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Original Article

Mid-upper arm circumference as an indicator of nutritional status improvement in children aged 6-59 months with severe acute malnutrition

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Abstract

Background The prevalence of severe acute malnutrition (SAM) in Indonesia remains high, especially in children with pre-existing chronic disease. These children often present with conditions that could interfere with weight measurements, such as edema or organomegaly. Mid-upper arm circumference (MUAC) is a potential indicator of nutritional status improvement.

Objective To analyze the correlation between MUAC and body weight as parameters for nutritional improvement in children with SAM.

Methods We performed registry analysis of patients admitted to the Pediatric Ward, Dr. Cipto Mangunkusumo Hospital, Jakarta, Indonesia, from November 2016 to December 2020. We included children aged 6-59 months who were severely wasted (z-score <-3 on the WHO weight-for-height growth chart), had no conditions that could alter weight measurement, and had a 7-day minimum hospital stay. Patients with missing body weight and/or MUAC data were excluded. MUAC and weight increment between admission and discharge were analyzed using bivariate correlation and linear regression analyses.

Results Out of 4,746 pediatric inpatients, 1,996 presented with SAM. Of these, 124 were eligible for analysis. Subjects' median age was 18 (IQR 11-32) months and median length of stay was 16 (IQR 9-29) days. Weight increment (g/kg/day) and MUAC increment (mm/day) were independently and significantly correlated (Spearman's rho=0.414; P<0.001). An adequate weight increment of 5-10 g/kg/day was equivalent to a MUAC increment of 0.319-0.439 mm/day (R=0.374; P<0.001).

Conclusion MUAC increment has a moderate positive correlated with weight increment. MUAC is a useful parameter of nutritional status improvement in SAM patients, especially in patients with conditions that could interfere with weight measurement. **[Paediatr Indones. 2024;64:300-4; DOI: 10.14238/pi64.4.2024.300-4].**

Keywords: *coronavirus; dengue; antibody; DENV; SARS-CoV-2*

The *World Health Organization* (WHO) criteria for severe acute malnutrition (SAM) in children aged 6 to 59 months include any of the following: weight-for-height z-score <–3 SD on the *WHO Child Growth Standards* charts, the presence of bilateral edema of the feet, and mid-upper arm circumference (MUAC) of <115 mm.[1] Severe acute malnutrition increases childhood morbidity and mortality, as a child with SAM is 10 times more likely to die than a well-nourished child.[2] This condition affected 13.6 million children globally in 2020, with more than half living in South Asia.[1] In Indonesia, SAM remains abundant. In 2018, the *Riset Kesehatan Dasar* (Basic Health Research Survey) in Indonesia reported that 805,000 children under five years of age had SAM.[3]

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Children with SAM and its complication should be treated as inpatients initially. Inpatient management of SAM consists of two phases: the initial stabilization phase followed by the rehabilitation phase, with a transition period in between.[1] During hospitalization, weight gain velocity is measured to monitor the response to treatment and identify children with failure to respond. Weight gain velocity is categorized as poor if it is <5g/kg/day, moderate if it is 5-10g/kg/day, and good if it is >10g/kg/day.[1] However, children with SAM often present with conditions that might interfere with weight measurements, such as edema and organomegaly.[4]

Since 2009, the WHO recommended using MUAC in addition to weight-for-height/length as anthropometric criteria for admission to therapeutic feeding programs and discharge from treatment.[1] Measurement of MUAC is relatively easy to perform. Errors of measurement associated with MUAC are less frequent than for weight or height.[5] In addition, MUAC has also been found to be as effective as other nutritional indices in predicting the risk of death in malnourished children.[6] One study showed that MUAC is less influenced by hydration status than body weight.[7] Another study reported average MUAC gain velocities during the rehabilitation phase ranging from 0.2-0.4 mm/day.[1] The rate of daily MUAC gain has been reported to be directly related to the rate of daily weight gain. Therefore, MUAC may be used as an alternative tool to assess nutritional status improvement in children with SAM.[3] However, studies on changes in MUAC gain velocities during treatment of children with complicated SAM have been limited. Thus, we aimed to assess MUAC increment compared to weight increment during the rehabilitation phase of inpatient management in children with SAM.

Methods

All children aged 6-59 months with a weight-for-length *z*-score of <-3 admitted to the Pediatric Ward, Dr. Cipto Mangunkusumo Hospital, Jakarta, from November 2016 to December 2020 were included in this study. We excluded children who were admitted for <7 days or who had incomplete medical record data on body weight and/or MUAC. Children with conditions affecting weight, such as organomegaly, edema, ascites, intra-abdominal mass, or hydrocephalus, were also excluded. Out of 4,764 pediatric inpatients during the study period, 1,966 fulfilled inclusion criteria. Of these, 124 were included in the study. Children with a weight-for-height *z*-score of <-3 based on the WHO Child Growth Reference Standards growth charts were diagnosed with SAM. We recorded the subjects' age at admission. An episode was defined as a distinct period of hospital care for a patient. One patient may underwent multiple episodes, be it for the same medical condition or a different one.

The delta body weight and delta MUAC were measured by subtracting the measurements on initial admission from the final measurements before hospital discharge. The resulting delta was divided by the length of hospital stay in days. Body weight was also divided by the patient's average body weight during the admission in kg. The final result of the calculations were MUAC increment (mm/day) and body weight increment (g/kg/day).

Categorical data were reported as frequencies (percentages), whereas continuous data were presented as mean (SD) or median (interquartile range/IQR), depending on the distribution of the variables. Bivariate correlation and linear regression analyses were performed to assess the correlation between MUAC increment and body weight increment. Bivariate analysis was done using Pearson's or Spearman's correlation. Results with P values <0.25 were entered in a linear regression model to formulate the equation model between MUAC increment and weight increment. The study protocol was approved by the Medical Research Ethics Committee of the Faculty of Medicine, Universitas Indonesia. Following the guidelines, written informed consent was waived because of the retrospective study design.

Results

The baseline characteristics of the 124 subjects are shown in **Table 1**. The median age of subjects was 18 (IQR 11-32) months. All patients had improved nutritional status at hospital discharge compared to the time of admission, with an increase of median body weight from 7,100 (IQR 3,190-32,000) g to 7,450

(IQR 3,600-31,000) g. The mean weight increment was 4 g/kg/day. Median MUAC also increased from 105 (IQR 70-180) mm on admission to 110 (IQR 70-190) mm at discharge.

Subjects' weight increment and MUAC increment were not distributed normally, therefore, we used Spearman's rho in our bivariate correlation analysis. Weight increment was moderately and significantly associated with with MUAC increment (rho=0.414; P<0.001).

Linear regression analysis was conducted to formulate the correlation model of weight and MUAC increment. Weight increment significantly predicted MUAC increment (**Figure 1**) (R=0.374; P<0.001), with an adjusted R2 of 13.3%. The linearity test showed that all continuous independent variables were linearly related to the dependent variable, every unit increase of increment was associated with an increased MUAC increment. We obtained a model of [MUAC increment = 0.199 + 0.24 (weight increment)]. Hence, a weight increment of 5-10 g/kg/day, as expected during the rehabilitation phase according to WHO guidelines, was equivalent to a MUAC increment of 0.319-0.439 mm/day (rho=0.374; P<0.001).

Discussion

Our study showed that MUAC measurement is suitable for nutritional monitoring in children with SAM. We found a noticeable increase in weight and

Table 1. Characteristics of subjects

Characteristics	(N=124)
Median age (IQR), months	18 (11-32)
Male/female* (%)	53.2/44.4
Median hospital length of stay (IQR), days	16 (9-30)
Nutritional status at admission	
Median body weight (IQR), g	7,100 (5,300-9,000)
Median MUAC (IQR), mm	105 (95-115)
Nutritional status at discharge	
Median body weight (IQR), g	7,450 (5,700-9,775)
Median MUAC (IQR), mm	110 (100-120)

*N=121 (gender data for 3 subjects was unavailable)

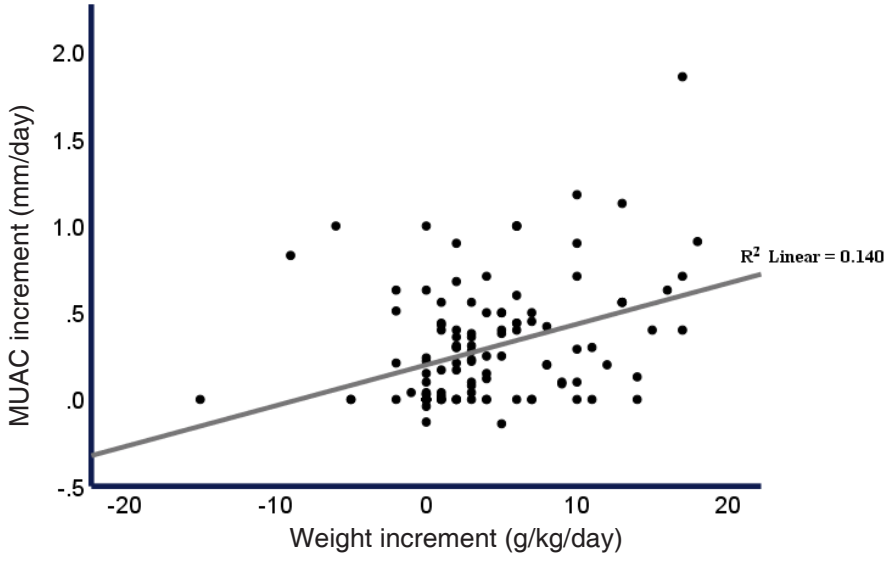

Figure 1. Relationship between MUAC increment (mm/d) and weight increment (g/kg BW/d)

MUAC during the rehabilitation phase of treatment in SAM patients aged 6-59 months. The key finding was that MUAC increment was positively correlated with weight increment. This finding was consistent with a previous study that found a moderate correlation between the two variables in 463 children with SAM in rural Gambia.[8] In another study, the correlation was found to be stronger, with Pearson's r of >0.8 in three datasets from three different countries: Ethiopia, Malawi, and Bangladesh.[9] MUAC is made up of the cross-section of bone, muscle, blood vessels, and fat in the upper arm. MUAC, therefore, reflects protein and lipid reserves in the body.[10] However, MUAC has been thought to lag behind weight and, therefore, be inappropriate for nutritional monitoring.[11] These significant correlations between MUAC increment and weight increment challenge the hypothesis that MUAC lags behind weight in recovery and treatment response.

Our finding was in agreement with two extensive studies from India. One study was a nutritional program in Burkina that analyzed the outcomes of over 24,792 patients.[4] The other was a community-based management of acute malnutrition (CMAM) program in Bihar, with 8,274 children aged 6-59 months with SAM.12 Both studies reported that MUAC and weight followed the same trend throughout recovery. *Médecins Sans Frontières* (MSF) have used MUAC as the only anthropometric parameter in their CMAM program for challenging emergency settings since 2007. MUAC is used in all steps from patient admission, monitoring, and discharge. The program yielded successful outcomes for both recovery and mortality.[13] These studies support the use of MUAC as nutritional monitoring parameter.

The MUAC measurement has several advantages compared to weight measurement for nutritional monitoring. First, MUAC measurement makes nutritional monitoring possible when weight measurement is difficult to perform, such as in debilitated or immobile patients. Patients with SAM often present with edema or organomegaly, which could make weight measurement unreliable.[4] MUAC also offers a benefit in cases of hydration status changes. Changes in total body water can cause temporary variations in weight. Since water comprises 75% of muscle tissue, MUAC is also affected by dehydration. However, a previous study found that MUAC was less affected by dehydration than weight.[7] This is important to note because diarrhea, which can cause severe dehydration, often occurs coincidentally with SAM. Therefore, MUAC is a promising alternative to weight measurement for nutritional assessment in these clinical settings.[7]

While the target values for weight increment during the rehabilitation phase have been established, adequate MUAC increment values remain unclear. The mean weight increment in our study was 4 g/kg BW/day. This value was within the range of weight increment found in other countries involved in the community-based therapeutic care program (Malawi, Ethiopia, and Sudan), which varied from 3 to 6.8 g/kg BW/day.[13] However, this average weight increment was still below the adequate weight gain values of 5-10g/kg BW/day.[14] Since MUAC increment corresponded with weight increment, the average MUAC increment was also inadequate. The mean MUAC increment in this study was 0.29 mm/day. Our linear regression showed that an adequate weight increment of 5-10 g/kg BW/day was equivalent to a MUAC increment of 0.319-0.439 mm/day. We suggest this range be the target value if MUAC were to be used as a parameter for nutritional monitoring.

Our study appears to be the first to establish an adequate MUAC increment cut-off value for nutritional status monitoring during the rehabilitation phase of treatment for SAM. In other studies, the mean MUAC increment varied from 0.2 to 0.4 mm/day.[1] Based on our findings, a MUAC increment of <0.319 mm/day corresponds to a weight increment of <5 g/kg BW/day, less than expected in the rehabilitation phase. This finding can be a valuable reference for nutritional monitoring programs that use MUAC as the parameter.

There were some limitations in our study. Some episodes with incomplete data had to be excluded from the analysis, which may result in biased data output. In addition, we did not consider subjects' illness and disease severity. Therefore, we could not perform further analysis to see if the correlation was irrespective of the type and severity of the disease. Also, we measured the body weight and MUAC in kg and cm instead of g and mm, respectively. These greater units may have limited the precision of the recorded data.

We observed MUAC and weight increment in

children with SAM during the rehabilitation phase. MUAC increment was positively correlated with weight increment, indicating no lag effect on MUAC. Therefore, MUAC can be used as an alternative parameter for nutritional status improvement in SAM patients. Further studies which address these limitations are needed to obtain a more precise and thorough result. A further prospective study using a smaller measurement unit that considers disease severity is needed to achieve better accuracy.

Conflict of interest

None declared.

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