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# Correlation between MUAC z-score and the anthropometric indexes, weight and height, in the assessment of the nutritional status of pediatric inpatients

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**Abstract.** Nutrition plays a crucial role in the growth of healthy children, and its role is particularly critical in pediatric patients to help increase response to treatment, reduce morbidity and mortality, improve quality of life, and reduce treatment costs. Anthropometric indexes are an integral part of screening and assessment of the nutritional status. The present study aimed to examine the correlation between the mid-upper arm circumference (MUAC) z-score with anthropometric indexes, such as weight and height, in the assessment of the nutritional status of pediatric inpatients. The present cross-sectional study was conducted on 500 pediatrics from 2 to 60 months of age. The nutritional status of all the pediatric patients was assessed using the following metrics: Weight for age, height for age, weight for height, MUAC for age. The nutritional status was then classified based on the z-score according to the WHO 2006 guidelines as follows: Weight/age: underweight (20.8%), overweight and obese (1.8%); weight/height: Wasting (14%), overweight and obese (5.4%); height/age: Stunting (24%), of which severe (10.2%); MUAC z-score: Malnutrition (27.2%), of which severe malnutrition (14.4%), and overweight (1%). The MUAC z-score was strongly associated with weight/height z-score (r=0.608; P<0.001). Thus, the present study demonstrates that it is necessary to use a combination of all three anthropometric indexes, namely weight, height and MUAC to detect early clinical malnutrition, particularly in patients whose weight is affected by fluid status; MUAC is an integral tool for assessing the nutritional status.

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## Introduction

Nutrition plays a crucial role in the growth of healthy children and is even more critical for pediatric patients to help increase response to treatment, reduce morbidity and mortality, improve quality of life, and reduce treatment costs. Malnutrition in inpatients is relatively common due to a number of influencing factors, such as the inflammatory response, reduced nutrient intake, increased metabolic requirements, malabsorption and psychosocial issues. These conditions may be related to acute conditions (trauma, burns, infections) or chronic conditions (cancer, chronic kidney disease, heart failure, inflammatory bowel disease, neurological disease (1).

Anthropometric indexes are an integral part of screening and assessment of the nutritional status (2). The use of appropriate tools, accurate measurement techniques and appropriate reference data are necessary for the collection and interpretation of anthropometric indexes. However, there are a number of challenges associated with the measurement of anthropometric indexes in inpatients due to disease severity, associated technical interventions such as respiratory support, hemodynamics, or clinical situations, such as trauma, burns and casts. Therefore, anthropometric indexes, such as weight, or height are sometimes based solely on a doctor's estimation or information provided by parents/caregivers, and may be affected by the fluid status of the body. By contrast, mid-upper arm circumference (MUAC) is a simple, low-cost and objective method of assessing nutritional status that has been widely used in the community to detect malnutrition. A recent consensus statement by the Academy of Nutrition and Dietetics/American Society for Parenteral and Enteral Nutrition (AND/ASPEN) on the indicators recommended for the detection of childhood undernutrition admits that 'MUAC is the predicted mortality with a higher sensitivity than the weight for height in malnourished pediatric patients' (3,4). Nonetheless, the detection of malnutrition in the hospital by anthropometric indexes is still limited; thus, MUAC can be considered as an index for the screening and monitoring of the nutritional status. Therefore, the present study was conducted with the aim of investigating the correlation between the MUAC z-score and the anthropometric indexes, weight and height, in assessing the nutritional status of pediatric inpatients.

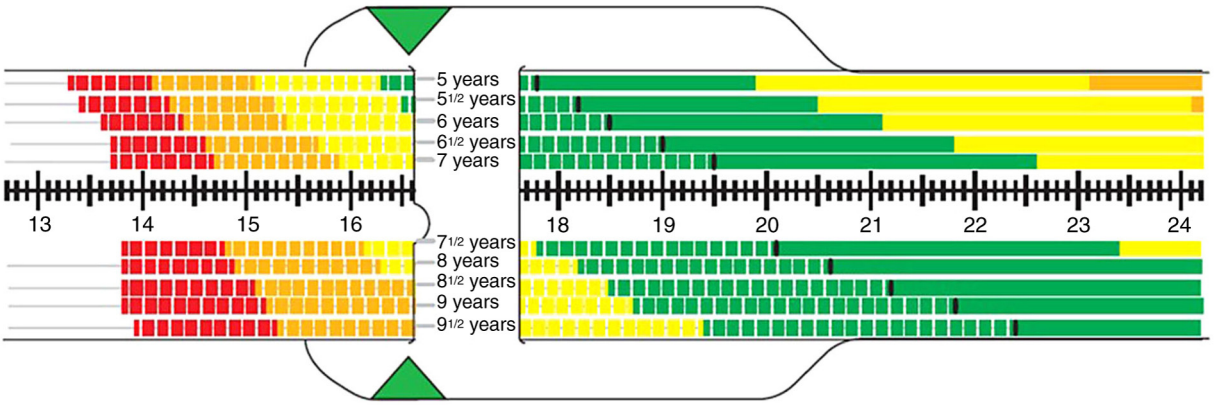


Figure 1. MUAC and z-score results. Orange: 2 to 3 MUAC z-score, moderately overweight; yellow: 1 to 2 MUAC z-score, slightly overweight; green: 0 to 1 MUAC z-score, normal; green + brick: -1 to 0 MUAC z-score, Normal; yellow + brick: -2 to -1 MUAC z-score, mild malnutrition; orange + brick: -3 to -2 MUAC z-score, moderate malnutrition; red + brick: -4 to -3 MUAC z-score, severe malnutrition. MUAC, mid-upper arm circumference.

Table I. General characteristics of the study subjects (n=500).

| General characteristics | No. of patients | % |
|---|---|---|
| Sex | | |
| Male | 298 | 59.6 |
| Female | 202 | 40.4 |
| Age group | | |
| 1-<12 months | 202 | 40.4 |
| 12-24 months | 113 | 22.6 |
| 25-60 months | 185 | 37 |
| Mean ± SD | 21,4±16.6 | |
| (minimum-maximum) | (2-59) | |

## Patients and methods

*Subjects*. The present study was conducted on 500 pediatric inpatients from 2 to 60 months of age who were treated at the Vietnam National Hospital of Pediatrics (Hanoi, Vietnam) between August, 2021 and August, 2022. The exclusion criteria include patients with physical restrictions that precluded the determine of standing height or recumbent length. All guardians/parents of the children were explained about the purpose of the study and were required to sign the consent forms. Children information was kept completely confidential and used for research purposes only. The present study was conducted after the research protocol was approved by the Vietnam National Hospital of Pediatrics (Decision no. 646/BVNTW-HDDD).

*Data collection*. The nutritional status of the children was assessed through data collection using measurement methods based on the WHO 2006 guidelines. The nutritional status was then classified based on the z-score according to the WHO 2006 guidelines (5) as follows: i) Weight was measured using the UNICEF SECA floor scale to measure the weight of the pediatric inpatients (weighing accuracy, 100 g); ii) recumbent length was obtained in infants up to 24 months of age (6); iii) standing height was determined in children >24 months of age; iv) MUAC was measured using tape provided by the Clinical Nutrition Center of the Vietnam National Hospital of Pediatrics; this was used to measure the MUAC in cm and the z-score (MUAC accuracy, 1 mm). The midpoint of the arm was deemed as the midpoint of the segment from the sacral process to the superior process of the humerus; the midpoint was marked, and the tension of the ruler was then adjusted, not too tight or too loose. The color range corresponding to the age of the patient was determined. The MUAC and z-score results were then read. Anthropometric data (z-core results) were processed using WHO 2006 Anthro software (version 3.2, a web link for Anthro version 3.2 software: https://who-anthro.software.informer.com/3.2/#google_vignette). The MUAC measurements are illustrated in Fig. 1.

*Statistical analysis*. Statistical analysis was performed using SPSS 20.0 software (IBM Corp.). Descriptive statistics of frequencies and percentages were used to describe qualitative variables. Quantitative variables are presented as the mean ± standard deviation. The Kappa coefficient and Pearson's correlation coefficient (r) were used to determine the correlation between the MUAC z-score and other anthropometric indexes. With the coefficient r, r<0.25 was considered to indicate a weak correlation, r=0.25-0.5 a moderate correlation, r=0.5-0.75 a strong correlation, and r≥0.75 to indicate a very strong correlation. With the Kappa coefficient, ≤0.2 was considered to indicate a slight consensus; 0.21-0.40 a fair consensus, 0.41-0.60 a moderate consensus, 0.61-0.80 a substantial consensus, and 0.81-1.00 to indicate a perfect consensus. Receiver operating characteristic (ROC) curve analysis for the MUAC z-score was performed based on weight/height ≥-2SD. Non-malnourished children were defined as having positive results. The area under the ROC curve (AUC) was calculated to compare the classification ability of the new index. The optimal MUAC z-score cut-off score was determined based on the highest sensitivity and specificity. An AUC from 0.5-0.6 was considered unsatisfactory, an AUC from 0.6-0.7 was considered satisfactory, an AUC from 0.7-0.8 was considered good, an AUC from 0.8-0.9 was considered very good, and an AUC of >0.9 was considered excellent. In all analytical results, a value of P<0.05 was considered to indicate a statistically significant difference.

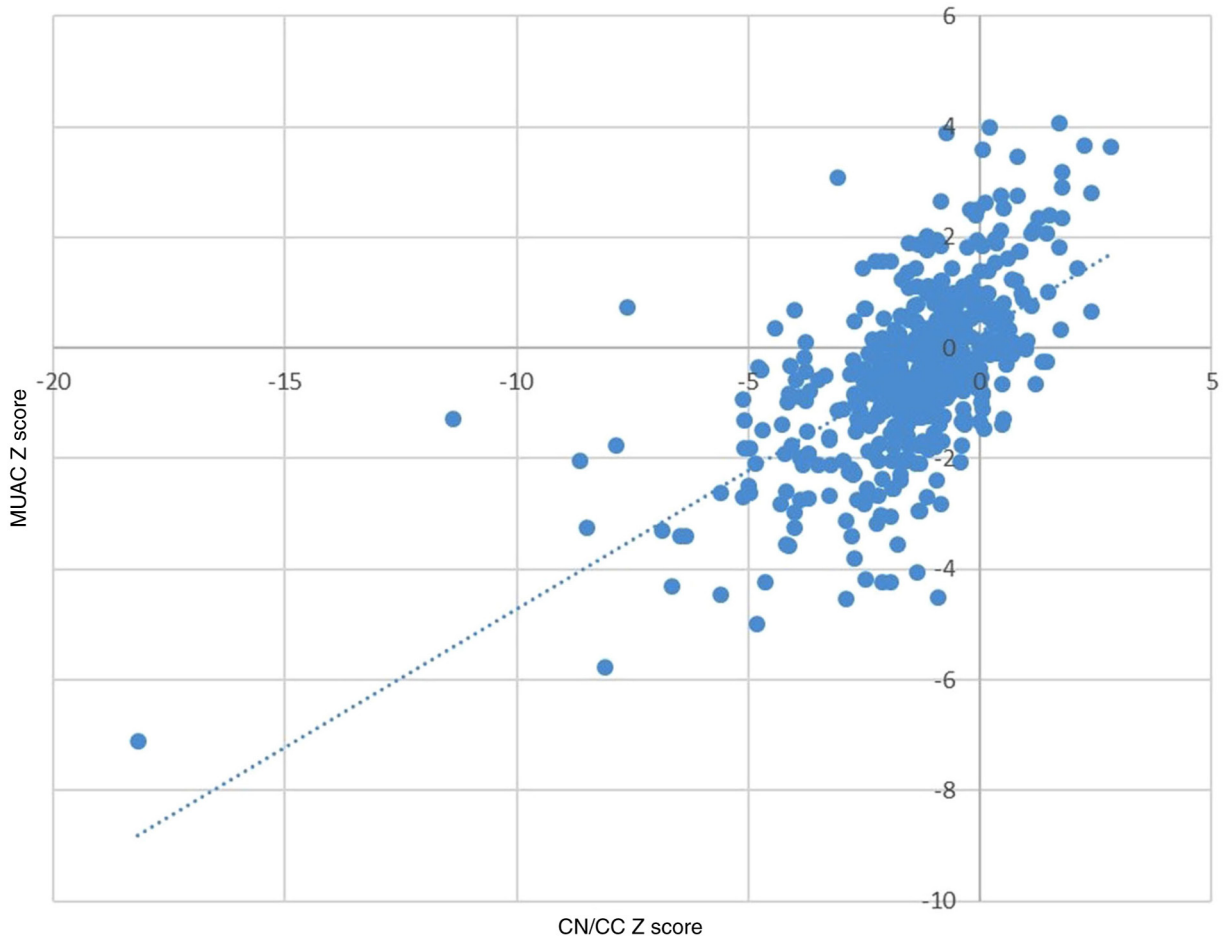


Figure 2. MUAC z-score has a strong correlation with weight/height z-score (r=0.608; P<0.001). MUAC, mid-upper arm circumference.

## Results

The general characteristics of the 500 pediatric inpatients participating in the study are presented in Table I. In terms of sex, the percentage of boys was greater than that of girls (at 59.6 and 40.4%, respectively). The median age of the study subjects was 17 months. The mean age of the children in the study group was 21.4±16.6 months. The age group of <12 months accounted for the highest rate, at 40.4% (Table I).

The nutritional status of the pediatric inpatients according to anthropometric indexes is presented in Table II. Of note, as regards weight for age, 20.8% of the patients were underweight, and 1.8% of the patients were overweight and obese. As regards weight for height, 14% of the patients were classified as wasting, and 5.4% of the patients were classified as overweight and obese. For height for age, 24% of the patients were classified as stunting; in 10.2% of these patients, this was considered as severe. As regards the MUAC z-score, 27.2% of the patients were classified as having malnutrition; in 14.4% of these patients, this was considered as severe malnutrition. Of note, 1% of the patients were classified as being overweight (Table II).

The MUAC z-score was found to have a strong correlation with the weight/height z-score (r=0.608; P<0.001) (Fig. 2). The MUAC z-score was also found to have a moderate consensus with the WHO absolute value MUAC classification (k=0.458, P<0.001) (Table III).

Furthermore, ROC curve analysis with weight/height ≥-2SD is the standard index and children without malnutrition exhibited positive results; the optimal cut-off point for MUAC z-score was -1.88. The AUC was 0.84 (95% confidence interval), indicating that this cut-off has an 84% ability to distinguish between malnourished and non-malnourished children (Fig. 3).

## Discussion

Nutritional status affects the response of each pediatric patient to disease. A poor nutritional status in inpatients is associated with the duration of treatment, morbidity and mortality. Therefore, nutritional assessment is an integral part of the overall treatment of all pediatric inpatients. To date, anthropometric indexes (weight, height and MUAC) have been considered essential and are the preferred methods used to assess the nutritional status and for the monitoring of nutritional interventions in the community. However, these anthropometric indexes when used in hospitals still have limitations due to disease status and the distribution of body fluids (1).

The choice of which instrument is appropriate in the hospital should be considered based on resources, implementation and

Table II. Nutritional status of the pediatric inpatients according to anthropometric indexes (n=500).

| | Weight for age | | Height for age | | Weight for height | | MUAC | |
|---|---|---|---|---|---|---|---|---|
| Nutritional status | No. of patients | % | No. of patients | % | No. of patients | % | No. of patients | % |
| Severe malnutrition | 52 | 10.4 | 51 | 10.2 | 26 | 5.2 | 64 | 12.8 |
| Moderate malnutrition | 52 | 10.4 | 69 | 13.8 | 44 | 8.8 | 72 | 14.4 |
| Normal | 387 | 77.4 | 380 | 76 | 403 | 80.6 | 359 | 71.8 |
| Overweight | 7 | 1.4 | | | 18 | 3.6 | 5 | 1 |
| Obese | 2 | 0.4 | | | 9 | 1.8 | | |

MUAC, mid-upper arm circumference.

Table III. Consistency (consensus) between the MUAC z-score and the WHO MUAC cut-off (n=500).

| | MUAC z-score | | | | | | |
|---|---|---|---|---|---|---|---|
| | Severe malnutrition | Moderate malnutrition | Normal | Overweight | Total (n) | κ | P-value |
| MUAC | | | | | | 0.458 | 0.001 |
| Severe malnutrition | 39 | 6 | 0 | 0 | 45 | | |
| Moderate malnutrition | 12 | 13 | 14 | 0 | 39 | | |
| Normal | 13 | 53 | 345 | 5 | 416 | | |
| Total (n) | 64 | 72 | 359 | 5 | 500 | | |

MUAC, mid-upper arm circumference.

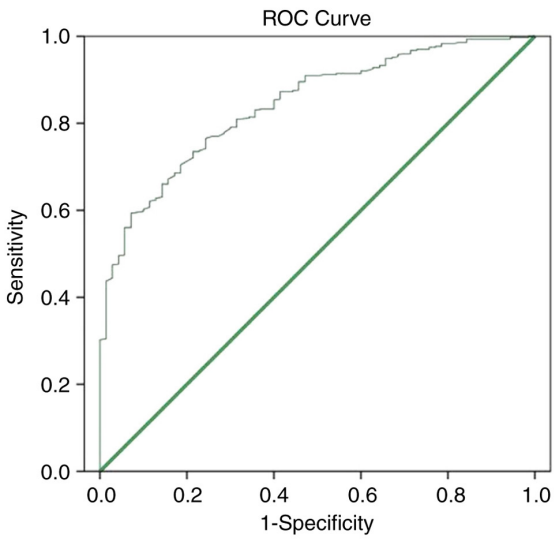


Figure 3. ROC curve analysis for mid-upper arm circumference z-score based on weight/height ≥-2SD. The area under the ROC curve was 0.84 (95% confidence interval), indicating that this cut-off has an 84% ability to distinguish between malnourished and non-malnourished children. ROC, receiver operating characteristic.

accuracy. Therefore, in the present study, in order to provide data for the selection of anthropometric indexes in the early identification of the nutritional status of patients upon admission, from August, 2021 to August, 2022, a total of 500 pediatric inpatients at Vietnam National Hospital of Pediatrics participated in the study.

In terms of sex, the percentage of boys was higher than that of girls (at 59.6 and 40.4%, respectively). The mean age of the study group was 21±16 months old (the lowest was 2 months and the highest was 60 months) with a median age of 17 months (Table I). The group of children <12 months of age accounted for the highest percentage (40.4%), followed by the groups of 12-24 months (22.6%) and 25-60 months (37%). In the study by Huong *et al* (7) on 337 inpatients aged between 6 months and 15 years, the children <2 years of age accounted for the highest rate (59.3%), followed by those aged 24 to 59 months (22%), 5 to 9 years (13.1%) and >9 years (5.6%).

The results of the present study are based on the reference population of the WHO (2006). The rate of underweight malnutrition (weight/age) was 20.8%, that of chronic malnutrition (stunting) was 24% and that of acute prevalence (wasting) was 14% (Table II). Currently, malnutrition is one of the key child health concerns in Vietnam. According to data from the Ministry of Health in 2021 (8), in the community, the rate of acute malnutrition (weight/height) in children was 5.2%, that of underweight malnutrition was 11.5%, and that of stunting (height/age) was 19.6%; this rate has decreased significantly compared to 2000 (8.6, 33.8 and 36.5%, respectively). However, the prevalence of malnutrition in the present study was higher than that reported in the community in the healthy group of children (14, 20.8 and 24%, respectively). The reason for this is that the causes of malnutrition in the

community and hospitalized children are different. In the community, malnutrition is often caused by a lack of food resources, socio-economic and psychological factors, and a lack of medical care, so as the country develops, the rate of malnutrition in the community will increase. Malnutrition in pediatric inpatients due to nutritional imbalances includes decreased nutrient intake (fluid restriction, heart failure, anorexia), increased nutrient loss (chronic diarrhea toxicity, burns, proteinuria), or increased nutritional requirements (increased metabolism) (burns) disproportionate to intake, and failure to absorb or utilize nutrients (malabsorption phase).

In the MUAC classification (Table III), there were 27.2% malnourished children, of which 12.8% were classified as having severe acute malnutrition and 14.4% were moderately acute malnourished children. The study results revealed that the use of the MUAC z-score significantly increased the ability to detect acute malnutrition in inpatients compared with weight/height and weight/age indexes. By contrast, the study by Lan *et al* (9) revealed a lower prevalence of malnutrition according to arm circumference (10.8%); the reason for this was that Lan *et al* (9) used the MUAC cut-off value to assess malnutrition and this was not based on the z-score. Similarly, the study by Hop *et al* (10) also demonstrated that when using a cut-off point of MUAC to assess nutritional status, the sensitivity and specificity were only high in groups 6-12 months, while in the group of 37-60 months, the sensitivity decreased to only 4% in boys and 10% in girls. In addition, the study by Hossain *et al* (11) in Bangladesh also demonstrated that MUAC thresholds varied by age group and that the use of the MUAC z-score will address these differences when assessing undernutrition. Therefore, in 2014, the American Dietetic Association recommended the use of the MUAC z-score for the assessment of the nutritional status in pediatric clinical practice (12). When compared with the study using the MUAC z-score at the hospital, the research results were lower than those of the study by Linh *et al* (13) with the prevalence of malnutrition according to the arm circumference of 41.7%. The present study was on patients with both acute and chronic disease, while the study by Pham Thao Linh was only on chronic liver disease with a high percentage of muscle wasting.

The present study on 500 inpatients (Fig. 2) revealed a strong correlation between the MUAC z-score and weight/height z-score (r=0.608); this result was similar to that of the study by Roberfroid *et al* (14) with a strong correlation (r=0.638). The MUAC z-score is quite similar to the WHO absolute MUAC classification of nutritional status (with k=0.458 and P<0.001) (Table III). Previously, there were some studies demonstrating that there was no consensus. There is a clear agreement between anthropometric indices to determine nutritional status, with body mass index (BMI), weight/height and MUAC tending to determine the prevalence of undernutrition differently (14,15). This is likely due to the majority of studies comparing age/sex-specific criteria (weight/height z-score or BMI z-score) and absolute value-based criteria (MUAC in cm), and it has also been demonstrated that classification based on z-score has a higher sensitivity and less bias than the absolute cut-off (16). For example, in the study by Roberfroid *et al* (14), the sensitivity to detect malnourished children using MUAC 125 cm was 31%, and weight/height was 70.6%. The study by Laillou *et al* (16) demonstrated that when using the current WHO cut-off point of 115 mm to screen for malnutrition, >90% of children with weight/height <-3SD were missed.

In the present study, the AUC was 84.1%, indicating that this cut-off value was a good index of malnutrition. Based on the ROC curve analysis, the present study demonstrated that the MUACZ <-1.88 was a useful and simple nutritional index to assess malnutrition in children.

In conclusion, assessing nutritional status in inpatients is essential. It is necessary to use a combination of all three anthropometric indexes: Weight, height and MUAC to detect early clinical malnutrition. Particularly for patients whose weight is affected by fluid status, MUAC is an important tool for assessing the nutritional status.

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**Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

**Authors' contributions**

TMTL and LTT conceptualized the study. TMTL and HNV were involved in the study methodology. ATTV and HNV provided the software and were involved in the formal analysis. LTT was involved in the investigative aspects of the study. LTT and TMYL were involved in data collection. ATTV, HNV and LTT were involved in the writing and preparation of the original draft of the manuscript. HNV and LTT were involved in the writing, reviewing and editing of the manuscript. TMTL supervised the study. TMTL and HNV was involved in project administration. TMTL and LTT confirm the authenticity of all the raw data. All authors have read and agreed to the published version of the manuscript.

**Ethics approval and consent to participate**

All guardians/parents of the children were explained about the purpose of the study and were required to sign the consent forms. Children information was kept completely confidential and used for research purposes only. The present study was conducted after the research protocol was approved by the Vietnam National Hospital of Pediatrics (Decision no. 646/BVNTW-HDDD).

**Patient consent for publication**

Not applicable.

**Competing interests**

The authors declare that they have no competing interests.

## References


1. Abdelhadi RA, Bouma S, Bairdain S, Wolff J, Legro A, Plogsted S, Guenter P, Resnick H, Slaughter-Acey JC and Corkins MR; ASPEN Malnutrition Committee: Characteristics of hospitalized children with a diagnosis of malnutrition: United States, 2010. JPEN J Parenter Enteral Nutr 40: 623-635, 2016.
2. Vermilyea S, Slicker J, El-Chammas K, Sultan M, Dasgupta M, Hoffmann RG, Wakeham M and Goday PS: Subjective global nutritional assessment in critically ill children. JPEN J Parenter Enteral Nutr 37: 659-666, 2013.
3. Briend A, Maire B, Fontaine O and Garenne M: Mid-upper arm circumference and weight-for-height to identify high-risk malnourished under-five children. Matern Child Nutr 8: 130-133, 2012.
4. Garenne M, Maire B, Fontaine O and Briend A: Adequacy of child anthropometric indicators for measuring nutritional stress at population level: A study from Niakhar, Senegal. Public Health Nutrition 16: 1533-1539, 2012.
5. World Health Organization: WHO Child Growth Standards, 2006.
6. Mehta NM, Corkins MR, Lyman B, Malone A, Goday PS, Carney LN, Monczka JL, Plogsted SW and Schwenk WF; American Society for Parenteral and Enteral Nutrition Board of Directors: Defining pediatric malnutrition: A paradigm shift toward etiology-related definitions. JPEN J Parenter Enteral Nutr 37: 460-481, 2013.
7. Hương PTT, Lâm NT, Thu NN, Quyen TC, Lien DT, Anh NQ, Henry EG, Oliver L, Apovian CM, Ziegler TR and Lenders C: Prevalence of malnutrition in patients admitted to a major urban tertiary care hospital in Hanoi, Vietnam. Asia Pac J Clin Nutr 23: 437-444, 2014.
8. Ministry of Health (2021). Nutrition census 2019-2020. https://moh.gov.vn/tin-noi-bat/-/asset_publisher/3Yst7YhbkA5j/content/bo-y-te-cong-bo-ket-qua-tong-ieu-tra-dinh-duong-nam-2019-2020.
9. Lan BN, Ha TT, Linh VT, Thanh DC and Dung LTT: Some factors related to malnutrition in pediatric cancer patients under 5 years old at the National Children's Hospital. Journal of Pediatrics Research and Practice 5: 31-37, 2021 (In Vietnamese).
10. Hop T, Gross R, Sastroamidjojo S, Giay T and Schultink W: Mid-upper-arm circumference development and its validity in assessment of undernutrition. Asia Pac J Clin Nutr 7: 65-69, 1998.
11. Hossain MI, Ahmed T, Arifeen SE, Billah SM, Faruque A, Islam MM and Jackson AA: Comparison of midupper arm circumference and weight-for-height z score for assessing acute malnutrition in Bangladeshi children aged 6-60 mo: An analytical study. Am J Clin Nutr 106: 1232-1237, 2017.
12. Hartman C, Shamir R, Hecht C and Koletzko B: Malnutrition screening tools for hospitalized children. Curr Opin Clin Nutr Metab Care 15: 303-309, 2012.
13. Linh PT, Hoa NPA, Thi N and Hong TT: Micronutrient deficiencies status in children with chronic liver disease at the national children's hospital. J Med Res 160: 116-126, 2022.
14. Roberfroid D, Huybregts L, Lachat C, Vrijens F, Kolsteren P and Guesdon B: Inconsistent diagnosis of acute malnutrition by weight-for-height and mid-upper arm circumference: Contributors in 16 cross-sectional surveys from South Sudan, the Philippines, Chad, and Bangladesh. Nutr J 14: 86, 2015.
15. Grellety E and Golden MH: Severely malnourished children with a low weight-for-height have a higher mortality than those with a low mid-upper-arm-circumference: I. Empirical data demonstrates Simpson's paradox. Nutr J 17: 79, 2018.
16. Laillou A, Prak S, de Groot R, Whitney S, Conkle J, Horton L, Un SO, Dijkhuizen MA and Wieringa FT: Optimal screening of children with acute malnutrition requires a change in current WHO guidelines as MUAC and WHZ identify different patient groups. PLoS One 9: e101159, 2014.