

RELATIONSHIP BETWEEN NUTRITIONAL INTAKE AND CLINICAL OUTCOMES DURING THE FIRST WEEK IN A SURGICAL INTENSIVE CARE UNIT: A PILOT STUDY

Pei-Chun Chao^{1,3}, Hsien-Hua Liao^{2,4}, Lu-Huan Chou^{4,5}

Abstract

Background and Objectives: Currently, the optimal energy and protein requirements for critically ill patients to reduce their morbidity and mortality remain unknown. Medical nutrition therapy is essential, especially during the first week of intensive care unit (ICU) treatment, because energy deficiency can affect clinical outcomes.

Methods and Study Design: A retrospective analysis of surgical ICU (SICU) cases was conducted from January to December 2023. Patients aged >18 years who required more than 7 days of hospitalization in the SICU were included and divided into three groups: a low-calorie low-protein (LCLP) group (<20 kcal/kg, <1.0 g/kg protein; n = 19), a standard-calorie standard-protein (SCSP) group (20–25 kcal/kg, 1.0–1.2 g/kg protein; n = 25), and a high-calorie high-protein (HCHP) group (>25 kcal/kg, >1.2 g/kg protein; n = 31).

Results: Significant decreases in Nutritional Risk Index scores (-1.64 ± 1.65 , $p < 0.001$), hemoglobin levels (-1.5 ± 3.07 g/dL, $p = 0.048$), weight (-2.52 ± 2.58 kg, $p < 0.001$), and body mass index ($p < 0.001$) were observed in the LCLP group. Similarly, significant decreases in Acute Physiology and Chronic Health Evaluation II scores were observed in the SCSP (-5.92 ± 5.48 , $p < 0.001$) and HCHP (-5.42 ± 6.76 , $p < 0.001$) groups. By contrast, significant increases in Glasgow Coma Scale scores were observed in the SCSP ($+3.56 \pm 3.91$, $p < 0.001$) and HCHP ($+4.23 \pm 4.99$, $p < 0.001$) groups.

Conclusions: During the first week of nutritional therapy in the SICU, adequate energy and protein intake may help improve patient care and clinical outcomes.

Key Words: surgical intensive care unit, energy, protein, critically ill patients

Correspondence: Registered Dietitian Pei-Chun Chao

School of Health Diet and Industry Management, Chung Shan Medical University; No. 110, Sec. 1, Jianguo N. Rd., Taichung City 402, Taiwan (R.O.C.)

Phone: +886-4-24739595 ext.34303; E-mail: cshc029@csh.org.tw

School of Health Diet and Industry Management¹, College of Medicine², Chung Shan Medical University, Taichung, Taiwan
Department of Nutrition³, Department of Surgery⁴, Department of Nursing⁵, Chung Shan Medical University Hospital, Taichung, Taiwan

Introduction

Intensive care units (ICUs) offer advanced facilities for the management of unstable patients.¹ Nutritional status is regarded as a key indicator of recovery in the ICU because nutritional health plays a central role in ameliorating critical illnesses and adverse clinical outcomes.² Insufficient feeding is common among critically ill patients, particularly among those with extended ICU stays.³ Therefore, ICU professionals should pay close attention to the nutritional status of their patients.

The prevalence of malnutrition among ICU patients is approximately 78%.⁴ Malnutrition is associated with poor clinical outcomes; it depletes health-care resources and increases medical costs.⁵ In critically ill patients, the priority is to provide adequate nutritional support to optimize organ function and host response.⁶ Enteral nutrition can regulate inflammation. For example, it can modulate the gut microbiome,⁷ maintain intestinal mucosal barrier function,⁸ and restore gut immunity.^{8,9}

Despite medical advancements, no consensus on optimal energy and protein delivery targets has yet been reached.¹⁰ Clinicians should determine their patients' energy requirements to determine the goals of nutritional therapy. Active nutrition does not always benefit patients.¹¹ The majority of nutritional guidelines recommend that energy delivery be lower than expenditure during the acute phase. These guidelines are generally based on findings regarding infection rates.¹² Permissive underfeeding may reduce mortality in critically ill patients admitted to ICUs.¹³ The American Society for Parenteral and Enteral Nutrition recommends achieving 12-25 kcal/kg body weight within 7-10 days of ICU admission and, for cases in which indirect calorimetry is not possible, 70% of estimated energy expenditure during the first week of ICU admission.¹²

No studies have yet explained how delivery

targets affect health outcomes. Some studies have indicated that early overfeeding should be avoided. In the Augmented versus Routine Approach to Giving Energy Trial and the Early Goal-Direct Nutrition in ICU study, aggressive early calorie intake led to additional episodes of hyperglycemia, and high-dose insulin therapy was required to counteract this effect.¹⁴ Despite these findings, whether permissive underfeeding is safe remains unclear. Full feeding is recommended for patients who require prolonged ventilator use or are at a high risk of nutritional deficiencies.¹⁵ Critically ill patients are usually hypermetabolic and hypercatabolic and therefore have high energy requirements during the early stages of the disease, which has been found to differ in guidelines published by different international societies.¹⁶

The optimal nutritional support strategy for ICU patients remains unclear, and guidelines and ICU practices on this matter often differ. Therefore, further research is required to clarify the optimal calorie and protein targets for effective nutritional therapy in the ICU.

Methods

Study Cohort

This single-center, retrospective cohort study included 75 critically ill patients who were admitted to a surgical ICU (SICU). These patients were divided into three groups: a low-calorie low-protein (LCLP) group (daily energy intake < 20 kcal/kg, daily protein intake < 1.0 g/kg; n = 19), a standard-calorie standard-protein (SCSP) group (daily energy intake = 20-25 kcal/kg, daily protein intake = 1.0-1.2 g/kg; n = 25), and a high-calorie high-protein (HCHP) group (daily energy intake > 25 kcal/kg, daily protein intake > 1.2 g/kg; n = 31). Data on the patients' demographic characteristics, nutritional intake, laboratory results, and clinical outcomes were compared at admission to and at discharge from the SICU. Enteral nutrition

was provided with or without supplemental peripheral parenteral nutrition. We searched our ICU database to identify eligible patients who were admitted to the SICU between January and December 2023. Details regarding ICU admission for enteral nutrition support were obtained from the patients’ medical records. Data extracted from the Hospital Information System of Chung Shan Medical University Hospital (CSMUH), Taiwan, were retrospectively analyzed. We integrated data from several hospital units, such as the information center, SICU, and management and nutrition departments.

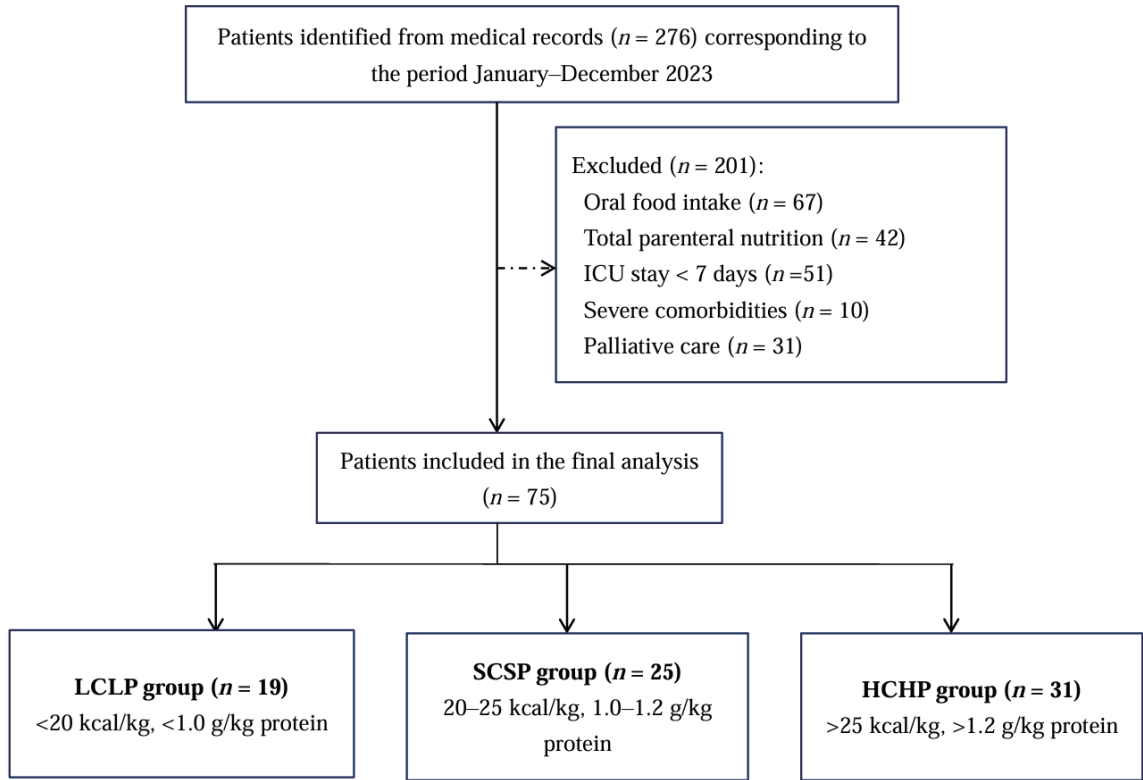
Inclusion and Exclusion Criteria

This study included patients who received enteral tube feeding (aged >18 years) after they were admitted to the SICU of CSMUH between

January and December 2023. Patients who received total parenteral nutrition, palliative care, or oral nutrition or stayed for <7 days were excluded. Patients with severe medical conditions that could affect their nutritional status or cause renal or hepatic failure were also excluded. The patient selection process is illustrated in Fig. 1.

ICU Scoring Systems

The Glasgow Coma Scale (GCS) is an instrument used to objectively determine the extent of impaired consciousness in patients with acute medical conditions or trauma. It is used to evaluate patients’ visual, motor, and verbal responses. Visual responses are scored from 1 (no response) to 4 (best response), verbal responses are scored from 1 (no response) to 5 (best response), and motor responses are scored from 1 (no response) to 6 (best



Abbreviations: ICU, intensive care unit; LCLP, low-calorie low-protein; SCSP, standard-calorie standard-protein; HCHP, high-calorie high-protein.

Fig. 1. Flowchart of Patient Selection

response). The total score ranges from 3 to 15.¹⁷

Acute Physiology and Chronic Health Evaluation II (APACHE II) is a severity-of-disease classification system used for assessing ICU patients. It is usually administered within 24 h of ICU admission. An integer score ranging from 0 to 71 is calculated on the basis of several parameters. A higher APACHE II score indicates greater disease severity and a higher risk of mortality.¹⁸

Nutritional Parameters

Body mass index (BMI) is widely used as a first-line biomarker of nutritional status. It is a simple, low-cost, noninvasive biomarker calculated by dividing body mass (in kilograms) by the square of body height (in meters). In adults, a BMI of <18.5 kg/m² indicates underweight, a BMI of 18.5–24.9 kg/m² indicates normal weight, a BMI of 25–29.9 kg/m² indicates overweight, and a BMI of ≥30 kg/m² indicates obesity.¹⁹

Nutritional Risk Screening 2002 (NRS-2002) is a tool used to identify patients susceptible to malnutrition. It helps determine nutritional status (on the basis of weight loss, BMI, and general condition or food intake) and disease severity (on the basis of metabolic stress), which are factors that affect health. Items are scored on a scale with endpoints ranging from 0 to 3 points, with an extra point awarded if the patient is aged ≥70 years. A total NRS-2002 score of ≥3 indicates a high risk of malnutrition.²⁰

The Nutritional Risk Index (NRI) is an instrument that quantifies the risk of malnutrition on the basis of body weight and serum albumin concentration. NRI scores are calculated as follows: $1.519 \times \text{serum albumin (g/L)} + 41.7 \times (\text{current body weight/usual body weight})$. NRI scores of >100, 97.5–100, 83.5–97.5, and <83.5 indicate no risk, mild risk, moderate risk, and high risk of malnutrition, respectively. Usual body weight is defined as the patient's typical body weight over the

preceding 6 months. Lower NRI scores indicate a higher risk of ICU mortality.²¹

Biochemical Parameters

Several biochemical indicators of the nutritional status and organ function of critically ill patients were evaluated. These indicators included albumin, C-reactive protein, glucose, blood urea nitrogen, creatinine, aspartate transaminase, alanine transaminase, sodium, and potassium. Routine blood analyses included hemoglobin levels, white blood cell counts, and lymphocyte counts. Changes in body weight were also measured.

Study Design and Ethical Considerations

This single-center, retrospective, observational study was conducted using clinical dietetic data. Data regarding demographic characteristics, nutritional intake, laboratory results, and clinical outcomes were collected at admission to (T1) and at discharge (T2) from the SICU. These data were compared between T1 and T2. Information on food consumption was documented on the Hospital Information System by nursing staff. The ICU team determined the timing of initial enteral feeding. Patients in both groups received enteral nutrition support, decided by a dietician who calculated calorie and protein intake. Enteral nutrition was initiated with a standard polymeric formula. Feeding consisted of intermittent bag feeding with five meals per day. Because of the retrospective nature of this study, the requirement for informed consent was waived by the Ethical Committee of CSMUH (reference: CSH-2024-A-042). This study adhered to the guidelines of the Declaration of Helsinki. The study protocol was approved by the Institutional Review Board of CSMUH (approval no. CS2-23220).

Statistical Analysis

All statistical analyses were conducted

using SPSS (version 18.0; SPSS, Chicago, IL, USA). Normally distributed continuous variables are presented as means $\pm$ standard deviations. Categorical variables are presented as numbers and percentages. One-way analysis of variance and a chi-square test were used for intergroup comparisons of continuous and categorical variables, respectively. Paired *t* tests were used for intragroup comparisons of continuous variables. A two-sided *p* value of <0.05 indicated statistical significance.

Results

Patient Characteristics

A total of 276 potentially eligible patients were identified. Of these patients, 75 met the inclusion criteria and were included in the study. These patients were divided into the following groups: an LCLP group ($n = 19$), an SCSP group ($n = 25$), and an HCHP group ($n = 31$). Table 1 presents the characteristics of the three groups. No significant intergroup differences were observed in age, sex, initial APACHE II score, initial GCS score, mechanical ventilation duration, comorbidity count, or initial nutritional parameters (anthropometric parameters, NRS-2002 score, albumin concentration, and daily protein and calorie requirements). However, significant intergroup differences were observed in SICU admission criteria ($p = 0.04$).

Effects of Blood Parameters

Changes in clinical parameters were examined in each group before and after the nutritional intervention (Table 2). In terms of body weight parameters, only the LCLP group exhibited significant changes (weight: -2.52 ± 2.58 kg, $p < 0.001$). In terms of APACHE II scores, the SCSP and HCHP groups exhibited significant changes (SCSP: -5.92 ± 5.48 , $p < 0.001$; HCHP: -5.42 ± 6.76 , $p < 0.001$). In terms of NRI scores, a

significant decrease was observed in the LCLP group (-1.64 ± 1.65 , $p < 0.001$), and a significant increase was observed in the HCHP group (1.00 ± 2.31 , $p = 0.022$).

In terms of biochemical parameters, no significant differences were observed between the three groups in terms of albumin, glucose, blood urea nitrogen, aspartate transaminase, alanine transaminase, or sodium concentrations. However, the concentration of C-reactive protein significantly decreased in the SCSP group (-6.93 ± 13.05 mg/dL, $p = 0.014$), the concentration of creatinine significantly decreased in the SCSP (-0.29 ± 0.73 mg/dL, $p = 0.003$) and HCHP (-0.16 ± 0.43 mg/dL, $p = 0.046$) groups, and the concentration of potassium significantly increased in the LCLP (0.71 ± 0.98 mEq/L, $p = 0.006$) and SCSP (0.29 ± 0.64 mEq/L, $p = 0.032$) groups.

In terms of blood parameters, no significant differences were observed between the three groups in terms of white blood cell or lymphocyte counts. However, the level of hemoglobin significantly decreased in the LCLP group (-1.5 ± 3.07 g/dL, $p = 0.048$).

Clinical Outcomes in Each Group

Significant between-group differences in calorie and protein intake were observed during the first week of admission. The actual calorie intake values were 17.72 ± 2.32 , 22.44 ± 1.65 , and 26.50 ± 2.07 kcal/kg body weight in the LCLP, SCSP, and HCHP groups, respectively ($p < 0.001$). Additionally, the actual protein intake values were 0.83 ± 0.16 , 1.07 ± 0.06 , and 1.25 ± 0.14 g/kg body weight in the LCLP, SCSP, and HCHP groups, respectively ($p < 0.001$). No significant between-group differences were observed in the number of days on mechanical ventilation, length of ICU stay, length of hospital stay, or mortality rate (Table 3). Similarly, no significant difference in survival rates was observed between the three groups (Fig. 2, $p = 0.946$).

Table 1. Patient Baseline Characteristics in the Low-Calorie Low-Protein (LCLP), Standard-Calorie Standard-Protein (SCSP), and High-Calorie High-Protein (HCHP) Groups

	LCLP (n= 19)	SCSP (n=25)	HCHP (n= 31)	P value
Age (years)	58.37 ± 12.56§	64.40 ± 15.41	63.94 ± 17.09	0.377
Male (%)	14 (73.68)	15 (60.00)	15 (48.39)	0.208
Initial ICU scoring systems				
APACHE II score [†]	20.53 ± 5.98	20.56 ± 5.95	20.10 ± 4.18	0.937
GCS score [‡]	5.68 ± 4.37	5.60 ± 3.94	6.13 ± 4.51	0.885
Mechanical ventilation (%)	15 (78.95)	20 (80.00)	20 (64.52)	0.349
ICU admission criteria (%)				0.040
Trauma Surgery	9 (47.37)	1 (4.00)	6 (19.35)	
Gastrointestinal surgery	2 (10.53)	5 (20.00)	4 (12.90)	
Vascular Surgery	7 (36.84)	17 (68.00)	17 (54.84)	
General Surgery	1 (5.26)	2 (8.00)	4 (12.90)	
Number of comorbidities (%)				0.908
0-1	12 (63.16)	16 (64.00)	21 (67.74)	
≥2	7 (36.84)	9 (36.00)	10 (32.26)	
Initial Nutritional parameters				
Height (cm)	165.79 ± 6.21	163.08 ± 8.37	162.06 ± 9.12	0.299
Weight (kg)	65.74 ± 6.45	63.54 ± 7.69	60.83 ± 6.45	0.0499
BMI (kg/m ²)	23.88 ± 1.33	23.91 ± 2.51	23.13 ± 1.07	0.177
NRS 2002 score [*]	3.16 ± 1.12	3.12 ± 1.05	3.10 ± 0.75	0.976
Albumin < 3 g/dL	9 (47.37)	11 (44.00)	12 (38.71)	0.824
Requirements				
Daily energy (kcal/day)	1,786.84 ± 144.19	1,732.00 ± 207.61	1,708.06 ± 239.48	0.433
kcal/kg IBW/day	29.52 ± 1.16	29.56 ± 2.04	29.46 ± 2.04	0.978
Daily protein (gm/day)	81.84 ± 7.30	79.60 ± 9.99	78.55 ± 11.34	0.530
gm/kg IBW/day	1.35 ± 0.08	1.36 ± 0.14	1.36 ± 0.16	0.980

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

[†] Scores on the Acute Physiology and Chronic Health Evaluation II (APACHE II) range from 0 to 71, with higher scores indicating greater illness severity.

[‡] The Glasgow Coma Scale (GCS) is used to assess consciousness in patients in a coma. A higher score indicates a clearer level of consciousness, offering a total score range of 3-15 points.

^{*} The Nutrition Risk Screening 2002 (NRS-2002) tool is used to detect the presence of malnutrition. A score of ≥3 indicates that the patient is nutritionally at risk, requiring a nutritional care plan.

BMI = body mass index, ICU = intensive care unit. Significance indicated by $p < 0.05$.

[§] Results are expressed as mean ± standard deviation.

Table 2. Clinical Parameters of the LCLP, SCSP, and HCHP Groups

	LCLP (n=19)			SCSP (n=25)			HCHP (n=31)		
	Pre	Post	p value	Pre	Post	p value	Pre	Post	p value
Anthropometric									
Weight (kg) §	65.74 ± 6.45§	63.22 ± 7.19	<0.001	63.54 ± 7.69	62.80 ± 7.52	0.206	60.83 ± 6.45	61.67 ± 6.69	0.098
BMI (kg/m ²)	23.88 ± 1.33	22.95 ± 1.57	0.001	23.91 ± 2.51	23.65 ± 2.54	0.217	23.13 ± 1.07	23.45 ± 1.26	0.099
ICU scoring systems									
APACHE II score	20.53 ± 5.98	18.26 ± 7.37	0.276	20.56 ± 5.95	14.64 ± 6.02	<0.001	20.10 ± 4.18	14.68 ± 7.81	<0.001
GCS score	5.68 ± 4.37	7.16 ± 3.99	0.184	5.60 ± 3.94	9.16 ± 3.72	<0.001	6.13 ± 4.51	10.35 ± 4.24	<0.001
NRI	45.71 ± 2.11	44.06 ± 2.84	<0.001	46.27 ± 1.75	45.94 ± 2.28	0.393	48.73 ± 3.20	49.74 ± 4.77	0.022
Biochemical									
CRP (mg/dL)	4.93 ± 6.48	8.57 ± 8.83	0.086	10.50 ± 13.56	3.58 ± 2.83	0.014	6.81 ± 7.98	5.54 ± 5.64	0.382
Albumin (g/dL)	3.02 ± 0.72	2.97 ± 0.49	0.744	3.20 ± 0.56	3.27 ± 0.39	0.529	3.11 ± 0.59	3.31 ± 0.58	0.185
Glucose (mg/dL)	162.84 ± 51.74	157.89 ± 63.99	0.691	158.48 ± 54.35	150.12 ± 73.39	0.466	161.16 ± 66.59	139.84 ± 62.34	0.167
BUN (mg/dL)	30.84 ± 18.93	51.95 ± 56.63	0.092	24.61 ± 20.06	25.26 ± 14.21	0.776	24.81 ± 19.25	31.76 ± 28.25	0.114
Creatinine (mg/dL)	1.50 ± 1.34	2.35 ± 3.07	0.108	1.22 ± 0.80	0.93 ± 0.68	0.003	1.17 ± 1.28	1.01 ± 1.25	0.046
AST (U/L)	61.00 ± 56.52	66.84 ± 62.31	0.637	42.04 ± 29.73	36.80 ± 15.52	0.428	53.77 ± 53.04	54.52 ± 38.47	0.951
ALT (U/L)	65.68 ± 64.35	70.32 ± 72.19	0.778	30.04 ± 21.14	34.48 ± 19.78	0.260	38.97 ± 25.53	42.71 ± 27.04	0.400
Na (mEq/L)	140.58 ± 6.88	138.32 ± 5.93	0.280	138.12 ± 5.90	138.32 ± 4.71	0.814	139.29 ± 6.35	139.10 ± 7.22	0.903
K (mEq/L)	3.51 ± 0.74	4.21 ± 0.83	0.006	3.65 ± 0.61	3.94 ± 0.36	0.032	3.67 ± 0.58	3.84 ± 0.62	0.191
Blood routine									
Hemoglobin (g/dL)	11.45 ± 2.94	9.95 ± 1.87	0.048	12.66 ± 2.16	12.13 ± 1.74	0.159	11.89 ± 2.22	12.11 ± 2.06	0.703
WBC (103/mm)	9,799.47 ± 3,492.07	9,814.74 ± 4,393.16	0.985	9,889.60 ± 3,988.02	9,927.20 ± 4,636.21	0.973	9,953.87 ± 7,033.99	9,908.06 ± 3,924.22	0.972
Lymphocyte (%)	15.70 ± 14.03	9.75 ± 4.97	0.056	17.83 ± 13.32	12.35 ± 6.27	0.063	15.45 ± 14.12	14.06 ± 7.11	0.552

Data are presented as number (%) or mean ± standard deviation. BMI = body mass index, APACHE II = Acute Physiology and Chronic Health Evaluation II, GCS = Glasgow Coma Scale, NRI = Nutritional Risk Index, ICU = intensive care unit, CRP = C-reactive protein, BUN = blood urea nitrogen, AST = aspartate transaminase, ALT = alanine transaminase, WBC = white blood cell. Significance indicated by $p < 0.05$; paired t test comparing prestudy and poststudy results in each group.

§ Results are expressed as mean ± standard deviation.

Table 3. Clinical Outcomes of the LCLP, SCSP, and HCHP Groups

Intervention Period	LCLP (n=19)	SCSP (n=25)	HCHP (n=31)	P value
Energy				
Actual Calories (kcal/day)	1,168.91 $\pm$ 215.70 [§]	1,421.00 $\pm$ 158.85	1,614.55 $\pm$ 245.32	<0.001
Actual Calories (kcal/kg BW)	17.72 $\pm$ 2.32	22.44 $\pm$ 1.65	26.50 $\pm$ 2.07	<0.001
% Requirements daily energy	65.30 $\pm$ 10.25	82.73 $\pm$ 10.13	94.74 $\pm$ 7.73	<0.001
Protein				
Actual Protein (g/day)	55.19 $\pm$ 12.85	67.99 $\pm$ 7.77	76.42 $\pm$ 14.09	<0.001
Actual Protein (g/kg BW)	0.83 $\pm$ 0.16	1.07 $\pm$ 0.06	1.25 $\pm$ 0.14	<0.001
% Requirements daily protein	67.35 $\pm$ 14.87	86.17 $\pm$ 10.41	97.71 $\pm$ 13.32	<0.001
MV (days)	11.47 $\pm$ 14.00	9.36 $\pm$ 8.19	7.58 $\pm$ 11.44	0.493
Mortality (%)	4 (21.05)	4 (16.00)	6 (19.35)	0.932
ICU LOS (days)	15.05 $\pm$ 12.23	13.28 $\pm$ 7.28	13.39 $\pm$ 9.99	0.806
Length of stay (days)	28.37 $\pm$ 19.75	27.72 $\pm$ 11.61	25.94 $\pm$ 12.19	0.819

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

ICU = intensive care unit, MV = mechanical ventilation, LOS = length of stay.

Results are significant at $p < 0.05$, as determined by one-way analysis of variance or chi-square test conducted for each group.

[§] Results are expressed as mean $\pm$ standard deviation.

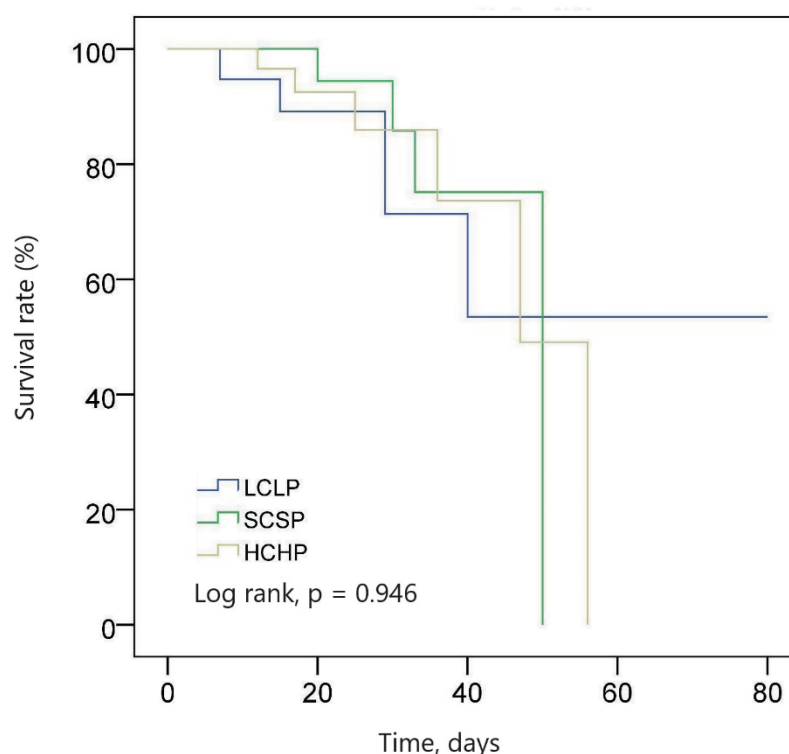


Fig. 2. Survival Curves of Patients in the Low-Calorie Low-Protein (LCLP), Standard-Calorie Standard-Protein (SCSP), and High-Calorie High-Protein (HCHP) Groups

Discussion

This study explored the effects of calorie and protein intake levels on clinical outcomes in patients admitted to the SICU. Nutritional support is regarded as the cornerstone of therapy for patients with critical illnesses.²² Various factors may cause major daily variations in energy expenditure within and between critically ill patients, highlighting the complexity of managing these patients and underscoring the importance of personalized nutrition therapy.²³

Metabolic responses to injury have been widely described as including an early acute “ebb” phase, a catabolic “flow” phase, and an anabolic or convalescent “recovery” phase.^{24,25} The ebb phase is brief and is marked by a reduction in oxygen consumption and energy expenditure. The flow phase is characterized by catabolism, insulin resistance, and increased energy expenditure, which may last for weeks after injury.²⁵ Given these metabolic changes and findings from key randomized controlled trials, energy provision should be gradually titrated over the first week of ICU admission to avoid overfeeding in light of endogenous glucose production.^{12,26} The majority of nutritional guidelines recommend energy delivery below expenditure during the acute phase,²⁷ referred to as permissive underfeeding, consistent with previous findings indicating a reduced incidence of infection associated with this type of feeding.²⁸ Although no optimal protein delivery goal has yet been established, the majority of guidelines recommend protein delivery at >1 g/kg/day.²⁷ However, this recommendation is not supported by strong evidence.

Weight loss due to insufficient nutritional intake and malabsorption is a common symptom of postoperative malnutrition in the SICU.^{29,30} Durán Poveda et al.³¹ highlighted insufficient nutritional intake as a reason for weight loss and malnutrition in patients who undergo surgery, even after

discharge. A study demonstrated an association between postoperative malnutrition and weight loss and emphasized the importance of postoperative nutritional interventions.³² In our LCLP group, significant reductions were observed in body weight and BMI at discharge (Table 2).

Accurate assessment of nutritional status requires a validated and appropriate instrument. Several comprehensive nutritional assessment tools have been developed, such as the Subjective Global Assessment, the NRS-2002, the NRI, and the Mini Nutritional Assessment. All patients in this study were at a similar risk of malnutrition at ICU admission, as indicated by their baseline NRS-2002 scores (Table 1).

The NRI is a simple screening tool that considers serum albumin concentration, current body weight, and optimal body weight and is used to predict the risk of nutrition-related postoperative morbidity and mortality in critically ill patients.³³ Low albumin concentrations have been associated with short- and intermediate-term mortality.³⁴ In our study, the LCLP group exhibited considerable deterioration in overall nutritional status, as evidenced by a significant decrease in NRI scores. By contrast, the HCHP group maintained favorable nutritional status (Table 2).

Predictive ICU scoring systems are tools that evaluate the extent of an ICU patient's illness and predict disease prognosis, usually in terms of mortality.¹⁸ Currently, critically ill patients admitted to ICUs are evaluated on the basis of their physiological state and the primary cause leading to a condition necessitating continuous monitoring. In this study, we used the GCS and the APACHE II system for patient evaluation. The GCS exhibits high accuracy in predicting in-hospital outcomes in patients with trauma. Given its ease of use and calculation, the GCS can be regarded as the optimal predictive tool for this patient population.³⁵ In our study, the SCSP and HCHP groups exhibited

significant improvements in their APACHE II and GCS scores at discharge (Table 2).

C-reactive protein concentration is used to improve risk stratification and prognosis prediction in the ICU.³⁶ In our study, the SCSP group exhibited a significant decrease in C-reactive protein concentration, indicating a major improvement in the patient's inflammatory status in response to the intervention. Blood creatinine and urea nitrogen concentrations, key indices in renal function, play a key role in assessing the severity of illness in ICU patients.³⁷ In the present study, we investigated the effects of blood creatinine and urea nitrogen concentrations on renal function in ICU patients. We observed that the concentration of creatinine decreased in the SCSP and HCHP groups. A decrease in creatinine concentration is important because it typically indicates improved kidney function or reduced muscle breakdown. Anemia is common in critically ill patients and is associated with poor outcomes. Lower hemoglobin levels at ICU admission are independently associated with higher in-hospital mortality in a graded manner.³⁸ In our study, the hemoglobin level significantly decreased and fell below the normal range in the LCLP group. (Table 2).

This study has several limitations. For instance, the sample size was relatively small, and the study was conducted at a single center, limiting random variability and the generalizability of the results. Retrospective studies have low control over variables and potential confounders because they rely on existing data. In this study, we minimized information bias by collecting standardized data, and we reduced selection bias by using inclusion and exclusion criteria. Additionally, certain patient characteristics, such as the criteria for admission to the SICU and admission weight, may have influenced the clinical outcomes. Patients undergoing different types of surgery, such as neurosurgery or gastrointestinal surgery, may have

different nutritional needs and recovery processes. Nutritional status and treatment responses may vary by region and level of medical care. Despite these limitations, our research provides compelling evidence of the limitations associated with LCLP diets.

Conclusion

LCLP diets are associated with a decline in nutritional status and a reduction in body weight and NRI score. This study provides valuable insights into the application of nutrition during the first week in the SICU and lays the foundation for further research. Future studies should consider adopting a larger-scale prospective design to better control variables and improve the reliability of the results. Additionally, long-term follow-up may enhance our understanding of the sustained effects of nutritional interventions on patient recovery and quality of life.

Acknowledgments

The authors would like to thank the coauthors of this article and the involved researchers from the Department of Surgery, CSMUH, Taiwan. They would also like to thank the staff at the Health Data Analytics and Statistics Center, Office of Data Science, CSMUH, for providing statistical consultation and for editing the figures. This manuscript was edited by Wallace Academic Editing.

Conflicts of Interest and Funding Disclosure

The authors have no conflicts of interest to declare. This study was supported by CSMUH, Taiwan (grant number: CSH-2024-A-042).

References

1. Marshall JC, Bosco L, Adhikari NK, et al. What is an intensive care unit? A report of

- the World Federation of Societies of Intensive and Critical Care Medicine task force. *J Crit Care*. 2017;37:270-276. doi: 10.1016/j.jcrc.2016.07.015.
2. Mohialdeen Gubari MI, Hosseinzadeh-Attar MJ, Hosseini M, et al. Nutritional status in intensive care unit: a meta-analysis and systematic review. *Galen Med J*. 2020; 9:e1678. doi: 10.31661/gmj.v9i0.1678.
 3. Fadeur M, Preiser JC, Verbrugge AM, et al. Oral nutrition during and after critical illness: spices for quality of care. *Nutrients*. 2020;12:3509. doi: 10.3390/nu12113509.
 4. Lew CCH, Yandell R, Fraser RJL, et al. Association between malnutrition and clinical outcomes in the intensive care unit: a systematic review [formula: see text]. *JPEN J Parenter Enteral Nutr*. 2017;41:744-758. doi: 10.1177/0148607115625638.
 5. Correia MITD, Perman MI, Pradelli L, et al. Economic burden of hospital malnutrition and the cost-benefit of supplemental parenteral nutrition in critically ill patients in Latin America. *J Med Econ*. 2018;21:1047-1056. doi: 10.1080/13696998.2018.1500371.
 6. Kondrup J. Nutritional-risk scoring systems in the intensive care unit. *Curr Opin Clin Nutr Metab Care*. 2014;17:177-182. doi: 10.1097/MCO.0000000000000041.
 7. Andersen S, Banks M, Bauer J. Nutrition support and the gastrointestinal microbiota: a systematic review. *J Acad Nutr Diet*. 2020;120:1498-1516. doi: 10.1016/j.jand.2020.04.024.
 8. Szeffel J, Kruszewski WJ, Buczek T. Enteral feeding and its impact on the gut immune system and intestinal mucosal barrier. *Prz Gastroenterol*. 2015;10:71-77. doi: 10.5114/pg.2015.48997.
 9. Schörghuber M, Fruhwald S. Effects of enteral nutrition on gastrointestinal function in patients who are critically ill. *Lancet Gastroenterol Hepatol*. 2018;3:281-287. doi: 10.1016/S2468-1253(18)30036-0.
 10. Patkova A, Joskova V, Havel E, et al. Energy, Protein, Carbohydrate, and Lipid Intakes and Their Effects on Morbidity and Mortality in Critically Ill Adult Patients: A Systematic Review. *Adv Nutr*. 2017;8:624-634. doi: 10.3945/an.117.015172.
 11. Casaer MP, Wilmer A, Hermans G, et al. Role of disease and macronutrient dose in the randomized controlled EPaNIC trial: a post hoc analysis. *Am J Respir Crit Care Med*. 2013;187:247-255. doi: 10.1164/rccm.201206-0999OC.
 12. Compher C, Bingham AL, McCall M, et al. Guidelines for the provision of nutrition support therapy in the adult critically ill patient: The American Society for Parenteral and Enteral Nutrition. *JPEN J. Parenter Enter Nutr*. 2022;46:12-41. doi: 10.1002/jpen.2267.
 13. Yue HY, Peng W, Zeng J, et al. Efficacy of permissive underfeeding for critically ill patients: an updated systematic review and trial sequential meta-analysis. *J Intensive Care*. 2024;12:4. doi: 10.1186/s40560-024-00717-3.
 14. Chapman M, Peake SL, Bellomo R, et al. TARGET Investigators, for the ANZICS clinical trials group, energy-dense versus routine enteral nutrition in the critically ill. *N Engl J Med*. 2018;379:1823-1834. doi: 10.1056/NEJMoa1811687.
 15. Compher C, Chittams J, Sammarco T, et al. Greater protein and energy intake may be associated with improved mortality in higher risk critically ill patients. *Crit Care Med*. 2017;45:156-163. doi: 10.1097/CCM.0000000000002083.
 16. Singer P, Blaser AR, Berger MM, et al. ESPEN guideline on clinical nutrition in the intensive care unit. *Clin Nutr*. 2019;38:48-79. doi: 10.1016/j.clnu.2018.08.037.
 17. Jain S, Iverson LM. Glasgow Coma Scale. 2023

- Jun 12. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2025 Jan
18. Mumtaz H, Ejaz MK, Tayyab M, et al. APACHE scoring as an indicator of mortality rate in ICU patients: a cohort study. *Ann Med Surg (Lond)*. 2023;85:416-421. doi: 10.1097/MS9.0000000000000264.
 19. Zierle-Ghosh A, Jan A. Physiology, Body Mass Index. 2023 Nov 5. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2024.
 20. Hersberger L, Bargetzi L, Bargetzi A, et al. Nutritional risk screening (NRS 2002) is a strong and modifiable predictor risk score for short-term and long-term clinical outcomes: secondary analysis of a prospective randomised trial. *Clin Nutr*. 2020; 39:2720-2729. doi: 10.1016/j.clnu.2019.11.041.
 21. Kundu R, Seeger R, Elfassy MD, et al. The association between nutritional risk index and ICU outcomes across hematologic malignancy patients with acute respiratory failure. *Ann Hematol*. 2023;102:439-445. doi: 10.1007/s00277-022-05064-7.
 22. Reignier J, Rice TW, Arabi YM, et al. Nutritional Support in the ICU. *BMJ*. 2025;388:e077979. doi: 10.1136/bmj-2023-077979.
 23. Veldsman L, Richards GA, Lombard C, et al., Course of measured energy expenditure over the first 10 days of critical illness: A nested prospective study in an adult surgical ICU. *Clin Nutr ESPEN*. 2025;65:227-235. doi: 10.1016/j.clnesp.2024.11.009.
 24. Tatucu-Babet OA, Ridley EJ. How much underfeeding can the critically ill adult patient tolerate? *J Intensive Med*. 2022;2:69-77. doi: 10.1016/j.jointm.2022.01.002.
 25. Wernerman J, Christopher KB, Annane D, et al. Metabolic support in the critically ill: a consensus of 19. *Crit Care*. 2019;23:318. doi: 10.1186/s13054-019-2597-0.
 26. Singer P, Blaser AR, Berger MM, et al. ESPEN practical and partially revised guideline: clinical nutrition in the intensive care unit. *Clin Nutr*. 2023;42:1671-1689. doi: 10.1016/j.clnu.2023.07.011.
 27. Cederwall CJ, Naredi S, Olausson S, et al. Prevalence and Intensive Care Bed Use in Subjects on Prolonged Mechanical Ventilation in Swedish ICUs. *Respir Care*. 2021;66:300-306. doi: 10.4187/respcare.08117.
 28. Rice TW, Mogan S, Hays MA, et al. Randomized trial of initial trophic versus full-energy enteral nutrition in mechanically ventilated patients with acute respiratory failure. *Crit Care Med*. 2011;39:967-974. doi: 10.1097/CCM.0b013e31820a905a.
 29. Feasel-Aklilu S, Marcus A, Parrott JS, et al. Is nutrition specific quality of life associated with nutritional status? *J Ren Nutr*. 2018;28:283-291. doi: 10.1053/j.jrn.2017.12.011.
 30. Park JY, Kim YJ. Successful laparoscopic reversal of gastric bypass in a patient with malnutrition. *Ann Surg Treat Res*. 2014;87:217-221.
 31. Santos HVDD, Araújo IS. Impact of protein intake and nutritional status on the clinical outcome of critically ill patients. *Rev Bras Ter Intensiva*. 2019;31:210-216. doi: 10.5935/0103-507X.20190035
 32. Durán Poveda M, Suárez-de-la-Rica A, Cancer Minchot E, Ocón Bretón J, Sánchez Pernaute A, Rodríguez Caravaca G, et al. The prevalence and impact of nutritional risk and malnutrition in gastrointestinal surgical oncology patients: a prospective, observational, multicenter, and exploratory study. *Nutrients*. 2023;15:3283. doi: 10.3390/nu15143283.
 33. Bector S, Vagianos K, Suh M, et al. Does the subjective global assessment predict outcome in critically ill medical patients? *J Intensive Care Med*. 2016;31:485-489. doi: 10.1177/0885066615596325.

34. Mas-Peiro S, Papadopoulos N, Walther T, et al. Nutritional risk index is a better predictor of early mortality than conventional nutritional markers after transcatheter aortic valve replacement: a prospective cohort study. *Cardiol J*. 2021;28:312-320. doi: 10.5603/CJ.a2019.0038.
35. Kim SM, Ryoo SM, Shin TG, et al. Early mortality stratification with serum albumin and the sequential organ failure assessment score at emergency department admission in septic shock patients. *Life*. 2024;14:1257. doi: 10.3390/life14101257.
36. Qu R, Hu L, Ling Y, et al. C-reactive protein concentration as a risk predictor of mortality in intensive care unit: a multicenter, prospective, observational study. *BMC Anesthesiol*. 2020;20:292. doi: 10.1186/s12871-020-01207-3.
37. Joannidis M, Druml W, Forni LG, et al. Prevention of acute kidney injury and protection of renal function in the intensive care unit: update 2017: expert opinion of the Working Group on Prevention, AKI section, European Society of Intensive Care Medicine. *Intensive Care Med*. 2017;43:730-749. doi: 10.1007/s00134-017-4832-y.
38. Christine C, Rasheed D, Carlos A, et al. Anemia as a potent marker of in-hospital mortality in patients admitted to the cardiac intensive care unit: Data from the Critical Care Cardiology Trials Network (CCCTN) Registry. *Journal of Intensive Medicine*. 2025;13:45.

外科加護病房第一週營養攝取與臨床結果的關係： 一項前導研究

趙佩君^{1,3*}，廖憲華^{2,4}，周律寰^{4,5}

摘要

背景與目的：目前尚不清楚能有效降低重症病患併發症與死亡率的最佳熱量與蛋白質需求量為何，營養治療在加護病房治療的第一週特別關鍵，因為能量不足可能會影響臨床結果。

方法與研究設計：本回溯性分析研究，針對2023年1月至12月間住於外科加護病房(SICU)的病例進行探討。納入年齡超過18歲，且於SICU住院超過7天的病患，並依照第一週熱量與蛋白質攝取量分為三組：低熱量低蛋白組（LCLP組，<20 kcal/kg、蛋白質<1.0 g/kg；n = 19）、標準熱量標準蛋白組（SCSP組，20–25 kcal/kg、蛋白質1.0–1.2 g/kg；n = 25）、高熱量高蛋白組（HCHP組，>25 kcal/kg、蛋白質>1.2 g/kg；n = 31）。

結果：在LCLP組中觀察到營養風險指數顯著下降（ -1.64 ± 1.65 ， $p < 0.001$ ）、血紅素濃度下降（ -1.5 ± 3.07 g/dL， $p = 0.048$ ）、體重下降（ -2.52 ± 2.58 kg， $p < 0.001$ ），以及身體質量指數下降（ $p < 0.001$ ）。同時，SCSP組（ -5.92 ± 5.48 ， $p < 0.001$ ）與HCHP組（ -5.42 ± 6.76 ， $p < 0.001$ ）的急性生理與慢性健康評估II（APACHE II）分數亦顯著下降。相對地，SCSP組（ $+3.56 \pm 3.91$ ， $p < 0.001$ ）與HCHP組（ $+4.23 \pm 4.99$ ， $p < 0.001$ ）的格拉斯哥昏迷指數（GCS）分數則顯著上升。

結論：在外科加護病房（SICU）營養治療的第一週期間，提供足夠的熱量與蛋白質攝取可能有助於改善病患的臨床照護與預後。

關鍵詞：外科加護病房，熱量，蛋白質，重症病患

通訊作者：趙佩君營養師

402臺中市南區建國北路一段110號；中山醫學大學健康餐飲暨產業管理學系

電話：04-24739595 轉34303；E-mail：cshc029@csh.org.tw

中山醫學大學 健康餐飲暨產業管理學系¹ 醫學研究所²

中山醫學大學附設醫院 營養科³ 外科⁴ 護理⁵