

# Target calorie intake achievements for patients treated in the surgical intensive care unit

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## Research article

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# Abstract

## Background

Adequate nutritional therapy in critically ill patients is integral to an optimal outcome. This study determined which clinical factors affect the target calorie approach during SICU admission.

## Methods

Consecutive patients that were provided with nutritional support during their hospitalization in the Chung-Ang university hospital SICU from August 2014 to July 2016 were included in this retrospective study. Data on demographics, supplied calorie amount and method, lengths of stay in the hospital and the intensive care unit, and mortality outcomes when discharged from the SICU were collected and analyzed.

## Results

In 279 patients, 36.9% approached target calorie intake during SICU stay. In multivariate regression analysis, patients' sex and nasogastric tube insertion were significant factors affecting target calorie approach. (OR 2.00 for female sex, 2.03 for nasogastric tube insertion; p-value 0.012 and 0.024 for each, respectively) When we divide the patients into two groups by SICU stay length, nasogastric tube insertion is more important variable in  $\leq 7$  days of SICU stay for achieve the target calorie goal. (OR 4.13; p-value 0.006) As higher amounts of calories are supplied to the patients, total lymphocyte count (TLC) and C-reactive protein (CRP) levels improved significantly without changes in mortality.

## Conclusion

Existence of nasogastric tube and patient sex were important clinical factors to reach target calorie supply for SICU patients and their importance is different according to SICU stay length.

## 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 calories and protein is thought to influence both short-term outcomes (intensive care unit 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 intensive care units (ICU) with a prevalence of approximately 40 to 80% [3,4], which result in increased complications, costs, and mortality [5].

To date, medical ICU (MICU) patients have been the focus of most research on calorie or protein deficits. However, patients in 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 surgical ICU (SICU) patients is less convincing.

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

### *(1) 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 Aug. 2014 to Jul. 2016, as much as calculated sample size were included in this retrospective study. We excluded the patients who died in initial 48hrs of SICU admission. Nutritional supports were based on recommendations of our Nutritional 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 gender, age, and weight with consideration of stress and activity; 20-30 kcal/kg body weight/day) [8,9]. The protein requirement was estimated through 1.0-1.5g/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) x 100%. Patients' malnutrition status was assessed with their baseline Ideal Body Weight (IBW) and albumin at ICU admission (Table 1) [10].

### *(2) Data collection and Assessment*

Demographics of patients' age, gender, 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, presence of nasogastric tube and C-line, their target calorie and protein, and actual daily achievement of enteral or parenteral amount each were carefully reviewed and collected from the medical charts. These datas 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.

### *(3) 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  $\chi^2$  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 Chi-square 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.

This study was approved by the Medical Ethics Committee of Chung-Ang University Hospital (IRB No. 1810-007-16209).

## Results

In the review of 2709 daily nutritional records from 279 SICU patients, individuals were 60.6% of male patients and the majority was from the neurosurgery department. Their median (interquartile range) age was 63.34 ±15.38 years, and their median SICU length of stay was 12.45±11.1 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 (65%). Others (35%) were supplied by parenteral nutrition only during SICU stay.

### *(1) 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 two 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 higher nasogastric tube and central line insertion rate and 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 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-value = 0.012) and nasogastric tube insertion (OR = 2.03, p-value = 0.024) were significant factors affecting target calorie approach (Table 3).

### *(2) Clinical factors affecting target calorie approach according to ICU days*

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  $\chi^2$  analysis). In Table 4, nasogastric tube insertion was identified as a more important variable for ≤7 days of SICU stay to achieve the target calorie goal (OR 4.13; p-value 0.006). Patients with shorter SICU stay were more affected by the enteral nutrition therapy than those staying longer. Patients' gender was associated with target calorie approach in >7 days SICU stay group. (OR 2.953; p-value 0.003).

### *(3) 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 level have 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 level were not statistically significantly related to patients' death.

## 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 also reported that mean received calorie for SICU patients were only 68% of requirements [2]. However, in hospital mortality of SICU patients were 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 nasogastric tube 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 supplementation 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].

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 ( $p = 0.73$ ,  $OR = 1.02$ ) [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. 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 [13]. 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' gender 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 supplementation, optimal energy delivery provides beneficial clinical variables in surgical critically ill patients. When aspiring to achieve target calorie supplementation for SICU patients, active insertion of a nasogastric tube and enteral feeding should be performed whenever possible.

In this study, we found that existence of nasogastric tube and patient sex were important clinical factors to reach target calorie supply for SICU patients and their importance is different according to SICU stay length. Higher numbers of calories are 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.

## **Declarations**

### **Authors' contributions**

YSC designed the report and analyzed the data. SWS collected the patient's clinical data. MKK drafted the manuscript. HK and MKK analyzed the data and interpreted the results. All authors read and approved the final manuscript.

### **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.

### **Consent for publication**

Not applicable.

### **Competing interests**

The authors declare that they have no competing interests in this paper.

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## **Abbreviations**

TLC: Total lymphocyte count; CRP: C-reactive protein; ICU: Intensive care units; MICU: Medical ICU; SICU: Surgical ICU; ESPEN: The European Society for Clinical Nutrition and Metabolism; BMI: Body Mass Index; ASPEN: The American Society for Parenteral and Enteral Nutrition

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## Tables

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

		% IBW			
		<60%	60%–75%	76%–90%	>90%
<b>Albumin</b>	<b>&lt;2.5</b>	Severe PEM	Severe PEM	Moderate malnutrition	Protein malnutrition (kwashiorkor)
	<b>2.5–3.0</b>	Severe PEM	Moderate malnutrition	Moderate malnutrition	Protein malnutrition (kwashiorkor)
	<b>3.1–3.5</b>	Moderate malnutrition	Moderate malnutrition	Mild malnutrition	Mild malnutrition
	<b>&gt;3.5</b>	Energy malnutrition (marasmus)	Energy malnutrition (marasmus)	Mild malnutrition	No malnutrition present

**Table 2. Patients' demographics and clinical characteristics**



<b>Variables</b>		<b>N or mean value</b>
<b>Age</b>		63.34±15.38
<b>Sex</b>	male	169(60.6)
	female	110(39.4)
<b>BMI</b>		23.19±4.13
<b>Department</b>	neurology and neurosurgery	207(74.2)
	general surgery	21(7.5)
	cardiovascular surgery	11(3.9)
	others	40(14.3)
<b>Nasogastric tube/C-line</b>	present/present	79(28.3)
	present/absent	102(36.6)
	absent/present	12(4.3)
	absent/absent	86(30.8)
<b>Target calorie approach</b>	accomplished	103(36.9)
	failed	176(63.1)
<b>Target protein approach</b>	accomplished	135(48.4)
	failed	144(51.6)
<b>SAPS</b>		52.09±18.12
<b>Expected mortality rate</b>		0.27±0.26
<b>Hospital stay (days)</b>		63.09±50.82
<b>ICU stay (days)</b>		12.45±11.13
<b>Underlying malnutrition</b>	no malnutrition	66(23.7)
	mild malnutrition	79(28.3)
	moderate malnutrition	27(9.7)
	Kwashiorkor state	107(38.4)
<b>Mortality</b>	death	25(9.0)
	alive	254(91.0)
<b>Total</b>	N	279

BMI=body mass index; C-line=Central line; SAPS=simplified acute physiology score

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

Target calorie approach		Univariate analysis			Multivariate analysis			
		Yes (n=103) N (%)	No (n=176) N (%)	p value	p value	Exp(B)	95% CI(lower)	95% CI(upper)
<b>Age</b>		64.13±14.5	62.88±15.9	0.515	0.68	1.004	0.986	1.022
<b>Sex</b>	female	50(48.5)	60(34.1)	0.022	0.012	2.004	1.167	3.442
	male	53(51.5)	116(65.9)					
<b>BMI</b>		23.37±4	23.08±4.2	0.578	0.309	1.033	0.97	1.101
<b>Department</b>	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)					
<b>nasogastric tube</b>	present	78(75.7)	103(58.5)	0.004	0.024	2.029	1.096	3.758
	absent	25(24.3)	73(41.5)					
<b>C-line</b>	present	45(43.7)	46(26.1)	0.003	0.176	1.485	0.837	2.632
	absent	58(56.3)	130(73.9)					
<b>Target protein approach</b>	accomplished	99(96.1)	36(20.5)	<0.001				
	failed	4(3.9)	140(79.5)					
<b>SAPS</b>		49.93±17.2	55.8±19.1	0.009	0.84	1.006	0.945	1.072
<b>Expected mortality rate</b>		0.24±0.2	0.32±0.3	0.008	0.863	1.461	0.02	108.02
<b>Hospital stay</b>		54.52±40.6	77.72±62.2	<0.001				
<b>ICU stay</b>		10.78±11.5	15.3±9.9	0.001				
<b>Mortality</b>	death	10(9.7)	15(8.5)	0.829				
	alive	93(90.3)	161(91.5)					

BMI=body mass index; C-line=Central line; SAPS=simplified acute physiology score

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

Clinical factors affecting Target calorie approach	ICU stay ≤7days				ICU stay >7days			
	<i>p</i> value	OR	95%CI (lower)	95% CI (upper)	<i>p</i> value	OR	95%CI (lower)	95% CI (upper)
Age	0.057	1.04	0.999	1.084	0.77	0.997	0.975	1.019
<b>Sex</b>	0.266	1.754	0.652	4.723	<b>0.003</b>	<b>2.953</b>	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
<b>Nasogastric tube</b>	<b>0.006</b>	<b>4.13</b>	1.505	11.328	0.153	0.512	0.204	1.283
C-line	0.73	1.337	0.257	6.952	0.449	1.307	0.654	2.612
SAPS	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	2451.6	0.893	1.444	0.007	310.782

OR=Odds ratio; BMI=body mass index; C-line=Central line; SAPS=simplified acute physiology score

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

Variables		Death	Alive	<i>p</i> -value
<b>Sex</b>	Male	15(8.9)	154(91.1)	0.951
	Female	10(9.1)	100(90.9)	
<b>Age</b>		60.37±13.9	61.82±15..8	0.136
<b>BMI</b>		23.49±2.4	23.12±3.6	0.084
<b>Hb</b>		10.49±1.8	10.53±1.7	0.683
<b>Albumin</b>		2.94±0.6	3.12±0.6	<0.001
<b>TLC</b>		1333.02±788.9	1393.4±646.5	0.144
<b>Prealbumin</b>		18.17±8.3	18.49±7.5	0.545
<b>CRP</b>		106.23±96.8	65.8±70.0	<0.001
<b>Underlying malnutrition</b>	No malnutrition	6(9.1)	60(90.9)	0.018
	Mild malnutrition	2(2.5)	77(97.5)	
	Moderate malnutrition	6(22.2)	21(77.8)	
	Kwashiorkor state	11(10.3)	96(89.7)	

BMI=body mass index; TLC=total lymphocyte count; CRP=C-reactive protein;