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Research

Evaluation of the efficacy of laparoscopic hepatolobectomy for primary liver cancer with early combined enteral and parenteral nutritional support

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Abstract

The recovery of patients with liver cancer (LC) after laparoscopic hepatolobectomy is often affected by malnutrition, low immune function, and inflammatory responses, which may lead to an increase in postoperative complications and delayed recovery. Therefore, choosing a reasonable nutritional support plan is crucial for improving the postoperative recovery of patients. Material and Method: One hundred and fifty patients with primary LC who underwent laparoscopic hepatolobectomy were grouped: nutritional group (NG) and control group (CG). The NG implemented early enteral nutrition (EN) combined with parenteral nutrition (PN) support within 24 h postoperatively, while the CG only received early EN support. The liver function, nutritional indicators, plasma endotoxin levels, European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30) score, and postoperative recovery of the subjects were assessed. Result: Compared with the CG, the NG suggested visible improvement in postoperative aspartate aminotransferase (AST) and alanine aminotransferase (ALT), and a marked increase in albumin (ALB), prealbumin (PA), and total protein (TP). In addition, the plasma endotoxin levels were visibly lower, and the postoperative time to first bowel movement was visibly shortened in the NG as against the CG. There was no statistically meaningful distinction in hospital stay, time to ambulation, and time to first flatus in the subjects. The total score of the EORTC QLQ-C30 scale in the NG was significantly higher than that in the CG after intervention ($P = 0.012$). The overall incidence of complications in the NG was 6.7% (5/75), which was significantly lower than the 17.3% (13/75) in the CG ($P = 0.042$). Conclusion: Early EN combined with PN support can visibly improve the liver function and nutritional status of patients with primary LC after laparoscopic hepatolobectomy, promote postoperative immune recovery, and shorten recovery time.

Keywords Laparoscopic hepatolobectomy · Primary LC · Liver function · EN · PN

1 Introduction

Hepatocellular carcinoma (HCC) is one of the leading causes of cancer-related deaths worldwide, with a particularly heavy disease burden in the Asian region [20]. According to the latest statistical data, the annual number of new cases of LC in China accounts for about half of the global total, and most patients are diagnosed at an intermediate or advanced stage, resulting in an overall poor prognosis [9, 10, 15]. With the development of minimally invasive surgical techniques, laparoscopic hepatolobectomy has become one of the standard treatments for early-stage LC due to its advantages of

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minimal trauma and rapid recovery [1]. Numerous clinical studies have confirmed that compared with traditional open surgery, laparoscopic surgery can significantly reduce the incidence of postoperative complications, shorten hospital stay, and improve patients' quality of life [14]. However, as an important metabolic organ in the human body, the liver faces unique challenges in the postoperative recovery process. Patients undergoing hepatectomy often experience varying degrees of liver function impairment and metabolic disorders, leading to a significant increase in the risk of malnutrition [21]. Clinical observations have found that about 40–60% of patients with LC surgery have varying degrees of malnutrition, which not only affects wound healing but also increases the risk of infection and prolongs the recovery time 2. More importantly, malnutrition is closely related to postoperative survival rates and is an independent risk factor affecting the long-term prognosis of patients with LC [13]. Therefore, optimizing perioperative nutritional support strategies is of great significance for improving patient outcomes.

Currently, nutritional support programs are primarily divided into two forms: EN and PN. EN, by maintaining the intestinal mucosal barrier function, can effectively reduce bacterial translocation and infection risk [8]. PN, on the other hand, ensures that patients receive adequate nutrition when gastrointestinal function has not fully recovered [22]. In recent years, the strategy of early combined application of enteral and parenteral nutrition (EPN) has gradually gained attention in the field of abdominal surgery. This combined mode can not only exert the physiological advantages of enteral nutrition but also compensate for early intake insufficiency through parenteral nutrition, potentially providing patients with more comprehensive nutritional support [23]. Although EPN has shown good effects in open liver resection, its application value in laparoscopic hepatolobectomy has not been fully studied. Especially in the early postoperative period, how to balance nutritional supply with liver function protection and how to optimize nutritional formulas to meet the metabolic characteristics after minimally invasive surgery remain key questions to be answered [3]. Moreover, existing studies mostly focus on single nutritional support methods, lacking a systematic evaluation of combined nutritional support programs.

This article explored the clinical application value of early EPN in laparoscopic hepatolobectomy for the treatment of primary LC. Through a prospective controlled study design, it focuses on evaluating the effects of EPN on postoperative liver function recovery, complication incidence, nutritional status improvement, and quality of life in patients. The study results are expected to provide new evidence-based references for the perioperative management of minimally invasive LC surgery and promote the development of individualized nutritional support programs. This article also investigated the differences in responses to EPN among patients with different nutritional risk stratifications, providing references for the implementation of precise nutritional interventions in clinical practice.

2 Materials and methods

2.1 Subjects

One hundred and fifty patients with primary LC who underwent laparoscopic hepatolobectomy at the Second People's Hospital of Lanzhou from October 2022 to October 2024 were selected as the subjects, including 92 males and 58 females, aged 35 to 72 years. The trial obtained the approval by the Second People's Hospital of Lanzhou Ethics Committee, and all patients and their families signed informed consent forms before surgery. The design, implementation, and reporting of the trial were in accordance with the ethical principles of the *Declaration of Helsinki*, ensuring the privacy and confidentiality of patient data, and guaranteeing patients' rights to be informed and to withdraw from the trial.

Inclusion criteria: Preoperative liver function Child-Pugh scores were in Class A or B, with a low expected surgical risk; Preoperative imaging examinations (such as CT, MRI) suggested that the tumor was limited to the liver without obvious distant metastasis; Complete preoperative examination data were available, including blood biochemistry, liver function, coagulation function, and other indicators; Patients who met the surgical indications for laparoscopic hepatolobectomy and were assessed by a professional team as suitable for surgery.

Exclusion criteria: Patients who had undergone chemotherapy, radiotherapy, or other anti-cancer treatments before surgery; Patients with other malignancies in addition to primary LC; Patients with severe mental illness or cognitive dysfunction who could not understand or cooperate with the study requirements; Patients who could not undergo postoperative follow-up or were expected to have poor compliance with postoperative follow-up.

2.2 Grouping and nutritional support methods

A random number table from 1 to 150 was generated using computer software. Patients were numbered in the order of their admission, from 1 to 150. Subjects with odd numbers were assigned to the nutritional group (NG, early EN combined with PN support), and those with even numbers were assigned to the control group (CG, early EN support), with 75 cases in each.

All patients received standardized antibiotic prophylaxis (ceftriaxone 2 g q24 h × 48 h), multimodal analgesia (sufentanil patient-controlled analgesia + parecoxib sodium), hepatoprotective therapy (reduced glutathione + magnesium isoglycyrrhizinate), acid suppression (pantoprazole), and anticoagulation (low-molecular-weight heparin). The two groups differed only in the nutritional support programs, while other pharmacological treatments were kept consistent to ensure the comparability of the study results.

The CG began EN support within 24 h postoperatively. A whole protein EN agent (Nutrison) rich in dietary fiber and fructooligosaccharides (H20090007, Milupa GmbH, Germany) was selected. The initial infusion rate was low (10–20 mL/h), and the speed and dosage were gradually increased according to the subject's tolerance, reaching a full nutritional supply of 25–30 kcal/kg/day by the fifth day postoperatively. Subjects' blood sugar, electrolytes, liver function, and kidney function were monitored daily, and the nutritional fluid formula and supply were adjusted according to the results.

The NG also began enteral nutrition support within 24 h postoperatively, using the same enteral nutritional formula as the CG. The initial infusion rate was 10–20 mL/h, and if no significant discomfort was noted, the rate was increased by 10 mL/h every 4 h, reaching a total of 25–30 kcal per kilogram of body weight per day by the fifth postoperative day. Additionally, PN support was initiated via central venous or peripheral venous catheter within 24 h postoperatively. The nutritional solution consisted of amino acids (1.2–2.0 g per kilogram of body weight per day), lipid emulsion (0.8–1.2 g per kilogram of body weight per day), glucose (3–4 g per kilogram of body weight per day), electrolytes, and vitamins, with the specific formulation tailored to the individual needs of the patients. The initial infusion rate for PN was 20–30 mL/h, with an increase of 10 mL/h every 6 h if no significant discomfort was observed. On the fifth postoperative day, the total caloric intake from enteral and PN reached 25–30 kcal per kilogram of body weight per day, with PN contributing approximately 12–15 kcal per kilogram of body weight per day. This total caloric intake reflects a combined supplementation of enteral and PN in addition to small amounts of regular food (mainly easily digestible, light foods with limited intake), rather than a simple sum of the caloric contributions from both types of nutrition. This is primarily because the body's absorption and utilization of nutrients are not a simple linear addition, and during the actual supplementation process, adjustments were made dynamically based on factors such as the patient's gastrointestinal tolerance and metabolic status, to avoid overfeeding. By the fifth postoperative day, the combined supply of enteral and PN reached 50% of the total required caloric intake. Blood glucose, electrolytes, liver function, and kidney function were monitored daily, with adjustments made to the PN formula and supply volume based on the results. In this study, most patients were in a more severe condition, in a state of stress, with significant body depletion and potential degrees of malnutrition, and their gastrointestinal function might also have been affected. Therefore, a substantial volume of nutritional support was required to meet the patients' energy and nutritional needs and to promote recovery.

Additionally, standard postoperative pharmacological support was administered to all patients. Prophylactic antibiotic therapy with cefuroxime (1.5 g, intravenous infusion, every 12 h for 3 days) was provided to prevent infections. For pain management, acetaminophen tablets (0.5 g, orally, every 6–8 h as needed) were prescribed for mild pain, while intramuscular pethidine hydrochloride injection (50–100 mg, as needed) was used for moderate to severe pain relief. To prevent postoperative stress ulcers, omeprazole sodium injection (40 mg, intravenous infusion, once daily) was administered for 5 consecutive days.

2.3 Observational indicators

1. Preoperative clinical data were collected for each patient, including sex, age, body mass index (BMI), hepatitis history (distinguishing between hepatitis B and hepatitis C), hepatic resection site (left or right hemihepatectomy), tumor type, *American Society of Anesthesiologists* (ASA) classification, Eastern Cooperative Oncology Group (ECOG) performance status score, tumor staging, and comorbidities (presence of cardiovascular disease, diabetes, or respiratory disorders).
2. 8 mL of fasting venous blood from subjects were collected, subjected to centrifugation, and the upper liquid was stored in a – 45 ℃ refrigerator for subsequent testing. An automatic biochemical analyzer was used to test liver func-

tion indicators, including serum AST, ALT, and TBIL; nutritional indicators such as ALB, PA, and TP changes, as well as plasma endotoxin concentration were detected.
3. Clinical indicators of subjects after surgery were recorded, including time to first flatus, time to first bowel movement, time to ambulation, and hospital stay.
4. Postoperative complications were recorded, including occurrences of infection, bleeding, bile leakage, and other relevant adverse events.
5. The quality of life of patients before and after intervention was systematically assessed using the EORTC QLQ-C30. The main observation indicators included overall health status, physical function, role function, emotional function, social function.
6. Postoperative complications and mortality of patients were collected, and the incidence of complications and mortality rate were calculated.

2.4 Statistical processing

SPSS 22.0 software was employed. Measurement data conforming to normal distribution were presented by mean ± sd ($\bar{x} \pm s$), and categorical data were presented by frequency and percentage (%). Non-normally distributed quantitative data were analyzed adopting Mann-Whitney test, normally distributed quantitative data were analyzed adopting one-way ANOVA, and comparisons for categorical data were made using χ^2 test. A two-tailed test with $P < 0.05$ was considered statistically meaningful.

3 Results

3.1 Contrast of clinical data of subjects

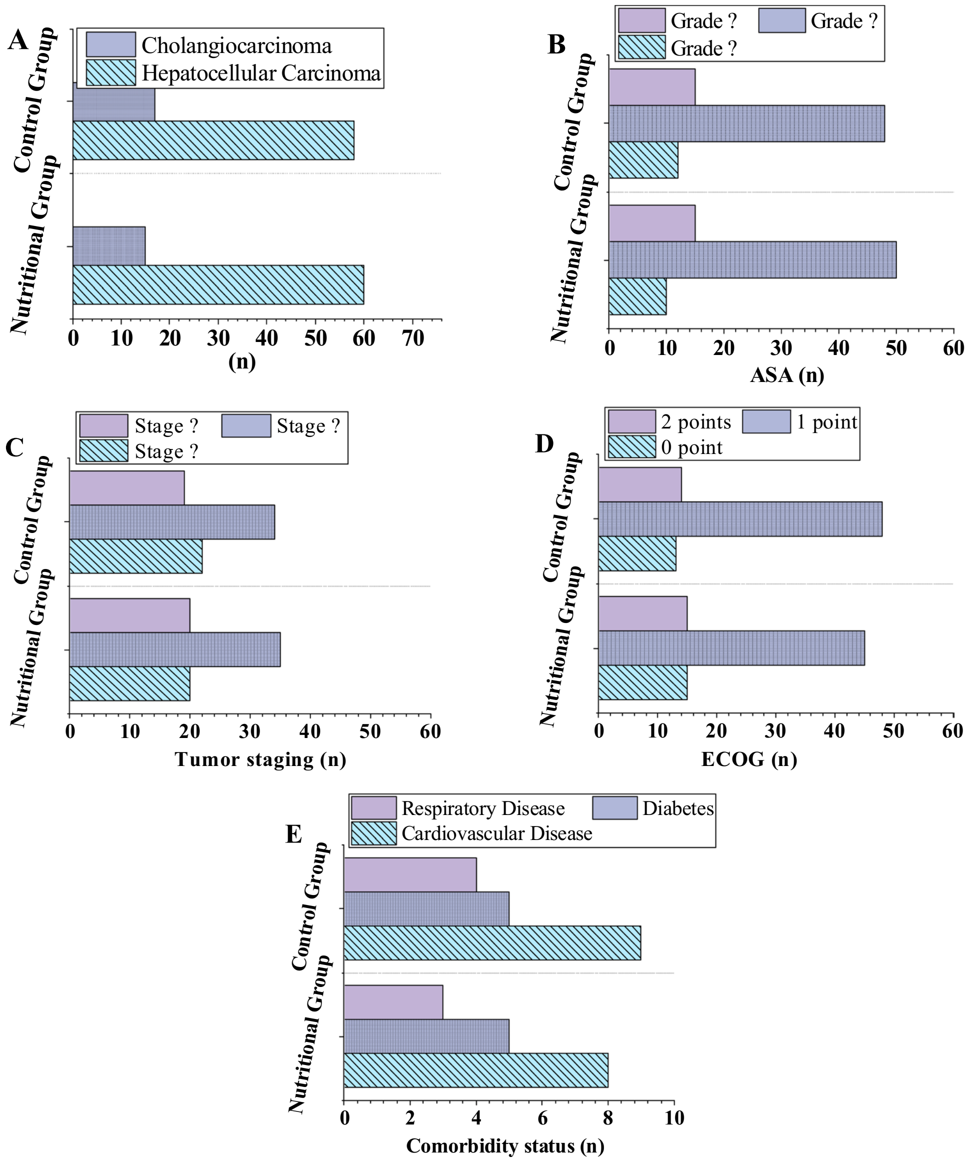
In Table 1, no statistically meaningful distinction was noted in gender, age, BMI, history of hepatitis, and liver resection site (left, right) between the NG and the CG ($P > 0.05$).

In Fig. 1, the NG included 60 cases of hepatocellular carcinoma and 15 cases of cholangiocarcinoma. The ASA classification distribution was as follows: 10 patients in Class I, 50 in Class II, and 15 in Class III. ECOG performance status scores were 0 in 15 patients, 1 in 45 patients, and 2 in 15 patients. Tumor staging was as follows: 20 cases in Stage I, 35 in Stage II, and 20 in Stage III. Comorbidities included 8 cases of cardiovascular disease, 5 cases of diabetes, and 3 cases of respiratory diseases. In the CG, there were 58 cases of hepatocellular carcinoma and 17 cases of cholangiocarcinoma. The ASA classification was distributed as follows: 12 patients in Class I, 48 in Class II, and 15 in Class III. ECOG performance status scores were 0 in 13 patients, 1 in 48 patients, and 2 in 14 patients. Tumor staging included 22 cases in Stage I, 34 in Stage II, and 19 in Stage III. Comorbidities included 9 cases of cardiovascular disease, 5 cases of diabetes, and 4 cases of respiratory diseases. Comparisons between the NG and CG regarding tumor type, ASA classification, ECOG performance status score, tumor stage, and comorbidities showed no statistically significant differences ($P > 0.05$).

Table 1 Contrast of clinical data of subjects

Item	NG (n = 75)	CG (n = 75)	Statistic (χ^2/t)	*P* value
Age (years)	48.83 ± 7.03	47.97 ± 6.55	0.76	0.448
Gender [n(%)]				
Male	48 (64.0%)	44 (58.7%)	0.46	0.498
Female	27 (36.0%)	31 (41.3%)		
History of hepatitis [n(%)]				
Hepatitis B	68 (90.7%)	7 (9.3%)	0.48	0.175
Hepatitis C	66 (88.0%)	9 (12.0%)	1.13	0.356
Surgical site [n(%)]				
Left hepatic lobe	41 (54.7%)	43 (57.3%)	0.11	0.744

Fig. 1 Comparison of partial clinical data between the two groups of patients: **A** tumor type; **B** ASA classification; **C** tumor staging; **D** ECOG performance status score; **E** comorbidities



3.2 Contrast of liver function indicators in subjects

In Fig. 2, no statistically meaningful distinction was noted in the levels of liver function indicators such as AST, ALT, and TBIL between the NG and the CG before intervention (P >0.05). Following intervention, AST ($P = 0.023$) and ALT ($P = 0.031$) in the NG were visibly lower, while TBIL ($P = 0.018$) was visibly higher ($P < 0.05$); AST ($P = 0.015$) and ALT ($P = 0.027$) in the NG were visibly lower as against the CG (P <0.05), while no statistically meaningful distinction was noted in TBIL of the NG compared to the CG ($P > 0.05$).

3.3 Contrast of nutritional indicators in subjects

In Fig. 3, no statistically meaningful distinction was noted in the levels of nutritional indicators such as ALB, PA, and TP between the NG and the CG before intervention ($P > 0.05$). Following intervention, ALB ($P = 0.018$), PA ($P = 0.24$), and TP ($P = 0.033$) in the NG were visibly higher than those before intervention, while TBIL was visibly elevated; ALB ($P = 0.045$), PA ($P = 0.011$), and TP ($P = 0.017$) in the NG were visibly higher as against the CG ($P < 0.05$).

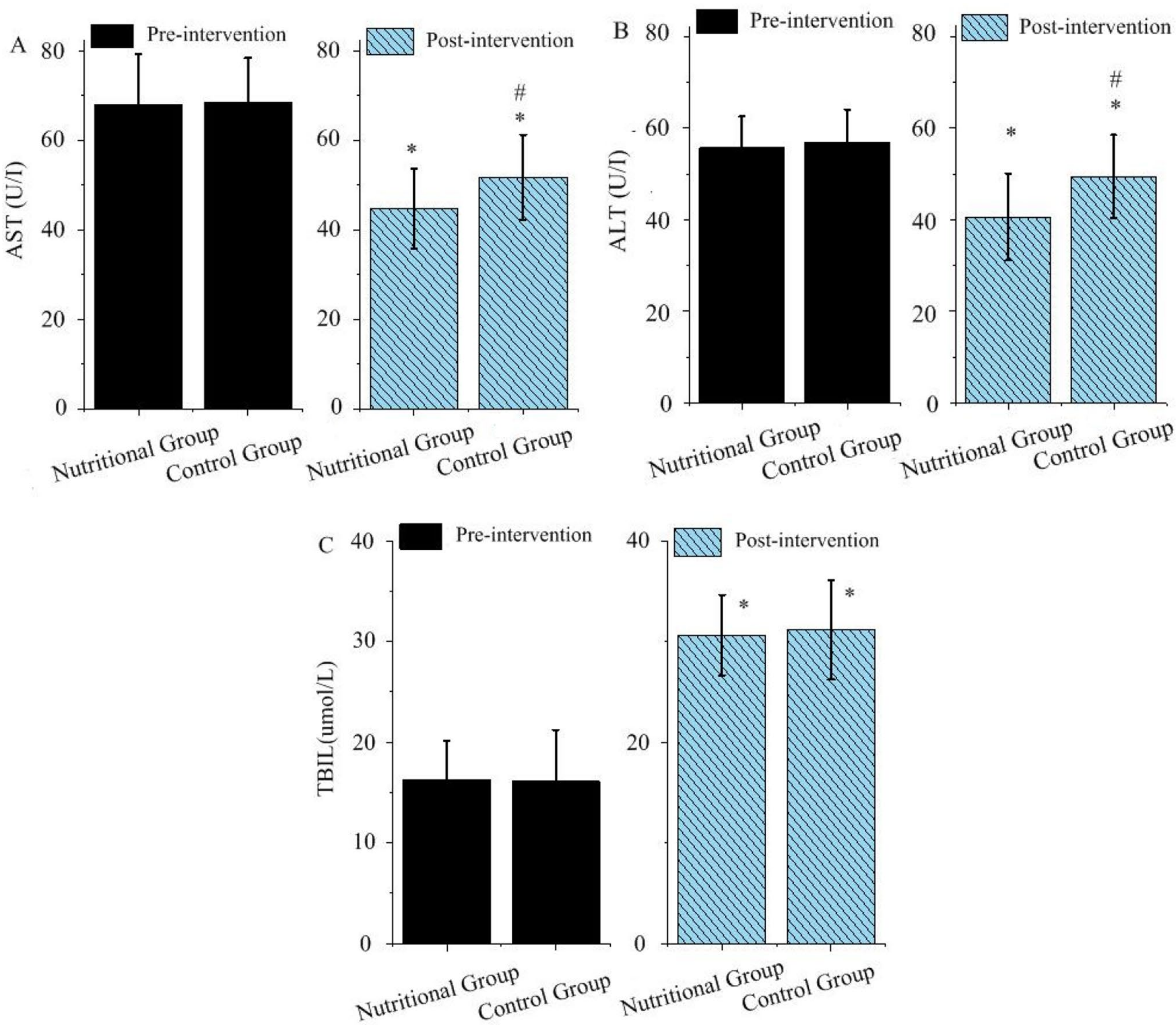


Fig. 2 Contrast of liver function indicators in subjects. (**A** for AST; **B** for ALT; **C** for TBIL). Note: * as against before intervention, # as against the NG, $P < 0.05$

3.4 Contrast of plasma endotoxin concentrations in subjects

In Fig. 4, no statistically meaningful distinction was noted in the levels of plasma endotoxin between the NG and the CG before intervention ($P > 0.05$). Following intervention, plasma endotoxin ($P = 0.009$) in the NG was visibly higher than that before intervention; plasma endotoxin ($P = 0.015$) in the NG was markedly lower as against the CG ($P < 0.05$).

3.5 Contrast of postoperative clinical indicators in subjects

In Figs. 5, 6, no statistically meaningful distinction was noted in the time to first flatus, time to ambulation, and hospital stay between the NG and the CG ($P > 0.05$). The time to first bowel movement ($P = 0.048$) in the NG was markedly lower as against the CG ($P < 0.05$).

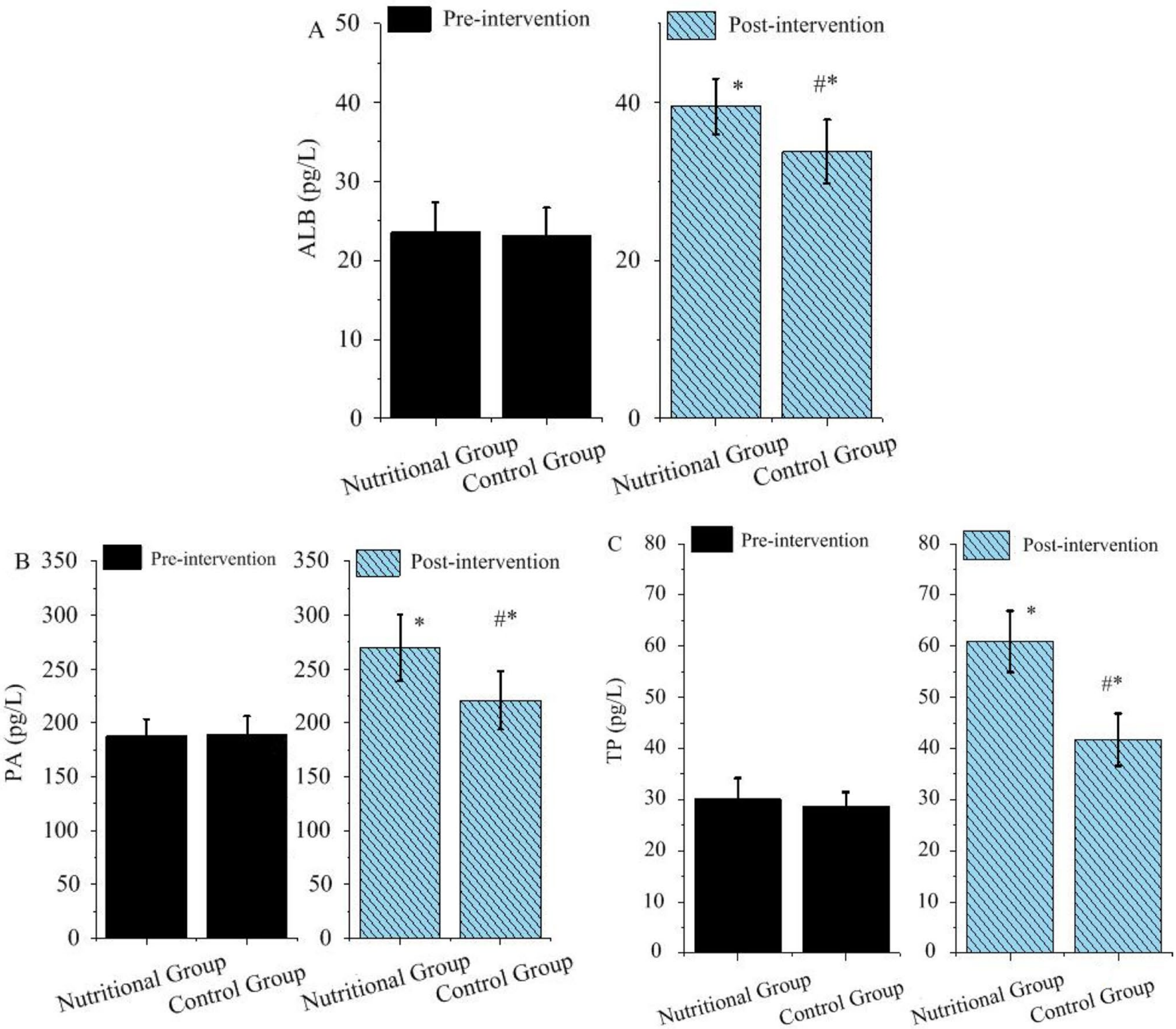


Fig. 3 Contrast of nutritional indicators in subjects. (**A** for ALB; **B** for PA; **C** for TP). Note: * as against before intervention, # as against the NG, *P* <0.05

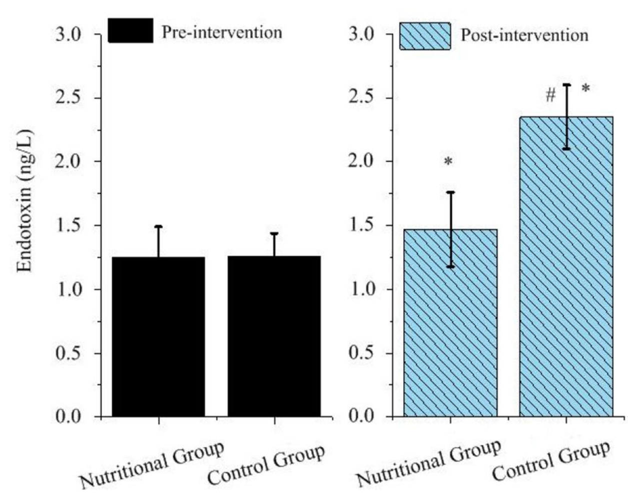


Fig. 4 Contrast of plasma endotoxin in subjects. Note: * as against before intervention, # as against the NG, *P* < 0.05

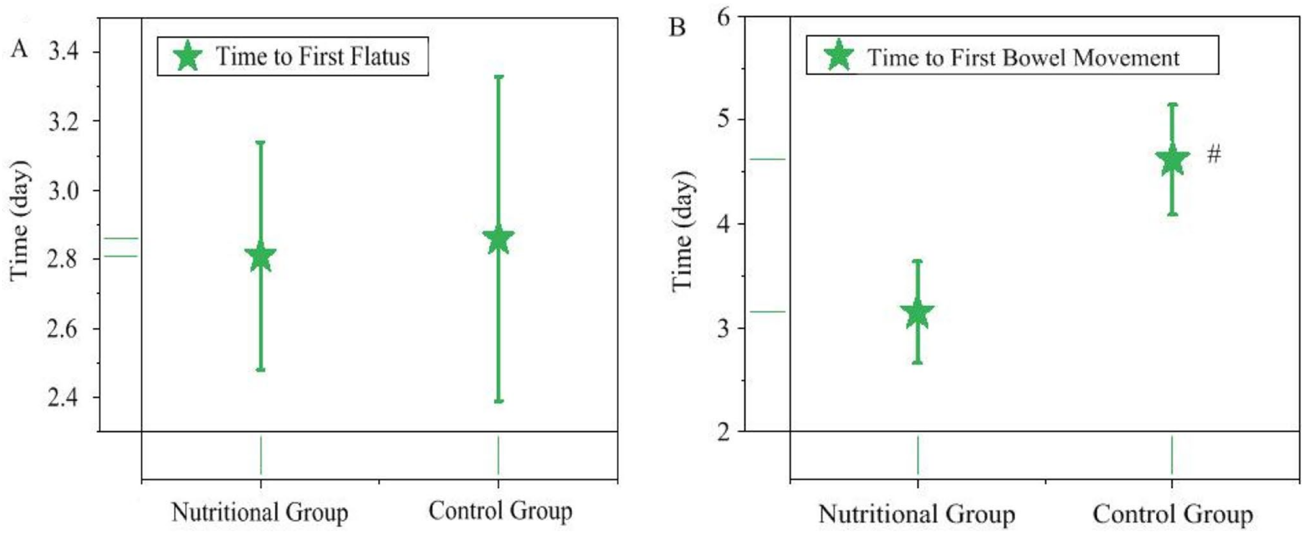


Fig. 5 Contrast of time to first flatus and time to first bowel movement in subjects. (**A** for time to first flatus; **B** for time to first bowel movement). Note: # as against the NG, $P < 0.05$

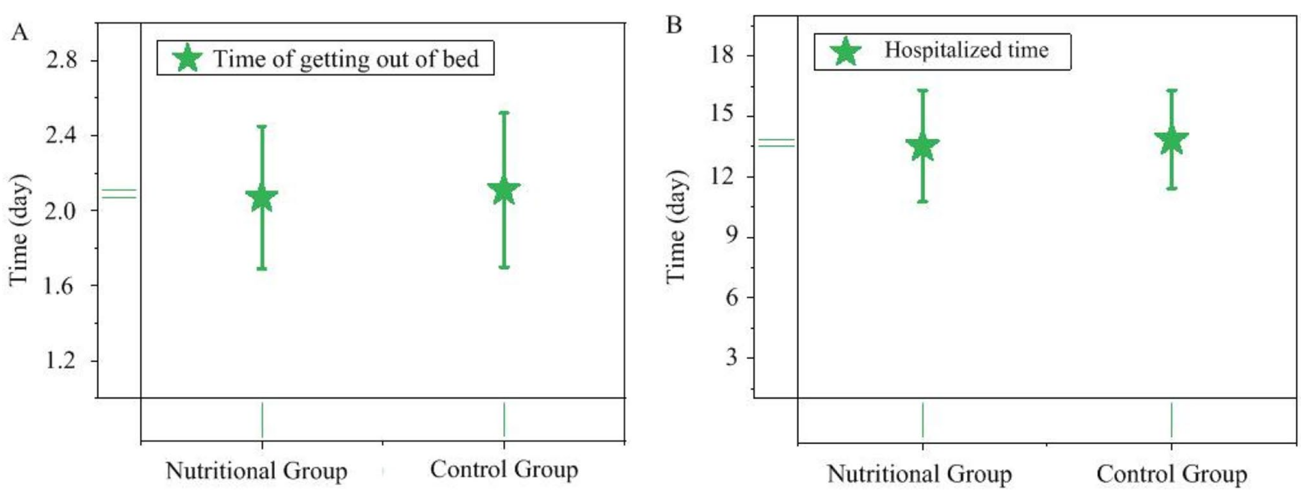


Fig. 6 Contrast of time to ambulation and hospital stay in subjects. (A for time to ambulation; B for hospital stay)

3.6 Comparison of postoperative complications between the two groups

In Fig. 7, the NG experienced 8 cases of infection (10.67%), including 5 cases of pulmonary infection and 3 cases of wound infection. There were 3 cases of bleeding (4.00%), all of which were early postoperative intra-abdominal hemorrhages. Additionally, 2 cases of bile leakage (2.67%) occurred, both of which healed with conservative treatment. In the CG, 12 cases of infection (16.00%) were observed, including 7 cases of pulmonary infection and 5 cases of wound infection. There were 5 cases of bleeding (6.67%), consisting of 4 cases of intra-abdominal bleeding and 1 case of gastrointestinal bleeding. Furthermore, 3 cases of bile leakage (4.00%) were reported, with 2 cases recovering through drainage and other conservative treatments, and 1 case improving after a second surgical intervention. Statistical analysis revealed that the infection ($P = 0.014$), bleeding ($P = 0.038$), and bile leakage ($P = 0.035$) rates in the NG were significantly lower than those in the CG.

3.7 Comparison of quality of life between the two groups

In Fig. 8, there was no significant difference in the total score of the EORTC QLQ-C30 scale between the NG and the CG before intervention ($P > 0.05$). After intervention, the total score of the EORTC QLQ-C30 scale in the NG was

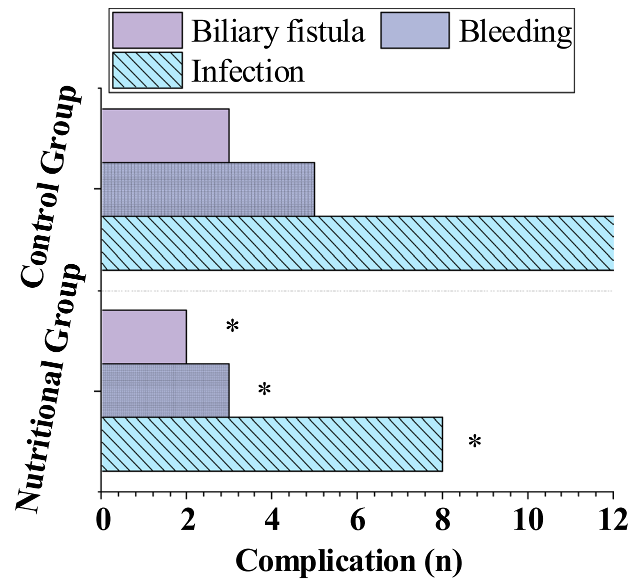


Fig. 7 Comparison of postoperative complications between the two groups. Note: * indicates a statistically significant difference compared to the CG ($P < 0.05$)

significantly higher than that before intervention, while the total bilirubin level was significantly increased, with the differences being statistically significant ($P < 0.05$). The total score of the EORTC QLQ-C30 scale in the NG after intervention was also significantly higher than that in the CG, with the difference being statistically significant ($P = 0.012$).

3.8 Comparison of postoperative complications and mortality between the two groups

The analysis of postoperative complications showed that the total incidence of complications in the NG was 6.7% (5/75), which was significantly lower than the 17.3% (13/75) in the CG ($P = 0.042$). The specific distribution of complications was as follows: wound infection (2 cases in the NG vs. 5 cases in the CG), bile leakage (1 case vs. 3 cases), intra-abdominal hemorrhage (1 case vs. 2 cases), and pulmonary infection (1 case vs. 3 cases). There was no significant difference in 30-day mortality between the two groups (0 cases in the NG vs. 1 case in the CG, $P = 0.154$) (Fig. 9).

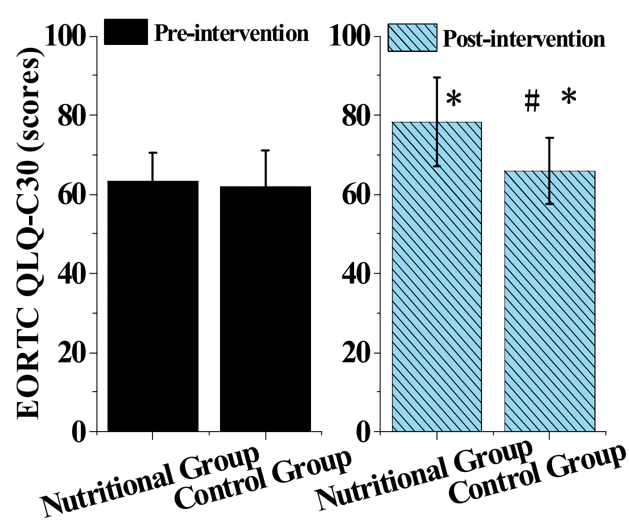


Fig. 8 Comparison of quality of life between the two groups. Note: * indicates a statistically significant difference compared with before intervention ($P < 0.05$); # indicates a statistically significant difference compared with the NG ($P < 0.05$)

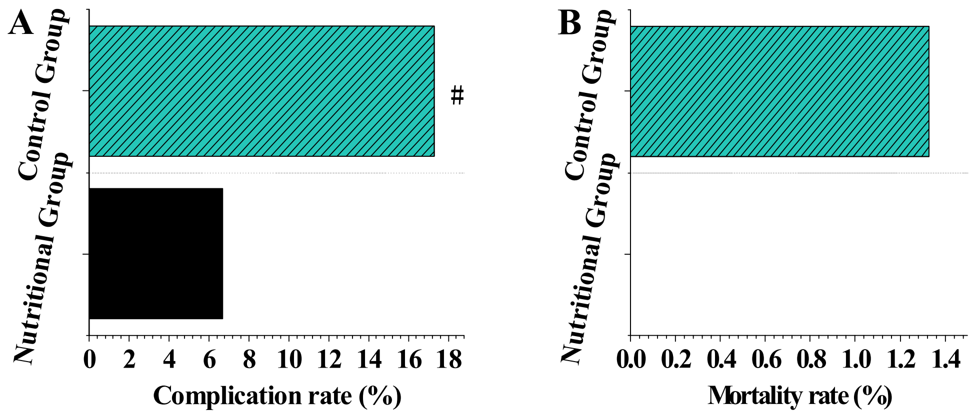


Fig. 9 Comparison of quality of life between the two groups. (**A**: incidence of complications; **B**: mortality rate). Note: # indicates a statistically significant difference compared with the NG ($P < 0.05$)

4 Discussion

LC is one of the malignant tumors with high incidence and mortality rates worldwide. Laparoscopic hepatolobectomy, as an important surgical method for the treatment of primary LC, has been widely applied in clinical practice. Despite continuous advancements in surgical techniques, postoperative recovery of patients is still influenced by various factors, among which nutritional support is a key component in postoperative recovery [7, 18]. Postoperative malnutrition not only affects patients' immune function but also delays the recovery process and increases the incidence of complications. Therefore, how to choose a reasonable nutritional support plan to promote postoperative recovery has become an important issue in clinical treatment [4]. This article aimed to explore the clinical effects of early combined EN plus PN support on patients with primary LC after laparoscopic hepatolobectomy and compare it with traditional single EN support. Firstly, the improvement in liver function indicators was one of the important findings of this article. It suggested that the levels of AST and ALT in the NG were markedly lower after surgery relative to before intervention, while the level of TBIL increased. These changes indicate that nutritional support can effectively reduce the metabolic burden on the liver and promote the recovery of liver function. Especially in the recovery process of LC patients after surgery, the recovery of liver function is crucial for prognosis. Compared with the CG, the markedly lower levels of liver enzymes in the NG further confirmed that EN plus PN support contribute to the improvement of liver function, which is consistent with existing clinical understanding and suggests that early comprehensive nutritional intervention can better promote liver repair [17]. The results showed that patients who received early EPN support experienced significant improvements in quality of life after laparoscopic hepatolobectomy, with a marked increase in their total EORTC QLQ-C30 scale scores compared to before intervention, and significantly better outcomes than those in the conventional nutrition support group. This improvement may be attributed to the combined nutrition program more comprehensively meeting the nutritional needs during the postoperative recovery period and effectively alleviating the metabolic stress response caused by surgical trauma [19]. Although a transient increase in total bilirubin levels was observed in the early postoperative period, this temporary change in liver function indicators did not have a negative impact on the overall quality of life of patients. Instead, the EPN group demonstrated a faster recovery trend, with significant advantages in relieving fatigue symptoms and restoring the ability to perform daily activities. This finding suggests that implementing early combined nutritional intervention after laparoscopic hepatectomy not only supports the physiological recovery of patients but also enhances their overall postoperative rehabilitation experience and quality of life, holding important clinical value for wider application [5].

In addition, ALB, PA, and TP in the NG were markedly higher after surgery relative to before intervention, and there were also visible distinctions compared with the CG, indicating that early combined nutritional support can effectively improve the nutritional status of patients. ALB and TP are important indicators reflecting the nutritional status of the body, especially in LC patients, where postoperative nutritional recovery is crucial for the recovery of immune function [6]. By providing comprehensive nutritional support, the NG could recover physical strength more quickly and reduce the occurrence of postoperative complications. This result further confirms the important role of early combined nutritional support in LC patients after surgery, especially in improving the nutritional status and immune function of patients. It is worth noting that plasma endotoxin levels are also an important indicator for assessing postoperative inflammatory responses and immune status [11]. This article suggested that the plasma endotoxin levels in the NG were markedly lower as against the CG after surgery. This finding indicates that early EN plus PN support not only helps to improve nutritional status but also regulates postoperative inflammatory responses and reduces the risk of postoperative infection. Traditional clinical management usually focuses on drug treatment and other supportive treatments, but this article further proves that early nutritional intervention can play a positive role in improving immune function and suppressing inflammatory responses, promoting postoperative recovery of patients. Finally, although there was no visible distinction in the time to first flatus, time to ambulation, and hospital stay in the subjects, the time to first bowel movement in the NG was markedly lower as against the CG, suggesting that early combined nutritional support helps to promote the recovery of gastrointestinal function. A shorter time to first bowel movement usually means that intestinal motility recovers quickly, and patients can return to normal physiological functions as soon as possible, further accelerating the overall recovery process. This is consistent with the conventional understanding of LC patients after surgery, that the recovery of gastrointestinal function is crucial for the overall postoperative recovery of patients [16]. In this study focused on patients undergoing laparoscopic liver lobectomy, the occurrence of postoperative complications in the NG and the CG was carefully observed and analyzed. According to the data, regarding infections, the infection rate in the NG was 10.67% (8 cases), including 5 cases of pulmonary infection and 3 cases of wound infection. In the CG, the infection rate was 16.00% (12 cases), with 7 cases of pulmonary infection and 5 cases of wound infection. Statistical analysis showed that the infection rate in the NG was significantly lower than that in the CG ($P = 0.014$), suggesting that early combined enteral and PN support (nutrition group) may help enhance the patient's resistance and reduce the risk of infection. This may be because nutritional support optimizes the patient's nutritional status, thereby improving immune function [12]. In terms of bleeding, the bleeding rate in the nutrition group was 4.00% (3 cases), all of which were early postoperative intra-abdominal hemorrhages. The bleeding rate in the CG was 6.67% (5 cases), including 4 cases of intra-abdominal bleeding and 1 case of gastrointestinal bleeding. The bleeding rate in the NG was significantly lower than that in the CG ($P = 0.038$). This may be related to nutritional support promoting the recovery of postoperative coagulation function or improving the quality of the vascular wall, thereby reducing the occurrence of bleeding. Regarding bile leakage, the bile leakage rate in the NG was 2.67% (2 cases), both of which healed with conservative treatment. The bile leakage rate in the CG was 4.00% (3 cases), with 2 cases recovering through drainage and other conservative treatments, and 1 case improving after a second surgical intervention. The bile leakage rate in the NG was significantly lower than that in the CG ($P = 0.035$). This may suggest that nutritional support played a positive role in the repair and healing of the liver and biliary system, thereby reducing the probability of bile leakage. The results showed that perioperative nutritional support significantly reduced the total incidence of complications after hepatectomy in patients with LC (6.7% vs 17.3%, $P = 0.042$). This finding suggests that nutritional support may exert a comprehensive protective effect by improving the nutritional status and immune function of patients [mechanism explanation] [24]. It is worth noting that although no deaths were observed in the NG while one death occurred in the CG ($P = 0.154$), this difference needs to be verified by larger-scale studies due to the limitation of sample size. Overall, the results support the clinical value of perioperative nutritional intervention for patients undergoing hepatectomy for LC, and its benefit in reducing postoperative complications deserves attention.

5 Conclusion

This article confirmed that early EPN support during the perioperative period is more effective in promoting the recovery of patients with primary LC after laparoscopic hepatolobectomy than traditional single enteral nutrition. This nutritional support program not only significantly improved the liver function indicators and nutritional status of patients but also reduced the overall incidence of postoperative complications, showing significant advantages in key complications such as infection, bleeding, and bile leakage. The results support the inclusion of early combined nutritional intervention as an important part of the standard treatment after hepatectomy for LC.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Zhouxia Wei. The first draft of the manuscript was written by Yingxian Li, Suyan Jiang and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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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

Informed consent The authors affirm that human research participants provided informed consent for publication of the images in Figure(s) 1A, 1B and 1C. The participant has consented to the submission of the case report to the journal.

Patients signed informed consent regarding publishing their data and photographs.

Competing interests and Ethics approval The authors declare no competing interests. The authors have no relevant financial or non-financial interests to disclose. This retrospective chart review study involving human participants was in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Human Investigation Committee (IRB) of the Second People's Hospital of Lanzhou approved this study. [Approval number: 23-54].

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