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Target Calorie Intake Achievements for Patients Treated in the Surgical Intensive Care Unit

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Conflict of Interest
The authors declare that they have no competing interests.

ABSTRACT

Adequate nutritional support in critically ill patients is important, however, sometimes it has been neglected in perioperative period of patients at surgical intensive care units (SICU). The aim of this study was to investigate whether approaching target calorie intake of surgical patients influences on their clinical outcomes. A total of 279 patients who admitted at SICU in perioperative period from August 2014 to July 2016 at our hospital were analyzed. Demographics, supplied calorie amount and its method, lengths of SICU and hospital stay, and mortality of study population were collected. Among 279 patients, 103 patietns (36.9%) approached target calorie intake during SICU stay. Patients who approached target calorie intake had significantly decreased length of stay in SICU (10.78 ± 11.5 vs. 15.3 ± 9.9, p = 0.001) and hospital (54.52 ± 40.6 vs. 77.72±62.2, p < 0.001), than those did not, however there was no significant difference of mortality (9.7% vs. 8.5%, p = 0.829). Enteral feeding was a significant factor for target calorie achievement (odd ratio [OR], 2.029; 95% confidence interval [CI], 1.096–3.758; p = 0.024) and especially in patients with ≤ 7 days of SICU stay (OR, 4.13; 95% CI, 1.505–11.328; p = 0.006). Target calorie achievement in surgical patients improves clinical outcomes and enteral feeding, especially in early postoperative period would be an effective route of nutrition.

Keywords: Surgical intensive care unit; Malnutrition; Nasogastric tube; Total lymphocyte count; C-reactive protein

INTRODUCTION

The stress experienced during critical illness, along with an insufficient intake of nutritional supplements trigger various mechanisms which enhance prolonged catabolism [1]. Providing timely and sufficient calorie and protein is thought to influence both short-term outcomes (intensive care unit [ICU] length of stay, infections, duration of mechanical ventilation) and long-term outcomes (hospital length of stay, discharge disposition) [2]. However, malnutrition is still common in ICU with a prevalence of approximately 40% to 80% [3,4], which result in increased complications, cost, and mortality [5].

To date, medical intensive care unit (MICU) patients have been the focus of most research on calorie or protein deficits. However, patients in surgical intensive care units (SICUs) are less likely to achieve their caloric targets compared with their medical counterparts [6,7]. For surgical patients, many invasive procedures and diagnostic tests, and a variety of patients' physical, chemical response to surgery could affect nourishment. Also, the evidence on the association between nutritional intake and outcomes in SICU patients is less convincing.

Reaching the target calorie helps to determine the status of individual patient nutrition supply rather than simply comparing the amount of calorie provided. The objectives of this study were to investigate the actual rate of target calorie achievement in SICU patients and to figure out associated factors affecting target calorie achievement and understand the impact of different calorie intake levels on SICU patients' results.

MATERIALS AND METHODS

Study population and determination of nutritional status

Consecutive patients provided with nutritional support during their hospitalization in the SICU of Chung-Ang university hospital, from August 2014 to July 2016, as much as calculated sample size were included in this retrospective study. We excluded the patients who died in initial 48 hours of SICU admission. Nutrition supports were based on recommendations of our Nutrition Support Team in daily rounds by the surgeon, pharmacist, and clinical dietitian. The adequacy of feeding and the actual intake of energy and nutrients were assessed. Commercial formulas were used for enteral feeding according to underlying disease such as diabetes or renal failure.

In accordance with ESPEN guidelines, the energy provision target was aimed to be as close as possible to the total energy need calculated using Schofield Equation (basal metabolic rate in calories estimated based on sex, age, and weight with consideration of stress and activity; 20–30 kcal/kg body weight/day) [8,9].[REMOVED HYPERLINK FIELD] The protein requirement was estimated through 1.0–1.5 g/kg/day by tailoring for each patients with consideration of ventilator, bedridden status, kidney disease, or hemodialysis. Ideal or adjusted body weight was applied to equations according to patients' age and BMI. The energy and protein achievement rate (%) was calculated as: (actual intake/estimated requirement) × 100%. Patients' malnutrition status was assessed with their percent of ideal body weight (IBW) and albumin at ICU admission (**Table 1**) [10].

Data collection and Assessment

Demographics of patients' age, sex, and body mass index (BMI), as well as clinical measures including the severity of illness (Simplified Acute Physiology Score [11], hospital-mortality risk prediction score [12]), length of hospital and ICU stay, mortality, route of nutrition, their

Table 1. Assessment of nutritional status based on % IBW and albumin

Variables	% IBW			
	< 60%	60%–75%	76%–90%	> 90%
Albumin (mg/dL)				
< 2.5	Severe PEM	Severe PEM	Moderate malnutrition	Protein malnutrition (kwashiorkor)
2.5–3.0	Severe PEM	Moderate malnutrition	Moderate malnutrition	Protein malnutrition (kwashiorkor)
3.1–3.5	Moderate malnutrition	Moderate malnutrition	Mild malnutrition	Mild malnutrition
> 3.5	Energy malnutrition (marasmus)	Energy malnutrition (marasmus)	Mild malnutrition	No malnutrition present

IBW, ideal body weight; PEM, protein-energy malnutrition.

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target calorie and protein, and actual daily achievement of enteral or parenteral amount each were carefully reviewed and collected from the medical charts. Serum levels of hemoblobin, albumin, and C-reactive protein (CRP) were measured in patients at least once every 3 days during their stay in the SICU, or more frequently depending on their condition. We used the average values of those tests (before SICU discharge or death) during our stay in the SICU in the analysis. These data were analyzed to find out the associations with the target calorie intake during the course of SICU hospitalization.

In the analysis of 2,709 daily nutritional records from 279 patients, we attempted to discover the factors affect the survival outcome. Thus, we divided patients into survivor and non-survivor groups based on in-hospital results and compared these with patients' clinical factors.

Statistics

The primary endpoint of this study was to show the relationship between clinical variables and the accomplishment of the target calorie intake. To evaluate the primary endpoint, we planned to use binary logistic regression analysis with the accomplishment of the target calorie intake as a dependent variable and other clinical factors as independent variables. The target calorie accomplishment rate is thought to be 40% in patients treated in the SICU. We wanted to detect an odds ratio of 2.0. For 80% power at the 0.05 significance level with a two-sided test, we needed 264 patients. Considering 5% of missing values, we enrolled 279 patients in this study. PASS 11 software (NCSS) was used to calculate the sample size. We determined the effect size as 0.416 using our total sample size and the differences between the two groups with or without target calorie intake accomplishment. Using G Power analysis, we calculated the power of the study as 0.999 (critical χ^2, 11.07).

All data were analyzed by SPSS statistical software version 23.0 (SPSS Inc., Chicago, IL, USA). Continuous variables were described using the mean and standard deviation, and Student's t-test or Mann-Whitney Rank-Sum test were used to compare the groups for significance. Categorical variables were described with frequency and percentage rates using the χ^2 test or Fisher's exact test to examine for significance. Multivariate logistic regression was used to estimate the odds ratios and 95% confidence intervals for mortality. All tests were two-sided, and p values < 0.05 were considered statistically significant.

Ethics approval and consent to participate

The study protocol was approved by the Medical Ethics Committee of Chung-Ang University Hospital (IRB No. 1810-007-16209). Signed informed consent was obtained from each patient for using samples, materials and publication.

RESULTS

In the review of 2,709 daily nutritional records from 279 SICU patients, individuals were 60.6% of male patients and the majority was from the neurosurgery department. Their age (mean ± standard deviation) was 63.34 ± 15.38 years, and their mean SICU length of stay was 12.45 ± 11.13 days. The patients' demographics and clinical characteristics are described in **Table 2**. Among specific categories, 38% had underlying caloric malnutrition, with 9% having moderate severity. Enteral feeding was started at mean 2.07 ± 1.9 days in 180 patients (64.5%). Others (35.5%) were supplied by parenteral nutrition only during SICU stay.

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Table 2. Patients' demographics and clinical characteristics

Variables	Values
Age (yr)	63.34 ± 15.38
Sex	
Male	169 (60.6)
Female	110 (39.4)
BMI (kg/m^2)	23.19 ± 4.13
Department	
Neurology and neurosurgery	207 (74.2)
General surgery	21 (7.5)
Cardiovascular surgery	11 (3.9)
Others	40 (14.3)
Nasogastric tube/C-line	
Present/present	79 (28.3)
Present/absent	102 (36.6)
Absent/present	12 (4.3)
Absent/absent	86 (30.8)
Target calorie approach	
Accomplished	103 (36.9)
Failed	176 (63.1)
Target protein approach	
Accomplished	135 (48.4)
Failed	144 (51.6)
SAPS score	52.09 ± 18.12
Expected mortality rate	0.27 ± 0.26
Hospital stay (days)	63.09 ± 50.82
ICU stay (days)	12.45 ± 11.13
Underlying malnutrition	
No malnutrition	66 (23.7)
Mild malnutrition	79 (28.3)
Moderate malnutrition	27 (9.7)
Kwashiorkor state	107 (38.4)
Mortality	
Death	25 (9.0)
Alive	254 (91.0)
Total	279

Values are presented as mean ± standard deviation or number (%).
BMI, body mass index; C-line, central line; SAPS, simplified acute physiology score.

Association of target calorie approach with patients' clinical characteristics

We defined the target calorie or protein approach group as individuals who approached 100% of target calorie or protein during their stay in the SICU. Of the 279 patients, only 103 (36.9%) approached target calorie intake during their SICU stay. For a protein approach, 48.4% of patients accomplished the estimated requirement. To figure out which factors impact on target calorie approach, we compared two groups of patients according to target calorie accomplishment. **Table 3** describes the characteristics of 2 groups with or without target calorie accomplishment.

Patients with or without target calorie accomplishment did not differ with regard to age, BMI, or treated clinical department. Patients with target calorie accomplishment had a significantly shorter length of hospital days. Higher enteral nutrition rate was observed in target calorie accomplishment group. Their mean enteral nutrition rate to parenteral nutrition was 53.2% versus 46.8%. In the patients who failed target calorie accomplishment, mean enteral nutrition rate to parenteral nutrition was 34.0% versus 66.0%.

The target calorie approach group showed a lower SAPS score, more female patients, and a lower mortality risk prediction. Patients who met their target calorie intake also

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Table 3. Comparisons of two groups with or without target calorie accomplishment

Variables	Target calorie approach	Univariate analysis			Multivariate analysis		
		Yes (n = 103)	No (n = 176)	p value	p value	Exp(B)	95% CI
Age (yr)		64.13 ± 14.5	62.88 ± 15.9	0.515	0.68	1.004	0.986–1.022
Sex	Female	50 (48.5)	60 (34.1)	0.022	0.012	2.004	1.167–3.442
	Male	53 (51.5)	116 (65.9)				
BMI (kg/m^2)		23.37 ± 4	23.08 ± 4.2	0.578	0.309	1.033	0.97–1.101
Department	Neurology and neurosurgery	83 (80.6)	124 (70.5)	0.119	0.14	1.601	0.858–2.987
	General surgery	3 (2.9)	18 (10.2)				
	Cardiovascular surgery	4 (3.9)	7 (4)				
	Others	13 (12.6)	27 (15.3)				
Enteral feeding	Present	78 (75.7)	103 (58.5)	0.004	0.024	2.029	1.096–3.758
	Absent	25 (24.3)	73 (41.5)				
Parenteral feeding	Present	45 (43.7)	46 (26.1)	0.003	0.176	1.485	0.837–2.632
	Absent	58 (56.3)	130 (73.9)				
Target protein approach	Accomplished	99 (96.1)	36 (20.5)	< 0.001			
	Failed	4 (3.9)	140 (79.5)				
SAPS score		49.93 ± 17.2	55.8 ± 19.1	0.009	0.84	1.006	0.945–1.072
Expected mortality rate		0.24 ± 0.2	0.32 ± 0.3	0.008	0.863	1.461	0.02–108.02
Hospital stay (days)		54.52 ± 40.6	77.72 ± 62.2	< 0.001			
ICU stay (days)		10.78 ± 11.5	15.3 ± 9.9	0.001			
Mortality	Death	10 (9.7)	15 (8.5)	0.829			
	Alive	93 (90.3)	161 (91.5)				

Values are presented as mean ± standard deviation or number (%).
CI, confidence interval; BMI, body mass index; SAPS, simplified acute physiology score; ICU = intensive care unit.

accomplished a greater target protein rate. However, they showed the same mortality rate as patients who did not meet their target calorie intake. In multivariate regression analysis, we found that female sex (OR = 2.00, p = 0.012) and enteral feeding (OR = 2.03, p = 0.024) were significant factors affecting target calorie approach (**Table 3**).

Clinical factors affecting target calorie approach according to ICU days

Patients who have been hospitalized for a long time in SICU are likely to have other complex problems, such as the severity of the disease itself and intractable infection, so it was thought that the factors influencing target calories would vary depending on the SICU stay period. Therefore, we wanted to analyze the related factors by dividing the SICU hospitalization period into 7 days or more and less.

When the patients were divided into two groups by SICU stay length, 61.3% (171/279) belonged to the ≤ 7 days group. Stays of ≤ 7 days or > 7 days in the SICU groups showed no differences in the target calorie approach (34.5% vs. 40.7% in each group, p = 0.310 in the χ^2 analysis). In **Table 4**, enteral feeding was identified as a more important variable for ≤ 7 days of SICU stay to achieve the target calorie goal (OR = 4.13; p = 0.006). Patients with shorter SICU stay were more affected by the enteral nutrition therapy than those staying longer. Patients' sex was associated with target calorie approach in > 7 days SICU stay group (OR = 2.953; p = 0.003).

In-hospital mortality and affecting factors

The associations between the patients' clinical factors with in-hospital survival are presented in **Table 5**. About 9% (n = 25) of patients were died during hospitalization. There was no correlation between mortality and target calorie approach in the formal analysis. We found that patients' mean albumin and CRP levels had a significant correlation with patients' in-hospital mortality. Patients' underlying moderate malnutrition status was also related with higher mortality. Their sex, age, BMI, and mean hemoglobin levels were not statistically significantly related to patients' death.

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Table 4. Multivariate analysis of clinical factors affecting target calorie approach according to ICU days

Clinical factors affecting target calorie approach	ICU stay ≤ 7 days		ICU stay > 7 days	
	p value	OR (95% CI)	p value	OR (95% CI)
Age	0.057	1.04 (0.999–1.084)	0.77	0.997 (0.975–1.019)
Sex	0.266	1.754 (0.652–4.723)	0.003	2.953 (1.438–6.064)
BMI	0.816	1.012 (0.914–1.12)	0.121	1.083 (0.979–1.198)
Department	0.732	1.194 (0.433–3.294)	0.549	1.311 (0.541–3.177)
Enteral feeding	0.006	4.13 (1.505–11.328)	0.153	0.512 (0.204–1.283)
Parenteral feeding	0.73	1.337 (0.257–6.952)	0.449	1.307 (0.654–2.612)
SAPS score	0.382	0.948 (0.841–1.069)	0.82	1.009 (0.932–1.093)
Expected mortality rate	0.337	59.154 (0.014–2,451.6)	0.893	1.444 (0.007–310.782)

ICU = intensive care unit; OR, odds ratio; CI, confidence interval; BMI, body mass index; SAPS, simplified acute physiology score.

Table 5. The associations of the patients' clinical factors with in-hospital survival

Variables	Death	Alive	p value
Sex			0.951
Male	15 (8.9)	154 (91.1)	
Female	10 (9.1)	100 (90.9)	
Age (yr)	60.37 ± 13.9	61.82 ± 15..8	0.136
BMI (kg/m^2)	23.49 ± 2.4	23.12 ± 3.6	0.084
Hemoglobin	10.49 ± 1.8	10.53 ± 1.7	0.683
Albumin (mg/dL)	2.94 ± 0.6	3.12 ± 0.6	< 0.001
TLC (cells/mm^3)	1,333.02 ± 788.9	1,393.4 ± 646.5	0.144
Prealbumin (mg/dL)	18.17 ± 8.3	18.49 ± 7.5	0.545
CRP (mg/L)	106.23 ± 96.8	65.8 ± 70.0	< 0.001
Underlying malnutrition			0.018
No malnutrition	6 (9.1)	60 (90.9)	
Mild malnutrition	2 (2.5)	77 (97.5)	
Moderate malnutrition	6 (22.2)	21 (77.8)	
Kwashiorkor state	11 (10.3)	96 (89.7)	

Values are presented as number (%) or mean ± standard deviation.
BMI, body mass index; TLC, total lymphocyte count; CRP, C-reactive protein.

DISCUSSION

In our retrospective cohort study, only 36.9% of patients approached target calorie intake during SICU stay. Compared to other similar study focusing on target calorie approach in medical ICU patients, which reported 85.7% of target calorie accomplishment [13], surgical patients were less likely to achieve their caloric targets. Yeh et al. [2] also reported that mean received calorie for SICU patients was only 68% of requirements. However, hospital mortality of SICU patients was relatively lower than that of MICU patients' in those studies (9%–16% versus 41.9%).

In this study, patients who met their target calorie intake had a significantly higher enteral nutrition and central line insertion rate and shorter length of hospital stay. Over several years, enteral nutrition has improved in aspects of techniques, materials, and composition and has gained popularity because of both its lower cost and the lower rate of complications compared to parenteral nutrition. Additionally, our findings support enteral feeding as an effective way to approach target calorie intake as an artificial nutrition technique. Therefore, when we want to achieve target calorie intake in SICU patients, we should actively insert nasogastric tubes and enterally feed when possible. Meanwhile, a recent study emphasized target calorie achievement within three days, insisting on the importance of prompt commencement of supplemental parenteral nutrition whenever enteral nutrition fails to meet energy demands [2].

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SICU patient mortality was affected by underlying malnutrition rather than the target calorie approach during the course of ICU admission. A recent meta-regression analysis showed that average calories delivered did not have an overall effect on mortality (OR, 1.02; p = 0.73) [14], which is in agreement with our results.

We found that patients' mean albumin and CRP levels had a significant correlation with their in-hospital mortality. Harmandar et al. [13] reported observing a significant decrease in CRP levels in patients who achieved the target calorie intake but not in patients who failed to achieve their target calorie intake. Some studies showed that although the initial serum albumin levels were reflective of the baseline nutrition status, serum albumin and serum prealbumin level trends did not correlate with calorie or protein deficits and should not be solely used to assess the adequacy of nutrition delivery [15,16]. Their serum levels are good predictors for the risk of postoperative complications; when they are used with other methods of assessing nutritional status, such as subjective global assessment or the percentage of adequacy of skinfolds, they can be useful for identifying the nutritional risk [16]. Besides subjective nutritional assessment, the American Society for Parenteral and Enteral Nutrition (ASPEN) recommends a combination of clinical, biochemical, and anthropometric parameters for diagnosing malnutrition [17].

The strength of this study is that our study population is relatively large number of SICU patients which clinical characteristics and nutritional approaches might be different from MICU's. However, certain limitations of this study need to be acknowledged. Its retrospective design means that it is impossible to establish cause-and-effect relationships between related variables. For example, patients' sex was an impacting factor for achieving the target calorie intake; however, we could not suggest any specific explanation. Additionally, we could not account for the potential of patient-related factors, such as hemodynamic instability, oral reluctance, and procurement problems.

As the number of patients surviving critical illness has risen, there has been an increase in the reported physical and functional disability as well as quality of life impairment following discharge from the ICU. Although the mortality rate would not change with sufficient nutrition intake, optimal energy delivery provides beneficial clinical variables in surgical critically ill patients. When aspiring to achieve target calorie intake for SICU patients, active insertion of a nasogastric tube and enteral feeding should be performed whenever possible.

In this study, we found that enteral nutrition and patient sex were important clinical factors to reach target calorie supply for SICU patients and their importance was different according to SICU stay length. Higher calories were supplied to the patients and TLC and CRP levels improved significantly. However, no mortality change was observed according to the target calorie approach. SICU patient mortality was affected more by their underlying malnutrition than target calorie approach and patients' mean albumin and CRP levels.

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