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Malnutrition in Critical Illness: Is It an Independent Risk Factor for PICU Admission and Do Anthropometric Measures Matter?

Batuhan Türkoğlu
drturkoglubatuhan@gmail.com
University of Health Sciences Kanuni Sultan Suleyman Training and Research Hospital
Nihal Akçay
University of Health Sciences Kanuni Sultan Suleyman Training and Research Hospital
İlyas Bingöl
University of Health Sciences Kanuni Sultan Suleyman Training and Research Hospital
Abdurrahman Özel
University of Health Sciences Bagcilar Training and Research Hospital
Taha Mert Yaşar
University of Health Sciences Bagcilar Training and Research Hospital
Ülkem Koçoğlu Barlas
İstanbul Medeniyet University, Göztepe Prof. Dr. Süleyman Yalçın City Hospital
İrem Kunter
İstanbul Medeniyet University, Göztepe Prof. Dr. Süleyman Yalçın City Hospital
Elanur Yolal Karimov
University of Health Sciences Kanuni Sultan Suleyman Training and Research Hospital
Merve Şakar Mehmet
University of Health Sciences Kanuni Sultan Suleyman Training and Research Hospital
Servet Yüce
İstanbul University

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Abstract

Purpose:

Malnutrition is common in critically ill children; however, whether it represents a consequence of critical illness or an independent risk factor for pediatric intensive care unit (PICU) admission remains unclear. This study aimed to evaluate the association between nutritional status, PICU admission, and clinical outcomes using different anthropometric indicators.

Methods:

In this prospective, multicenter observational study conducted in three PICUs in Istanbul between March and September 2025, a total of 697 children (472 patients and 225 healthy controls) were included. Anthropometric measurements obtained at admission included mid-upper arm circumference (MUAC), triceps skinfold thickness (TSF), weight standard deviation score (SDS), height SDS, and body mass index (BMI) SDS. Standard deviation scores were calculated using age- and sex-specific reference data, while MUAC and TSF were assessed according to established classification systems. Group comparisons, multivariable logistic regression, and receiver operating characteristic (ROC) analyses were performed to identify factors independently associated with PICU admission and mortality and to evaluate the discriminative performance of anthropometric measures.

Results:

Indicators of malnutrition were significantly more prevalent in the patient group. MUAC and TSF were markedly lower in patients (both $p < 0.001$). Weight SDS, head circumference SDS, and BMI SDS were also significantly lower, whereas absolute BMI values differed only minimally between groups despite differences in BMI SDS distribution. Moderate and severe malnutrition based on MUAC classification were observed exclusively in the patient group ($p < 0.001$). In multivariable analysis, MUAC was the only anthropometric parameter independently associated with PICU admission (OR: 0.88 per 1 cm increase, 95% CI: 0.82–0.94; $p < 0.001$), whereas BMI SDS was not associated with admission risk ($p = 0.118$). In contrast, chronic disease (OR: 12.77, $p = 0.006$) and higher urea levels (OR: 1.011 per 1 mg/dL increase, $p = 0.001$) were independently associated with mortality, whereas lower BMI SDS values (BMI SDS < − 2) showed a trend toward increased mortality risk without reaching statistical significance ($p = 0.059$). ROC analysis demonstrated that MUAC had acceptable discriminative performance for PICU admission (AUC: 0.721, 95% CI: 0.684–0.758; $p < 0.001$).

Conclusion:

Our findings suggest that malnutrition may act as a predisposing factor for PICU admission rather than solely a consequence of critical illness. MUAC emerged as a simple and clinically applicable parameter independently associated with PICU admission, whereas low BMI SDS values may reflect chronic nutritional depletion associated with poorer outcomes. These findings highlight the importance of multidimensional nutritional assessment in critically ill children.

What is Known

Malnutrition is common in children admitted to pediatric intensive care units and is associated with adverse outcomes. However, the optimal anthropometric parameter for assessing nutritional risk in critically ill children remains unclear.

What is New:

MUAC was independently associated with PICU admission, whereas BMI SDS was not. These findings suggest that malnutrition may act as a predisposing factor for critical illness and that different anthropometric indices may reflect distinct dimensions of nutritional risk.

INTRODUCTION

Malnutrition is common among critically ill children, with reported prevalence rates ranging from 20% to 50% in pediatric intensive care units (PICUs) [1,2]. It has been consistently associated with adverse clinical outcomes, including prolonged hospital stay, increased need for mechanical ventilation, and higher mortality rates [1]. Despite this well-established association, malnutrition is often considered a consequence of critical illness rather than a pre-existing condition that may contribute to disease severity and the subsequent need for intensive care [2].

From a pathophysiological perspective, malnutrition may directly predispose children to the development of critical illness. Protein–energy deficiency impairs both innate and adaptive immune responses, reduces respiratory muscle strength, and disrupts inflammatory regulation, thereby increasing susceptibility to severe infections and respiratory failure [3,4]. In addition, malnutrition is associated with systemic inflammation, metabolic dysregulation, and impaired tissue repair mechanisms, all of which may exacerbate disease severity and contribute to the progression of organ dysfunction [4]. These mechanisms suggest that malnutrition is not merely a marker of disease severity but may play an active role in the pathogenesis of critical illness.

Nevertheless, whether malnutrition itself constitutes an independent risk factor for PICU admission remains unclear. To date, most studies have focused primarily on outcomes within the PICU population, whereas data comparing the nutritional status of critically ill children with that of healthy peers at the time of admission are limited [2]. This distinction is clinically important, as recognizing malnutrition as a

potential predisposing factor could improve early risk stratification and enable timely implementation of preventive and therapeutic interventions.

Another important challenge is the optimal assessment of nutritional status in critically ill children. Although body mass index (BMI) is widely used in clinical practice, it may be insufficient for accurately detecting malnutrition in pediatric patients, particularly in the presence of fluid imbalance, edema, and acute illness [1,5]. BMI reflects body mass relative to height but does not adequately distinguish between fat mass and lean body mass, limiting its sensitivity for detecting early or acute nutritional deterioration.

In contrast, alternative anthropometric measures such as mid-upper arm circumference (MUAC) and triceps skinfold thickness (TSF) have been proposed as more reliable indicators of acute nutritional status. These measurements are less affected by hydration status and better reflect muscle and fat reserves, making them particularly useful in critically ill populations [6,7]. Previous studies have also suggested that MUAC may serve as a practical and sensitive screening tool for identifying children at increased risk of adverse outcomes, particularly in resource-limited settings [7,8]. However, the comparative clinical utility of these parameters relative to BMI-derived indices remains uncertain, and it is still unclear which measures provide the most accurate prediction of PICU admission and clinical outcomes.

Importantly, early identification of children at risk of clinical deterioration remains a major challenge in pediatric practice. In many cases, children who ultimately require intensive care may not be recognized as high-risk at initial presentation, particularly when traditional clinical and laboratory parameters are inconclusive. In this context, simple, rapid, and non-invasive tools that can be applied at the bedside are of considerable clinical value. Anthropometric measurements, especially those reflecting acute nutritional status, may provide additional insight into physiological reserve and vulnerability to severe illness. However, their role in predicting the need for intensive care has not been adequately defined [8,9,10].

To the best of our knowledge, few studies have comprehensively evaluated multiple anthropometric indicators while simultaneously comparing critically ill children with healthy controls to determine the contribution of malnutrition to PICU admission risk. Addressing this gap is essential for improving early identification of vulnerable children and refining nutritional assessment strategies in pediatric clinical practice.

Accordingly, the present study aimed to evaluate the nutritional status of children admitted to PICUs using multiple anthropometric indicators and to compare these findings with those of healthy controls. In addition, we sought to determine whether malnutrition is associated with PICU admission and to assess the relative contribution of different anthropometric parameters to both admission risk and clinical outcomes. We hypothesized that malnutrition would be associated with PICU admission and that different anthropometric indicators and laboratory parameters may provide complementary contributions in assessing this association and clinical outcomes.

MATERIALS AND METHODS

This prospective, multicenter observational study was conducted in three pediatric intensive care units (PICUs) in Istanbul, Türkiye, between March 1 and September 1, 2025.

Study Population

Children aged between 28 days and 18 years who were admitted to the PICU and had a length of stay exceeding 24 hours were eligible for inclusion. Patients with a PICU stay shorter than 24 hours and those with repeated admissions during the study period were excluded. In cases of multiple admissions, only the first admission was considered for analysis.

A control group comprised age-matched healthy children recruited from general pediatric outpatient clinics and pediatric endocrinology clinics, with no prior history of PICU admission.

Data Collection

Demographic and clinical data were prospectively collected at the time of PICU admission, including age, sex, reason for admission (medical or surgical), primary diagnostic category, presence of chronic disease, requirement for invasive and/or non-invasive mechanical ventilation, duration of mechanical ventilation, length of PICU stay, and in-hospital mortality.

Laboratory parameters obtained as part of routine clinical care included white blood cell count, lymphocyte count, serum albumin, glucose, and urea levels.

Anthropometric Assessment

Nutritional status was evaluated on the day of PICU admission using standardized anthropometric measurements, including height/length, body weight, head circumference, body mass index (BMI), mid-upper arm circumference (MUAC), and triceps skinfold thickness (TSF).

Standard deviation scores (SDS) for weight, height, head circumference, and BMI were calculated using the LMS method based on age- and sex-specific reference data for Turkish children (Neyzi et al.) [11].

MUAC measurements were interpreted according to World Health Organization (WHO) criteria for children aged 6–59 months [7], with values <11.5 cm indicating severe acute malnutrition (SAM), 11.5–12.5 cm indicating moderate acute malnutrition (MAM), and ≥12.5 cm indicating normal nutritional status. For children younger than 6 months and older than 59 months, MUAC values were analyzed as continuous variables due to the absence of universally accepted cut-off thresholds.

TSF measurements were evaluated using age- and sex-specific percentile references defined by Frisancho [6], with values <5th percentile indicating reduced subcutaneous fat stores, 5th–95th percentile considered normal, and ≥95th percentile indicating increased subcutaneous fat stores.

Measurement Standardization

All anthropometric measurements were performed by trained healthcare professionals following standardized protocols across participating centers. Prior to study initiation, personnel underwent structured training to ensure consistency in measurement techniques. Measurement instruments were regularly calibrated according to manufacturer specifications. Each parameter was measured at least twice, and the mean value was used for analysis. Periodic cross-validation assessments were conducted to monitor inter-observer variability.

Outcomes

The primary outcome was PICU admission (comparison between patients and healthy controls). Secondary outcomes included in-hospital mortality among PICU patients. In addition, the association between anthropometric and laboratory parameters and PICU admission, as well as their relationship with mortality, was evaluated using multivariable logistic regression analyses.

Statistical Analysis

Continuous variables were expressed as mean ± standard deviation or median (interquartile range), depending on distribution, and categorical variables as counts and percentages. Group comparisons were performed using the Mann–Whitney U test for continuous variables and the chi-square test for categorical variables.

Univariable analyses were initially performed to identify variables associated with PICU admission and mortality. Variables with clinical relevance and those with $p<0.10$ in univariable analysis were included in multivariable logistic regression models. For mortality analyses, BMI SDS was additionally evaluated categorically using a cut-off value of <-2 to indicate low BMI SDS values, due to the limited number of mortality events and the absence of mortality among patients with high BMI SDS values.

Multivariable logistic regression analyses were conducted to identify factors independently associated with PICU admission and mortality. Odds ratios (ORs) with 95% confidence intervals (CIs) were reported. A two-sided p value <0.05 was considered statistically significant.

Receiver operating characteristic (ROC) curve analysis was performed to evaluate the discriminative performance of anthropometric parameters for predicting PICU admission. The area under the curve (AUC) with 95% confidence intervals was calculated, and optimal cut-off values were determined using the Youden index.

Ethical Approval

The study protocol was approved by the Clinical Research Ethics Committee of Kanuni Sultan Suleyman Training and Research Hospital (approval number: KAEK/2025.03.79). Written informed consent was obtained from the parents or legal guardians of all participants prior to enrollment.

RESULTS

A total of 697 children were included in the study, comprising 472 patients admitted to the PICU and 225 healthy controls.

Demographic and clinical characteristics

Children in the PICU group were significantly younger than those in the control group (median 37.8 months [IQR: 12.8–111.5] vs. 82.2 months [54.7–113.1], p<0.001). Male sex was more frequent among patients than controls (55.7% vs. 46.2%, p=0.019). Turkish ethnicity was more prevalent in the control group (98.2% vs. 81.1%, p<0.001), whereas chronic disease was observed exclusively in the patient group (49.3% vs. 0%, p<0.001) (Table 1).

Anthropometric measurements

All baseline anthropometric measurements were significantly lower in the patient group compared to controls. Weight (13.0 [8.0–25.0] kg vs. 22.0 [16.0–29.7] kg), height (90 [66–126] cm vs. 120 [104–133] cm), and head circumference (43 [39–47] cm vs. 47 [46–48] cm) were significantly lower in patients (all p<0.001).

Similarly, mid-upper arm circumference (MUAC) (15.0 [13.0–19.0] cm vs. 19.0 [17.0–20.0] cm) and triceps skinfold thickness (TSF) (8.0 [6.0–10.0] mm vs. 21.0 [18.5–28.0] mm) were significantly lower in the patient group (all p<0.001) **(**Table 1).

Anthropometric SDS and nutritional status

Weight SDS and BMI SDS were significantly lower in the patient group (both p<0.001). Head circumference SDS was also lower (p=0.010), whereas height SDS did not differ between groups (p=0.232).

Although absolute BMI values differed only minimally between groups (p=0.008), BMI SDS distribution was significantly more impaired in the patient group. The proportion of patients with BMI SDS <-2 was significantly higher in the patient group compared to controls (29.7% vs. 4.5%, p<0.001).

In contrast, BMI SDS values within the normal range (-2 to +2) were more frequent in the control group (89.5% vs. 61.4%).

According to MUAC classification, moderate (MAM) and severe (SAM) malnutrition were observed exclusively in the patient group (p<0.001). Low triceps skinfold thickness (<5th percentile) was more frequent in patients (23.9% vs. 13.3%), whereas increased subcutaneous fat (≥95th percentile) was more common in controls (37.8% vs. 1.9%) (p<0.001) (Table 1).

Laboratory findings

Leukocyte count and glucose levels were significantly higher in the patient group, whereas lymphocyte count and albumin levels were lower (all p<0.001). Urea levels were slightly lower in patients (p=0.035) (Table 1).

Mortality Analysis

The overall mortality rate among PICU patients was 4.1% (n=19). No significant differences were observed between survivors and non-survivors in terms of age, sex, or ethnicity. However, chronic disease was significantly more common among non-survivors (84.2% vs. 47.9%, p=0.002).

Non-survivors required invasive mechanical ventilation more frequently and for longer durations (both p<0.001).

In anthropometric analyses, TSF was significantly lower in non-survivors (p=0.013). In addition, weight SDS, height SDS, and BMI SDS were significantly lower in non-survivors (all p<0.05).

Low BMI SDS values (BMI SDS <−2) were more prevalent in the mortality group (58.8% vs. 28.5%, p=0.020).

Leukocyte and urea levels were significantly higher in non-survivors (p=0.024 and p=0.003, respectively) (Table 2).

Multivariable analyses

Predictors of mortality

In multivariable logistic regression analysis, the presence of chronic disease (OR: 12.77, 95% CI: 2.06–79.13; p=0.006) and higher urea levels (OR: 1.011 per 1 mg/dL increase, 95% CI: 1.003–1.018; p=0.001) were independently associated with mortality.

Lower BMI SDS values (BMI SDS <−2) showed a trend toward increased mortality risk (OR: 2.71, 95% CI: 0.96–7.64; p=0.059), although statistical significance was not reached. Leukocyte count was not independently associated with mortality (OR: 1.01, 95% CI: 0.996–1.032; p=0.138) (Table 3).

Predictors of PICU admission

To identify independent predictors of PICU admission, a multivariable logistic regression model was constructed including age, sex, ethnicity, BMI SDS, TSF, and MUAC (continuous). In this adjusted model, ***mid-upper arm circumference (MUAC) was the only anthropometric parameter independently associated with PICU admission*** (OR: 0.88 per 1 cm increase, 95% CI: 0.82–0.94; p<0.001). Specifically, each 1 cm decrease in MUAC was associated with a significant increase in the likelihood of PICU admission. BMI SDS (p=0.118) and TSF (p=0.813) were not independently associated with PICU admission after adjustment. Age was not significantly associated with PICU admission (p=0.469), while male sex

showed a borderline association (OR: 1.71, p=0.053). Ethnicity remained strongly associated with PICU admission (OR: 12.17, 95% CI: 3.76–39.40; p<0.001) (Table 4).

Discriminative performance of MUAC

Receiver operating characteristic (ROC) analysis showed that MUAC had acceptable discriminative performance between PICU patients and controls, with an area under the curve (AUC) of **0.721 (95% CI: 0.684–0.758; p<0.001)** (Figure 1).

The optimal cut-off value for MUAC was identified as approximately **15.8 cm**, yielding a sensitivity of **52.8%** and a specificity of **94.4%**.

DISCUSSION

In this multicenter prospective study, we demonstrated that children admitted to the PICU had significantly poorer nutritional status compared to healthy controls. Mid-upper arm circumference (MUAC) was the only anthropometric parameter independently associated with PICU admission after adjustment for key confounders, whereas lower BMI SDS values (BMI SDS <−2) showed a trend toward association with mortality. These findings suggest that different anthropometric indicators capture distinct and clinically relevant dimensions of nutritional risk.

Our results extend the current literature by shifting the focus from outcomes within the PICU to pre-admission risk stratification. While previous studies have consistently shown that malnutrition is associated with worse outcomes in critically ill children, including prolonged hospitalization and increased mortality, they have largely treated malnutrition as a consequence of critical illness rather than a predisposing factor [9,10,13]. In contrast, our findings suggest that acute nutritional depletion, as reflected by MUAC, may be associated with an increased likelihood of requiring intensive care.

Among the anthropometric parameters evaluated, only MUAC remained independently associated with PICU admission. This finding is biologically plausible. MUAC reflects muscle mass and short-term nutritional reserves and is relatively unaffected by fluid shifts, which are common in acutely ill children [8,14,15]. In contrast, BMI-based indices are influenced by hydration status and do not distinguish between fat mass and lean body mass, limiting their sensitivity in detecting acute nutritional deterioration [5].

ROC analysis further showed that MUAC had acceptable discriminative performance for PICU admission (AUC: 0.721). This level of discrimination is comparable to that reported for several pediatric screening tools. The identified cut-off value provided high specificity, suggesting that low MUAC values may be particularly useful for identifying high-risk children. Although sensitivity was moderate, this trade-off may be acceptable in clinical settings where minimizing false positives is important.

The differential behavior of MUAC and BMI SDS in our analyses supports the concept that acute and chronic nutritional status have distinct clinical implications. While MUAC was associated with PICU

admission, lower BMI SDS values (BMI SDS <−2) showed a trend toward association with mortality. This suggests that acute depletion of nutritional reserves may be related to the development of severe illness, whereas chronic nutritional depletion may adversely affect resilience and recovery once critical illness has developed [9,10].

Interestingly, although TSF differed significantly between groups in univariable analyses, it was not independently associated with PICU admission or mortality. This may reflect the limited utility of subcutaneous fat measurements in acute illness, where metabolic and inflammatory changes may preferentially affect lean body mass rather than fat stores [6]. The strong association observed between ethnicity and PICU admission should be interpreted with caution. Given the imbalance between patient and control groups, this finding most likely reflects selection bias related to control group composition rather than a true causal relationship.

From a clinical perspective, our findings support the integration of MUAC into routine pediatric assessment, particularly in settings where rapid risk stratification is required. MUAC is inexpensive, easy to perform, and does not require complex calculations, making it especially valuable in emergency departments and low-resource settings [7,8]. Its independent association with PICU admission and acceptable discriminative performance support its potential role as a screening tool.

This study has several strengths, including its prospective design, multicenter setting, and comprehensive evaluation of multiple anthropometric parameters. The inclusion of a healthy control group enabled direct comparison of baseline nutritional status.

However, several limitations should be acknowledged. First, residual confounding cannot be excluded. Second, the use of outpatient-based controls may have introduced selection bias. Third, MUAC cut-off values are not standardized across all pediatric age groups [7]. Fourth, the relatively small number of mortality events limits the robustness of mortality analyses and may increase the risk of model overfitting. Finally, biochemical markers of nutritional status were limited.

In conclusion, our findings suggest that malnutrition may act as a predisposing factor for PICU admission, rather than solely a consequence of critical illness, and is also associated with adverse clinical outcomes [1,2,16]. MUAC emerged as a simple and clinically applicable parameter independently associated with PICU admission, whereas lower BMI SDS values (BMI SDS <−2) showed a trend toward association with mortality. These findings highlight the importance of multidimensional nutritional assessment and support the potential role of MUAC in early pediatric risk stratification.

Abbreviations

BMI
Body Mass Index
CI
Confidence Interval

MAM
Moderate Acute Malnutrition
MUAC
Mid-upper arm circumference
OR
Odds Ratio
PICU
Pediatric Intensive Care Unit
ROC
Receiver Operating Characteristic
SAM
Severe Acute Malnutrition
SDS
Standard Deviation Score
TSF
Triceps Skinfold Thickness
WHO
World Health Organization

Declarations

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Competing Interests

The authors have no relevant financial or non-financial interests to disclose.

Author Contributions

Batuhan Türkoğlu, Nihal Akçay, and İlyas Bingöl contributed to the conception and design of the study. Data collection and acquisition were performed by Batuhan Türkoğlu, İlyas Bingöl, Abdurrahman Özel, Taha Mert Yaşar, Ülkem Koçoğlu Barlas, İrem Kunter, Elanur Yolal Karimov, and Merve Şakar Mehmet. Anthropometric measurements and coordination of clinical data across participating centers were supervised by Batuhan Türkoğlu and Nihal Akçay. Statistical analyses were performed by Batuhan Türkoğlu and Servet Yüce. The first draft of the manuscript was written by Batuhan Türkoğlu. All authors contributed to data interpretation, critically revised the manuscript, and approved the final version.

Data Availability

The data generated and analyzed during this study include clinical and anthropometric information

obtained from pediatric intensive care patients and healthy controls. Due to ethical and institutional restrictions related to patient confidentiality, the datasets are not publicly available but are available from the corresponding author upon reasonable request.

Ethics Approval

This study was conducted in accordance with the principles of the Declaration of Helsinki and approved by the Clinical Research Ethics Committee of University of Health Sciences Turkey Kanuni Sultan Suleyman Training and Research Hospital (approval number: KAEK/2025.03.79).

Consent to Participate

Written informed consent was obtained from the parents or legal guardians of all participants.

References

1. Mehta NM, Skillman HE, Irving SY, Coss-Bu JA, Vermilyea S, Farrington EA et al (2017) Guidelines for the provision and assessment of nutrition support therapy in the pediatric critically ill patient. JPEN J Parenter Enter Nutr 41:706–742. https://doi.org/10.1177/0148607117711387
2. Joosten KF, Hulst JM (2011) Malnutrition in pediatric hospital patients: current issues. Nutrition 27:133–137. https://doi.org/10.1016/j.nut.2010.06.001
3. Bourke CD, Berkley JA, Prendergast AJ (2016) Immune dysfunction as a cause and consequence of malnutrition. Trends Immunol 37:386–398. https://doi.org/10.1016/j.it.2016.04.003
4. Katona P, Katona-Apte J (2008) The interaction between nutrition and infection. Clin Infect Dis 46:1582–1588. https://doi.org/10.1086/587658
5. Cole TJ, Lobstein T (2012) Extended international (IOTF) body mass index cut-offs for thinness, overweight and obesity. Pediatr Obes 7:284–294. https://doi.org/10.1111/j.2047-6310.2012.00064.x
6. Frisancho AR (1990) Anthropometric standards for the assessment of growth and nutritional status. University of Michigan Press, Ann Arbor (MI)
7. World Health Organization (WHO) (2013) Guideline: updates on the management of severe acute malnutrition in infants and children. WHO, Geneva
8. Grellety E, Golden MH (2016) Weight-for-height and mid-upper-arm circumference should be used independently to diagnose acute malnutrition: policy implications. BMC Nutr 2:10. https://doi.org/10.1186/s40795-016-0049-7
9. de Souza Menezes F, Leite HP, Koch Nogueira PC (2012) Malnutrition as an independent predictor of clinical outcome in critically ill children. Nutrition 28:267–270. https://doi.org/10.1016/j.nut.2011.05.015
10. Mehta NM, Bechard LJ, Cahill N, Wang M, Day A, Duggan CP et al (2012) Nutritional practices and their relationship to clinical outcomes in critically ill children. Pediatr Crit Care Med 13:e231–e238. https://doi.org/10.1097/PCC.0b013e3182387a14

11. Neyzi O, Bundak R, Gökçay G, Günöz H, Furman A, Darendeliler F, Baş F (2015) Reference values for weight, height, head circumference, and body mass index in Turkish children. J Clin Res Pediatr Endocrinol 7:280–293. https://doi.org/10.4274/jcrpe.2183
12. Hulst JM, van Goudoever JB, Zimmermann LJ, Hop WC, Albers MJ, Tibboel D, Joosten KF (2004) The prevalence of malnutrition in critically ill children. Crit Care Med 32:1371–1376. https://doi.org/10.1097/01.CCM.0000126003.97865.5F
13. Berkley J, Mwangi I, Griffiths K, Ahmed I, Mithwani S, English M, Newton C, Maitland K (2005) Assessment of severe malnutrition among hospitalized children in rural Kenya: comparison of weight for height and mid upper arm circumference. JAMA 294:591–597. https://doi.org/10.1001/jama.294.5.591
14. Briend A, Maire B, Fontaine O, Garenne M (2012) Mid-upper arm circumference and weight-for-height to identify high-risk malnourished children. Am J Clin Nutr 95:153–158. https://doi.org/10.3945/ajcn.111.023036
15. Hulst JM, Joosten KF (2009) Malnutrition in critically ill children: from admission to 6 months after discharge. Clin Nutr 28:223–227. https://doi.org/10.1016/j.clnu.2009.02.006
16. Becker P, Carney LN, Corkins MR, Monczka J, Smith E, Smith SE et al (2014) Consensus statement of the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition. J Acad Nutr Diet 114:1988–2000. https://doi.org/10.1016/j.jand.2014.08.011

Tables

Table 1. Demographic, Clinical, and Anthropometric Characteristics of Patient and Control Groups.

Variable	Patient Group (n = 472)	Control Group (n = 225)	p-value
Demographic Characteristics			
Age (months), median (IQR)	37.8 (12.8–111.5)	82.2 (54.7–113.1)	<0.001
Gender, male, n (%)	263 (55.7)	104 (46.2)	0.019*
Ethnic origin, Turkish, n (%)	383 (81.1)	221 (98.2)	<0.001*
Presence of chronic disease, n (%)	232 (49.3)	0 (0.0)	<0.001*
Anthropometric Measurements			
Weight (kg), median (IQR)	13.0 (8.0–25.0)	22.0 (16.0–29.7)	<0.001
Height (cm), median (IQR)	90 (66–126)	120 (104–133)	<0.001
Head circumference (cm)*, median (IQR)	43 (39–47)	47 (46–48)	<0.001
Mid-upper arm circumference (cm), median (IQR)	15.0 (13.0–19.0)	19.0 (17.0–20.0)	<0.001
Triceps skinfold thickness (mm), median (IQR)	8.0 (6.0–10.0)	21.0 (18.5–28.0)	<0.001
Anthropometric SDS Values			
Weight SDS, median (IQR)	-0.61 (-1.96–0.48)	-0.21 (-0.83–0.61)	<0.001
Height SDS, median (IQR)	-0.11 (-1.66–1.13)	-0.11 (-0.86–0.64)	0.232
Head circumference SDS, median (IQR)	-0.91 (-2.25–0.25)	-0.09 (-0.90–0.17)	0.010
BMI, median (IQR)	15.55 (13.27–18.47)	15.80 (14.80–18.14)	0.008
BMI SDS, median (IQR)	-0.71 (-2.34–0.57)	-0.22 (-0.85–0.63)	<0.001
BMI Categories, n (%)			
> +2 SDS	38 (8.9)	13 (5.9)	<0.001*
-2 to +2	262 (61.4)	197 (89.5)	
< -2 SDS	127 (29.7)	10 (4.5)	
MUAC (WHO classification), n (%)			
Normal	164 (34.7)	72 (32.0)	<0.001*
MAM	20 (4.2)	0 (0.0)	
SAM	15 (3.2)	0 (0.0)	
Raw measurement	273 (57.8)	153 (68.0)	

Triceps Skinfold (TSF), n (%)			
Low (<5p)	113 (23.9)	30 (13.3)	<0.001*
Normal	350 (74.2)	110 (48.9)	
High (≥95p)	9 (1.9)	85 (37.8)	
Laboratory Parameters			
Leukocyte (×10³/μL), median (IQR)	12.9 (8.5–18.0)	7.64 (6.5–9.6)	<0.001 □
Lymphocyte (×10³/μL), median (IQR)	2.5 (1.5–4.6)	3.1 (2.5–3.9)	<0.001 □
Albumin (g/dL), median (IQR)	4.10 (3.60–4.40)	4.46 (4.30–4.60)	<0.001 □
Glucose (mg/dL), median (IQR)	114 (95–147)	87 (82–94)	<0.001 □
Urea (mg/dL), median (IQR)	20.0 (14.2–28.6)	22.0 (18.0–26.1)	0.035 □

**Pearson chi-square test, □ Mann-Whitney U test.*

Table 2. Clinical and Anthropometric Characteristics According to Mortality

Variable	Mortality (n = 19)	Survivors (n = 453)	p-value
Demographic Characteristics			
Age (months), median (IQR)	50.3 (10.2–142.4)	37.3 (12.8–111.3)	0.618
Gender, male, n (%)	13 (68.4)	249 (55.3)	0.260*
Ethnic origin, Turkish, n (%)	14 (73.7)	366 (81.3)	0.405*
Presence of chronic disease, n (%)	16 (84.2)	215 (47.9)	0.002*
Anthropometric Measurements			
Weight (kg), median (IQR)	12.0 (5.0–20.0)	13.0 (8.0–25.0)	0.427
Height (cm), median (IQR)	86 (68–120)	90 (65–126)	0.994
Head circumference (cm) *, median (IQR)	41 (39–47)	43 (39–47)	0.703
Mid-upper arm circumference (cm), median (IQR)	14.3 (11.5–17.0)	15.0 (13.0–19.0)	0.239
Triceps skinfold thickness (mm), median (IQR)	6.0 (4.0–8.0)	8.0 (6.0–10.0)	0.013
Anthropometric SDS Values			
Weight SDS, median (IQR)	-2.30 (-5.03 – -0.84)	-0.59 (-1.85–0.49)	0.004
Height SDS, median (IQR)	-1.95 (-4.04–0.68)	-0.10 (-1.50–1.12)	0.047
Head circumference SDS, median (IQR)	-1.36 (-2.47 – -0.98)	-0.84 (-2.19–0.26)	0.337
BMI, median (IQR)	12.36 (10.75–16.22)	15.61 (13.38–18.55)	0.007
BMI SDS, median (IQR)	-3.42 (-4.70 – -0.51)	-0.66 (-2.28–0.59)	0.005
BMI Categories, n (%)			
> +2 SDS	0 (0.0)	38 (9.3)	0.020*
-2 to +2	7 (41.2)	253 (62.2)	
< -2 SDS	10 (58.8)	116 (28.5)	
MUAC (WHO classification), n (%)			
Normal	5 (26.3)	159 (35.3)	0.424*
MAM	0 (0.0)	20 (4.4)	
SAM	0 (0.0)	15 (3.3)	

Raw measurement	14 (73.7)	256 (56.9)	
Triceps Skinfold (TSF), n (%)			
Low (<5p)	4 (21.1)	108 (24.0)	0.543*
Normal	14 (73.7)	334 (74.2)	
High (≥95p)	1 (5.3)	8 (1.8)	
Laboratory Parameters			
Leukocyte (×10³/μL), median (IQR)	18.8 (10.2–24.2)	12.8 (8.4–17.3)	0.024 □
Lymphocyte (×10³/μL), median (IQR)	2.35 (1.40–4.60)	2.50 (1.50–4.60)	0.904 □
Albumin (g/dL), median (IQR)	3.70 (2.90–4.40)	4.10 (3.70–4.40)	0.106 □
Glucose (mg/dL), median (IQR)	123 (92–154)	114 (95–147)	0.886 □
Urea (mg/dL), median (IQR)	31.6 (19.7–121.0)	19.8 (14.1–28.0)	0.003 □
Intensive Care Unit Features			
Invasive MV, n (%)	14 (73.7)	108 (24.0)	<0.001*
Non-invasive MV, n (%)	6 (31.6)	130 (29.0)	0.810*
IMV duration (days), median (IQR)	2 (1–9)	0 (0–0)	<0.001 □
Median length of stay at ICU (days), (IQR)	7 (3–16)	5 (3–8)	0.916 □

**Pearson chi-square test, □ Mann-Whitney U test.*

Table 3. Multivariable Logistic Regression Analysis for Mortality

Variable	B	SE	p-value	OR (Exp(B))	95% CI
BMI SDS <−2	0.998	0.529	0.059	2.71	0.96–7.64
Chronic disease	**2.547**	**0.931**	**0.006**	**12.77**	**2.06–79.13**
Urea (mg/dL)	0.011	0.003	0.001	1.01	1.003–1.018
Leukocyte (×10³/μL)	0.014	0.009	0.138	1.01	0.996–1.032

***Note**: A multivariable logistic regression model including BMI SDS <−2, chronic disease, urea level, and leukocyte count was constructed. BMI SDS was categorized using a cut-off value of <−2 due to the limited number of mortality events and the absence of mortality among patients with BMI SDS >+2.*

Table 4. Multivariable Logistic Regression Analysis for Predicting PICU Admission

Variable	B	SE	p-value	OR (Exp(B))	95% CI
Age (months)	0.002	0.003	0.469	1.002	0.997–1.007
Sex (male)	0.537	0.278	0.053	1.71	0.99–2.95
Ethnicity (Turkish)	2.499	0.599	<0.001	12.17	3.76–39.40
BMI SDS	-0.076	0.049	0.118	0.93	0.84–1.02
TSF (mm)	-0.042	0.178	0.813	0.96	0.68–1.36
MUAC (cm)	**-0.129**	**0.034**	**<0.001**	**0.88**	**0.82–0.94**

Note: *A multivariable logistic regression model including age, sex, ethnicity, BMI SDS, TSF, and MUAC (continuous) was constructed. MUAC was entered as a continuous variable to reflect acute nutritional status.*

Figures

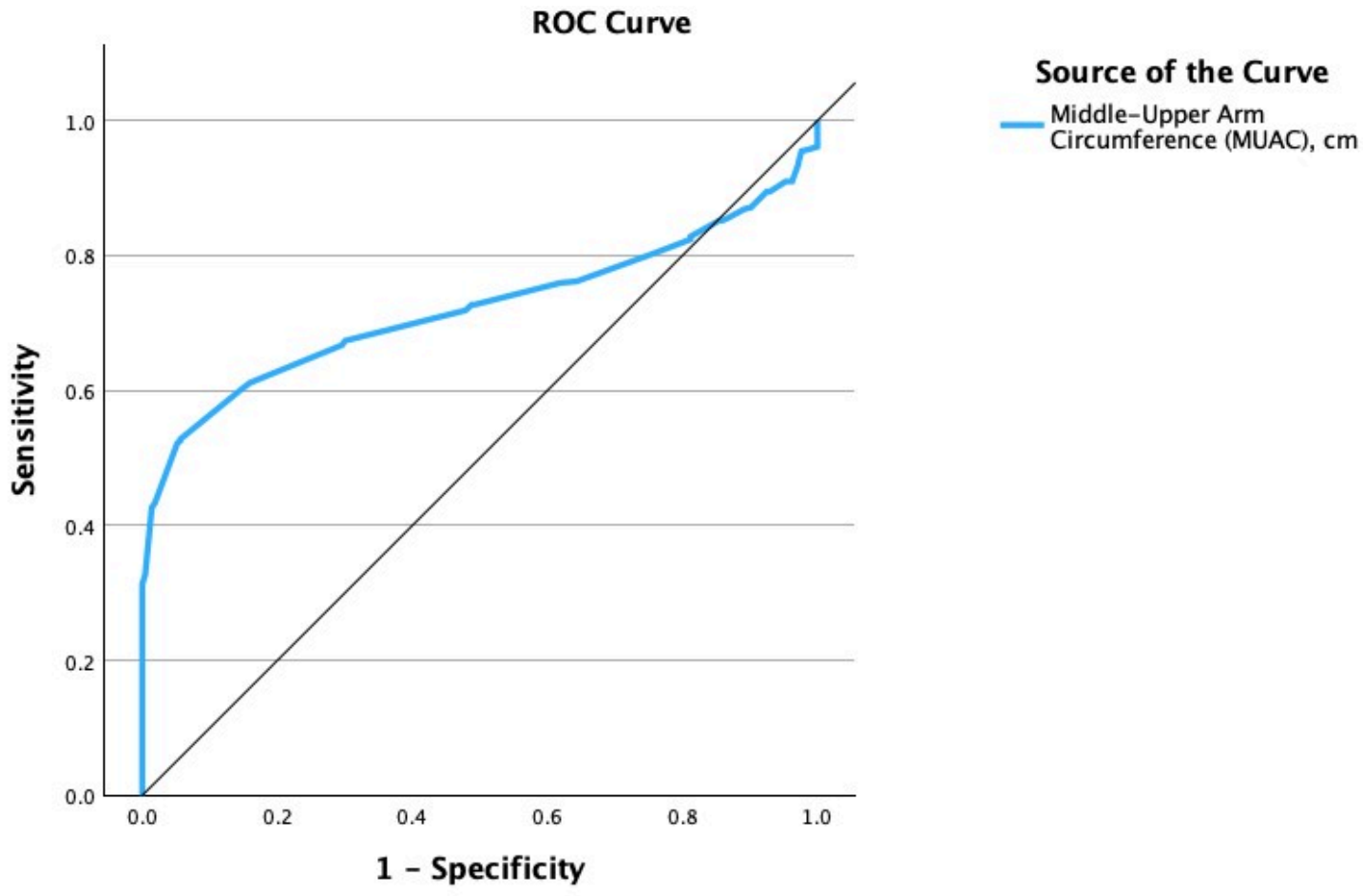


Figure 1

Receiver operating characteristic (ROC) curve of mid-upper arm circumference (MUAC) for predicting PICU admission (AUC: 0.721, 95% CI: 0.684–0.758).