Original Article

Effect of supplementary parenteral nutrition on glucose and lipid metabolisms, risk of infection, and prognosis in critically ill patients with low body weight

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Background: While enteral nutrition (EN) is the preferred route of nutrition support, and total EN often fails to meet the nutritional needs of patients. A combination of multiple nutritional strategies can reach nutritional goals earlier and improve clinical outcomes.

Methods: Totally 108 critically ill patients with a body mass index (BMI) of <22 who were admitted to our intensive care unit (ICU) from May 2017 to December 2018 were randomly divided into EN group (EN support alone) and supplementary parenteral nutrition (SPN) group (EN followed by SPN), with 54 patients in each group. The actual nutrient intake and biochemical markers before and after nutritional support as well as the duration of mechanical ventilation, length of stay (LOS) in ICU, LOS in hospital, ICU/hospital mortality, and infection complications were compared between these two groups.

Results: There were no significant differences in albumin, urea nitrogen, alanine aminotransferase, fasting blood glucose, and triglyceride between the EN group and the SPN group before the nutritional support therapy (P>0.05). After the treatment, the albumin level was significantly higher in SPN group than in EN group (P<0.05), although the levels of urea nitrogen, alanine aminotransferase, fasting blood glucose, and triglyceride showed no significant changes in both groups (all P>0.05). The actual calories and protein intakes in the SPN group were significantly higher than those in the control group (both P<0.05). The SPN group had a considerably shorter duration of mechanical ventilation, LOS in ICU, and LOS in hospital and considerably lower incidences of infection complications than the EN group (all P<0.05). The ICU and hospital mortality rates showed no significant difference between these two groups (both P>0.05).

Conclusions: SPN can improve the caloric and protein intakes, shorten the duration of mechanical ventilation, LOS in ICU, and LOS in hospital, and reduce the incidences of infection complications without apparent impact on blood lipid and sugar profiles or liver/kidney functions.

Keywords: Nutritional support; supplementary parenteral nutrition (SPN); prognosis; intensive care therapy; body mass index (BMI)

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Introduction

Nutritional support plays a critically important role in the treatment of critically ill patients. The patient's body is featured by high decomposition and high metabolism under severe stress, and proper nutritional support can meet the body's requirements on energy and nutrients, improve gastrointestinal function, promote recovery, and eventually improve prognosis. However, gastrointestinal intolerance or even interruption during enteral nutrition (EN) often leads to failure in achieving the nutrition targets. Supplemental parenteral nutrition (SPN) is a reasonable supplement to EN. In our current study, we explored the role of SPN in treating low-weight critically ill patients by focusing on its impacts on energy supply and clinical outcomes.

Methods

Subjects

Critically ill patients who were admitted to the intensive care unit (ICU) of our hospital from May 2017 to December 2018 were enrolled in this study. The inclusion criteria were as follows: (I) aged ≥18 years; (II) with an APACHE II score of ≥10; (III) with a body mass index (BMI) of <22; (IV) with an expected duration of mechanical ventilation of >72 h; (V) expected to live more than 7 days; (VI) with gastrointestinal function but unable to eat independently; (VII) with a nutritional risk screening (NRS) score of ≥3; and (VIII) having received EN within 48 h after ICU admission but less than 60% of the prescribed nutrition goal had been reached after three days of EN. The exclusion criteria included: (I) unstable vital signs; (II) in the end stage of chronic diseases; (III) with the contraindications (e.g., intestinal obstruction, intestinal perforation, etc.) of EN; and (IV) with accompanying nutritional and metabolic diseases.

The study was approved by the Ethics Committee of the Sixth Hospital affiliated to Sun Yat-sen University, and the ethical approval number is 2017SYSUSH-003.

Grouping and nutritional support

The subjects were divided into the EN group and SPN group by using the random number table. According to the nutritional support protocol, the calorie target was 20–25 kcals/kg, and the protein target was 1.2–1.5 g/kg. In the EN group, the EN solution (short-peptide EN formula) (Leskon, Xi'an, China) was fed through an EN pump. Gastric juice was collected every 4 hours to judge if there was any gastric retention. Frequency of defecation, fecal characteristics and amount, abdominal distension, gastric retention, and gastrointestinal bleeding, if any, were observed. The dose of the nutrient solution was adjusted based on the patient's tolerance. In the SPN group, a premixed nutrient solution (containing glucose, fat emulsion, amino acids, vitamins, and trace elements, which were prepared in specific ratios and filled in a 3-L bag) was applied based on EN.

Observations

NRS was performed at admission, and the nutritional status and biochemical parameters of the patients were recorded at admission and 10 days after treatment. The length of stay (LOS) in ICU and hospital, duration of mechanical ventilation, as well as ICU-related infections, ICU mortality, and hospital mortality, were recorded.

Statistical analysis

Statistical analysis was performed using the SPSS 17.0 software package. Measurement data are presented as ($\bar{x} \pm SD$). The means were compared using a *t*-test, and Welch's t-test was performed for unequal variances. Comparison of count data was performed using the chi-square test, with a P value of less than 0.05 being considered statistically significant.

Results

General data

A total of 118 patients were enrolled in this study, among whom six patients stopped EN due to gastrointestinal bleeding and/or refractory diarrhea, and four patients gave up treatment halfway. Thus, 108 patients entered the final analysis, with 54 patients in each group. The baseline data of these two groups showed no significant difference (all P>0.05) (*Table 1*).

Actual nutrient intakes

In the EN group, the actual protein intake accounted for (64.08±26.11)% of the protein required, and the actual calorie intake accounted for (69.03±27.76)% of the calories needed. In the SPN group, the actual protein

Table 1 Comparison of baseline data between two groups

Item	EN	SPN	t/X^2	P
Age (years)	45.66±10.14	47.81±10.57	1.079	0.283
Males	35	33	0.159	0.690
BMI	20.81±5.07	20.13±4.85	1.983	0.478
APACHE II score	16.09±5.37	16.03±6.09	0.054	0.957
Diseases (n)			1.615	0.656
Pulmonary infections	21	23		
Trauma	16	18		
Cerebrovascular diseases	12	7		
Non-digestive surgery	5	6		
Glycated hemoglobin (%)	5.08±2.72	5.15±2.33	0.144	0.886
Albumin (g/L)	35.62±5.94	34.84±3.61	1.316	0.191
Urea nitrogen (mmol/L)	4.93±1.04	4.89±1.26	0.180	0.858
Alanine aminotransferase (IU/L)	35.09±4.53	35.94±6.54	0.785	0.434
Fasting blood glucose (mmol/L)	9.23±4.17	9.31±4.09	0.101	0.920
Triglyceride (mmol/L)	1.73±0.57	1.77±0.82	0.352	0.725
Theoretical protein requirement (g/d)	1,810.97±339.03	1,834.03±320.93	0.363	0.717
Theoretical calorie requirement (kcal/d)	63.98±16.03	66.87±12.05	1.059	0.292

EN, enteral nutrition; SPN, supplementary parenteral nutrition; BMI, body mass index.

Table 2 Comparisons of biochemical indicators between two groups

Group	n	Albumin (g/L)	Urea nitrogen (mmol/L)	Alanine aminotransferase (IU/L)	Fasting blood glucose (mmol/L)	Triglyceride (mmol/L)
EN group	54	36.84±3.34	4.98±1.57	40.78±7.48	8.57±4.37	1.70±0.54
SPN group	54	42.78±3.27	5.36±1.25	43.09±6.33	9.12±5.47	1.77±0.82
t		9.338	1.391	1.732	0.577	0.524
P		0.000	0.167	0.086	0.565	0.601

EN, enteral nutrition; SPN, supplementary parenteral nutrition.

intake accounted for (85.97±18.88)% of the necessary protein, significantly higher than that in EN group (t=4.992, P=0.000); the exact calorie intake accounted for (94.58±12.67)% of the calories required, substantially higher than that in EN group (t=6.218, P=0.000).

Changes in biochemical parameters one week after treatment

One week after treatment, the albumin level was significantly higher in SPN group than in EN group (P<0.05); however, the levels of urea nitrogen, alanine aminotransferase, fasting blood glucose, and triglyceride showed no significant changes in both groups (all P>0.05) (*Table 2*).

Clinical outcomes

The duration of mechanical ventilation, LOS in ICU, and LOS in hospital in the SPN group were significantly shorter than those in the EN group (all P<0.05). However, there

Table 3 Comparisons of clinical outcomes between two groups

Group	Duration of mechanical ventilation (d)	LOS in ICU (d)	LOS in hospital (d)	ICU mortality (%)	Hospital mortality (%)
EN group	12.07±5.03	17.60±6.33	26.07±7.98	17.82	23.34
SPN group	9.98±5.23	13.84±8.09	20.93±8.87	13.46	15.37
t/X^2	2.117	2.690	3.166	0.628	0.982
P	0.037	0.008	0.002	0.428	0.322

EN, enteral nutrition; SPN, supplementary parenteral nutrition; LOS, length of stay; ICU, intensive care unit.

Table 4 Incidences of infection complications in two groups

Group	n	Pulmonary infections	Urinary tract infections	Bloodstream infections	Other infections	Total	Pathogens	
							Bacteria	Fungi
EN group	54	6	5	3	2	16/29.63	11/73%	5/7%
SPN group	54	4	2	1	0	7/12.96	5/89%	2/26%
X^2						4.475		0.017
P						0.034		0.898

EN, enteral nutrition; SPN, supplementary parenteral nutrition.

was no significant difference in ICU mortality and hospital mortality (both P>0.05) (*Table 3*).

Infection complications

Nosocomial infection occurred in 7 cases in the SPN group, and the incidence rate was 12.96%, which was significantly lower than that in the EN group (P<0.05). The composition of the pathogens showed no significant difference between two groups (P>0.05) (*Table 4*).

Discussion

Nutritional support is an integral part of the multidisciplinary treatment of critically ill patients. In these patients, a series of metabolic and physiological changes occur under severe stress conditions, causing abnormal carbohydrate, fat, and protein metabolism. Proper nutritional support is vital to avoid malnutrition, reduce protein catabolism, and even improve prognosis (1). EN is more consistent with human physiology and helps to maintain the structure and function of the intestines; meanwhile, it is less expensive and with fewer metabolism-related complications. Thus, EN is the preferred nutritional support method in clinical practice. However, EN alone often can not meet the energy needs of critically ill patients due to stress and/or poor intestinal function and thus may affect organ function and even prognosis (2,3). Reasonable SPN can compensate for EN; however, few pieces of literature have described its impacts on energy intake/metabolism and prognosis in low-weight critically ill patients.

The primary goal of SPN is to improve the nutritional status of patients and increase calorie and protein intakes. In our current study, the calories and protein intakes were significantly higher in the SPN group than in EN group, suggesting SPN can increase the inputs of energy and protein and improve the nutritional status (4). Similarly, a multicenter prospective randomized controlled study also found that SPN helped to increase caloric and protein intakes in patients, and albumin level in the SPN group was higher than that in the EN group after nutritional support (5). Decreased glucose oxidation and utilization (6), insulin resistance, gluconeogenesis, and many other conditions under severe stress often lead to stress-induced hypertension, while PN can easily cause acute and chronic metabolic complications such as blood sugar fluctuations, hyperlipidemia, and hypercalciuria. In our current study, the glucose infusion rate during PN was strictly controlled at 4–5 mg/(kg·min) and fasting blood glucose and triglyceride levels showed no significant difference between SPN group

and EN group, indicating that SPN has no remarkable impact on blood sugar in low-weight critically ill patients.

Also in our current study, the SPN group had significantly shorter duration of mechanical ventilation, LOS in ICU, and LOS in hospital and considerably lower incidences of infection complications, suggesting SPN can shorten the mechanical ventilation time and hospital stay, improve the quality of life, and lower the rates of complications associated with ICU infections. The body of critically ill patients is under stress status, which is featured by increased protein catabolism and decreased immunity, and delayed and/or insufficient nutritional supplementation will affect the structures and functions of organs and even lead to multiple organ dysfunction and death. Also, the strength and endurance of respiratory muscles decrease during malnutrition, which increases the risk of respiratory failure. While the standard caloric and protein targets may not be achieved by EN alone (7), excessive EN will exceed the endurance of the digestive system, increase the burden of the gastrointestinal tract, and finally worsen the stress-related gastric mucosal lesions, weaken the gastric mucosal barrier function, and injure the gastrointestinal hormone- and immunoglobulin-secreting functions. Early SPN can help reduce the incidences of infection complications and improve prognosis (7). SPN increases energy and protein intake, improves nutritional status and ensures the proper regulations of metabolism, physiology, and immune by the body, which facilitates tissue repair, improves gastric mucosal barrier function and micro-ecological environment, lowers the incidences of infection complications, and eventually shortens the duration of mechanical ventilation and LOS in ICU (8). However, it has also been argued that early SPN did not significantly reduce hospitalization time or increase 60-day survival rate and even worsened the prognosis (9,10), which might be explained by patient heterogeneity and SPN timing (11) and/or by variations in energy and protein demands, intestinal function, and SPN dose and compositions (12).

In summary, SPN can shorten the duration of mechanical ventilation, ICU stays, and hospital visits in low-weight critically ill patients, reduce the incidence of infectious complications, and supplement the energy and protein supply when EN cannot meet the needs of the body.

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Footnote

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Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013). The study was approved by the Ethics Committee of the Sixth Hospital affiliated to Sun Yat-sen University, and the ethical approval number is 2017SYSUSH-003. Informed consent was waived.

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