

## Poor preoperative enteral nutrition would be a risk factor for readmission due to infection after liver transplantation

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**Received** January 7, 2020

**Revised** February 17, 2020

**Accepted** February 21, 2020

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**Background:** Most patients who undergo liver transplantation (LT) have advanced cirrhosis and poor nutritional status. The aim of this study was to investigate the effect of enteral nutrition (EN) on the clinical outcomes after LT.

**Methods:** From 2015 to 2019, the medical records of recipient of LT at Kosin University Gospel Hospital were retrospectively reviewed.

**Results:** Thirty-seven patients underwent LT. Nineteen patients underwent living donor liver transplantation (LDLT) and 18 patients underwent deceased donor liver transplantation (DDLT). One LDLT patient was excluded because transplantation was done within 1 month. Five DDLT patients were excluded either because they died within 1 month (n=4) or received transplantation within 1 month. (n=1). Therefore, 31 patients were analyzed. Psoas-muscle index (P=0.715) and serum albumin (P=0.111) were not statistically different between the LDLT and DDLT groups. Four patients (4/31) were readmitted because of infection. One LDLT patient was diagnosed with genitourinary infection. The three DDLT patients were diagnosed with pulmonary tuberculosis (n=1), diverticulitis (n=1), and sepsis (n=1). Readmission caused by infection was not statistically different between LDLD and DDLT patients (P=0.284). Preoperative EN <25% of the recommended amount (P=0.016) was significantly associated with readmission related to infection. In multivariate analyses, preoperative EN <25% was an independent risk factor for readmission due to infection after LT regardless of psoas-muscle index, baseline Model for End-Stage Liver Disease score, or LT type.

**Conclusions:** Preoperative poor EN is significantly associated with readmission risk due to infection within 3 months of LT.

**Keywords:** Liver transplantation; Enteral nutrition; Infection; Psoas-muscle index

### INTRODUCTION

Protein energy malnutrition is a common clinical mani-

festation of patients with end-stage liver disease waiting for liver transplantation (LT) [1], and it is a risk factor for morbidity and mortality after LT [2]. The nutritional status

**HIGHLIGHTS**

- Resumption of oral nutrition within 12 hours after liver transplantation (LT) has been shown to reduce postoperative viral infection and maintain adequate nitrogen balance.
- In addition, our study revealed that preoperative poor enteral nutrition (EN) was significantly associated with readmission risk due to infection within 3 months of LT.
- Therefore, patients who are preparing for liver transplantation should be encouraged to maintain adequate EN to reduce risk of infection and readmission after liver transplantation.

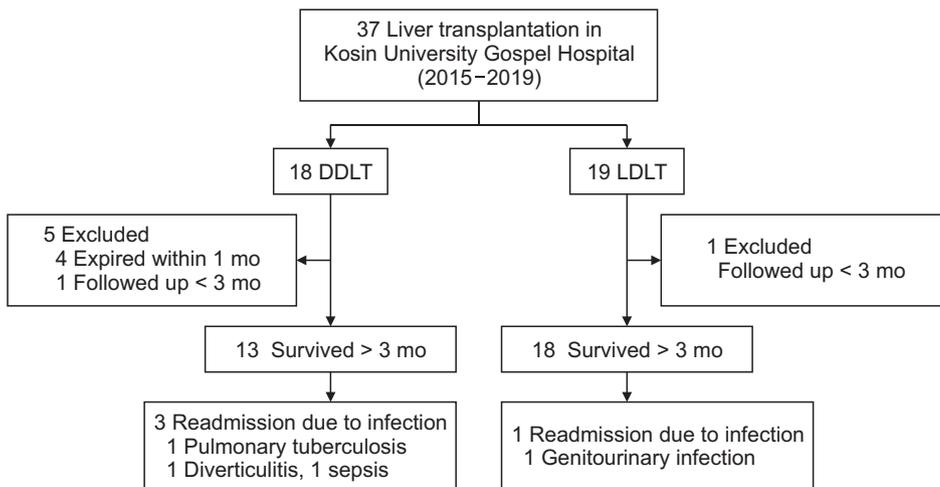
of liver transplant recipients can deteriorate rapidly due to underlying malnutrition, surgical stress, immunosuppressive therapy, postintervention complications, postoperative protein metabolism, and pretransplant fasting periods [3]. Resumption of oral nutrition within 12 hours after LT has been shown to reduce postoperative viral infection and maintain adequate nitrogen balance. Therefore, the transplant recipient should start to consume small amounts of oral nutrition after LT and gradually increase their amount according to their ability [4]. However, there is little research on the clinical importance of enteral feeding before LT. The aim of this study is to investigate the effect of enteral feeding before surgery on clinical outcomes after LT.

**METHODS**

This study was approved by the Institutional Review Board/Ethics Committee of Kosin University Gospel Hospital (IRB No. KUGH 2019-09-019). Informed consent was waived because of the retrospective study design.

**Study Population**

From January 2015 to May 2019, the medical records of patients who underwent LT at Kosin University Gospel Hospital were retrospectively analyzed. A total of 37 patients underwent LT: 18 with deceased donor liver transplantation (DDLT) and 19 with living donor liver transplantation (LDLT). Liver recipients who survived for more than 3 months after transplantation were defined as subjects of this study. In the DDLT group, four patients died within 1 month after LT. Forty-seven-year-old male recipient died at 25 days after LT due to graft failure. The amount of enteral nutrition (EN) before LT was poor (EN <25%). Fifty-seven-year-old male recipient died at 23 days after transplantation due to acute rejection (EN 25%–50%). Sixty-year-old male recipient died at 4 days after LT due to graft failure caused by vascular complication (EN 50%–75%). Forty-year-old male recipient died at 31 days after transplantation due to graft failure (EN <25%). One patient in DDLT group received transplantation within 1 month. In the LDLT group, only one patient received transplantation within 1 month. Consequently, 13 DDLT patients and 18 LDLT patients, for a total of 31 patients, were analyzed in this study (Fig. 1).



**Fig. 1.** Flowchart of study population. A total of 37 patients underwent liver transplantation (LT): 18 with deceased donor liver transplantation (DDLT) and 19 with living donor liver transplantation (LDLT). Recipients survived for more than 3 months after LT were enrolled in this study. In the DDLT group, four patients died within 1 month after LT and 1 patient received transplantation within 1 month. One patient in the LDLT group received transplantation within 1 month. One patient with LDLT was diagnosed with genitourinary infection and hospitalized. Three patients who received DDLT were diagnosed and hospitalized for pulmonary tuberculosis, diverticulitis, and sepsis, respectively.

### Nutritional Status

We estimated skeletal muscle mass as an objective nutritional measure of patients with advanced liver cirrhosis. Since it is practically impossible to estimate a patient's total skeletal muscle, we used the psoas-muscle index (PMI), which is known to be highly correlated with total skeletal muscle mass. Patients' PMI was measured via abdominal computed tomography (CT) within the month before LT. All abdominal CT images were analyzed using

PACS (picture archiving and communication system). The cross-sectional area of the bilateral psoas on the axial plane was measured at the lower level of the third lumbar vertebra. PMI was obtained by summing the areas of both sides of the lumbar vertebrae at the third lumbar spine on CT and patients' squared heights were standardized ( $\text{cm}^2/\text{m}^2$ ). The ImageJ program developed at the National Institutes of Health (Bethesda, MD, USA) was used to measure the psoas muscle area.

**Table 1.** Baseline characteristics and clinical outcomes of liver transplantation recipients

Variable	Total	DDLT	LDLT	P-value
Number	31	13	18	
Age (yr)	55.16±7.41	55.92±7.40	52.11±13.94	0.378
Sex				0.129
Male	21 (67.7)	11 (84.6)	10 (55.5)	
Female	10 (32.3)	2 (15.4)	8 (44.5)	
BMI ( $\text{kg}/\text{m}^2$ )	23.84±3.20	24.09±4.02	23.66±2.57	0.718
PMI ( $\text{cm}^2/\text{m}^2$ )	12.23±3.81	11.93±4.20	12.44±3.62	0.715
HCC	10 (32.3)	5 (38.5)	5 (27.8)	0.701
Blood chemistry				
Platelet ( $\times 10^3/\mu\text{L}$ )	64.29±34.57	50.15±30.26	74.50±34.63	0.051
PT-INR	2.63±1.71	3.41±2.19	2.06±1.00	0.028
Total bilirubin (mg/dL)	14.48±13.41	19.00±11.50	11.22±14.04	0.112
Cr (mg/dL)	0.90±0.46	1.20±0.55	0.69±0.20	0.006
Albumin (g/dL)	3.45±0.58	3.25±0.6	3.59±0.55	0.111
Ammonia ( $\mu\text{Mol}/\text{L}$ )	65.13±37.15	58.92±19.40	69.61±46.03	0.439
MELD baseline	21.42±11.91	29.46±11.65	15.61±8.33	0.001
Post-LT care				
ICU stay (day)	6.87±4.23	8.77±3.27	5.50±4.38	0.031
Mechanical ventilation (day)	2.23±1.45	2.92±1.26	1.72±1.41	0.020
Post-LT enteral nutrition start (day)	4.07±2.38	4.77±2.01	3.56±2.55	0.165
Enteral nutrition				
Post-LT				0.016
<25	6 (19.4)	6 (45.2)	0	
25–50	15 (48.4)	4 (30.8)	11 (61.1)	
50–75	8 (25.8)	3 (23.1)	5 (27.8)	
>75	2 (6.5)	0	2 (11.1)	
Post-LT				0.287
Poor	7 (22.6)	4 (30.8)	3 (16.7)	
Moderate	17 (54.8)	7 (53.8)	10 (55.6)	
Good	7 (22.6)	2 (15.4)	5 (27.8)	
Clinical outcome				
Readmission due to infection	4 (12.9)	3 (23.1)	1 (5.6)	0.284

Values are presented as mean±standard deviation or number (%).

DDLT, deceased donor liver transplantation; LDLT, living donor liver transplantation; BMI, body mass index; PMI, psoas-muscle index; HCC, hepatocellular carcinoma; PT, prothrombin time; INR, international normalized ratio; Cr, creatinine; MELD, Model for End-Stage Liver Disease; LT, liver transplantation; ICU, intensive care unit.

### Enteral Nutrition Assessment

The liver transplant waiting list is typically assessed by a nutritionist in our transplantation center before transplant. Clinical dietitians interviewed the patients and evaluated their oral intake for 2 weeks before LT. Patients' enteral nutritional status was divided into four categories: <25%, 25%–50%, 50%–75%, and >75% of target nutritional intake. Target nutritional intake was defined by European Association for the Study of the Liver (EASL) Clinical Practice Guidelines on nutrition in chronic liver disease [5]: >30 kcal/kg/day for preoperative cirrhotic patients. After LT, the enteral nutritional intake of patients was evaluated by our transplantation center's nurses who specialize in LT. The post-LT enteral nutritional intake level was divided into: poor (<30%), moderate (30%–60%), and good (>60%).

### Clinical Outcome of LT

To evaluate clinical outcomes after LT, we analyzed the duration of intensive care unit (ICU) stay, mechanical ventilatory care and total admission duration after LT. From the time of LT, we evaluated initiation and amount of EN intake. Importantly, we also reviewed patients' rehospitalization frequency due to infection, cause of infection and treatment progress from their medical records.

### Statistical Analysis

Means, and standard deviations were calculated for all continuous variables, and an independent t-test was performed to compare means between transplantation type (DDLT and LDLT) groups. Categorical variables were expressed as percentages and the chi-square test was used to compare patient groups. Multivariate logistic regression analyses were performed to identify risk factors for rehospitalization due to infection. Statistical significance was determined at  $P < 0.05$ , and IBM SPSS ver. 21.0 (IBM Corp., Armonk, NY, USA) was used for all analyses.

## RESULTS

### Baseline Characteristics

Thirty-one patients underwent LT were included in this study. The mean patient age was 55.1 years, and 21 patients were male and 10 were female. The thirteen patients who underwent DDLT had a mean age of 55.9 years and included 11 males and two females. The eighteen patients who underwent LDLT had a mean age of 52.1 years

and included 10 men and 8 women. (Table 1). Ten patients (32.3%) underwent LT due to hepatocellular carcinoma: five with DDLT and five with LDLT. Baseline Model for End-Stage Liver Disease score ( $P = 0.001$ ), PT-INR ( $P = 0.028$ ), and serum creatinine ( $P = 0.006$ ) were statistically different between the LDLT and DDLT groups, respectively. However, serum albumin level was not different ( $P = 0.006$ ).

### Nutritional Status before LT

Mean baseline body mass index (BMI) for all patients was 23.8 kg/m<sup>2</sup>: 24.1 kg/m<sup>2</sup> for the DDLT group, and 23.6 kg/m<sup>2</sup> for the LDLT group, and the groups were not significantly different ( $P = 0.718$ ). The mean PMI for all patients was 12.227±3.812 cm<sup>2</sup>/m<sup>2</sup>, which we used as an objective measure of baseline nutritional status. The mean baseline PMI was 11.925±4.197 cm<sup>2</sup>/m<sup>2</sup> among DDLT patients and 12.444±3.619 cm<sup>2</sup>/m<sup>2</sup> among LDLT patients; this difference was not statistically different ( $P = 0.715$ ) (Table 1).

### Nutritional Support Peritransplantation

#### Pretransplantation

Clinical dietitians interviewed all patients and evaluated their enteral intake for 2 weeks before LT. The enteral intake was classified into four levels according to a comparison with the recommended 30 kcal/kg/day for preoperative cirrhotic patients suggested by the EASL [5]. Among the 31 liver transplant recipients, six (19.4%) had <25% enteral intake before surgery. Fifteen patients (48.4%) had enteral intake of 25%–50%, eight patients (25.8%) had enteral intake of 50%–75%, and two patients (6.5%) had enteral intake of ≥75%. In the DDLT group, six patients (45.2%) had enteral intake <25%, four patients (30.8%) had 25%–50%, three patients (23.1%) had 50%–75% and no patients (0.0%) had ≥75%. In the LDLT group, 11 patients (61.1%) had enteral intake between 25% and 50%, five patients (27.8%) between 50% and 75%, and two patients (11.1%) had ≥75%. Differences in enteral intake between the two groups were statistically significant ( $P = 0.016$ ) (Table 1).

#### Posttransplantation

Recipients' enteral intake was assessed by specialized nurses in the transplantation center until discharge. Among all 31 recipients, seven (22.6%) showed poor enteral intake, 17 (54.8%) were able to maintain moderate enteral intake, and seven patients (22.6%) had good enteral intake. In the DDLT group, four patients (30.8%) had poor enteral intake, seven patients (53.8%) had moderate

enteral intake, and two patients (15.4%) had good enteral intake. In the LDLT group, three patients (16.7%) had poor enteral intake, 10 (55.6%) maintained moderate intake, and five (27.8%) had good enteral intake. Enteral intake after LT was not associated with LT type ( $P=0.287$ ) (Table 1).

### Post-LT Care

The total mean duration of ICU admission was 6.8 days: 8.7 days for DDLT and 5.5 days for LDLT ( $P=0.031$ ). In addition, the mechanical ventilation period was 2.9 days in the DDLT group, but only 1.7 days in LDLT group ( $P=0.020$ ).

**Table 2.** Baseline characteristics and clinical outcomes according to amount of enteral nutrition before liver transplantation

Variable	Pre-LT enteral nutrition <25%	Pre-LT enteral nutrition $\geq$ 25%	P-value
Patient	6 (19.4)	25 (80.6)	
Age (yr)	57.5 $\pm$ 6.66	54.6 $\pm$ 7.6	0.391
Sex			0.141
Male	6 (100.0)	15 (60.0)	
Female	0	10 (40.0)	
BMI (kg/m <sup>2</sup> )	22.63 $\pm$ 3.53	24.13 $\pm$ 3.13	0.174
PMI (cm <sup>2</sup> /m <sup>2</sup> )	11.08 $\pm$ 4.64	12.50 $\pm$ 3.64	0.422
LT type			0.002
DDLT	6 (100.0)	7 (28.0)	
LDLT	0	18 (72.0)	
HCC			0.358
Yes	3 (50.0)	7 (28.0)	
No	3 (50.0)	18 (72.0)	
Post-LT enteral nutrition grade			1.000
Poor	1 (16.7)	6 (24.0)	
Moderate	4 (66.7)	13 (52.0)	
Good	1 (16.7)	6 (24.0)	
Readmission			0.172
Yes	5 (83.3)	11 (44.0)	
No	1 (16.7)	14 (56.0)	
Readmission due to infection			0.016
Yes	3 (50.0)	1 (4.0)	
No	3 (50.0)	24 (96.0)	
Blood chemistry			
Platelet ( $\times 10^3/\mu\text{L}$ )	55,000 $\pm$ 39,000	66,520 $\pm$ 33,916.7	0.339
PT-INR	2.35 $\pm$ 0.98	2.69 $\pm$ 1.86	1.000
Total bilirubin (mg/dL)	15.19 $\pm$ 11.9	14.31 $\pm$ 13.97	0.478
Cr (mg/dL)	0.97 $\pm$ 0.34	0.89 $\pm$ 0.49	0.291
Albumin (g/dL)	3.28 $\pm$ 0.37	3.49 $\pm$ 0.62	0.291
Ammonia ( $\mu\text{Mol/L}$ )	53 $\pm$ 21.05	68.04 $\pm$ 39.84	0.419
MELD baseline	23.5 $\pm$ 8.76	20.92 $\pm$ 12.65	0.391
Post-LT care			
ICU stay (day)	9.17 $\pm$ 3.43	6.32 $\pm$ 4.27	0.053
Mechanical ventilation (day)	2.83 $\pm$ 1.17	2.08 $\pm$ 1.5	0.117
Post-LT admission (day)	27.5 $\pm$ 6.86	28.2 $\pm$ 16.23	0.419
Post-LT enteral nutrition start (day)	5 $\pm$ 2.45	3.84 $\pm$ 2.36	0.158

Values are presented as number (%) or mean $\pm$ standard deviation.

LT, liver transplantation; BMI, body mass index; PMI, psoas-muscle index; LT, liver transplantation; DDLT, deceased donor liver transplantation; LDLT, living donor liver transplantation; HCC, hepatocellular carcinoma; PT, prothrombin time; INR, international normalized ratio; Cr, creatinine; MELD, Model for End-Stage Liver Disease; ICU, intensive care unit.

However, the time to start EN after LT was not statistically different between the two groups, starting after 4.7 days in the DDLT group and 3.5 days in the LDLT group ( $P=0.165$ ). There was also no significant difference between the two groups in the amount of EN after transplantation between DDLT and LDLT ( $P=0.287$ ). Our transplant center recommended patients not to eat raw foods during the first three months after transplantation. Dietitians encouraged patients to take enough nutrition, especially protein. However, we did not recommend pre or probiotics, specifically. Moreover, we did not use different diet protocols between DDLT and LDLT. The admission duration after LT was 32.6 days in the DDLT group and 24.7 days in the LDLT group; the duration difference was not significant ( $P=0.141$ ).

**Readmission Due to Infection after LT**

*LT type*

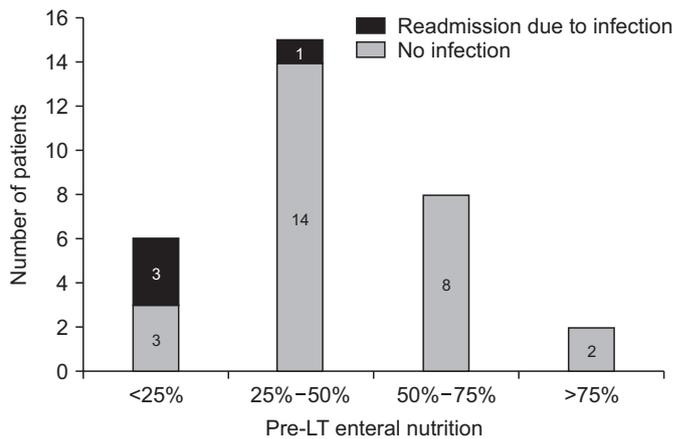
Four of the 31 recipients were readmitted for infection within 3 months after LT, including three DDLT patients and one LDLT patient. The LDLT patient was diagnosed with a genitourinary infection and was hospitalized due to severe oral and genital ulcers. The infectious cause was CMV virus. The three DDLT patients were diagnosed and hospitalized for pulmonary tuberculosis, diverticulitis, and sepsis, respectively (Fig. 1). Pulmonary tuberculosis was diagnosed with sputum AFB stain in patient with sustained cough, sputum and progressive dyspnea. Diverticulitis was confirmed with abdominal CT scan correlated with colonoscopy underwent before LT. This patient visited outpatient clinic for recurrent abdominal pain and fever. Sepsis was diagnosed in patient visited emergency room with sustained fever and general weakness. Initial vital sign was shock and fever. Blood culture result was gram negative bacteremia. There was no statistical correlation between infection occurrence and LT type ( $P=0.284$ ) (Table 2).

*Amount of enteral nutrition*

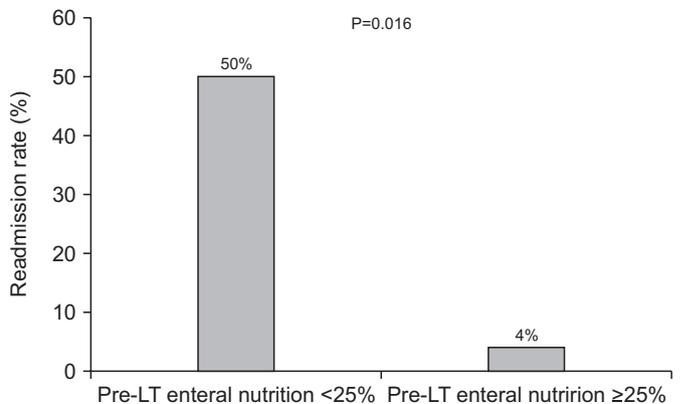
Prior to transplantation, six patients were ingesting <25% of recommended EN. Three of these patients (50%) were rehospitalized for infection after LT. Fifteen patients maintained 25%–50% of EN before transplantation, and only one (1/15) of these patients was readmitted for infection. Among patients who maintained >50% of EN, none (0/10) were readmitted for infection (Fig. 2). Among patients who only maintained <25% enteral intake before transplantation, the readmission rate for infection was 50%. However, this rate dropped to only 4% among patients who man-

aged  $\geq 25\%$  intake ( $P=0.016$ ) (Fig. 3).

Patients with pretransplant EN <25% were most at risk of readmission for infection within 3 months of LT ( $P=0.015$ ). Univariable analyses revealed that pretransplant EN <25% was closely associated with readmission due to infection (odds ratio, 24.0; 95% confidence interval, 1.852–310.999;  $P=0.015$ ) (Table 3). Pretransplant enteral intake was an independent risk factor for readmission after LT, regardless of LT type (DDLT vs. LDLT) or PMI.



**Fig. 2.** Pre-LT enteral nutrition and readmission due to infection after liver transplantation (LT). Six patients were ingesting <25% of the recommended enteral nutrition supply before transplantation, and three (50%) were rehospitalized for infection posttransplantation. Fifteen patients maintained 25%–50% of enteral nutrition before transplantation, and only one (1/15) was readmitted for infection. No patients who maintained >50% enteral nutrition (0/10) were readmitted due to infection after LT.



**Fig. 3.** Readmission rate due to infection after liver transplantation (LT) according to enteral nutrition. Among patients maintaining <25% enteral nutrition before transplantation, the readmission rate for infection was 50%. However, among patients maintaining  $\geq 25\%$ , only 4% were readmitted due to infection after LT.

**Table 3.** Risk factors for readmission due to infection after liver transplantation within 3 months

Variable	Univariable		Multivariable	
	OR (95% CI)	P-value	OR (95% CI)	P-value
LT type	5.100 (0.466–55.891)	0.182	0.000	0.999
BMI (kg/m <sup>2</sup> )	0.980 (0.709–1.354)	0.901		
PMI (cm <sup>2</sup> /m <sup>2</sup> )	1.392 (0.917–2.112)	0.120	1.340 (0.819–2.191)	0.244
HCC	2.375 (0.283–19.924)	0.425		
Blood chemistry				
Platelet (×10 <sup>3</sup> /μL)	1.035 (0.984–1.088)	0.186		
PT-INR	1.130 (0.539–2.371)	0.747		
Total bilirubin (mg/dL)	1.013 (0.932–1.101)	0.764		
Cr (mg/dL)	3.995 (0.127–126.137)	0.432		
Albumin (g/dL)	2.604 (0.404–16.789)	0.314		
Ammonia (uMol/L)	1.026 (0.979–1.074)	0.287		
MELD baseline	1.012 (0.923–1.111)	0.796	1.027 (0.870–1.212)	0.753
Pre-LT oral <25%	24.000 (1.852–310.999)	0.015	24.000 (1.852–310.999)	0.015

OR, odds ratio; CI, confidence interval; LT, liver transplantation; BMI, body mass index; PMI, psoas muscle index; HCC, hepatocellular carcinoma; PT, prothrombin time; INR, international normalized ratio; Cr, creatinine; MELD, Model for End-Stage Liver Disease.

## DISCUSSION

It is well known that pre-transplantation baseline nutritional status affects LT clinical outcomes. Pretransplant nutritional status can be evaluated with a range of objective tools, including BMI, and serum albumin, as well as by a subjective global assessment. However, the accuracy of these methods is poor in LT patients. The most objective nutritional assessment method for advanced liver-disease patients is skeletal muscle mass [6]. The reduction of skeletal muscle mass, defined as sarcopenia, is objectively reflected in the nutritional status of patients with advanced liver disease. Moreover, sarcopenia is not only a marker of nutritional status before LT, it is also the most important prognostic factor after LT [7,8]. The index that most correlates with total skeletal muscle mass is

L3-level muscle mass [9], which is the most widely used objective nutritional assessment method for measuring the psoas muscle area on CT or magnetic resonance imaging, after adjusting for height [6].

It is also well known that pretransplantation and post-transplant nutrition have a significant impact on LT outcome. A previous study showed that early enteral feeding within 12 hours after LT reduced infection complications. Although it did not directly affect survival, it was found that bacterial infection was reduced, confirming the benefit of early enteral feeding after LT [10]. Another study reported that after LT, EN with immunomodulating diets could reduce bacteremia incidence [11].

These studies have motivated transplantation hospitals to accept the importance of posttransplant EN. With respect to this study, our transplantation center started EN at an early stage, regardless of transplant type; thus, there was no statistical difference between the two groups (P=0.165). Additionally, it has been reported that perioperative nutritional therapy improved survival after LT in patients with sarcopenia, which is considered a marker of poor nutritional status [12]. The average psoas-muscle index of patients in our study was low; most of the patients had malnutrition. Therefore, they were more sensitive to nutritional supply.

Several other studies have identified the importance of pre- and posttransplantation nutritional supply for liver-disease patients. In a small number of patients, pre-transplantation immunonutrition supply was found to improve pretransplantation nutritional status, improve posttransplantation recovery, and reduce posttransplant complications [13]. Infection is one of the most serious complications that can occur in liver-transplant patients, and can increase mortality [14]. The colon is the organ with the most complex microbiome in the body. Therefore, the intestinal immune system and the mucosal barrier play an important role in protecting the body from bacterial infections [15]. Consequently, dysbiosis of the intestines in advanced liver-disease patients is an important cause of systemic infection [16]. Additionally, EN can increase the flow of bile, which prevents intestinal mucosal atrophy and consequently preserves intestinal structure and function [15]. Based on these results, researchers conducted a study of continuous probiotics administration before and after LT. Continuous administration of probiotics before LT did not reduce mortality after surgery. However, they did observe that 30 days and 90 days after surgery, infection incidence was reduced. Additionally,

liver function was recovered relatively early after transplantation [17]. In other words, EN in liver-transplant patients determines intestine health, and the health of the intestine influences infection risk, which in turn shapes LT outcomes.

To our knowledge, this is the first report of the clinical significance of EN before LT in Korea. Through patient interviews, clinical nutritionists directly and objectively measured the amount of preoperative EN by comparing the guideline-recommended nutrients to each patient's actual enteral nutritional intake [5]. Clinical outcomes were different according to enteral nutritional supply. Liver transplant recipients who had less than 25% EN compared to the recommendation before transplantation were found to have higher readmission rates due to infection. Preoperative EN was found to independently affect the LT clinical course, regardless of preoperative nutritional status as assessed by PMI, LT type, and nutritional supply after LT.

This study had several limitations. First, our data are limited because this was a retrospective analysis of a single center. Second, it is difficult to generalize our findings because we had a small number of patients. Third, most recipients had a low psoas-muscle index and were suspected to have relatively poor nutritional status, which could be a confounding factor for our results. Nevertheless, this study yielded the important conclusion that pre-LT EN has clinical significance. In conclusion, patients who are preparing for LT should be encouraged to maintain adequate EN to reduce risk of infection and readmission after LT. In addition, severe liver-disease patients who are waiting for DDLT may be able to improve their LT clinical outcome by acquiring EN even through a feeding tube.

## ACKNOWLEDGMENTS

### Conflict of Interest

No potential conflict of interest relevant to this article was reported.

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