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Mid-upper arm circumference cut-off for detection of severe acute malnutrition in infants aged between one and six months

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Objective: To find the MUAC cut-off for detection of severe acute malnutrition in infants between 1 to 6 months of age. **Material and Methods:** A prospective observational study at IPD and OPD of a tertiary care hospital. 303 infants between one and six months of age above the length of 45cms were included in the study. In infants between one and six months of age, the length, weight, and MUAC were measured. SAM infants were identified using the WHO definition. Sensitivity, specificity, and Youden index for a particular MUAC was calculated in SAM infants. **Results:** 11cms was found to have a sensitivity of 85.1% and specificity of 65.9%. It had the maximum Youden index of 0.55 with a positive likelihood ratio of 2.79 and a negative likelihood ratio of 0.21. **Conclusions:** MUAC of 11cms can be used as a cut-off for SAM infants between 1 to 6 months of age. MUAC does not vary with gender. Weight and MUAC are significantly lower in SAM infants. But there is no difference when it comes to length as in acute malnutrition, the weight and MUAC are affected but length is not.

Keywords: MUAC, Cut-off, SAM, Infants, Malnutrition, Severe acute malnutrition

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Introduction

Undernutrition accounts for nearly half of all deaths in children under five globally. 17 million children suffer from Severe acute malnutrition globally [1].

Undernutrition accounts for 22% of the burden of disease in India. It adversely affects the economic growth of the country with an estimated adult productivity loss of 1.4% of GDP. Childhood undernutrition accounts for 45% of Under 5 mortality alone and remains a key public health challenge in India [2]. The maximum prevalence of wasting was seen in Jharkhand (29%) and the minimum in Kerala (15.7%). Prevalence of SAM in Karnataka is 10.5% and in Belgaum 16% [3].

The number of underweight children in India is among the highest in the world and is nearly double that of Sub-Saharan Africa. 19.8% of Indian under-five children are wasted and 6.4% of under-five children are severely wasted, which would translate to almost astounding 8 million children in India who are severely wasted out of the 25 million children who are wasted. The prevalence is even higher in infants below 6 months of age i.e., 13.1%. [2]. The mortality due to SAM in infants less than 6 months is higher compared to that of children between 6-59 months of age [4].

Early infancy is the representation of a period of transition from neonatal life to childhood during which there is rapid growth, neurological and immunologic development, and changes in the mode of feeding. Nutrition programs and surveys have usually excluded infants under 6 months of age because adequate nutrition is assumed to be ensured by breastfeeding [5]. However, there is increasing recognition that malnutrition occurs before age 6 months and is associated with higher mortality [6,7].

An analysis of Demographic and Health Survey data reported that, worldwide, 4.7 million under 6 months' infants have moderate acute malnutrition and 3.8 million have severe acute malnutrition (SAM), diagnosed by using the weight-for-length z score (WLZ) [8]. In children above 6 months, mid-upper arm circumference (MUAC) is more discriminatory for mortality than is WLZ [9].

Relations between anthropometry and mortality may be confounded by age, HIV, or low birth weight arising from prematurity or small-for-gestational-age status.

Low-birth-weight infants could have been classified as malnourished by anthropometry at a single time point despite growing normally. Because of these concerns, the WHO and a recent Child Health and Nutrition Research Initiative exercise have highlighted establishing diagnostic criteria for SAM among Under 6 months' infants as the leading research question in the field. [10,11].

Severe acute malnutrition (SAM) in infants less than 6 months of age is defined by World Health Organization (WHO) and UNICEF as an infant more than 45 cm in length having any of the following features: (i) weight for length below -3 standard deviation (SD or Z scores) of the median WHO growth reference; and/or (ii) visible severe wasting; and/or (iii) presence of bipedal edema; for children less than 45 cm in length, visible severe wasting is used as the criteria [10-14]. The role of MUAC in the diagnosis of SAM below the age of 6 months of age has not been considered adequately.

Mid-upper arm circumference (MUAC) cut-off of 11.5 cm is used as an independent diagnostic criterion to identify severe acute malnutrition (SAM) in children aged between 6 months and 5 years [15]. MUAC is useful for mass screening and community diagnosis. Mid-upper arm circumference has many advantages overweight for the length. It is cheap, quick, simple, and acceptable. Colour coded tapes allow the illiterate field workers and mothers to easily diagnose SAM, [12] whereas weight for length assessment requires- scales, a length board, which are troublesome to transport, and sufficient numeracy and literacy to convert the raw measurements into a weight for length category.

In a few studies, it has been found that MUAC has a better sensitivity than Weight for length for predicting mortality [13].

Hence, in the present study, it was aimed to find the MUAC cut-off for SAM in infants between 1 to 6 months of age.

Materials and Methods

Study design: A prospective observational study

Inclusion criteria: Infants between one and six months of age above the length of 45 cms.

Exclusion criteria: Infants with clinical evidence of

- edema
- ascites

- c) pleural effusion
- d) significant tumor or organomegaly

Setting: OPD and IPD infants between 1 and 6 months fulfilling inclusion and exclusion criteria were included in this study.

Duration: For 1 year, between January 2018 to December 2018.

Sample size:

Formula n= Z^2*p*q/d^2

Z= z value for alpha error = 1.96
p= prevalence (20.9) [14]
q=100-p
d=absolute error 10%
n=1.96^2 x 20.9 x 79.1 /10 x 10

=63 with 10% error

Based on this a minimum of 63 infants were taken in each group. Total of 303 infants were included in this study.

Method of collection of data

The particulars of the infant and relevant history were taken.

The length of the child was measured by an infantometer. The child was made to lie on his back on the measuring board, positioning the crown of the head against the headboard compressing the hair. The head was held and tilted upwards until the eyes look straight up and the line of sight was perpendicular to the measuring board. The knees were straightened as much as possible. The soles of the feet were flat on the foot piece, toes pointing straight up. The length was recorded to the nearest centimeter [15].

MUAC was measured on the left upper arm. The midpoint between the acromion process and the tip of the olecranon was marked. The non-stretchable measuring tape was placed snugly around the arm at this point. It was measured to the nearest millimeter [15].

The weight of the child was measured with minimal clothing. Weight was measured using an electronic weighing scale (Goldtech weighing scales, ISO 9001:2008 certified, New Delhi, Delhi, India). Weight was measured to the nearest 10 grams [15].

Length, weight, and MUAC were recorded of all the infants taken in the sample.

The measurements were taken by the Principal Investigator or any postgraduate student.

The weight for length Z scores was calculated according to 2006 WHO Multicentre Growth Reference Study (MGRS) growth curves using weight and length which were recorded.

The infants were divided into 3 groups based on age

(I) Between 1 to 2 and a half months (2 months 15 days)

(Ii) Between 2 and half months to 4 months

(Iii) Between 4 months to 6 months

The average MUAC, weight, and length for normal infants of the corresponding age groups were calculated.

One more group containing only SAM infants between the ages of 1 to 6 months was taken. Severe acute malnutrition (SAM) defined as an infant more than 45 cm in length having any of the following features: (i) weight for length below -3 standard deviation (SD or Z scores) of the median WHO growth reference; and/or (ii) visible severe wasting [8].

The average MUAC, weight, length of the SAM infants was calculated.

Ethical clearance: Taken

Statistical analysis: Basic data presented in percentages or proportions and graphs. A T-test was used to see the significant difference between MUAC of SAM and normal infants. Sensitivity, specificity, Youden index (sensitivity+specificity-1), and the likelihood ratio of positive and negative tests were calculated for MUAC cut-offs of 9.5 cm, 10 cm, 10.5 cm, 11 cm, 11.5 cm, and 12 cm against the presence of SAM (WLZ <–3). The receiver operating characteristic (ROC)curve was plotted. a p-value of <0.05 was taken as significant.

Youden index measures the effectiveness of the diagnostic test and enables the selection of an optimal threshold point (cutoff).

The positive likelihood ratio is the probability of a person testing positive divided by the probability of a person who does not have the disease testing positive. The negative likelihood ratio is the probability of a person who has disease testing negative divided by the probability of the person who does have not the disease testing negative.

Results

Totally 303 infants were studied of which 67 were SAM infants. Among those infants who were not SAM, 42.3 % (i.e., 100) infants were between 1 to 2 months 15 days, 27.5% (i.e., 65) were between 2 months 16 days to 4 months, 30.1% (i.e., 71) were between 4 to 6 months. In infants between 1 to 2 months 15 days, 56% (56) were median, 28% (28) were <-1SD and 16% (16) were <-2SD. In infants between 2 months 16 days to 4 months, 58% (38) were median, 23% (15) were <-1SD and 19% (12) were <-2SD. In infants between 4 to 6 months, 60.5% (43) were median, 22.5% (16) were <-1SD and 17% (12) were <-2SD. In the present study, in non-SAM infants between 1 to 2 months 15 days, the average length in males was 53.05±3.80cms and females 52.95±3.74cms. There was no significant difference in length. In infants between 2 months 16 days to 4 months, the average length in males was 58.45±5.17cms and females 57.63±3.53cms. There was no significant difference in length. In infants between 4 months to 6 months, the average length in males was 62.13±3.57cms and females 60.12±4.18cms. There was a significant difference in length between males and females. (p=0.034). In the present study, in non-SAM infants between 1 to 2 months 15 days, the average weight in males was 3.96±0.91kgs and females 3.96±0.83kgs. There was no significant difference in weight. In infants between 2 months 16 days to 4 months, the average weight in males was 5.53±1.32kgs and females 4.87±0.88kgs. There was a significant difference in weight in males and females. (p=0.027) In infants between 4 months to 6 months, the average weight in males was 62.13±0.85cms and females 60.12±0.96cms. There was no significant difference in weight between males and females. In the present study, in non-SAM infants between 1 to 2 months 15 days, the average MUAC in males was 11.11±1.51cms and females 11.12±1.42cms. In infants between 2 months 16 days to 4 months, the average MUAC in males was 12.87±1.32cms and females 12.23±1.37cms. In infants between 4 months to 6 months, the average MUAC in males was 13.24±3.57cms and females 12.69±1.34cms. There was no significant difference in MUAC between males and females in any of the age groups. In SAM infants, the average length of males was 55.74±8 .93cms and females 55.22±7.42cms, the average weight of males was 3.34±1.73kgs and females 3.19±1.31kgs, the average MUAC of males was 8.99±2.37cms and females 9.08±2.02cms. There was no significant difference in the average length, weight, and MUAC between males and females who were SAM.

In the present study, the average weight of non-SAM infants was 4.92±1.31kg, and that of SAM infants 3.26±1.51kg. There was a significant difference in the weight between non-SAM and SAM infants. (p=<0.001) The average length of non-SAM infants was 56.88±5.36cms and that of SAM infants was 55.46±8.1cms. There was no significant difference in the length between SAM and non- SAM infants. THE average MUAC of non-SAM infants was 12.09±1.64cms and that of SAM infants was 9.04±2.18cms. There was a significant difference in the MUAC between non-SAM and SAM infants. (p= <0.001)

In the present study, the average weight of the WLZ score of the median was 5.16kg, -1SD was 4.79kg, -2SD was 4.31kg and <-3SD was 3.26kg. The average length of the WLZ score of the median was 56.39cms, -1SD was 57.76cms, -2SD was 57.23cms and <-3SD was 55.46cms. The average MUAC of WLZ score of the median was 12.46cms, -1SD was 11.77cms, -2SD was 11.28cms and <-3SD was 9.04cms.

Table-1: Evaluation of different cut-offs of MUAC for diagnosis of SAM.

S no	MUAC in cms	Sensitivity (%)	Specificity (%)	Youden Index	Likelihood ratio +	Likelihood ratio -
1	≤ 12.0	95.5	44.9	0.40	1.73	0.10
2	≤ 11.5	89.6	62.3	0.52	2.37	0.17
3	≤ 11.0	85.1	69.5	0.55	2.79	0.21
4	≤ 10.5	67.2	80.9	0.48	3.52	0.41
5	≤ 10.0	64.2	86.4	0.51	4.73	0.41
6	≤ 9.5	53.7	91.9	0.46	6.67	0.50

This shows that the MUAC cutoff for detection of SAM infants between 1 to 6 months of age is 11cms.

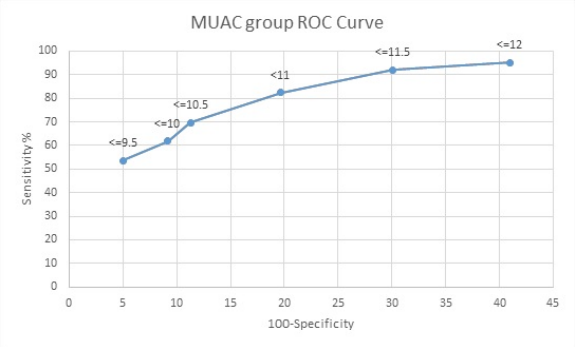

Fig-1: ROC curve with MUAC plotted.

The area under the curve is 0.84

P-value < 0.001, shows that the MUAC cut-off of 11cms is very significant

Table-2: Comparison of length based on WHO charts.

Groups	Length in cms			
	Male		Female	
	Mean (SD) in the present study	WHO Chart [16]	Mean (SD) in the present study	WHO Chart [16]
Infants between 1 to 2 months 15 days	53.05 (3.80)	50.5-63.5	52.95 (3.74)	49.5-62
Infants between 2 and half months to 4 months	58.45 (5.17)	55.5-68	57.63 (3.53)	54-66.5
Infants between 4 to 6 months	62.13 (3.57)	59.7-72	60.12 (4.18)	58- 70

Table-3: Comparison of Weight based on WHO charts.

Group	Weight in kg			
	Male		Female	
	Mean (SD) in our study	WHO charts [16]	Means (SD) in our study	WHO charts [16]
Infants between 1 to 2 months 15 days	3.969(0.91)	3.4-6.6	3.96(0.83)	3.1-6.9
Infants between 2 and half months to 4 months	5.53(1.32)	5.1-8.7	4.87(0.88)	4.1-8.2
Infants between 4 to 6 months	6.19(0.85)	5.6-9.8	5.73(0.96)	5-9.3

Discussion

Among the total 303 infants, median were 137 (45%), -1SD were 59 (19%), -2SD were 40 (13%) and SAM 67(22%). In a study conducted by Chand et al, the number of infants with WLZ >−2, between −2 and −3, and <−3, were 176 (58.2%), 63 (20.9%), and 63 (20.9%) respectively [14].

Groups	Length in cms			
	Male		Female	
	Mean (SD) in the present study	WHO Chart [16]	Mean (SD) in the present study	WHO Chart [16]
Infants between 1 to 2 months 15 days	53.05 (3.80)	50.5-63.5	52.95 (3.74)	49.5-62
Infants between 2 and half months to 4 months	58.45 (5.17)	55.5-68	57.63 (3.53)	54-66.5
Infants between 4 to 6 months	62.13 (3.57)	59.7- 72	60.12 (4.18)	58- 70

In the present study, despite the significant difference of length between male and female infants between 4 to 6 months and significant difference of weight between male and female infants between 2 months 16 days, and 4months, there is no significant difference in MUAC between male and female infants of corresponding age groups. This shows that MUAC does not depend on gender.

Total SAM infants taken in this study were 67. Out of this, 46% (31) were males and 54% (36) were females. There was no significant difference in length, weight, and MUAC between male and female SAM infants.

The weight and MUAC of SAM infants were significantly lesser than that of non-SAM infants. But there was no difference in the length between them. In acute malnutrition, the weight and MUAC are affected but length is not.

The length didn't decrease based on the WLZ scores. But the weight and MUAC decreased as the WLZ scores reduced.

From the present study, 11cms was found to have a sensitivity of 85.1% and specificity of 65.9%. It had the maximum Youden index of 0.55 with a positive likelihood ratio of 2.79 and a negative likelihood ratio of 0.21. The area under the ROC curve was 0.84 and the p-value was <0.001 which showed that the MUAC cut-off of 11cms was highly significant. This was following to study by Chand et al MUAC cut-off </= 11.0 cm yielded the highest Youden index of 0.63 and highest specificity (80.3%) and sensitivity (82.5%).

The area under ROC curve was 0.884 and p-value <0.001 [14]. In a study by Mwagome et al, a single MUAC threshold of 11.0 cm measurement in infants around the age of vaccination (6–14 weeks) has predictive value concerning infant death and has shown that WFLz had poor predictive value concerning infant death [13]. A study by Murphy et al used <11cms as screening MUAC for identifying infants between 2-6 months who were at risk of acute malnutrition [17].

Conclusion

MUAC cut-off of 11.5cms is used as an independent criterion for detection of SAM children between 6 months- 5 years.

What does the study add to the existing knowledge?

MUAC cut-off of 11cms can be used as a cut-off for detection of SAM infants between 1- 6 months.

Author's contribution

Dr. Jyothi S.D.: Concept, study design

Dr. Spoorthi L. Bendre: Manuscript writing

Dr. Arunkumar S. Desai: Statistical analysis

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