinoma · Controlling nutrition status

Introduction

The enhanced recovery after surgery (ERAS) pathway is a well-known evidence-based multimodal program used to plan perioperative care. Use of the program has been suggested to result in significantly reduced surgical stress and been shown to facilitate postoperative recovery in colorectal surgery, resulting in a reduced morbidity, length of hospital stay (LOS), and costs after surgery [1]. Recently, ERAS protocols have been applied in several other fields of surgery [2–4] and have been reported to improve postoperative outcomes.

New perioperative care protocols in hepatectomy that include several ERAS items have been reported to reduce the LOS and morbidity [5–7]. These studies largely reported data from patients undergoing hepatectomy for liver metastasis and few reports have explored the relationship between the use of ERAS pathways in hepatectomy for hepatocellular carcinoma (HCC) and short-term outcomes, including the nutritional status.

It is not uncommon for HCC to develop in patients with chronic hepatitis and liver cirrhosis and the liver's prothrombin, fibrinogen, and albumin production are impaired in these patients compared with patients without chronic liver disease. Hepatectomy for HCC is regarded as major surgery and a high-risk procedure in the field of digestive surgery. Even in high-volume centers, the mortality rate is not 0% and morbidity rates remain high, ranging from 15 to 50% [8]. The postoperative course in these patients often does not proceed as expected and improved surgical techniques and perioperative care for HCC patients could decrease the

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mortality and morbidity rates after hepatectomy. We therefore implemented a new ERAS pathway in hepatectomy for HCC that included consideration of the nutritional status with the aim of improving surgical results.

The present study investigated the impacts of the ERAS pathway on the total LOS and postoperative short-term outcomes, including the nutritional status after hepatectomy for HCC.

Methods

Patient and data collection

Between January 2011 and August 2014, we recruited 97 patients who underwent hepatectomy for HCC at our hospital. The ERAS pathway was introduced in December 2012, so patients who underwent hepatectomy between December 2012 and August 2014 received ERAS pathway treatment, while those who underwent hepatectomy between January 2011 and November 2012 received conventional perioperative care. Patients were thus classified into an ERAS group ($n = 42$) and a control group ($n = 55$).

Patient and outcome data were extracted from clinical records and laboratory reports. In both groups, patients undergoing hepatectomy were considered eligible for the study if their Child–Pugh score was A or B. Patients were excluded if they required biliary reconstruction. Hepatectomy was categorized as partial resection, segmentectomy, sectionectomy, or lobectomy.

The present study was approved by the Institutional Review Board of Tohoku University (2018-1-444) and was therefore performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. The need for informed consent for was waived because of the retrospective nature of the study.

ERAS pathway

The ERAS pathway that we used was originally designed for elective colonic surgery [9] and has been modified by our group to cover all aspects of hepatectomy. The details of the ERAS protocol are presented in Table 1. Preoperative education and counseling were delivered by a doctor after admission to hospital. At that time, plans for discharge were discussed, including an expected date of discharge. The nutritional status was screened at admission using the controlling nutritional status (CONUT) score, which is calculated using measurements of the serum albumin concentration, total peripheral lymphocyte count, and total cholesterol concentration [10]. All patients received a regular diet preoperatively. When the CONUT score was ≥ 2, the patient also received a branched-chain amino acid-enriched beverage

Table 1 The enhanced recovery after surgery pathway protocol for hepatectomy

Day before surgery
Preoperative education and counseling by a doctor
Nutrition screening via the CONUT score
Receive BCAA supplement when the CONUT score was ≥ 2
Use of oral symbiotic treatment
Day of surgery
Avoid preoperative bowel preparation
Carbohydrate drinks provided up to 2 h preoperatively
Laparoscopic surgery where possible
Removal of nasogastric tube as early as possible after surgery
Postoperative day 1
Restart the oral intake of water and enteral nutrition supplementation
Send patient to general ward
Encourage to stand and mobilize out of bed by medical stuff
Postoperative multimodal analgesia including NSAIDs
Start laxative administration
Use of potassium-sparing diuretics
Postoperative day 2–3
Start the intake of solid food
Continue mobilization by medical staff
Try to remove urinary catheter
Postoperative day 4 or later
Check the discharge criteria
Discharge

BCAA branched-chain amino acids, *CONUT* controlling nutrition status, *NSAIDs* non-steroidal anti-inflammatory drugs

(HepasII®; Clinico Co., Ltd., Tokyo, Japan) for preoperative enteral nutrition supplementation. Patients received an enteral supplementation product enriched with glutamine, dietary fiber, and oligosaccharides (GFO®; Otsuka Pharmaceutical Factory, Inc., Tokushima, Japan); a fermented lactic beverage containing 3×10^8/ml *Lactobacillus casei Shirota* (Yakult®; Yakult Honsha, Tokyo, Japan) and an antiflatulent drug mixed with *Bacillus mesentericus*, *Clostridium butyricum*, and *Enterococcus faecalis* (BIO-THREE®; Toa Pharmaceutical Co., Ltd., Gunma, Japan) 3 days prior to surgery as perioperative synbiotic treatment. Preoperative mechanical bowel preparation was avoided. Patients received Arginaid® Water (Nestlé Japan Ltd., Hyogo, Japan), which is a carbohydrate-rich beverage, up until 2 h before operation.

For non-anatomical partial resection, we performed laparoscopic hepatectomy (LH) where possible. The nasogastric tube was removed as early as possible after surgery. All patients were returned to the intensive care unit on the day of operation. On postoperative day 1, patients were allowed to drink without restriction and were returned to the general ward. An epidural catheter was inserted prior to surgery to prevent perioperative abdominal pain and all patients received celecoxib (200 mg) twice daily. Laxatives were administered to prevent ileus and potassium-sparing diuretics were administered to prevent pleural and abdominal effusion. Patients were encouraged to stand and move out of their bed by medical stuff after returning to the general ward. In patients over 70 years old, perioperative rehabilitation was performed by physical therapists. Meals that provided 900 and 1600 kcal a day were offered on postoperative days 2 and 3, respectively. If the oral intake was sufficient, parenteral nutrition was stopped.

The primary endpoint of this study was the total LOS. The criteria for patients to be discharged were as follows: normal or decreasing levels of serum bilirubin and liver enzymes, good pain control with oral analgesics only, tolerance of solid food, no requirement for intravenous fluids, performance status equivalent to the preoperative levels, and a willingness to go home. The secondary endpoints were the day of ambulation, period of intravenous parenteral nutrition infusion, and CONUT score on postoperative day 7. In addition, we examined the risk factors for a delayed discharge using a receiver operating characteristic area under curve (ROCAUC) analysis. Complications were defined according to the Clavien-Dindo classification [11].

Statistical analyses

Continuous data are expressed as the median and range. The Mann–Whitney *U* test was used to compare differences between continuous variables. Fisher's exact test or the Chi-squared test was used for categorical variables. Parameters that were identified by a univariate analysis to be associated with the outcome at $P<0.05$ were subjected to a multivariate logistic regression analysis to identify independent risk factors for a delayed discharge. All analyses were performed using the JMP® pro 14 software program (SAS Institute Inc., Cary, NC, USA). A value of $P<0.05$ was considered to be statistically significant.

Results

Patients' characteristics

Table 2 summarizes the achievement of each ERAS element. All patients in the ERAS group received preoperative education and nutritional screening. However, one patient was unable to receive oral synbiotic treatment and carbohydrate drinks due to diarrhea. LH was limited to partial resection, accounting for 40% of all patients and 56.5% of partial resections. Over 83.3% of the patients had their nasogastric tubes removed in the operating room immediately after surgery, while 16.7% underwent removal in the intensive care unit, because of slower awakening from anesthesia. The oral intake of solid food and moving out of the bed were achieved by 90.5% and 81.0% of patients in the ERAS group, respectively.

Table 3 summarizes the preoperative and perioperative patient characteristics, which were similar in the ERAS and control groups. The ERAS group received preoperative enteral nutrition supplementation; therefore, the median preoperative CONUT score was higher for the control group than the ERAS group, although not to a statistically significant degree. The operative time was similar for both groups,

Table 2 Achievement of the ERAS pathway for hepatectomy elements

	Achievement of ERAS (%)
Day before surgery	
Preoperative education and counseling by a doctor	100% (42/42)
Nutrition screening via the CONUT score	100% (42/42)
Use oral synbiotic treatment	97.6% (41/42)
Day of surgery	
Avoid preoperative bowel preparation	100% (42/42)
Carbohydrate drinks up to 2 h preoperatively	97.6% (41/42)
Laparoscopic surgery	40% (13/42)
Removal of nasogastric tube as early as possible after surgery	83.3% (35/42)
Postoperative day	
Early feeding	90.5% (38/42)
Early mobilization	81.0% (34/42)
Postoperative multimodal analgesia (including NSAIDs)	100% (42/42)
Start laxative on postoperative day 1	100% (42/42)
Use of potassium-sparing diuretic	66.7% (28/42)

CONUT controlling nutrition status, *ERAS* enhanced recovery after surgery, *NSAIDs* non-steroidal anti-inflammatory drugs

Table 3 Preoperative (a) and perioperative (b) characteristics of patients in the ERAS and control groups

	Control ($n=55$)	ERAS ($n=42$)	*P* value
(a)			
Age (years; [range])	66 (40–86)	67.5 (41–82)	0.271
Gender (male/female)	45/10	36/6	0.608
Hepatitis (HBV/HCV/NBC)	19/23/13	12/13/17	0.201
Child–Pugh (A/B)	51/4	42/0	0.074
Preoperative CONUT score	3 (0–7)	2 (0–6)	0.054
Body mass index	23.8 (14.9–32.1)	23.9 (17.4–30.1)	0.578
ICGR15	13.5 (1.8–48.8)	14.5 (2.7–38.1)	0.608
(b)			
Blood loss (ml)	895 (25–11,686)	635 (5–3585)	0.024*
Operative time (min)	269 (112–545)	297 (184–918)	0.122
Laparoscopic resection	3 (5.5%)	13 (40.0%)	0.007*
Total volume infused during surgery (ml)	4280 (1100–16,110)	3550 (1500–10,000)	0.079
Blood transfusion	23 (41.8%)	17 (40.5%)	0.894
Type of liver resection			
Partial resection	30 (54.5%)	23 (54.8%)	0.987
Segmentectomy	4 (7.3%)	4 (9.5%)	0.670
Sectionectomy	12 (21.8%)	9 (21.4%)	0.992
Lobectomy	9 (16.4%)	6 (14.3%)	0.827
Tumor size (mm)	30 (6–150)	21 (7–135)	0.052
Number of tumors (solitary/multiple)	39/15	31/11	0.862
Fibrosis stage (0/I/II/III/IV)	3/3/14/18/17	1/4/17/8/9	0.271

Continuous data are presented as the median (range) and categorical data are presented as the number (%)

ERAS enhanced recovery after surgery, *HBV* hepatitis B virus, *HCV* hepatitis C virus, *NBC* non-hepatitis B or C virus, *CONUT* controlling nutrition status, *ICGR15* indocyanine green retention rate after 15 min

*Significant difference

but the blood loss in the ERAS group was significantly reduced compared with the control group. The rate of LH surgeries was significantly higher in the ERAS group than in the control group. The types of liver resection performed were similar between the groups. Pathological factors, including the tumor size, number of tumors per patient, and liver fibrosis stage, showed no marked difference between the groups.

The outcome data are summarized in Table 4. Patients in the ERAS group were discharged from hospital significantly earlier than those in the control group, with a consequent reduction in the median LOS in the ERAS group. The mean time for independent ambulation was significantly shorter in the ERAS group than in the control group. Almost all patients in the ERAS group resumed oral fluid and solid food intake within 24 and 48 h after hepatectomy, respectively. Therefore, the periods of intravenous infusion were significantly shorter in the ERAS group than in the control group. The nutritional status of patients in the ERAS group was significantly better than in the control group and a statistically significant reduction in the median CONUT score on postoperative day 7 was observed in the ERAS group compared with the control group.

Similar results were observed for patients undergoing open hepatectomy (OH) and those with a preoperative CONUT score of ≥ 2, undergoing either LH or OH, where the mean postoperative LOS was significantly shorter in the ERAS group as was the time to ambulation and period of intravenous infusion. The mean nutritional status on postoperative day 7 was improved in the ERAS group compared with the control group, although this difference was not statistically significant.

Table 5 summarizes the risk factors for delayed discharge. The most appropriate cutoff value for delayed discharge was shown by an ROC analysis to be 15 days (AUC = 0.771, $P = 0.001$, sensitivity = 0.796, specificity = 0.605). Risk factors for delayed discharge identified by a univariate analysis were being in the control group, undergoing OH, a high preoperative CONUT score, blood loss, an increased operative time, and an enlarged tumor size. The only risk factor identified by a multivariate logistic regression analysis was being in the control group.

Complications are detailed in Table 6. The number of complications below Grade III was significantly greater in the ERAS group than in the control group. In contrast, the incidence of Grade IIIa complications was significantly

Table 4 Postoperative characteristics of patients in each group undergoing laparoscopic and open hepatectomy (a), open hepatectomy alone (b) and those with a preoperative CONUT score of ≥ 2 (c)

	Control (*n* = 55)	ERAS (*n* = 42)	*P* value
(a)			
Length of hospital stay	18 (8–46)	13 (6–75)	< 0.001*
Day of ambulation	4 (2–11)	2 (1–23)	< 0.001*
Period of intravenous infusion	7 (3–24)	4.5 (3–35)	< 0.001*
CONUT score on POD 7	8 (3–11)	6 (1–11)	0.012*
(b)			
Length of hospital stay	18 (8–46)	15 (9–75)	0.003*
Day of ambulation	4 (2–11)	2 (1–23)	< 0.001*
Period of intravenous infusion	7 (4–24)	5 (3–35)	0.004*
CONUT score on POD 7	7.5 (3–11)	7 (1–11)	0.315
(c)			
Length of hospital stay	19 (8–46)	13.5 (7–75)	0.003*
Day of ambulation	4 (2–11)	2 (1–23)	< 0.001*
Period of intravenous infusion	7 (3–24)	6 (3–35)	0.014*
CONUT score on POD 7	9 (4–11)	7 (2–11)	0.077

Data are presented as the median (range)

ERAS enhanced recovery after surgery, *CONUT* controlling nutrition status, *POD* postoperative day

*Significant difference

Table 5 Risk factors for delayed discharge according to univariate (a) and multivariate (b) logistic regression analyses

	Odds ratio	95% CI	*P* value
(a)			
Control group	5.882	2.442–15.019	< 0.001*
Open laparotomy	10.927	3.177–50.963	< 0.001*
Age	1.030	0.987–1.080	0.168
Sex	1.330	0.450–4.243	0.607
Body mass index	0.961	0.849–1.084	0.514
ICGR15	0.979	0.936–1.024	0.347
Preoperative CONUT score	1.338	1.038–1.771	0.024*
Partial resection	0.547	0.231–1.261	0.158
Segmentectomy	0.982	0.226–5.034	0.981
Sectionectomy	1.234	0.456–3.587	0.684
Lobectomy	2.694	0.783–12.485	0.121
Blood loss	1.001	1.001–1.002	< 0.001*
Operative time	1.006	1.002–1.012	0.007*
Tumor size	1.019	0.999–1.039	0.024*
(b)			
Control group	7.957	2.085–30.374	0.001*
Open laparotomy	3.057	0.641–14.570	0.150
Preoperative CONUT score	1.150	0.869–1.674	0.375
Blood loss	1.001	1.000–1.002	0.093
Operative time	1.007	1.000–1.016	0.090
Tumor size	1.005	0.983–1.029	0.650

CI confidence interval, *ICGR15* indocyanine green retention rate after 15 min, *CONUT* controlling nutrition status

*Significant difference

Table 6 Complications graded according to the Clavien–Dindo classification in the ERAS and control groups

	Control (*n* = 55)	ERAS (*n* = 42)	*P* value
Grade < II	35 (63.6%)	36 (85.7%)	0.013*
Grade IIIa	19 (34.5%)	4 (9.5%)	0.003*
Pleural effusion	9 (16.4%)	4 (9.5%)	
Ascites	5 (9.1%)	0 (0.0%)	
Bile leak	2 (3.6%)	0 (0.0%)	
Abdominal abscess	1 (1.8%)	0 (0.0%)	
Wound infection	1 (1.8%)	0 (0.0%)	
Pneumothorax	1 (1.8%)	0 (0.0%)	
Grade IIIb	0 (0.0%)	2 (4.8%)	0.226
Hemorrhaging	0 (0.0%)	1 (2.4%)	
Others	0 (0.0%)	1 (2.4%)	
Grade IVa	1 (1.8%)	0 (0.0%)	0.709
Sepsis	1 (1.8%)	0 (0.0%)	
Grade IVb and V	0 (0.0%)	0 (0.0%)	N/A

Data are presented as the number (%)

ERAS enhanced recovery after surgery, *N/A* not applicable

*Significant difference

reduced in the ERAS group compared with the control group. Two patients in the ERAS group developed Grade IIIb complications of postoperative hemorrhaging after posterior segmentectomy ($n = 1$) and hepatic necrosis of the lateral segment after central bisegmentectomy of the liver ($n = 1$). No patients in the ERAS group had Grade IV or V complications, whereas one patient in the control group suffered a Grade IV complication.

Discussion

The ERAS pathway is a structured, multimodal perioperative strategy that aims to reduce surgical stress and improve outcomes in several surgical fields. It provides the patient with preoperative education regarding the recovery plan, including a shortened period of fasting, limited use of catheters, and enforced early mobilization, and oral nutrition. To date, no validated guidelines have been published by the ERAS Society for use of the ERAS pathway in hepatectomy. Several studies have reported that ERAS protocols in hepatectomy mainly provide benefits in terms of a reduced LOS and reduced rate of surgical complications [5–7]. However, these studies were performed in patients with a normal liver parenchyma—e.g. patients with colon metastasis—and data for patients with liver dysfunction remain scarce. Therefore, we investigated the use of ERAS protocols for patients undergoing hepatectomy for liver disease.

In the present study, we showed that our ERAS pathway for hepatectomy in the context of HCC accelerates postoperative recovery and is associated with a reduced risk of complications and decreased postoperative LOS. These results are in line with those of previous studies investigating ERAS for liver surgery [5–7, 12–14]. We found the median LOS in the ERAS group to be 5 days shorter than that in the non-ERAS group, while a reduction of 2.5 days was reported in a recent systematic review [5]. The differences in the LOS may be attributed to the patient age, as the median patient age in our study was 67 years old, whereas that of the previous report was 56 years old.

In our country, an increasing number of elderly patients are eligible for hepatectomy. Elderly patients who do not undergo early ambulation require more time to recover their muscle strength and tend to require more time before discharge. This is supported by the findings of Coolsen et al., who reported that an increased LOS is a typical feature of postoperative recovery in older patients and that the requirement for ongoing inpatient care at the predicted time of discharge increases significantly with age [15]. Therefore, the finding that our ERAS pathway is effective even in older patients has clinical relevance. Kaibori et al. reported that the ERAS pathway in patients undergoing extended hepatectomy for HCC, such as resection of more than two sections, was feasible and effective in elderly subjects [16]. Although our results are similar to their own, we demonstrated that the ERAS pathway in hepatectomy for HCC was effective not only in patients undergoing extended hepatectomy, but also those in those undergoing all forms of liver resection, including partial resection, segmentectomy, and sectionectomy. HCC typically develops in patients with chronic hepatitis or liver cirrhosis, where extended hepatectomy cannot be performed and other resection methods are often employed. Our demonstration of the effectiveness of the ERAS pathway in all forms of hepatectomy for HCC can therefore be considered quite significant.

Our ERAS pathway was adapted from the recommended protocol for colorectal surgery published by the ERAS society [9]. Some elements that were not included in the colorectal protocol were added; specifically, we used the CONUT score for the preoperative screening of the nutritional status and determining appropriate nutritional intervention. It has been proposed that the CONUT score be the primary tool used for the early detection of a poor nutritional status in hospitalized patients [10]. Furthermore, Iseki et al. demonstrated that the preoperative CONUT score is a useful factor for predicting the survival in colorectal cancer [17]. Similarly, the utility of the CONUT score in liver disease has been reported in several studies [18, 19]. One report demonstrated that the preoperative immunonutritional status is linked to the prognosis after hepatectomy for HCC [18]. Another revealed that malnutrition, indicated by the CONUT score, is very frequent in patients with liver cirrhosis [19]. In light of these reports, it can be concluded that the CONUT score is closely related to the liver function. In the present study, we showed that our ERAS pathway in hepatectomy for HCC accelerates the postoperative recovery when the preoperative COUNT score is ≥ 2. Our results also indicated that the preoperative CONUT score was a risk factor for delayed discharge on a univariate logistic regression analysis. Therefore, appropriate nutritional intervention may be meaningful in terms of improving the short-term outcome. We also demonstrated that the CONUT score on postoperative day 7 was significantly better in patients who had been treated with the ERAS protocol than in control patients. Therefore, our results indicate that implementation of the protocol presented here will help improve the long-term outcomes, as improvement of the postoperative CONUT score seems to be meaningful for patients who undergo surgery for HCC.

Another additional feature of our ERAS pathway was the administration of potassium-sparing diuretics to decrease postoperative pleural and abdominal effusion. We used potassium-sparing diuretics in patients with macroscopic liver damage (66.7% of patients in the ERAS group). Complications of severe pleural and abdominal effusion were significantly decreased in our ERAS group, suggesting that this additional element was beneficial to patients. Although we cannot deny that minimizing the total volume infused during surgery, performing early oral nutrition, and achieving early parenteral administration withdrawal may have contributed to the reduction in pleural and abdominal effusion, we believe that the use of diuretics is a significant positive factor.

We also used oral synbiotic treatment in our protocol. Several reports have demonstrated that such treatment can attenuate the decrease in intestinal integrity and reduce the rate of infectious complications in patients undergoing hepatectomy [20, 21]. In our ERAS group, the number of surgical site infections was decreased compared with the control group, although the difference was not statistically significant. Further studies will be required to clarify whether or not the use of synbiotic treatment is beneficial for preventing postoperative infections.

Several limitations associated with the present study warrant mention. This was a retrospective analysis that relied on medical records, so the decision regarding the surgical approach was made prior to the study. There has been a significant increase in the popularity of LH surgery in recent decades. Compared with OH, several studies have demonstrated a reduced rate of complications and shorter LOS in association with LH [22–24]. Therefore, the reduction in the LOS might have been due to the laparoscopic nature of the surgery, rather than the new ERAS items applied in the present study. However, OH was not found to be a risk factor for a delayed discharge on multivariate logistic regression and the efficacy of the ERAS pathway in OH was clear. These results indicate that the non-technical aspects of the ERAS items affect the outcome of hepatectomy and the effectiveness of our ERAS pathway. Technological advances in LH have been remarkable and progress is expected to continue in the future. If the rate of LH adoption increases, the importance of the non-technical aspects of ERAS may become more obvious. In a retrospective analysis, unifying all tumor factors across the cohort is difficult. There was therefore some concern that tumor factors would have a greater effect on the outcomes than the ERAS pathway in hepatectomy for HCC. Indeed, our results indicated that an enlarged tumor size was a risk factor for a delayed discharge on a univariate logistic regression analysis; however, this result was not sustained in the multivariate logistic regression analysis. This implies that the ERAS pathway in hepatectomy for HCC has a larger effect on the outcome than tumor factors.

In the present study, not all elements of the ERAS were implemented at the same time, hampering the identification of significant elements. For example, we conducted nutritional intervention when the preoperative CONUT score was ≥ 2. Whether or not nutritional intervention is particularly important among ERAS elements should be examined by applying these ERAS elements, while excluding nutritional intervention. In addition, the results may vary due to differences in the awareness of the medical staff caring for the patient at the beginning of the study. To resolve these issues and draw firm conclusions, a randomized trial is necessary and one is currently underway.

In conclusion, our ERAS pathway protocol for hepatectomy accelerates postoperative recovery, reduces the risk of severe complications (potentially resulting in decreased postoperative LOS), and improves the long-term outcomes by improving the postoperative nutritional status. This study is the first to investigate the applicability of the ERAS protocol for evaluating the nutritional status using the CONUT score. Future research should concentrate on the perioperative care components of the protocol that are specific to LH.

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Compliance with ethical standards

Conflict of interest Atsushi Fujio and the other co-authors have no conflicts of interest to declare in association with this study.

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