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Evaluation of Energy and Protein Intakes and Clinical Outcomes in Critically Ill Patients: A Cross-sectional Study

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ABSTRACT

Introduction: Critically ill patients admitted to the intensive care unit are often hyper-metabolic, hyper-catabolic, and at malnutrition risk. This study aimed to evaluate the amount of energy and protein intake and its correlation with the required amount in critically ill patients.

Methods: A total of 70 patients with critical conditions admitted to the ICU were eligible (age≥18 years and over a 3-day stay in ICU). Basic characteristics, medical history, and laboratory test results were extracted from the patient's medical records. Anthropometric indicators and the APACHE II questionnaire were assessed. Patients' energy and protein requirements were 25kcal/kg/day and 1.2g/kg/day, respectively.

Results: The mean age in the target population was 57.69±20.81 years, and 48.6% were men. The mean actual energy intake was significantly lower than the requirement (531.27±365.40 vs. 1583.77±329.36 Kcal/day, P<0.001). The mean actual protein intake was significantly lower than the requirement (14.94±18.33 vs. 74.11±17.89 gr/day, respectively, P<0.001). Energy and protein provision to the patients had a growing trend over time. There was a significant reverse correlation between the age of patients and total lymphocyte count (r= -0.38, P=0.003). In addition, there was a significant reverse correlation between the Glasgow coma scale and mechanical ventilation duration (r=-0.49, P<0.001). The lowest average energy and protein intake were in patients with poisoning.

Conclusion: The energy and protein intake in critically ill patients is significantly less than recommended, requiring routine nutritional assessments.

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Introduction

Critically ill patients admitted to the intensive care unit (ICU) are often hyper-metabolic, hyper-catabolic, and at malnutrition risk (1). Malnutrition is independently associated with poorer clinical outcomes, higher mortality risk, longer ICU, and hospital length of stay (2). Systemic inflammatory responses occur during catabolic stress in critically ill patients (2, 3). An increase in mortality rate is predicted in this state because of physiologic instability (4).

Clinical nutrition can play a crucial role in alleviating and managing the morbidities of patients (5). Critically ill patients are often unable to eat. Therefore, early initiating nutrition support such as enteral nutrition (EN) and parenteral nutrition (PN) is essential (6). The nutritional intakes of many patients are either too many or too few compared to their metabolic

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needs (6, 7). The prevalence of malnutrition in ICU patients in developing and developed countries has been 78.1% and 50.8%, respectively (1). Inflammatory response associated with increased metabolic rate leads to hyperglycemia, lean body mass wasting, and inability to metabolize nutrients (2). Providing an adequate amount of each nutritional substrate may help these patients (8, 9). Generally, EN is superior to PN, and the guideline recommends starting as soon as possible (10, 11). A low calorie and protein intake, usually less than 70% of a patient's needs, has been associated with poor clinical outcomes (2). This study aimed to evaluate the amount of energy and protein intake and its correlation with the amount required for critically ill patients. A few clinical outcomes specialized for critically ill patients were also surveyed.

Methods

This Cross-sectional study was conducted from June 2018 to May 2019 after inspection by the Medical Ethics Committee of the Mashhad University of Medical Sciences (IR.MUMS.MEDICAL.REC.1398.078) about any possible ethical issues. Patients were recruited from two different ICUs (general and medical ICU), Imam Reza Hospital, Mashhad University of Medical Sciences, Mashhad, Iran, using simple sampling from available ICU patients according to the inclusion criteria (21-and 16-bed units).

A total of 70 patients with critical conditions admitted to ICU were screened for eligibility. The Inclusion criteria were age range >18-80 years, ICU admission, being evaluated from the first 24h of admission for three days. The exclusion criteria included death within the first three days of admission, pregnancy and lactation, chronic and acute renal failure and Hepatic encephalopathy, and inability to obtain informed consent.

A specialized nutritionist recorded data on the daily energy and protein intakes from EN and PN during ICU admission. Basic characteristics, medical history, and laboratory test results were extracted from the patient's medical records. Anthropometric and dietary data were measured by the specialized nutritionist or extracted from medical records. A tape measure was used to measure the ulna's length and determine the patients' heights. By calculating the ideal body weight based on height, we calculated the patients' ideal body weight. Mid-arm muscle circumference was assessed by measuring an accuracy of 0.1cm for each patient.

In both groups, initial EN via a nasogastric tube was performed using a hospital gavage formula with a specific amount of energy and protein (measured by Quality TESTA Laboratory Control), and nutrition-related confounders were modified. EN started continuously at the flow rate of 25ml/h, which was increased every 6 hours based on patient tolerance to achieve the desirable energy when the patients displayed no gastrointestinal symptoms (diarrhea, vomiting, abdominal distention, and gastric residual volume >300 mL).

Patients' energy and protein requirements were calculated based on ESPEN (European Society for Parenteral and Enteral Nutrition) guideline recommendations (10). The energy and protein requirements based on patients' condition and underlying disease were 25kcal/kg/day and 1.2g/kg/day, respectively (10). Hand-made formulas' energy and protein content (measured by Quality TESTA Laboratory Control) were compared with the required amount for each patient.

Sample Size

The sample size was calculated by a previous study (12), and the energy supply percentage was used as the primary variable. The total sample size was estimated at 65 patients based on the Type I error of 5% (α =0.05) and Type II error of 20% (β =0.20; the power of the study was 80%) with a 20% probability of drop-out patients during the study.

Statistical Analysis

Statistical analyses were conducted with SPSS software version 19 (SPSS Institute, Chicago, IL, USA). Descriptive statistics were used to examine the characteristics of patients. Independent samples t-tests determined the difference between patients' intake and requirements in each evaluation session. Pearson correlation coefficient was used to show the association of some clinical outcomes with age and GCS (Glasgow coma scale). A value of $p<0.05$ was used as a criterion for statistical significance.

Result

There were 70 eligible patients included in the study. The mean age in the target population was 57.69±20.81 years, of whom 48.6% (34) were men and 51.4% (36) were women. Among these participants, 25.7% (18) were poisoned patients, 21.4% (15) had respiratory problems, 15.7% (11) had sepsis, 11.4% (8) had gastrointestinal disorders, and 5.7% (4) had hematological disorders, 2.9% (2) renal disorders, 1.4% (1) cardiovascular disorders, and 15.7% (11) suffered from other disorders. Among the patients, 15.7% received EN, 22.8% received PPN, and 61.4% received SPN (Supplemental Parenteral Nutrition). The mean height was 157.97±9.26cm, weight was 65.26±7.40kg, and MAC was 26.10±3.47cm. The mean length of ICU and hospital stay was 24.18±25.20 days (range: 3-120 days) and 28.83± 26.81 days (range: 5-134 days), mean duration of mechanical ventilation was 2.43±2.17 days. A total of 61.7% (47) were dependent on mechanical ventilation. The mortality rate during the study was 60% (42 from 70 subjects) (Table 1).

Table 1. Demographic and baseline characteristics of patients (n = 70).

Variable	Value
Age (mean ±SD)	57.69 ± 20.81
Sex (n, percent)	48.6% men (34) 51.4% women (36)
Weight (means ±SD)	65.257± 7.399
Height (means ±SD	167.97± 9.261
MAC (mean ±SD)	26.10±3.475
Diagnosis (n, percent)	
Respiratory disorders	21.4% (15)
Poisoning	25.7% (18)
Gastrointestinal disorders	11.4% (8)
Sepsis	15.7% (11)
Renal disorders	2.9% (2)
Hematologic disorders	5.7% (4)
Cardiovascular disorders	1.4% (1)
Other	15.7% (11)
Type of feeding route (n, percent)	
EN	15.7% (11)
PPN	22.8% (16)
SPN	61.4% (15)
Ventilator Dependence (n, percent)	
Yes	67.1% (47)
No	32.9% (23)
Length of hospital stay (days)	28.833± 26.817(66)
Duration of ICU stay (days)	24.181±25.00(66)
Duration of mechanical ventilation (days)	2.428±2.170
APACHE	15.63± 4.428
Mortality rate (n, percent)	60% (42)

***** MAC, Mid Arm Circumference; EN, Enteral Nutrition; PPN, Parenteral Nutrition, SPN, Supplemental Parenteral Nutrition

Table 2. Mean actual energy and protein intakes and requirements

Variable	Mean ± SD
Actual energy intake (Kcal/day)	531.272 ±365.40
Energy requirement (Kcal/day)	1583.77 ± 329.36
P value	P<0.001
Actual protein intake (Kcal/day)	14.94 ±18.33
Protein requirement (Kcal/day)	74.11 ± 17.89
P-value	P<0.001

Note: Quantitative data are reported as mean (SD).

Table 3. Percentage of energy and protein supply in first 3 days of ICU admission

Time (days)	Energy (mean ± SD)	Protein (mean ± SD)
1	28.608± 18.977	12.389± 21.036
2	37.836± 25.464	21.552± 29.952
3	41.565± 27.483	27.056± 33.618
Total	34.708± 22.033	20.332± 14.854

Note: Quantitative data are reported as mean (SD).

The mean actual energy intake for the study population was 531.2726±365.40Kcal/day, while the mean energy requirement was 1583.77± 329.36Kcal/day, based on patients' stress and bedridden period time. A comparison of the means showed a significant difference between actual energy intakes and requirements (P<0.001). Mean essential protein intake and requirement were 14.94±18.33 and 74.11 ±17.89gr/day, respectively, and the analysis for comparing these means for protein showed a significant difference (P<0.001) (Table 2).

The data showed that the percentage of energy and protein supply based on requirements in the total population were 34.70±22.03 and 20.33±14.85, respectively. Over time, patients had a growing trend in providing the required energy and protein (Table 3).

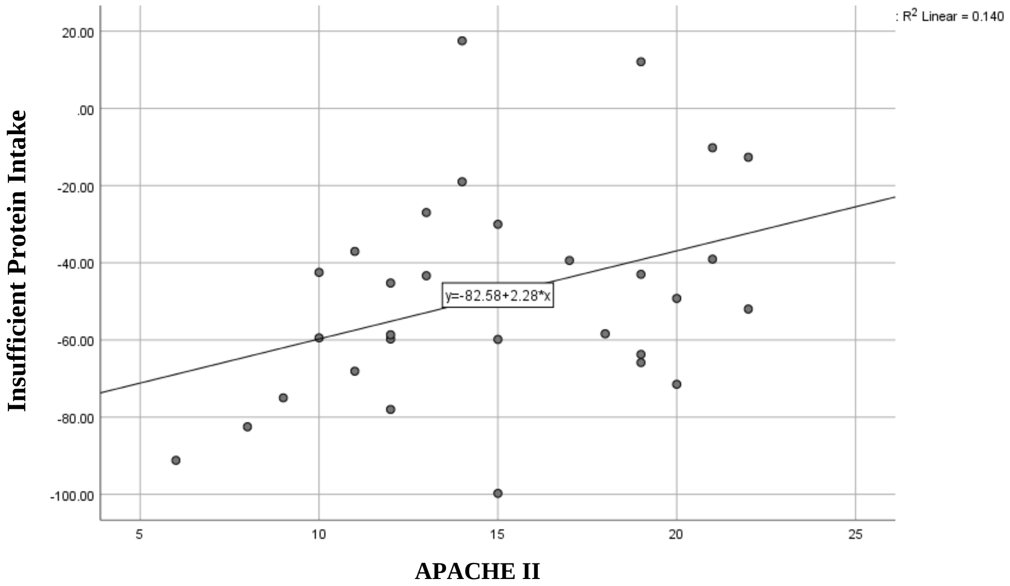

Figure 1. The Association between disease severity (according to the APACHE II score) and insufficient protein intake

There was a significant correlation between disease severity (APACHE II score) and insufficient protein intake (r=0.374, P=0.042) (Figure 1). Despite the correlation between disease severity and inadequate energy intake, no significant correlation exists (r=0.336, P=0.070).

The lowest average energy and protein intake is in patients with poisoning. Insufficient energy intake was associated with underlying diseases (P=0.03) but not with protein intake (P=0.417) (Table 4).

Table 4. The association between underlying diseases and energy intake

Underlying diseases	Mean Energy and Protein intake (MD±SD)		Mean Ratio Energy and Protein intake * (MD±SD)	
Respiratory disorders	652.37 ± 445.41	20.57 ± 22.23	43.51 ± 26.98	30.64 ± 36.05
Poisoning	378.85 ± 186.29	7.60 ± 12.30	24.57 ± 10.19	9.24 ± 13.34
Gastrointestinal disorders	421.66 ± 402.14	13.50 ± 20.11	32.61 ± 31.28	21.89 ± 33.08
Sepsis	766.69 ± 301.52	22.93 ± 14.50	44.03 ± 18.60	27.99 ± 19.99
Other	487.61 ± 377.75	13.33 ± 19.64	32.57 ± 19.88	17.72 ± 24.04
P value	0.03	0.15	0.08	0.15

*Percentage ratio of energy and Protein intake to required energy and Protein, respectively

Note: Quantitative data are reported as mean (SD). The association between underlying diseases and energy intake was compared using one-way ANOVA.

A significant reverse correlation existed between the patient's age and total lymphocyte count (coefficient= -0.38, P=0.003). In addition, the results indicated that the duration of mechanical ventilation decreases as the GCS increases (coefficient=-0.49, P<0.001). Other correlations between age and serum albumin and duration of

ICU stay and association between GCS and ICU and hospital stay were insignificant.

Discussion

The results showed that the actual intake of protein and energy in patients admitted to the ICU is significantly less than the values recommended by the guidelines. According to previous studies, achieving the desired energy level and protein intake is one of the essential points for achieving positive clinical outcomes (13). The study's low protein and energy intake were probably due to the NPO of several patients in the first three days of hospitalization, unstable hemodynamic conditions, gavage intolerance, and a low percentage of protein and energy in hospitalized gavage used to feed patients. These results were consistent with those of Campbell et al. (14). Another similar study showed that patients admitted to the ICU received only 65% of their calorie needs and 61% of their protein requirements (12).

Nutritional evaluation in patients in critical conditions differs from other patients; it is necessary to prepare an efficient nutritional treatment protocol and medical treatment (11, 15). Intermittent and continuous nutrition monitoring are essential components of nutritional assessment (15, 16). Nutritional protocols in ICU patients recommend feeding within the first 24 hours of admission and gradually increasing over time (9, 16).

Acutely ill patients suffer from reduced nutritional intake, muscle protein loss, and poor clinical outcomes due to the inflammatory cascade (17, 18), similar results were obtained in this study, and calorie and protein intake was significantly lower than recommended by guidelines. Therefore, nutrition interventions should begin when the patient's condition stabilizes to improve energy and protein intake and prevent malnutrition.

Increasing the level of consciousness reduces the rate of mechanical ventilation and consequently reduces the need for intubation (19). One study showed that increasing calorie and protein intake in patients admitted to the intensive care unit, especially patients with a body mass index (BMI) greater than 35 or less than 25, was associated with better clinical outcomes, including decreasing mortality rate and increased ventilator-free days (VFDs). This result was in line with that of the present study, which showed that increasing the GCS level reduces the duration of mechanical ventilation (16). The optimal amount of protein and calories in patients admitted to the ICU has not yet been entirely determined, but some studies have shown that a hypocaloric diet for obese patients admitted to the ICU has better clinical outcomes (12, 14, 20). Looijaard et al. showed that increasing protein intake in the acute phase of patients with low skeletal muscle area admitted to the ICU reduces the mortality rate (21). Generally, the results of studies on the administration of high-protein diets in patients admitted to the ICU are very controversial (22). Some observational studies have shown the beneficial effects of high protein intake on clinical outcomes. At the same time, these benefits have not been fully confirmed in clinical trial studies. However, few studies have found that very early protein intake is even harmful (23-28). A retrospective study showed that low protein intake (<0.8g/kg/day) in the first three days of ICU admission, along with high protein intake ((>0.8 g/kg/day)) after the third day of admission, was associated with a reduction in 6-month mortality. In addition, low protein intake throughout the all ICU stay was associated with worst clinical outcomes (29). Weijs et al. reported that high protein intake (>1.2 g/kg/day protein on day 4 of ICU admission) is associated with improved clinical outcomes (23).

Based on the systematic review conducted by Lew et al., malnutrition in patients admitted to the ICU leads to poor clinical outcomes and increased length of hospital stay in critically ill patients (1); therefore, performing nutritional assessments and starting nutritional support can prevent malnutrition or treat existing malnutrition. According to previous studies, nutritional support by a specialist nutrition team can improve calorie intake and reduce clinical complications and mortality in patients admitted to the intensive care unit (8, 30). Therefore, it can be concluded that nutritional support by a nutrition support team (NST) can effectively improve clinical complications, reduce ICU stay length, and ultimately reduce mortality. The medical and nutritional treatment of patients admitted to the ICU is a multidisciplinary task and should involve clinical nutrition specialists, surgeons, nurses, intensivists, and pharmacists, which leads to achieving the desired protein and calorie goals.

According to previous studies, enteral nutrition is the preferred method of feeding in ICU patients to reduce the rate of infections and decrease the length of ICU stay (1, 31). Only 15.7% of patients in our study received antral nutrition, indicating no nutrition support team in the intensive care unit. Therefore, nutritional guidelines in intensive care units of the studied hospitals should be re-evaluated, and nutritional assessments, nutritional care, and nutritional interventions performed by the nutrition support team should be considered.

Similar to other studies, the present work had some limitations. The first limitation was that the patient's weight was not measured but was asked by the patient or their companion. The patients were highly heterogeneous regarding the type of disease, which could affect the outcomes. In this study, even the amount of calories and protein needed was considered the same for all patients. Future studies should select homogeneous patients.

The difference between the energy received and the amount required leads to many problems. The primary use of hospital gavage without enough energy and protein, administration of gavage to all patients with the same volume based on a routine schedule, and failure to administration nutritional advice to adjust the appropriate diet for each patient can be the differences (32).

The reason for the low protein and calorie intake of patients in this study can be the NPO state of several patients in the first three days of hospitalization, unstable hemodynamic conditions and feeding intolerance, exclusion of TPN patients from this study, low protein and calorie percentage in hospital gavage solutions (in one study our hospital gavage contained 0.65kcal per cc and 4.2g of protein per 100cc), the variability of the gavage solution and frequent interruption of the gavage due to the non-implementation of standard protocols in intensive care units of the hospital. Further studies should be conducted after the first week to assess intake status and larger sample sizes.

Conclusion

Based on the results, the energy and protein intake in patients admitted to the ICU was significantly less than the recommended amount. Therefore, nutrition support teams should perform nutritional assessments and determine the feeding route and amount of energy and protein for feeding patients to prevent or treat malnutrition.

Author Contribution

Ahmad Bagheri Moghaddam: Supervision, Conceptualization, Methodology, Writing - Review & Editing, Project administration. Mohaddeseh Badpeyma: Project administration, Writing - Review & Editing, Data Curation, Visualization, Investigation. Mahsa Malekahmadi: Writing - Original Draft, Visualization. Alireza Sedaghat: Methodology, Project administration, Writing - Review & Editing. Andisheh Norouzian Ostad: Investigation. Majid Khadem-Rezaiyan: Formal analysis, Writing - Review & Editing. Naseh Pahlavani: Writing - Original Draft. Fatemeh Ebrahimbay Salami: Investigation

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Conflicts of Interest

The authors declare no conflict of interest.

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