Int J Clin Exp Med 2019;12(7):8502-8511
www.ijcem.com /ISSN:1940-5901/IJCEM0093202

Original Article

Enteral nutrition in combination with parenteral nutrition support improves liver function and immune cell and inflammatory cytokine levels after hepatectomy procedures in elderly patients with liver cancer

Feng Zhao[1], Ying Chen[2], Junliang Li[3], Dong Zhang[4]

[1]Catering Section, Gansu Provincial Hospital, Lanzhou, Gansu, China; [2]Department of Obstetrics and Gynecology, Gansu Provincial Hospital, Lanzhou, Gansu, China; [3]Department of General Surgery, Lanzhou, Gansu, China; [4]Department of Medical Quality Control, Gansu Provincial Hospital, Lanzhou, Gansu, China

Received March 1, 2019; Accepted May 10, 2019; Epub July 15, 2019; Published July 30, 2019

Abstract: Objective: The aim of the current study was to investigate the effects of the combination of enteral nutrition and parenteral nutrition on liver function, immune cells, and inflammatory cytokines after hepatectomy procedures in elderly patients with liver cancer. Methods: Of the 103 patients, 48 patients received enteral nutrition in combination with parenteral nutrition (study group). A total of 55 patients received only parenteral nutrition (control group) after hepatectomy procedures. This study recorded changes in nutrition indices at 1 day before nutrition (0 d) and 3 days (3 d) and 7 days (7 d) after nutrition initiation. Results: At 3 and 7 days after nutrition initiation, ALB and PA levels were significantly higher in the study group than the control group ($P < 0.05$). Differences were observed in IL-6, IL-10, and TNF-α levels. Intragroup comparisons showed that ALB and PA levels persistently increased, in a time-dependent manner, in both groups ($P < 0.05$). Changes in HGB levels in the control group showed no statistical significance ($P > 0.05$), while intragroup comparisons of HGB levels showed that levels at 7 days were significantly higher than those at 0 days ($P < 0.05$). Intragroup comparisons suggested that Tbil, Dbil, ALT, and AST levels all decreased in a time-dependent and persistent manner ($P < 0.05$). Significant differences were identified at 3 and 7 days in the numbers of $CD8^+$ and $CD4^+CD25^+$ T-cells ($P < 0.05$). In the study group, ALB and PA levels were higher than those in the control group ($P < 0.05$). Conclusion: Additional enteral nutrition can improve postoperative nutrition, liver function, and immune function, as well as mitigate inflammatory responses more efficiently, in patients undergoing hepatectomy procedures for liver cancer.

Keywords: Enteral nutrition, parenteral nutrition, hepatectomy, liver function, immune cells, inflammatory cytokines

Introduction

Liver cancer is a malignancy with a highest prevalence worldwide [1]. Liver cancer affects people at all ages, but mostly those between 40 and 49 years old [2]. Approximately 200,000 patients die of liver cancer each year [3, 4].

The liver is the central organ of nutrient metabolism. Liver cancer reduces the absorption of nutrition. Hepatectomy procedures result in a large wound, causing disorders in homeostasis and metabolism. This further contributes to malnutrition and a decline in immune function in patients undergoing this procedure. Such drawbacks decrease surgical efficacy, leading to hypoproteinemia and electrolyte disturbances, even recurrence of liver cancer in some severe cases [5, 6]. The elderly population is the most vulnerable to diseases. Thus, postoperative nutrition for elderly patients with liver cancer is particularly important.

Nutritional support has been widely accepted as one of the top 10 medical achievements in the 21st century [7, 8]. Currently, nutritional support is generally divided into 2 types, enteral nutrition and parenteral nutrition. Parenteral nutrition, the standard method for nutritional support, resolves the nutritional problems of

critically ill patients. However, long-term administration and large amounts of parenteral nutrition induce a series of complications, such as disturbances of carbohydrate metabolism, liver function impairment, and problems associated with the use of central venous catheters [9, 10]. Enteral nutrition, complying to the physiological pathway, prevents mucosal atrophy and intestinal flora disturbances. It has been frequently applied in surgical treatment. However, total enteral nutrition also induces various complications, including nausea, vomiting, and diarrhea. Moreover, elderly patients are less tolerant to early enteral nutrition [11, 12]. Recent studies have indicated that patients should receive enteral nutrition in combination with parenteral nutrition at an early stage after surgery [13, 14]. However, there is little information concerning the application of this combined nutritional support in the treatment of elderly patients with liver cancer.

Therefore, the current study retrospectively analyzed clinical data from 103 elderly patients with liver cancer that received postoperative nutrition after hepatectomy procedures. This study aimed to identify the value of combined enteral nutrition and parental nutrition in the postoperative treatment of elderly patients with liver cancer undergoing hepatectomy procedures.

Materials and methods

Subjects

A retrospective analysis was performed using clinical data from the 103 elderly patients with liver cancer that underwent hepatectomy procedures in Gansu Provincial Hospital, between March 2014 and May 2018. Of the 103 patients, 48 received enteral nutrition in combination with parental nutrition (study group), while 55 received only parenteral nutrition (control group), postoperatively. Inclusion criteria: Patients were diagnosed as having liver cancer [American Society of Anesthesiologists (ASA) grade II-III and Child-Pugh A] by pathological examinations, with no aberrant white blood cell counts or lymphocyte counts; Imaging diagnosis showed no distant metastasis; Patients were available for radical resections; Patients had received no anti-tumor therapies; No organ dysfunction involving the heart or kidneys, abnormal hemorrhages, or coagulation function; Patients had no portal hypertension, gastrointestinal diseases, or a history of tumors; After diagnosis, patients voluntarily underwent examination and treatment and cooperated with the medical staff of the hospital; Enrolled patients had integral clinical data. Exclusion criteria: Patients with a Mini Mental State Examination score of < 24 points; Loss of clinical data; History of hepatitis, mental disorders, or learning disabilities; Excessively large tumor volume and cardiovascular or cerebrovascular complications; Respiratory or gastrointestinal diseases; Patients transferred to other hospitals; Patients administered antibiotics or rehabilitation training in other hospitals. This study was approved by the Ethics Committee of the Gansu Provincial Hospital. Included patients and family members provided written informed consent.

Treatment methods

Patients in the control group received parenteral nutrition, while those in the study group received enteral nutrition in addition to parenteral nutrition. For all patients, nutritional support was initiated at day 2 after surgery, lasting for 7 days. Parenteral nutrition was given at day 2 after surgery via peripheral venous infusions (glucose, medium- and long-chain fat emulsion injection, vitamin and proteins, with total energy 43.2-57.6 kcal) for over 12 hours, with an osmotic pressure < 1200 mOsm/L H_2O. For enteral nutrition, a nose-duodenum tube was used to infuse 500-1000 mL of 5% glucose, based on patient conditions, for 24 hours on day 2 after surgery. On day 3, Fresubin (SFDA no. J20090096; Fresenius KABI SSPC) was infused at a rate of 20 mL/h initially. The rate was then adjusted depending on patient conditions. Daily energy demand = 30~40 kcal/kg × body weight (kg) × age coefficient × activity coefficient (AF) × body temperature coefficient (TF).

Observation indices

The current study observed changes in nutrition indices [prealbumin (PA), albumin (ALB), and hemoglobin (HGB)], indicators of liver function [total bilirubin (Tbil), direct bilirubin (Dbil), alanine transaminase (ALT), and aspartate aminotransferase (AST)], immune cells ($CD4^+$, $CD8^+$, and $CD4^+CD25^+$ T-cells), and inflammatory cytokines [interleukin [IL]-1, IL-6, IL-10, and

Table 1. General information of patients

	Control group (n = 48)	Study Group (n = 55)	χ^2	*p*-valued
Sex [(n%)]			0.001	0.969
Male	26 (54.17)	30 (54.55)		
Female	22 (45.83)	25 (45.45)		
Age (year)	65.24 ± 5.32	66.27 ± 5.29	0.983	0.328
BMI (kg/m^2)	18.83 ± 3.12	18.49 ± 3.28	0.537	0.593
ASA class [(n%)]			0.008	0.927
II	24 (50.00)	27 (49.09)		
III	24 (50.00)	28 (50.91)		
Diameter [(n%)]			0.014	0.993
≤ 5 cm	11 (22.92)	13 (23.64)		
> 5 cm, < 10 cm	27 (56.25)	31 (56.36)		
≥ 10 cm	10 (20.83)	11 (20.00)		
Postoperative liver volume (L)	0.53 ± 0.13	0.50 ± 0.12	1.217	0.226
Operative time (min)	242.49 ± 13.51	246.63 ± 13.29	1.565	0.121
Waking time (min)	31.45 ± 9.42	33.73 ± 9.48	1.221	0.225
Bleeding (mL)	912.45 ± 62.57	908.15 ± 61.69	0.351	0.727
Degree of education [(n%)]				
Junior high school and below	18 (37.50)	20 (36.36)		
Junior high school above	30 (62.50)	35 (63.64)		
Residence [(n%)]				
Village	21 (43.75)	29 (52.73)		
City	27 (56.25)	26 (47.27)		

Table 2. Changes in nutritional indicators in the two patient groups

		Control group (n = 48)	Study Group (n = 55)	t value	*p*-valued
ALB (g/L)	0 d	31.46 ± 3.85	31.87 ± 3.63	0.556	0.580
	3 d	34.83 ± 3.88*	36.72 ± 3.74*	2.514	0.014
	7 d	35.25 ± 3.92$^{*,\#}$	38.69 ± 4.03$^{*,\#}$	4.377	< 0.001
PA (mg/L)	0 d	121.89 ± 13.36	123.14 ± 13.28	0.475	0.636
	3 d	142.59 ± 15.67*	182.64 ± 16.43*	12.609	< 0.001
	7 d	194.57 ± 16.44$^{*,\#}$	223.12 ± 16.59$^{*,\#}$	8.749	< 0.001
HGB (g/L)	0 d	114.26 ± 13.52	115.96 ± 12.87	0.653	0.515
	3 d	116.97 ± 12.84	118.42 ± 13.45	0.557	0.579
	7 d	117.59 ± 14.33	122.37 ± 14.76*	1.662	0.100

Note: *P < 0.05 compared with 0 d; $^\#$P < 0.05 compared with 3 d.

tumor necrosis factor (TNF)-α] at 1 day before nutrition initiation (0d) and at day 3 (3 d) and day 7 (7 d) after nutrition initiation. Indicators of nutrition and lung function were assessed using a Beckman Coulter AU5800 automatic biochemical analyzer [Beckman Coulter Commercial Enterprise (China) Co., Ltd.]. Immune cells were measured using a flow cytometer [DxFLEX; Beckman Coulter Commercial Enterprise (China) Co., Ltd.]. Levels of inflammatory cytokines were determined using enzyme-linked immunosorbent assays (ELISA).

ELISA

Fasting peripheral blood samples were collected in the morning and tested within 1 hour. Serum was collected from centrifuged samples for measurement of inflammatory cytokines. In each well, 50 μL serum was incubated with 50 μL analytic buffer for 2 hours, then the plate was rinsed 5 times. Afterward, the biotinylated antibody was added (100 μL/well) and the plate was sealed for incubation in a dark place at room temperature for 20 minutes. Next, 100 μL TMB was added into each well before incubation for another 20 minutes. The reaction was then terminated by adding a stopping buffer (50 μL/well). Optical density values at a wavelength of 450 nm were measured within 15 minutes using a microplate

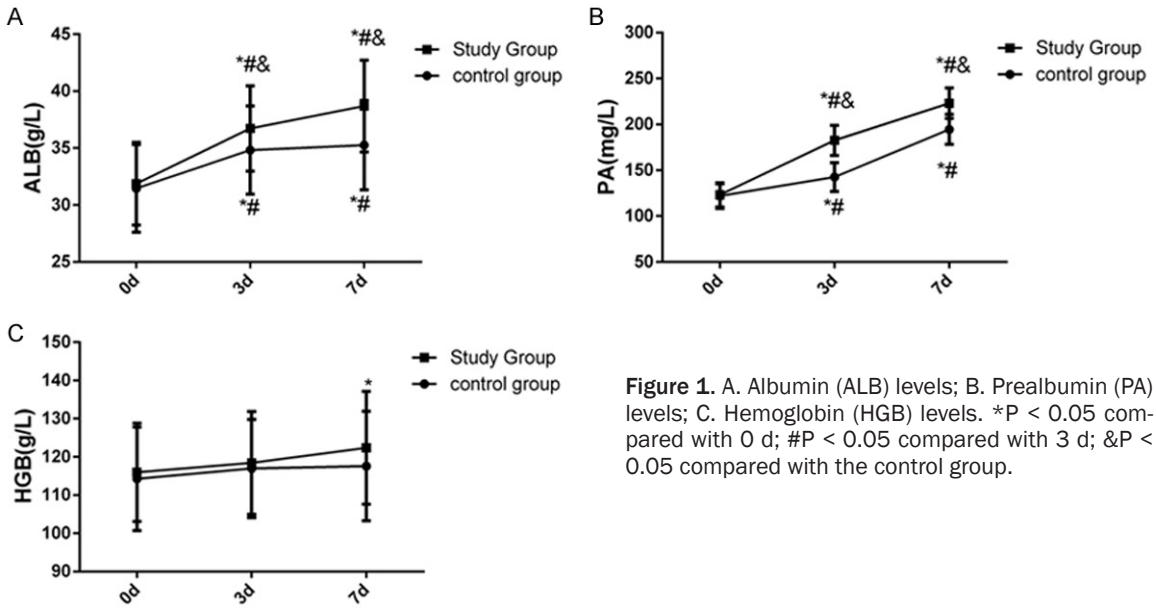

Figure 1. A. Albumin (ALB) levels; B. Prealbumin (PA) levels; C. Hemoglobin (HGB) levels. *P < 0.05 compared with 0 d; #P < 0.05 compared with 3 d; &P < 0.05 compared with the control group.

Table 3. Changes in liver function parameters in the two patient groups

		Control group (n = 48)	Study Group (n = 55)	t value	*p*-valued
Tbil (μmol/L)	0 d	28.25 ± 2.22	28.67 ± 2.18	0.967	0.336
	3 d	26.64 ± 2.17*	24.39 ± 1.96*	5.529	< 0.001
	7 d	19.43 ± 1.82*,#	17.48 ± 1.77*,#	5.505	< 0.001
Dbil (μmol/L)	0 d	22.58 ± 1.81	22.02 ± 1.88	1.534	0.128
	3 d	20.37 ± 1.62*	18.73 ± 1.65*	5.075	< 0.001
	7 d	17.46 ± 1.52*,#	14.48 ± 1.47*,#	10.102	< 0.001
AL (U/L)	0 d	122.33 ± 12.56	122.67 ± 12.49	0.137	0.891
	3 d	101.83 ± 12.24*	81.42 ± 11.06*	8.889	< 0.001
	7 d	71.29 ± 9.04*,#	56.13 ± 7.58*,#	9.257	< 0.001
AS (U/L)	0 d	125.69 ± 13.17	126.03 ± 13.42	0.129	0.897
	3 d	114.72 ± 12.98*	96.93 ± 10.54*	7.673	< 0.001
	7 d	84.12 ± 8.49*,#	62.42 ± 7.17*,#	14.063	< 0.001

Note: *P < 0.05 compared with 0 d; #P < 0.05 compared with 3 d.

reader. For this experiment, each sample was determined in triplicate, with 3 replicates each time. ELISA kits for IL-10 and IL-17 were purchased from Shanghai Jingkang Biological Engineering Co., Ltd.

Statistical analysis

SPSS 19.0 software (IBM, Armonk, NY, USA) was used for data processing. Enumeration data, in the form of n (%), were compared using Chi-square tests. Measurement data are expressed as mean ± standard deviation and were compared between the 2 groups using a *t*-tests. Data was compared within one group using analysis of variance of repeated measurements. P < 0.05 suggests differences are statistically significant.

Results

General data

The 48 patients in the study group consisted of 26 men and 22 women, with an average age of 65.24 ± 5.32 years. The 55 patients in the control group consisted of 30 men and 25 women, with an average age of 66.27 ± 5.29 years. Comparisons of sex and age between the two groups showed no statistical significance (P > 0.05). Furthermore, differences in body mass index, ASA grades, tumor diameter, postoperative liver volume, operative times, recovery times, bleeding amount, education levels, and residence of patients showed no statistical significance between the 2 groups (P > 0.05; **Table 1**).

Changes in nutrition indicators

At 0 days, differences in ALB and PA levels between the 2 groups showed no statistical significance (P > 0.05). At 3 and 7 days, statistical

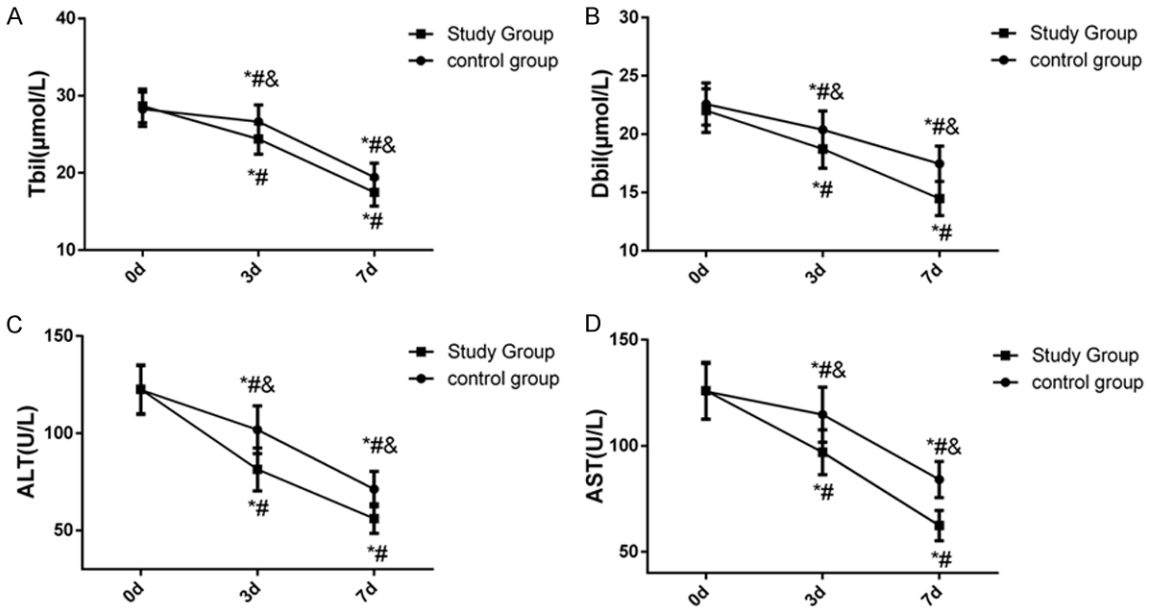

Figure 2. A. Total bilirubin (Tbil) levels; B. Direct bilirubin (Dbil) levels; C. Alanine transaminase (ALT) levels; D. Aspartate aminotransferase (AST) levels. *P < 0.05 compared with 0 d; #P < 0.05 compared with 3 d; &P < 0.05 compared with the control group.

Table 4. Changes in levels of immune cells in the two patient groups

		Control group (n = 48)	Study Group (n = 55)	t value	*p*-valued
$CD4^+$ T cell (%)	0 d	25.47 ± 1.62	25.18 ± 1.59	0.978	0.330
	3 d	27.69 ± 1.83*	28.33 ± 1.87*	1.750	0.083
	7 d	29.64 ± 1.86*,#	31.47 ± 2.04*,#	4.731	< 0.001
$CD8^+$ T cell (%)	0 d	26.34 ± 1.58	26.75 ± 1.64	1.287	0.201
	3 d	27.96 ± 1.62*	29.33 ± 1.81*	4.023	< 0.001
	7 d	30.17 ± 1.94*,#	32.24 ± 2.13*,#	5.128	< 0.001
$CD4^+$ $CD25^+$ T cell (%)	0 d	5.83 ± 1.02	5.67 ± 1.04	0.786	0.434
	3 d	6.16 ± 1.08*	6.73 ± 1.12*	2.620	0.010
	7 d	6.94 ± 1.13*,#	7.55 ± 1.17*,#	2.682	0.009

Note: *P < 0.05 compared with 0 d; #P < 0.05 compared with 3 d.

significance was identified in differences of ALB and PA levels between the 2 groups. Levels of ALB and PA in the study group were significantly higher than those in the control group (P = 0.014 and P < 0.001). HGB levels showed no statistically significant differences between the 2 groups at any time point (P > 0.05). Intragroup comparisons showed that ALB and PA levels persistently increased, in a time-dependent manner, in both groups (P < 0.001). Changes in HGB levels of patients in the control group showed no statistical significance (P > 0.05). Intragroup comparisons of HGB levels between 0 days and 3 days showed no statistically significant differences. However, levels at 7 days were significantly higher than those at 0 days (P < 0.001; **Table 2** and **Figure 1**).

Changes in liver function indicators

At 0 days, levels of Tbil, Dbil, ALT, and AST showed no statistically significant differences between the two groups (P > 0.05). However, statistical significance was identified in differences in these parameters at 3 and 7 days. Levels of the study group were all significantly lower than those of the control group (P < 0.001). Intragroup comparisons also suggested that levels of Tbil, Dbil, ALT, and AST decreased in a persistent and time-dependent manner (P < 0.001; **Table 3** and **Figure 2**).

Changes in the number of immune cells

At 0 days, patients in the 2 groups showed no statistically significant differences in the numbers of $CD4^+$, $CD8^+$, and $CD4^+CD25^+$ T-cells (*P* >

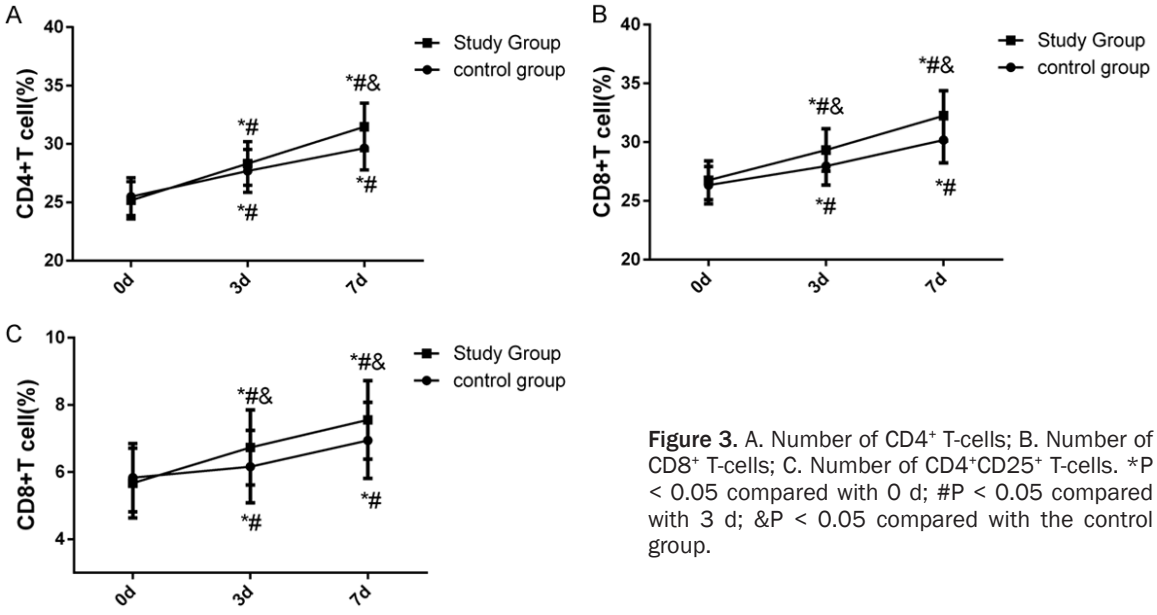

Figure 3. A. Number of $CD4^+$ T-cells; B. Number of $CD8^+$ T-cells; C. Number of $CD4^+CD25^+$ T-cells. *P < 0.05 compared with 0 d; #P < 0.05 compared with 3 d; &P < 0.05 compared with the control group.

0.05). However, statistically significant differences were identified at 3 and 7 days in the numbers of $CD8^+$ (P < 0.001) and $CD4^+$ (P = 0.010) $CD25^+$ T-cells (*P* = 0.009). In the study group, ALB and PA levels were higher than those in the control group (P < 0.001). At 3 days, there were no statistically significant differences in the number of $CD4^+$ T-cells between the 2 groups (P > 0.05). However, at 7 days, the number of $CD4^+$ T-cells in the study group was much greater than that in the control group (P < 0.001). Similarly, intragroup comparisons showed that the numbers of $CD4^+$, $CD8^+$, and $CD4^+CD25^+$ T-cells increased as the duration of nutrition increased (P < 0.001; **Table 4** and **Figures 3**, **4**).

Changes in levels of inflammatory cytokines

At 0 days, no statistically significant differences were identified in levels of IL-1, IL-6, IL-10, and TNF-α between the 2 groups (P > 0.05). At 3 and 7 day, statistically significant differences were observed in levels of IL-6, IL-10, and TNF-α between the 2 groups. Patients in the study group had higher levels of IL-6 and TNF-α (all P < 0.001) but had lower IL-10 levels (P < 0.001) than the control group. However, there was no statistical significance in differences in IL-1 level at 3 days between the 2 groups. At 7 days, the study group had significantly lower IL-1 levels than the control group (P < 0.001). Intragroup comparisons indicated that levels of IL-1, IL-6, and TNF-α continuously decreased, in a time-dependent manner (P < 0.001), although a reverse trend was identified in IL-10 levels (P < 0.001; **Table 5** and **Figure 5**).

Discussion

Liver cancer is a common malignancy with highest prevalence and mortality rates. However, concerning patients with liver cancer, about 25% die because of malnutrition instead of the cancer [15, 16]. Patients with malignancies are more susceptible to malnutrition, with incidence rates up from 40% to 80%, severely affecting the efficacy of treatment and survival and prognosis of patients [17, 18]. Thus, nutritional support is necessary for treatment and improvement of prognosis of patients.

Recent studies have confirmed the positive role of nutritional support [19, 20]. However, there is insufficient evidence supporting the usefulness of combining enteral nutrition with parenteral nutrition. Thus, the current study aimed to analyze the value of this method, providing reference for the clinical nutritional support of patients with liver cancer.

Comparisons of baseline data between the two groups showed no statistically significant differences, suggesting that the patients in the two groups were comparable. The nutritional status of patients with cancer is one of the factors affecting the safety of the operation. Malnutrition also greatly affects postoperative mortality rates and risk of complications [21, 22]. Hence, this study analyzed nutrition-relat-

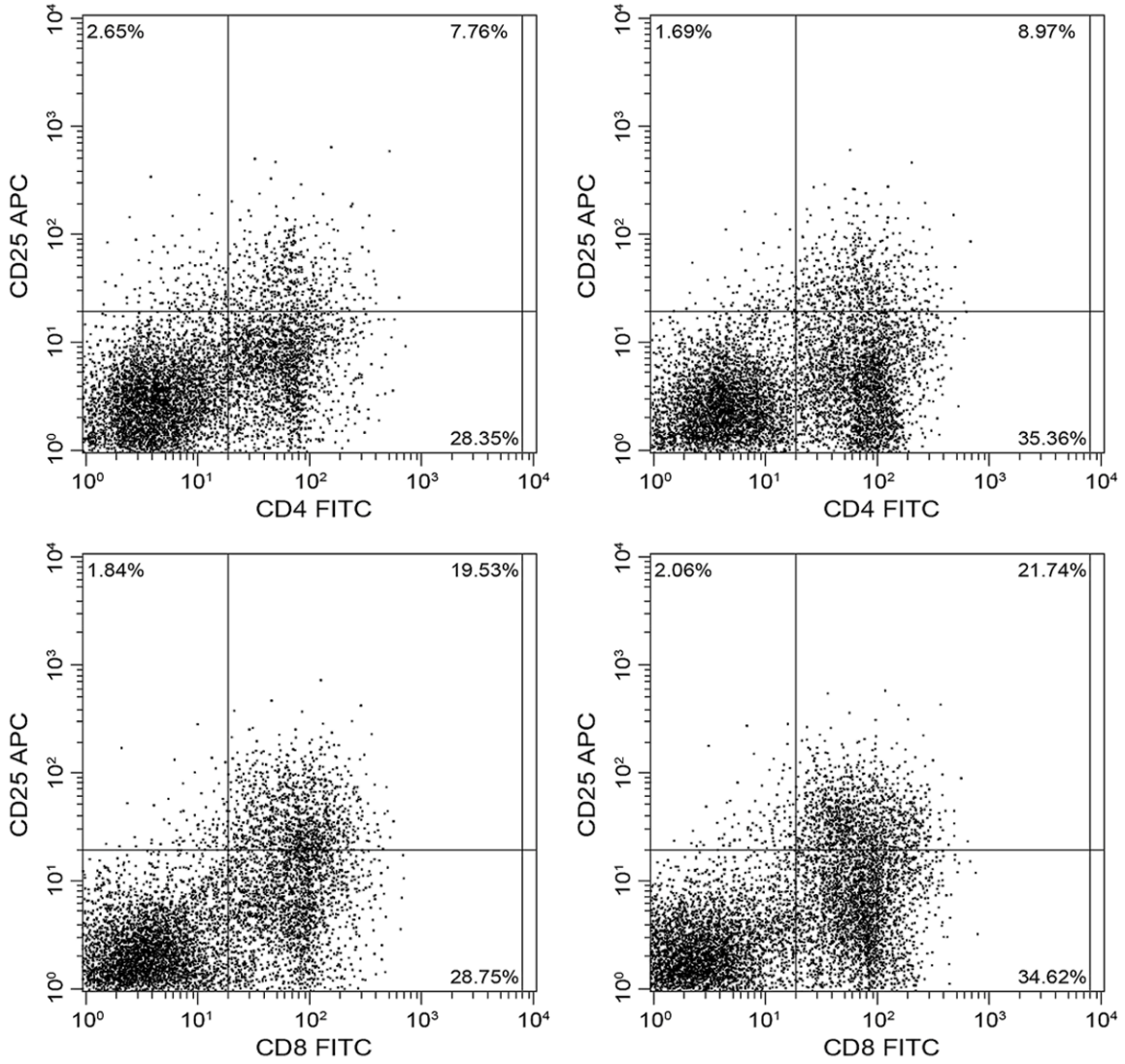

Figure 4. Flow cytometer results of $CD4^+$ T-cells and $CD8^+$ T-cells.

Table 5. Changes in levels of inflammatory factors in the two patient groups

		Control group (n = 48)	Study Group (n = 55)	t value	*p*-valued
IL-1 (pg/ml)	0 d	64.72 ± 10.13	66.39 ± 10.64	0.813	0.418
	3 d	60.69 ± 9.52*	58.83 ± 9.47*	0.992	0.324
	7 d	56.57 ± 8.24*,#	49.64 ± 7.73*,#	4.401	< 0.001
IL-6 (pg/ml)	0 d	233.49 ± 23.17	236.12 ± 22.86	0.579	0.564
	3 d	183.54 ± 21.64*	155.71 ± 18.53*	7.032	< 0.001
	7 d	132.19 ± 15.74*,#	89.62 ± 12.59*,#	15.235	< 0.001
IL-10 (pg/ml)	0 d	8.67 ± 1.24	8.83 ± 1.29	0.639	0.524
	3 d	11.76 ± 2.14*	13.42 ± 2.25*	3.821	< 0.001
	7 d	15.33 ± 2.36*,#	17.72 ± 2.47*,#	5.001	< 0.001
TNF-α (pg/ml)	0 d	73.14 ± 9.93	74.25 ± 10.02	0.563	0.575
	3 d	61.59 ± 9.57*	56.83 ± 9.14*	2.579	0.011
	7 d	54.22 ± 8.61*,#	47.32 ± 8.17*,#	10.213	< 0.001

Note: *P < 0.05 compared with 0 d; #P < 0.05 compared with 3 d.

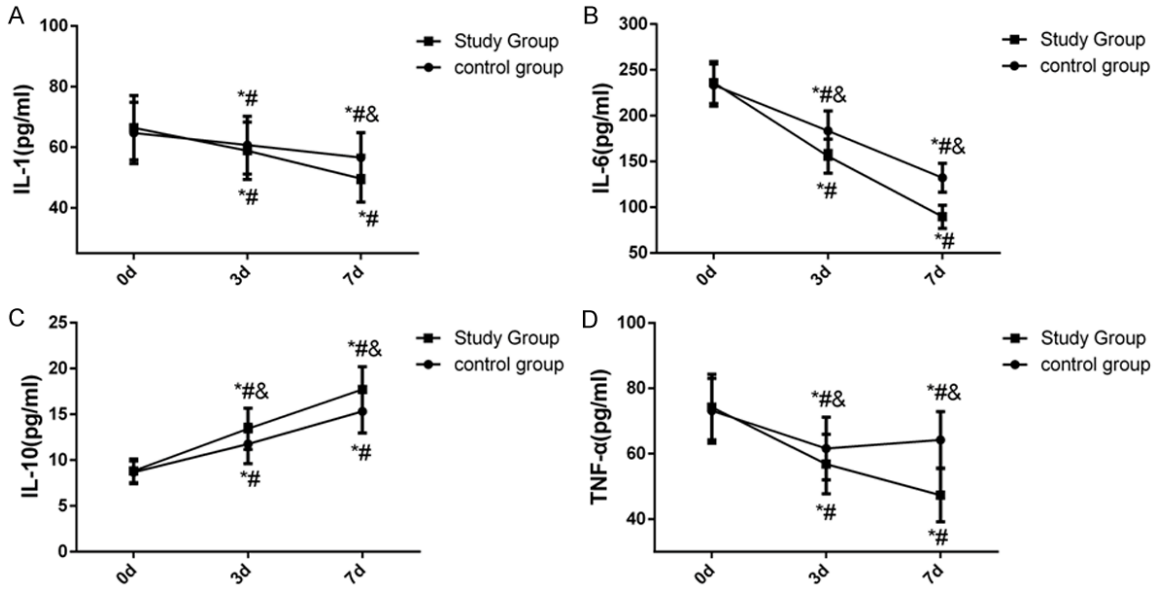

Figure 5. A. Interleukin (IL)-1 levels; B. IL-6 levels; C. IL-10 levels; D. Tumor necrosis factor (TNF)-α levels. *P < 0.05 compared with 0 d; #P < 0.05 compared with 3 d; &P < 0.05 compared with the control group.

ed indicators, including ALB, PA, and HGB, of patients in both groups. Results showed varying degrees of changes. However, improvements were more evident in the study group than the control group, suggesting that the combination of parenteral nutrition and enteral nutrition can better improve postoperative nutrition of patients after hepatectomy procedures. Liver function indicator analysis showed that the poor liver function of patients with liver cancer was further exacerbated after hepatectomy procedures, due to volume loss of the liver. Therefore, postoperative recovery of liver function is crucial. It can affect patient metabolism and induce a series of nutrition-related problems [23]. In both groups, levels of Tbil, Dbil, ALT, and AST continuously decreased as the duration of nutrition increased, suggesting a gradual recovery in liver function. However, apparently, the liver function of patients in the study group was much more improved than that of patients in the control group. Results suggest that the combined nutritional support not only facilitated the recovery of liver function, but also has superior efficacy over the simple application of enteral nutrition or parenteral nutrition alone. Next, this study analyzed changes in the numbers of immune cells and levels of inflammatory cytokines in both groups. After hepatectomy procedures, immunosuppression and exacerbated inflammation are major problems, severely affecting the recovery of patients and efficacy of treatment. Moreover, malnutrition leads to immunosuppression and further imbalances of inflammatory response [24, 25]. Patients in both groups showed gradual increases in the numbers of $CD4^+$, $CD8^+$, and $CD4^+CD25^+$ T-cells and in IL-10 levels. However, they showed progressive declines in IL-1, IL-6, and TNF-α levels, indicating that the immune function of patients was undergoing recovery and that inflammation was controlled.

Nutrients are the basis of sustaining physiological function. Thus, malnutrition can cause disorders in homeostasis and decreased immune function. These problems are more evident in elderly patients with liver cancer, due to decreased organ function and self-homeostasis adjustments [26, 27]. However, the lack of modern medical outlook in some countries has resulted in omission of correct evaluation of patients for nutritional support. Only a few patients receive such support based on their individual conditions [28]. Thus, the aim of this study was to facilitate the application and development of combined enteral nutrition and parenteral nutrition after surgical treatment of liver cancer, promoting the recovery of patients. In some related studies, parenteral nutrition in combination with enteral nutrition more efficiently improved postoperative albumin, PA, and the nutrition of patients with esophageal cancer [29]. In the treatment of obstructive jaundice, parenteral nutrition in combination with enteral nutrition has been shown to

improve the nutrition and liver function of patients in comparison with the simple application of enteral nutrition [30]. Furthermore, in studies on the postoperative nutrition of patients with gastric cancer, combined nutrition also showed better efficacy in improving immune function, inflammatory response, postoperative life quality, and prognosis of patients, compared to simple application of total parenteral nutrition [31]. The above findings are in accord with the results of this study. However, due to several limitations, the current study failed to analyze prognosis and survival quality of the patients. One meta-analysis showed that neither enteral nutrition nor parenteral nutrition affected in-hospital mortality rates of patients within 3 months after surgery. Overall, compared with parental nutrition alone, enteral nutrition in combination with parental nutrition can improve liver function and immune function, as well as mitigate inflammatory response more efficiently, in patients undergoing hepatectomy procedures for liver cancer.

Acknowledgements

This work was supported by the Gansu Youth Science and Technology Fund Plan (No. 1606RJYA272).

Disclosure of conflict of interest

None.

Address correspondence to: Dong Zhang, Department of Medical Quality Control, Gansu Provincial Hospital, No.204 Donggang West Road, Chengguan District, Lanzhou 730000, Gansu, China. Tel: +86-13893634664; E-mail: dzhang528@163.com

References

[1] Kudo M, Matsui O, Izumi N, Iijima H, Kadoya M, Imai Y, Okusaka T, Miyayama S, Tsuchiya K and Ueshima K. JSH consensus-based clinical practice guidelines for the management of hepatocellular carcinoma: 2014 update by the Liver Cancer Study Group of Japan. Liver Cancer 2014; 3: 458-468.

[2] Kudo M. Surveillance, diagnosis, treatment, and outcome of liver cancer in Japan. Liver Cancer 2015; 4: 39-50.

[3] Ryerson AB, Eheman CR, Altekruse SF, Ward JW, Jemal A, Sherman RL, Henley SJ, Holtzman D, Lake A and Noone AM. Annual report to the nation on the status of cancer, 1975-2012, featuring the increasing incidence of liver cancer. Cancer 2016; 122: 1312-1337.

[4] Sakamoto Y, Kokudo N, Matsuyama Y, Sakamoto M, Izumi N, Kadoya M, Kaneko S, Ku Y, Kudo M and Takayama T. Proposal of a new staging system for intrahepatic cholangiocarcinoma: analysis of surgical patients from a nationwide survey of the liver cancer study group of Japan. Cancer 2016; 122: 61-70.

[5] Hsu C, Chen BB, Chen CH, Ho MC, Cheng JC, Kokudo N, Murakami T, Yeo W, Seong J, Jia JD, Han KH, Cheng AL. Consensus development from the 5th Asia-Pacific primary liver cancer expert meeting (APPLE 2014). Liver Cancer 2015; 4: 96-105.

[6] Dang Z, Keji H, Guangwei N, Sun W, Cheng Y, Wang W and Rui L. Therapeutically targeting autophagy enhances cytotoxicity of emodin in liver cancer cell lines. China Oncology 2017; 27: 186-190.

[7] Harvey SE, Parrott F, Harrison DA, Bear DE, Segaran E, Beale R, Bellingan G, Leonard R, Mythen MG and Rowan KM. Trial of the route of early nutritional support in critically ill adults. N Engl J Med 2014; 371: 1673-1684.

[8] Preiser JC, van Zanten AR, Berger MM, Biolo G, Casaer MP, Doig GS, Griffiths RD, Heyland DK, Hiesmayr M, Iapichino G, Laviano A, Pichard C, Singer P, Van den Berghe G, Wernerman J, Wischmeyer P, Vincent JL. Metabolic and nutritional support of critically ill patients: consensus and controversies. Crit Care 2015; 19: 35.

[9] Gavin NC, Button E, Castillo MI, Ray-Barruel G, Keogh S, McMillan DJ and Rickard CM. Does a dedicated lumen for parenteral nutrition administration reduce the risk of catheter-related bloodstream infections? a systematic literature review. J Infus Nurs 2018; 41: 122-130.

[10] Bistrian BR. Early versus late parenteral nutrition in critically ill children. N Engl J Med 2016; 375: 385.

[11] McClave SA, Martindale RG, Vanek VW, McCarthy M, Roberts P, Taylor B, Ochoa JB, Napolitano L, Cresci G and Directors ABo. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (ASPEN). Journal of Parenteral and Enteral Nutrition 2009; 33: 277-316.

[12] Becker P, Carney LN, Corkins MR, Monczka J, Smith E, Smith SE, Spear BA, White JV; Academy of Nutrition and Dietetics; American Society for Parenteral and Enteral Nutrition. Consensus statement of the academy of nutrition and dietetics/American society for parenteral and enteral nutrition: indicators recommended for the identification and documentation of pediatric malnutrition (undernutrition). Nutr Clin Pract 2015; 30: 147-161.

[13] Fan J, Wu J, Wu LD, Li GP, Xiong M, Chen X, Meng QY. Effect of parenteral glutamine supplementation combined with enteral nutrition on Hsp90 expression and lymphoid organ apoptosis in severely burned rats. Burns 2016; 42: 1494-1506.
[14] Zhu X, Wu Y, Qiu Y, Jiang C and Ding Y. Effects of ω-3 fish oil lipid emulsion combined with parenteral nutrition on patients undergoing liver transplantation. JPEN J Parenter Enteral Nutr 2013; 37: 68-74.
[15] Zhang B, Wei G, Li R, Wang Y, Yu J, Wang R, Xiao H, Wu C, Leng C and Zhang B. n-3 fatty acid-based parenteral nutrition improves postoperative recovery for cirrhotic patients with liver cancer: a randomized controlled clinical trial. Clin Nutr 2017; 36: 1239-1244.
[16] Bradbury KE, Appleby PN and Key TJ. Fruit, vegetable, and fiber intake in relation to cancer risk: findings from the European Prospective Investigation into Cancer and Nutrition (EPIC). Am J Clin Nutr 2014; 100 Suppl 1: 394S-8S.
[17] Arends J, Baracos V, Bertz H, Bozzetti F, Calder PC, Deutz NEP, Erickson N, Laviano A, Lisanti MP, Lobo DN, McMillan DC, Muscaritoli M, Ockenga J, Pirlich M, Strasser F, de van der Schueren M, Van Gossum A, Vaupel P, Weimann A. ESPEN expert group recommendations for action against cancer-related malnutrition. Clin Nutr 2017; 36: 1187-1196.
[18] Bozzetti F. Nutritional support in patients with cancer. Clin Nutr 2015; 385-419.
[19] Cai M, Tang W, Hanxiang A and Xiaohong L. The clinical effect of enteral nutritional support combined with chemotherapy in advanced gastric cancer patients. Parenteral & Enteral Nutrition 2017; 24: 205-208.
[20] McClave SA, Taylor BE, Martindale RG, Warren MM, Johnson DR, Braunschweig C, McCarthy MS, Davanos E, Rice TW and Cresci GA. Guidelines for the provision and assessment of nutrition support therapy in the adult critically ill patient: Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (ASPEN). Journal of Parenteral and Enteral Nutrition 2016; 40: 159-211.
[21] Bai X, Ping D, Yanhui M, Mai X and Qin X. Effect of enteral nutrition support on nutritional status of patients with esophageal cancer complicated with dysphagia after CT guided percutaneous gastrostomy. Parenteral & Enteral Nutrition 2017; 24: 240-243.
[22] Reisinger KW, van Vugt JL, Tegels JJ, Snijders C, Hulsewé KW, Hoofwijk AG, Stoot JH, Von Meyenfeldt MF, Beets GL, Derikx JP, Poeze M. Functional compromise reflected by sarcopenia, frailty, and nutritional depletion predicts adverse postoperative outcome after colorectal cancer surgery. Ann Surg 2015; 261: 345-352.
[23] Shi X, Wang S, Yafu W, Tang N, Zhang W and Ding Y. Effects of structured triglyceride on postoperative recovery of patients with primary liver cancer after hepatectomy: a prospective study. Chinese Journal of Digestive Surgery 2015; 14: 370-375.
[24] Du T, Zhihong X, Deng Y, Zhang M and Zhang R. Effects of peptide-based enteral nutrition on inflammatory response and immune function in intestinal mucositis rat. Chinese Journal of Clinical Nutrition 2015; 23: 41-47.
[25] Wang J, Zhao L, Guo Q, Zhang K and Xiaodong M. Effect of immune enhanced enteral nutrition on immune function in postoperative patients with gastric cancer: a meta-analysis. Cancer Research and Clinic 2017; 29: 398-403.
[26] Huang D, Sun Z, Huang J and Shen Z. Early enteral nutrition in combination with parenteral nutrition in elderly patients after surgery due to gastrointestinal cancer. Int J Clin Exp Med 2015; 8: 13937.
[27] Rafii M, Chapman K, Elango R, Campbell WW, Ball RO, Pencharz PB and Courtney-Martin G. Dietary protein requirement of men > 65 years old determined by the indicator amino acid oxidation technique is higher than the current estimated average requirement. J Nutr 2015; 146: 681-687.
[28] Hébuterne X, Lemarié E, Michallet M, de Montreuil CB, Schneider SM and Goldwasser F. Prevalence of malnutrition and current use of nutrition support in patients with cancer. JPEN J Parenter Enteral Nutr 2014; 38: 196-204.
[29] Yao J, Xue M, Fan M, Liu J and Luo J. Postoperative application of enteral nutrition combined with parenteral nutrition and total parenteral nutrition in patients with gastrointestinal cancer. Journal of Chinese Physician 2016; 18: 8-10.
[30] Li J, Han L, Du T and Guo M. The effect of low-nitrogen and low-calorie parenteral nutrition combined with enteral nutrition on inflammatory cytokines and immune functions in patients with gastric cancer: a double blind placebo trial. Eur Rev Med Pharmacol Sci 2015; 19: 1345-1350.
[31] Lewis SR, Schofield-Robinson OJ, Alderson P and Smith AF. Enteral versus parenteral nutrition and enteral versus a combination of enteral and parenteral nutrition for adults in the intensive care unit. Cochrane Database Syst Rev 2018; 6: CD012276.