Adductor Pollicis Muscle Thickness, Energy Intake, Serum Albumin, and Neutrophil-to-Lymphocyte Ratio as Predictors of Mortality in Critically Ill Patients

Shandy Iskandar¹, Rudyanto Sedono², Aries Perdana², Diana Sunardi³

¹Intensive Care Fellowship Program, Department of Anesthesia and Intensive Care, Faculty of Medicine, Universitas Indonesia, Jakarta, Indonesia
²Department of Anesthesia and Intensive Care, Faculty of Medicine, Universitas Indonesia, Cipto Mangunkusumo Hospital, Jakarta, Indonesia
³Department of Nutritional Sciences, Faculty of Medicine, Universitas Indonesia, Cipto Mangunkusumo Hospital, Jakarta, Indonesia
*Corresponding author: iskandarshandy74@gmail.com

Received July 10, 2021; Revised August 14, 2021; Accepted August 23, 2021

Abstract Background: Critically ill patients usually experience muscle wasting, inadequate energy intake and hypoalbuminemia, all of which were associated with poor outcomes. Adductor pollicis muscle thickness (APMT) can be used to assess nutritional status. Assessment of nutritional status cannot ignore the importance of inflammatory process. Neutrophil-to-lymphocyte ratio (NLR) was recently introduced as an inflammatory biomarker.

Aims: To analyze the relationship between APMT, energy intake, serum albumin, and NLR with 28-day mortality.

Methods: A prospective study was conducted in intensive care unit (ICU)’s of a tertiary care hospital, Indonesia, from February to March 2020. APMT was measured at admission with a caliper. Energy intake was calculated based on the number of calories received by the patient. Albumin serum and leukocyte differential count were checked at ICU admission. The primary outcome was 28-day mortality.

Results: This study involved 49 patients with mortality rate of 20.4%. There was no statistically significant difference in the mean APMT between non-survivor and survivor groups (24.25±4.65 vs. 24.97±3.59 mm, p=0.596). Mean energy intake at first day was 552.2±235.6 kcal or 47.0% of the target. There was no statistically significant relationship between energy intake and mortality (less energy intake category as a comparison). There was no statistically significant difference in the mean serum albumin between non-survivor and survivor groups (2.67±0.54 vs. 2.64±0.80 g/dl, p=0.928). Median value of NLR of all subjects was 13.28 (minimum 3.50 – maximum 59.56). There was statistically significant relationship between the subject group with high NLR (≥13.28) and low NLR group (<13.28) for mortality (p=0.031). Multivariate analysis to assess combined ability of independent variables to predict mortality obtained a satisfactory area under curve (AUC) value of 78.7%.

Conclusions: The combination of APMT, energy intake, serum albumin, and NLR can be considered as predictors of mortality in critically ill patients.

Keywords: critical care, nutrition assessment, energy intake, serum albumin, neutrophil-to-lymphocyte ratio

Cite This Article: Shandy Iskandar, Rudyanto Sedono, Aries Perdana, and Diana Sunardi, “Adductor Pollicis Muscle Thickness, Energy Intake, Serum Albumin, and Neutrophil-to-Lymphocyte Ratio as Predictors of Mortality in Critically Ill Patients.” Journal of Food and Nutrition Research, vol. 9, no. 8 (2021): 415-421. doi: 10.12691/jfnr-9-8-3.

1. Introduction

Malnutrition is a common problem in critical illness. Stress-related catabolism and lack of nutritional intake are the main factors causing malnutrition in critical illness [1]. Typical in critically ill patients there is loss of lean body mass, especially skeletal muscle mass. Anthropometric measurements of adductor pollicis muscle thickness (APMT) can be used to assess muscle mass objectively [2].

Critically ill patients tend to experience less energy intake. Although some studies have shown poor outcomes from underfeeding, more recent studies have shown better outcomes from permissive underfeeding [3]. Hypoalbuminemia is also common in critically ill patients. A meta-analysis reported poor outcomes associated with hypoalbuminemia [4].

Assessment of nutritional status cannot ignore the importance of assessing the inflammatory process. GLIM (Global Leadership Initiative on Malnutrition) approved diagnostic criteria for malnutrition including inflammatory conditions as etiological criteria [5]. A neutrophil-to-lymphocyte ratio (NLR) was recently introduced as an indicator of an inflammatory response that is practical, readily available, recheckable, and inexpensive [6]. The
joint consensus between the Academy of Nutrition and Diet and the American Society of Parenteral and Enteral Nutrition (ASPEN) regarding the characteristics of malnutrition and its application in practice, recommends the differential leukocyte count as one of the parameters that can be used to assess inflammation [7].

Because malnutrition was associated with poor clinical outcomes, nutritional parameters can be used as a predictive model. The present study aimed to analyze the relationship between APMT, energy intake, serum albumin, NLR and mortality in critically ill patients.

2. Methodology

2.1. Patient Population and Study Setting

This was a prospective study conducted at intensive care unit (ICU) Cipto Mangunkusumo Hospital (a tertiary care hospital in Jakarta, Indonesia) from February to March 2020. We included medical and surgical patients over 18 years of age. Patients who stay in the ICU less than 24 hours would be excluded.

2.2. Procedure and Instrument

We measured patients' anthropometric at ICU admission. APMT measurements used the Holtain® skinfold caliper (Creamy, UK) on the dominant hand for three consecutive measurements, then the average value was taken. The caliper was applied to the adductor pollicis muscle which was located on the apex of an imaginary triangle formed by “the extension” of the thumb and index finger (Figure 1). We defined an abnormal APMT as a value below the 10th percentile.

![Figure 1](image)

**Figure 1.** Measurement of adductor pollicis muscle thickness using the Holtain skinfold caliper

We also measured patients’ height and upper arm circumference using a Seca® 201 measuring tape (Hamburg, Deutschland). Height was measured as the distance from heel to top of head of the patient lying flat. Estimated body weight was calculated with the formula (upper arm circumference ÷ 26.3) × (height × 100). Body mass index (BMI) was calculated based on height and estimated body weight and then split into three categories: underweight (BMI < 18.5), normal weight (BMI 18.5-22.9) and overweight + obesity (BMI ≥ 23.0).

We assessed nutritional status using Nutritional Risk Screening (NRS) 2002 and GLIM criteria, classified into well nourished, moderate malnutrition and severe malnutrition. Daily energy intake was calculated based on the number of kilocalories (kcal) received by the patient, either orally, enterally or parenterally, divided by 20 kcal/kg body weight according to the target recommended by European Society of Parenteral and Enteral Nutrition (ESPEN) [8]. We defined the category of adequate energy intake if the value was 50 to 70% of the target, while the category of less and optimal energy intake if the value was < 50% and > 70% respectively.

The serum albumin and leukocyte differential count were checked at ICU admission. We defined hypoalbuminemia if its level was < 3.0 g/dl. Meanwhile, NLR was calculated based on the number of neutrophils and lymphocytes. We defined high NLR if the value ≥ median value obtained in this study, while low NLR if the value < median value. The APACHE (Acute Physiology And Chronic Health Evaluation) II and MSOFA (Modified Sequential Organ Failure Assessment) scores would be assessed within the first 24 hours of ICU admission. The primary outcome was 28-day all cause mortality.

2.3. Statistic Analysis

We performed the Bland-Altman test to assess reliability among trained observers before proceeding to subjects’ APMT measurements. Observers were declared to have the same ability if the reliability value was high (p > 0.05). The results of descriptive analysis for categorical variables would be presented in percentage form, while for numerical variables as mean ± SD (standard deviation) or median (minimum-maximum) depending on the data distribution. Chi-square test was used to compare APMT (abnormal vs. normal) and mortality. If the chi-square condition was not met, the Fisher's test was used. Chi-square test was also used to compare energy intake categories and mortality (less energy intake as a comparison). Similarly, this test was used to compare serum albumin (hypoalbuminemia vs. normal) with mortality, and NLR (high vs. low) with mortality.

Multivariate logistic regression analysis was used to determine the relationship of independent variables (i.e. APMT, energy intake, serum albumin and NLR) with the dependent variable (mortality). Independent variables whose p values < 0.25 or clinically significant (difference in proportion was ≥ 20%) would be included in the analysis. Research data would be analyzed with Statistical Package for the Social Sciences version 20.0 software (IBM SPSS Statistics, New York, USA). Statistically significant difference was accepted at p < 0.05.

2.4. Ethical Considerations

This study was approved by the Health Research Ethics Committee, Faculty Medicine Universitas Indonesia (Number: KET-59/UN2.F1/ETIK/PPM.00.02/2020). The patient and/or patient's family would be given a detailed explanation of this study and the process. Participation was voluntary and the confidentiality of the subject's data would be maintained. The study would begin after receiving written consent from the patient or family.
3. Results

The samples obtained were 49 of the total 158 subjects planned. The sampling process was stopped on March 23, 2020 due to the Covid-19 outbreak in our region. Of all subjects, mortality rate was 20.4%. Our study subjects were predominantly female (67.3%), surgical patients (67.3%) and septic patients (63.3%) (Table 1). Thirty (61.3%) subjects were diagnosed with malnutrition at ICU admission.

Table 1. Demographic and clinical characteristics

| Variable                        | Total subjects (n = 49) |
|---------------------------------|-------------------------|
| Age, mean ± SD, year            | 48.0 ± 16.7             |
| Sex, n(%)                       |                         |
| Male                            | 16 (32.7)               |
| Female                          | 33 (67.3)               |
| Diagnosis, n(%)                 |                         |
| Medical                         | 16 (32.7)               |
| Surgical                        | 33 (67.3)               |
| Sepsis/non-sepsis, n(%)         |                         |
| Sepsis                          | 31 (63.3)               |
| Non-sepsis                      | 18 (36.7)               |
| APACHE II score, median (min-max)| 10 (1-30)               |
| MSOFA score, median (min-max)   | 5 (1-14)                |
| BMI, n(%)                       |                         |
| Underweight                     | 10 (20.4)               |
| Normal                          | 26 (53.1)               |
| Overweight + obesity            | 13 (26.5)               |
| Nutritional status, n(%)        |                         |
| Well nourished                  | 19 (38.8)               |
| Moderate malnutrition           | 14 (28.6)               |
| Severe malnutrition             | 16 (32.7)               |
| APMT, mean ± SD, mm             | 24.82 ± 3.79            |
| Energy intake, mean ± SD, kcal  | 552.2 ± 235.6           |
| Serum albumin, mean ± SD, g/dl  | 2.65 ± 0.74             |
| NLR, median (min-max)           | 13.28 (3.50-59.56)      |

Note: n, number; %, percentage; SD, standard deviation; APACHE, Acute Physiology And Chronic Health Evaluation; min, minimum; max, maximum; MSOFA, Modified Sequential Organ Failure Assessment; BMI, body mass index; APMT, adductor pollicis muscle thickness; kcal, kilocalories; g/dl, gram per deciliter; NLR, neutrophil-to-lymphocyte ratio; ICU, intensive care unit.

The mean energy intake at first day (D1) was 552.2 ± 235.6 kcal or 47.0% of the target. Twenty five subjects (51.0%) were categorized as less energy intake, 10 subjects (20.4%) as adequate energy intake and 14 subjects (28.6%) as optimal energy intake (Figure 2).

Figure 2. Percentage of subjects by category of energy intake during the first seven days in ICU. The mean protein intake (line chart) was increased from 0.50 g/kg body weight at D1 (day one) to 1.01 g/kg body weight at D7 (day seven) to 1.01 g/kg body weight at D7 (day seven).

Thirty three subjects (67.3%) received energy intake D1 via the enteral route, 14 subjects (28.6%) by parenteral and 2 subjects (4.1%) through combination of both. Of all subjects, 27 subjects (55.1%) had feeding interruption. The main causes of feeding interruption were digestive intolerance (63.0%) and procedures (22.2%) such as hemodialysis, relaparotomy, invasive cardiac procedure, abdominal ultrasound examine. Others causes were unstable clinical conditions (11.1%) and intubation or extubation (3.7%).

There was no statistically significant difference in the mean APMT between non-survivor and survivor groups (24.25±4.65 vs. 24.97±3.59 mm, p=0.596). We found that the 10th percentile value of the APMT was 19.8 mm. Thus, the APMT was considered normal for all values above or equal to 19.8 mm. There was no statistically significant relationship between APMT (abnormal vs. normal) with mortality (Table 2). The difference in the proportion of 21.8% between APMT abnormal dan normal means that there was clinically significant relationship with mortality.

Table 2. Bivariate analysis of independent variables to mortality

| Variable                      | Non-survivor (n=10) | Survivor (n=39) | p-value | OR (95% CI) |
|-------------------------------|---------------------|-----------------|---------|-------------|
| APMT, n(%)                    |                     |                 |         |             |
| Abnormal                      | 2 (40.0)            | 3 (60.0)        | 0.267   | 3.00 (0.43-21.01) |
| Normal                        | 8 (18.2)            | 36 (81.8)       |         |             |
| Energy intake, n(%)           |                     |                 |         |             |
| Optimal                       | 4 (28.6)            | 10 (71.4)       | 0.224   | 2.67 (0.51-14.06) |
| Adequate                      | 3 (30.0)            | 7 (70.0)        | 0.174   | 3.67 (0.58-23.03) |
| Less                          | 3 (12.0)            | 22 (88.0)       |         |             |
| Albumin, n(%)                 |                     |                 |         |             |
| Hypoalbuminemia               | 7 (21.2)            | 26 (78.8)       | 0.580   | 1.17 (0.26-5.27) |
| Normal                        | 3 (18.8)            | 13 (81.2)       |         |             |
| NLR, n(%)                     |                     |                 |         |             |
| High                          | 8 (33.3)            | 16 (66.7)       | 0.031   | 5.75 (1.08-30.72) |
| Low                           | 2 (8.0)             | 23 (92.0)       |         |             |

Note: n, number; %, percentage; OR, odds ratio; CI, confidence interval; APMT, adductor pollicis muscle thickness; NLR, neutrophil-to-lymphocyte ratio.
Our results indicated that hand edema acted as a confounding variable. We could not control it with restriction method because the prevalence of subjects with hand edema was quite large (51%) of all subjects. We performed the Mantel-Haensel stratification analysis to control it, obtained $OR = 2.92$, 95% CI 0.42-20.39, $p = 0.280$). This value was the strength of the relationship between APMT (abnormal vs. normal) and mortality after controlling for hand edema variable.

There was no statistically significant relationship between energy intake D1 and mortality ($p = 0.224$ for the optimal vs. less category, $p = 0.174$ for the adequate vs. less category).

Table 3. Relationship between serum albumin and clinical characteristics

| Variable            | Hypoalbuminaemia (n (%)) | Normal (n (%)) | p-value | OR (95% CI)   |
|---------------------|--------------------------|----------------|---------|---------------|
| Diagnosis           |                          |                |         |               |
| Surgical            | 26 (78.8)                | 7 (21.2)       | 0.033   | 4.78 (1.31-17.40) |
| Medical             | 7 (43.8)                 | 9 (52.9)       |         |               |
| Nutritional status  |                          |                |         |               |
| Malnutrition        | 18 (60.0)                | 12 (40.0)      | 0.287   | 0.40 (0.11-1.50) |
| Well nourished      | 15 (78.9)                | 4 (21.1)       |         |               |
| NLR                 |                          |                |         |               |
| High                | 19 (79.2)                | 5 (20.8)       | 0.154   | 2.99 (0.85-10.55) |
| Low                 | 14 (56.0)                | 11 (44.0)      |         |               |

Note: n, number; %, percentage; OR, odds ratio; CI, confidence interval; NLR, neutrophil-to-lymphocyte ratio.

Table 4. Relationship between NLR tertile categories and mortality

| Tertile     | Non-survivor (n(%)) | Survivor (n(%)) | p-value | OR (95% CI)   |
|-------------|----------------------|-----------------|---------|---------------|
| $< 11.59$   | 2 (12.5)             | 14 (87.5)       |         |               |
| 11.59-14.75 | 3 (17.6)             | 14 (82.4)       | 0.530   | 1.50 (0.22-10.40) |
| $> 14.75$   | 5 (31.2)             | 11 (68.8)       | 0.197   | 3.18 (0.52-19.6) |

Note: n, number; %, percentage; OR, odds ratio; CI, confidence interval.

Figure 3. Receiver operating characteristic (ROC) curves of APMT (A), energy intake (B), serum albumin (C), NLR (D) and all combined (E). The area under ROC curve (AUC)'s values = 0.446, 0.595, 0.508, 0.633, and 0.787 respectively.
The mean albumin level in all subjects was 2.65 ± 0.74 g/dl. Thirty-three subjects (67.3%) had hypoalbuminaemia. There was no statistically significant difference in the mean serum albumin between non-survivor and survivor groups (2.67 ± 0.54 vs. 2.64 ± 0.80 g/dl, p = 0.928). There was no statistically significant relationship between albumin (hypoalbuminaemia vs. normal) and mortality (Table 2).

We found that hypoalbuminaemia was more common in subjects with a surgical rather than medical diagnosis, likewise in subjects with a high NLR rather than a low NLR (Table 3). There was no significant relationship between nutritional status (moderate+severe malnutrition vs. good nutrition) and serum albumin. There was no statistically significant difference in the mean serum albumin between malnourished and well-nourished subjects (2.69 ± 0.78 vs. 2.58 ± 0.71 g/dl, p = 0.637).

We obtained median value of NLR for all subjects was 13.28 (3.50-59.56). There was statistically significant relationship between the subject group with high NLR (≥13.28) and low NLR (<13.28) for mortality (p=0.031). There was a stepwise increase in mortality with increasing tertiles of NLR (Table 4).

We assessed the ability of each independent variables to predict mortality. The ROC curves and AUC values can be seen in Figure 3 A-D. We selected the APMT, energy intake, and NLR as variables to be included in multivariate logistic regression analysis. Based on the results of multivariate logistic regression analysis, we got p values > 0.05, which means that statistically there was no significant difference between these variables and mortality. Clinical significance was assessed by comparing the ORs obtained with those expected. We set a minimum OR which was considered significant at 1.5. We obtained OR values greater than 1.5 for each of variables, suggested that there were clinically significant relationship. The area under curve (AUC) obtained was quite satisfactory (78.7%) (Figure 3 E).

4. Discussion

The mean APMT obtained in present study was higher than that obtained in the Brazilian study. A study by Caporossi and coauthors obtained a mean APMT for the non-survivor group of 14.1±6.4 mm and the survivor group 16.7±6.0 mm; p=0.03 [9]. Our results were closer to those obtained in the Singapore study. A study by Shu-Fen and co-authors reported mean APMT values for the non-survivor group of 20.0±5.3 mm and the survivor group of 20.5±6.1 mm; p=0.62 [10]. These differences may be caused by differences in the tools used. The Singapore study and ours both used Holtain caliper, while the Brazilian study used Cescorf caliper. It was also possible that such low APMT in the Caporossi study was indicative of poor nutritional status in the Brazilian population studied and therefore correlated better with mortality.

There is still no reference for the normal value of APMT in critically ill patients, so researchers generally used the 10th percentile as used in various anthropometric measurements. We found no statistically significant relationship between APMT (abnormal vs. normal) and mortality (Table 2). The small number of samples in present study affected the p-value obtained in the statistical test. However, a difference in the proportions of 21.8% showed a clinically significant relationship between the two groups (Table 2). Subjects with an abnormal APMT (<19.8 mm) were at higher risk for mortality than those with a normal APMT (≥19.8 mm) (OR = 3.00).

We found that the group of subjects with abnormal APMT had a higher mean APACHE II score than that of the normal APMT group (17.0 ± 6.4 vs. 11.0 ± 6.3, p = 0.043), likewise for the MSOFA score (8.0 ± 3.1 vs 5.1 ± 3.1, p = 0.051). This suggested that muscle wasting was a contributing factor to gastrointestinal intolerance in our subjects. The contributing factor to gastrointestinal intolerance in present study was the dominance of post-major abdominal surgery patients, covering 20 subjects or 40.8% of all subjects.

Our study showed that there was no statistically significant relationship between energy intake D1 and mortality (Table 2). The role of energy intake on clinical outcomes in the ICU is still controversial. Although several studies showed an association between underfeeding and poor outcomes, they have not been able to determine a causal relationship. In fact, some studies have reported poor results related to providing adequate energy [15,16]. Recently studies suggested that feeding in the early stages of critical illness need not be aggressive [17,18]. During early or acute phase of critical illness, the body can generate 50-75% of glucose requirements. This endogenous energy supply comes from the processes of glycolysis and gluconeogenesis in the liver [19].

Not only energy deficit, but also protein deficit was shown in present study. Until day seven, the mean protein intake achieved was 1.01 g/kg body weight/day, still below the recommended target of SCCM and ASPEN (1.2-2.0 g/kg body weight/day). Several studies have also reported low protein intake even though the number of calories provided was sufficient [20,21]. There are still no studies that establish a clear link between increased protein intake and improved outcomes.

About two-thirds of the subjects in present study had hypoalbuminemia. There was no statistically significant relationship between serum albumin (hypoalbuminemia vs. normal) and mortality (Table 2). We found that albumin was a poor predictor of mortality (Figure 3C). Meanwhile, Yin and co-authors prospective study of 116 ICU patients concluded that albumin levels were a strong predictor of mortality.
mortality (AUC value = 0.724) (22). A possible reason for this difference was the difference in subjects characteristics, where our study was dominated by surgical patients (67.3%), whereas their study by medical patients. Our study showed that surgical patients had a higher risk of hypoalbuminemia than medical patients (RR = 1.80, 95% CI 1.01-3.23). We also found that surgical subjects had lower mean APACHE II scores than medical subjects (9.9 ± 4.6 vs. 15.1 ± 8.5, p = 0.034). The proportion of surgical subjects who died was lower than that of medical patients (15.2 vs. 31.2%, p = 0.174).

Mechanisms for low albumin levels post major surgery include blood loss, hemodilution and capillary leak due to the inflammatory mediators, leading to redistribution of fluid into the interstitial space [23,24,25]. In the condition of the capillary leak there is a “fusion” of two compartments (ie. intra and extravascular) to form a larger compartment so that the intravascular albumin level seems to be reduced. The serum albumin level itself is not reduced quantitatively, but indicates a hemodilution. Perioperative fluid management, extent of surgery (type of surgery, blood loss, duration of surgery), administration of albumin transfusion and use of furosemide are factors that contribute to patient albumin levels and clinical outcomes. However, we did not include these factors in present study variables.

The median NLR obtained in present study was higher than that obtained by Salciccioli and co-authors (13.28 vs. 8.90) [26], may be due to difference in the characteristic of the subjects. Our study was dominated by septic patients (63.3%) while theirs was only 36.2% who belonged to the sepsis group. Our study showed that septic patients had a higher median NLR value than non-septic patients (14.29 vs. 12.28, p = 0.109).

We found that subjects with high NLR had a higher risk of mortality than subjects with low NLR (Table 2). An increased mortality was associated with a higher level of NLR (Table 3). Recently there have been many studies to determine the role of NLR in COVID-19 patients. They reported that an increased NLR had a higher level of mortality during hospitalization [27,28,29].

The high NLR in critically illness was based on the physiological link between neutrophilia and lymphopenia with systemic inflammation and stress response. The inflammatory response, which is the underlying process of most critical illness, can stimulate neutrophil production and accelerate lymphocyte apoptosis.

The strength of our research was its application to limited resources settings because we used simple and low-cost tools and methods. There were several limitations in this study. The small sample size due to the constraints of the Covid-19 pandemic outbreak affected the statistical test results. We did not examine urine urea nitrogen to assess nitrogen balance because of limited funds.

In conclusion, our study have shown that combination of APMT, energy intake, serum albumin and NLR had enough satisfactory predictive value. Further research with a larger sample size and better design is needed to determine the potential relationship of nutritional and inflammatory factors to outcomes in critical illness.

**Declarations**

Author contribution statement
S. Iskandar: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.
R. Sedono: Conceived and designed the experiments; Analyzed and interpreted the data; Wrote the paper.
A. Perdana: Analyze and interpreted the data; Contributed reagents, materials, analysis tools or data.
D. Sunardi: Conceived and designed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

**Funding Statement**

This work was supported by the Research and Development Center, Department of Anesthesia and Intensive Care, Universitas Indonesia, Indonesia.

**Competing Interest Statement**

The authors declare no conflict of interest.

**Additional Information**

No additional information is available for this paper.

**Acknowledgements**

This article was presented in the 5th International Conference and Exhibition on Indonesian Medical Education and Research Institute (5th ICE on IMERI), Faculty of Medicine, Universitas Indonesia.

**References**

[1] Kirkland LL. Extent and Impact of Malnutrition in Critically Ill Patients. In: Diet and Nutrition in Critical Care [Internet]. New York, NY: Springer New York; 2015. p. 265-78.

[2] Lameu EB, Gerude MF, Corrêa RC, Lima KA. Adductor pollicis muscle: a new anthropometric parameter. Rev Hosp Clin Fac Med Sao Paulo. 2004; 59(2): 57-62.

[3] Colman A, Peterson S, Sowa D. Calorie and Protein Deficit in the ICU. In: Diet and Nutrition in Critical Care [Internet]. New York, NY: Springer New York; 2014. p. 1-14.

[4] Vincent JL, Dubois MJ, Navickis RJ, Wilkes MM. Hypoalbuminemia in Acute Illness: Is There a Rationale for Intervention? A Meta-Analysis of Cohort Studies and Controlled Trials. Vol. 237; Annals of Surgery. 2003. p. 319-34.

[5] Cederholm T, Jensen GL, Corteia MITD, Gonzalez MC, Fukushima R, Higashiguchi T, et al. GLIM criteria for the diagnosis of malnutrition – A consensus report from the global clinical nutrition community. Clin Nutr. 2019 Feb 1; 38(1): 1-9.

[6] Zahorec R. Ratio of neutrophil to lymphocyte counts–rapid and simple parameter of systemic inflammation and stress in critically ill. Bratisl Lek Listy. 2001; 102(1): 5-14.

[7] Malone A, Hamilton C. The academy of nutrition and dietetics/the american society for parenteral and enteral nutrition consensus malnutrition characteristics: Application in practice. Vol. 28, Nutrition in Clinical Practice. 2013. p. 639-50.
[8] Kreymann KG, Berger MM, Deutz NEP, Hiesmayr M, Jollivet P, Kazandjiev G, et al. ESPEN Guidelines on Enteral Nutrition: Intensive care. Clin Nutr. 2006 Apr; 25(2): 210-23.

[9] Caporossi FS, Caporossi C, Borges Dock-Nascimento D, de Aguilar-Nascimento JE. Measurement of the thickness of the adductor pollicis muscle as a predictor of outcome in critically ill patients. Nutr Hosp [Internet]. 2015; 24(4): 605-9.

[10] Shu-Fen CL, Ong V, Kowitlawakul Y, Ling TA, Mukhopadhyay A, Henry J. The adductor pollicis muscle: A poor predictor of clinical outcome in ICU patients. Asia Pac J Clin Nutr. 2015; 24(2): 490-5.

[11] Rubinson L, Diette GB, Song X, Brower RG, Krishnan JA. Low caloric intake is associated with nosocomial bloodstream infections in patients in the medical intensive care unit. Crit Care Med. 2004 Feb; 32(2): 350-7.

[12] Adam S, Batson S. A study of problems associated with the delivery of enteral feed in critically ill patients in five ICUs in the UK. Intensive Care Med [Internet]. 1997 Mar; 23(3): 261-6.

[13] Reid C. Frequency of under- and overfeeding in mechanically ventilated ICU patients: Causes and possible consequences. J Hum Nutr Diet. 2006; 19(1): 13-22.

[14] McClave SA, Sexton LK, Spain DA, Adams JL, Owens NA, Sullins MB, et al. Enteral tube feeding in the intensive care unit. Crit Care Med. 1999 Jul; 27(7).

[15] Krishnan JA, Parce PB, Martinez A, Diette GB, Brower RG. Caloric intake in medical ICU patients: Consistency of care with guidelines and relationship to clinical outcomes. Chest. 2003 Jul 1;124(1): 297-305.

[16] Hise ME, Halterman K, Gajewski BJ, Parkhurst M, Moncure M, Brown JC. [A figure is presented] Feeding Practices of Severely Ill Intensive Care Unit Patients: An Evaluation of Energy Sources and Clinical Outcomes. J Am Diet Assoc. 2007 Mar; 107(3): 458-65.

[17] Arabi YM, Aldawood AS, Haddad SH, Al-Dorzi HM, Tamim HM, Jones G, et al. Permissive Underfeeding or Standard Enteral Feeding in Critically Ill Adults. N Engl J Med. 2015 Jun 18; 372(25): 2398-408.

[18] Rice TW, Mogan S, Hays MA, Bernard GR, Jensen GL, Wheeler AP. Randomized trial of initial trophic versus full-energy enteral nutrition in mechanically ventilated patients with acute respiratory failure. In: Critical Care Medicine. Lippincott Williams and Wilkins; 2011. p. 967-74.

[19] Wischmeyer PE. Tailoring nutrition therapy to illness and recovery. Vol. 21, Critical Care. BioMed Central Ltd.; 2017.

[20] Arabi YM, Haddad SH, Tamim HM, Rishu AH, Sakkija MH, Kahoul SH, et al. Near-target caloric intake in critically ill medical-surgical patients is associated with adverse outcomes. J Parenter Enter Nutr. 2010; 34(3): 280-8.

[21] Ibrahim EH, Mehringer L, Prentice D, Sherman G, Schaiff R, Fraser V, et al. Early versus late enteral feeding of mechanically ventilated patients: Results of a clinical trial. J Parenter Enter Nutr. 2002; 26(3): 174-81.

[22] Yin M, Si L, Qin W, Li C, Zhang J, Yang H, et al. Predictive Value of Serum Albumin Level for the Prognosis of Severe Sepsis Without Exogenous Human Albumin Administration: A Prospective Cohort Study. J Intensive Care Med. 2018 Dec 1; 33(12): 687-94.

[23] Fleck A, Hawker F, Wallace PI, Raines G, Trotter J, Ledingham IM, et al. Increased vascular permeability: a major cause of hypoalbuminemia in disease and injury. Lancet [Internet]. 1985 Apr; 325(8432): 781-4.

[24] McCluskey A, Thomas A, Bowles B, Kishen R. The prognostic value of serial measurements of serum albumin concentration in patients admitted to an intensive care unit. Vol. 5, Anaesthesia. 1996.

[25] Hübner M, Mantziari S, Demartines N, Pralong F, Ceti-Bertrand P, Schäfer M. Postoperative Albumin Drop Is a Marker for Surgical Stress and a Predictor for Clinical Outcome: A Pilot Study. Gastroenterol Res Pract. 2016; 2016.

[26] Salciccioli JD, Marshall DC, Pimentel MAF, Santos MD, Pollard T, Celi AA, et al. The association between the neutrophil-to-lymphocyte ratio and mortality in critical illness: An observational cohort study. Crit Care. 2015 Jan 19; 19(1).

[27] Liu Y, Du X, Chen J, Jin Y, Peng L, Wang HHX, et al. Neutrophil-to-lymphocyte ratio and mortality in severe sepsis: a prospective cohort study. J Intensive Care. 2015 Oct 20; 3(1): 5.

[28] Yan X, Li F, Wang X, Yan J, Zhu F, Tang S, et al. Neutrophil to lymphocyte ratio as prognostic and predictive factor in patients with coronavirus disease 2019: A retrospective cross-sectional study. J Med Virol. 2020 Nov 1; 92(11): 2573-81.

[29] Li X, Liu C, Mao Z, Xiao M, Wang L, Qi S, et al. Predictive values of neutrophil-to-lymphocyte ratio on disease severity and mortality in COVID-19 patients: a systematic review and meta-analysis. Crit Care. 2020 Dec 1; 24(1).