Research Article

Diagnostic accuracy of mid-upper arm circumference (MUAC) for detection of severe and moderate acute malnutrition among tribal children in central India

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Abstract

Background: Mid-upper arm circumference (MUAC) is used to diagnose severe acute malnutrition (SAM) and moderate acute malnutrition. The performance of MUAC measurements in terms of sensitivity and specificity was varied.

Objective: To evaluate the cutoff values of MUAC for screening SAM among tribal children of Melghat.

Materials and Methods: The cross-sectional study was carried out in the villages of Melghat block of Amravati district, Maharashtra, India. A total of 446 children in the age group 6–60 months from the study area were assessed by anthropometric measurements using newly developed WHO growth standard. Data were analyzed by using ANTHRO, EPI_INFO 2007, and R software. Sensitivity and specificity of WHO/UNICEF suggested cutoff of MUAC were calculated. Receiver-operating curve (ROC) and Youden Index was calculated to find out the best possible cutoff value of MUAC for diagnosing SAM in these tribal children.

Result: The sensitivity and specificity of MUAC < 11.5 cm was 13.6% and 99.3%, respectively. The best cutoff for screening SAM was obtained at MUAC < 12.8 cm where the sensitivity and specificity was 50% and 90.8%, respectively.

Conclusion: The present cutoff of MUAC < 11.5 cm captures only a small proportion of all children with SAM cases. There is an urgent need to revise cutoff value of MUAC to higher value to improve its sensitivity for detecting children with SAM.

KEYWORDS: Severe acute malnutrition (SAM), children, diagnosis, mid-upper arm circumference (MUAC), tribal

Introduction

A child with severe acute malnutrition (SAM) experience several folds increased risk of mortality when compared with normal children.[1] Hence, early, rapid, and accurate diagnosis of SAM is crucial for preventing SAM deaths in the community. The SAM is defined as weight for height < –3 SD from median.

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But, measuring height and weight of children in the age group of 6 months to 5 years is relatively difficult and time consuming. WHO and UNICEF have suggested mid-upper arm circumference (MUAC) < 11.5 cm as diagnostic criteria of SAM.[1] It is considered as proxy indicator of SAM and best indicator of mortality risk among malnourished children.[1,2] MUAC is easy to measure and is relatively independent of gender and age. Because of its simplicity and low cost of measuring, MUAC is used for rapid screening of SAM among 6 to 59 months of age in community.[3] Government of India in line with international recommendations adopted MUAC < 11.5 cm as one of the diagnostic criteria for operationalizing the community- and facility-based management of SAM in the country.[4]

Various studies have been conducted on the performance of MUAC in diagnosing SAM, of which majorities were hospital-based and very few were community-based studies. The performance of MUAC measurements in terms of sensitivity

and specificity was varied. At MUAC cutoff of 11.5 cm, the sensitivity was ranging from 17% to 43.5% and specificity ranging from 90% to 98.7%.[5–9] A study on wide geographic data has reported the sensitivity of 25% and specificity of 98.7%.[9] Another study conducted on Indian children has shown the sensitivity of MUAC at 11.5 cm as 43.55% and specificity of 90%.[8]

Some researchers have shown serious concern about utility of MUAC as screening tool, because of its low sensitivity.[5,10] Because of this, many researchers suggested changing MUAC cutoff at higher level for increasing the ability of MUAC in diagnosing SAM.[8,9] There was scarcity of studies on the role of MUAC in Indian tribal children.

Therefore, this study was conducted to evaluate the diagnostic accuracy of MUAC for screening SAM in Melghat tribal children. This may help for effective implementation of nutritional rehabilitation programs in India and to identify the children at greatest risk of death resulting from SAM.

Objective

To study the accuracy of WHO's cutoff of MUAC in diagnosing SAM and moderate acute malnutrition (MAM) by using new WHO's growth standards among 6–60 months Melghat tribal children.

Material and Methods

A cross-sectional study was carried out in the villages of Melghat block of Amravati district, Maharashtra, India. Study area has dominantly (75.5%) tribal population with 65% literacy.[11]

Study Subjects, Sampling Technique, and Sample Size

The original study was designed to study the prevalence of malnutrition among children in the age group of 0–6 years.[12] The sample size was calculated by considering 15.6% of wasting reported by NFHS-3 for Maharashtra[13] at 95% confidence level, 5% permissible error with design effect of 2.5. The sample size estimated was 526. The 30 cluster sampling method was used to select study subjects. Thus, it was decided to survey 18 children from each cluster to cover the desired sample size from 30 clusters, thus giving a total number of 540. Eighteen subjects from each cluster were selected by systematic random sampling method. For the analysis of performance of MUAC, the children in age group of 6–60 months were included, and children with bilateral pedal edema were also excluded from the study. After necessary exclusion, the final sample size of this study was 446.

Data Collection

The data were collected by interview method through house-to-house visit using a predesigned and pretested questionnaire from November 2009 to January 2010. The information was collected from mothers with children after obtaining informed written consent from mothers. A prior clearance from institutional ethics committee was obtained.

The information on age of child was obtained from a written birth record maintained at Anganwadi center/Gram Panchaayat. The age of children was calculated in completed months. Anthropometric measurements such as MUAC, weight, and height of children were taken. The standard guidelines were followed while taking anthropometric measurements.[14,15] The weights of children were measured in kilograms to the nearest 100 g by using Salter's weighing machine. For the children younger than 2 years, recumbent length was measured, and for children aged 2 years or older, standing height was measured.[14] MUAC was measured by using nonstretchable measuring tape.

Data Analysis

The data were entered and analyzed by using EPI_INFO 2007 and R software. Anthropometric analysis was done by using WHO's ANTHRO software.[16] The nutritional indicator of acute malnutrition, i.e., wasting (weight for height < −2 SD) was calculated and classified as no wasting (weight for height ≥ 2 SD), severe wasting or SAM (weight for height < −3 SD), and moderate wasting or moderate acute wasting (MAM; weight for height < -2 to −≥3 SD) for all children by using new WHO growth standards.[17] The diagnostic accuracy was calculated by determining sensitivity and specificity for various MUAC cutoff points including cutoff suggested by WHO.[1,17] The receiver-operating characteristic (ROC) curves and Youden Index (sensitivity + specificity − 100) was constructed to estimate optimal cutoff values of MUAC for SAM and MAM.[18]

Result

The selected background characteristics of study population are presented in Table 1. The mean age of study subjects was 28.8 months. Most of the children were belonging to the 6–12-month and 13–24-month age groups. There were 52% girls and 24.4% children were belonging to the lowest quartile of per capita income. The overall prevalence of wasting or acute malnutrition (<−2 SD) was 20.9% (93/446) by weight for height criteria. Among them, 4.9% (22/446) were experiencing SAM and 16.9% MAM.

The performance of different cutoffs of MUAC for diagnosing SAM is shown in Table 2. The sensitivity of WHO's recommended cutoff of MUAC < 11.5 cm was 13.6% and specificity was 99.3%. Figure 1 is showing the ROC curve plotted for sensitivity and 1 − specificity of various cutoffs of MUAC. The optimal cutoff of MUAC was 12.8 cm where the Youden Index was highest. The sensitivity at this cutoff of MUAC was found to be 50% and specificity of 90.8%.

The sensitivity for diagnosing MAM for WHO's MUAC cutoff of < 12.5 cm was 23.7% and specificity was 97.5%. The optimal level of MUAC cutoff for diagnosing MAM was 13.6 cm with sensitivity of 60.2% and specificity of 80.7% [Table 3 and Figure 2].

Table 1: Background characteristics

Characteristics	Number of children	Percentages
Age of children (in months)		
• 6–12	102	22.9
• 13–24	100	22.4
• 25–36	85	19.1
• 37–48	92	20.6
• 49–60	67	15.0
Sex		
• Male	214	48.0
• Female	232	52.0
Type of family		
• Nuclear family	191	42.8
• Joint family	255	57.2
Per capita income		
• Lowest quartile	109	24.4
• Second quartile	99	22.2
• Third quartile	121	27.2
• Highest quartile	117	26.2
Weight for height		
• SAM (<–3 SD)	22	4.9
• MAM (<–2 to ≥3 SD)	71	16.0

Table 2: Sensitivity, specificity, and Youden Index at various cutoff values of MUAC for diagnosing SAM

MUAC	Sensitivity	Specificity	Youden Index (SEN + SPE – 100)
<11.5	13.6	99.3	12.9
<12.0	22.7	98.6	21.3
<12.2	27.3	97.2	24.5
<12.4	36.4	96	32.4
<12.6	45.5	92.9	38.4
<12.8	50.0	90.8	40.8
<13.0	50.0	88.7	38.7
<13.2	50.0	83.7	33.7
<13.4	54.5	81.4	35.9
<13.6	59.1	73.8	32.9
<13.8	63.6	69.1	32.7
<14.0	72.7	64.8	37.5
<14.2	86.4	51.9	38.3
<14.4	90.9	46.2	37.1

Discussion

The early, rapid, and accurate diagnosis of SAM is crucial in prevention of deaths of SAM cases in the community. The MAUC has been considered a valid and simple and rapid screening measure for wasting in children between 6 months and 5 years of age. The advantage of MUAC over weight for

Table 3: Sensitivity and specificity of various values of MUAC and Youden Index for MAM

MUAC	Sensitivity	Specificity	Youden Index (SEN + SPE – 100)
<12.5	23.7	97.5	21.2
<12.6	29.1	96.3	25.4
<12.8	34.4	94.9	29.3
<13.0	36.6	92.9	29.5
<13.2	46.2	89.5	35.7
<13.4	50.5	87.5	38.0
<13.6	60.2	80.7	40.9
<13.8	64.5	75.9	40.4
<14.0	68.8	71.4	40.2
<14.2	81.7	58.4	40.1
<14.4	86.1	52.4	38.5
<14.6	94.6	42.8	37.4
<14.8	95.7	38.2	33.9
<15.0	96.8	34.0	30.8

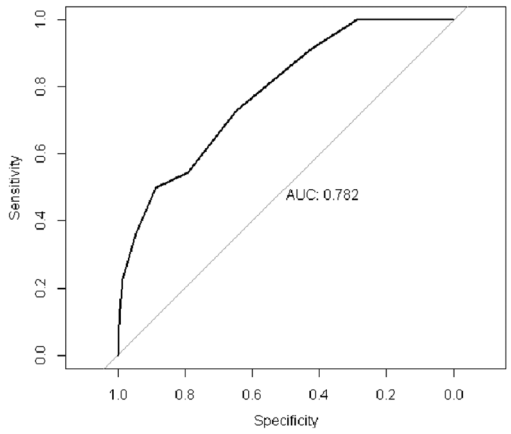

Figure 1: Receiver's operating characteristic curve of MUAC for SAM against weight for age.

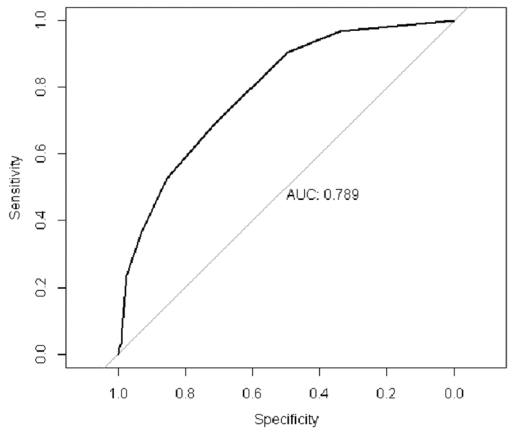

Figure 2: Receiver's operating characteristic curve of MUAC for MAM against weight for age.

height criteria in diagnosing SAM is its simple, rapid tool and has great advantage on operational problem of taking height and weight in resource-poor settings.

This study has reported very low sensitivity of the WHO suggested MUAC cutoff of <11.5 cm. The various studies have reported very wide range of sensitivity of MUAC, ranging from 17.5% to 43.5% and consistently higher specificity.[5–9] Similar to our study, a study on Indian children including tribal children from Madhya Pradesh has reported the sensitivity of 17.5%.[5] Such low sensitivity may lead to inefficient screening and diagnosis of SAM in community and leaving major SAM cases unattended for facility-based management of SAM. The Government of India is using this cutoff for active screening and diagnosing SAM in the community for nutritional rehabilitation in the country.[4] Considering the problem of low sensitivity, it is expected that a lot of children with SAM will be missed by using the current cutoff of MUAC.

This study adds the new cutoff for diagnosing SAM and MAM in Indian tribal children. The new MUAC cutoff for diagnosing SAM suggested in our study was 12.8 cm and for MAM 13.6 cm. Similar recommendations of rising MUAC cutoff for diagnosing SAM were also given by other researchers.[6,8,9] A multicentric study conducted in 10 countries including India reported the best cutoff of MUAC at 13.5 cm.[9] Another study conducted on urban western Nigeria children suggested 15.5 cm as the best MUAC cutoff for diagnosis of SAM.[6] A hospital-based study done on Indian children also suggested to increase MUAC cutoff to 12 cm for diagnosing SAM.[8] This increase in cutoff is increasing the efficiency of MUAC to its reasonably high sensitivity when compared with the present WHO's recommendation with little compromise in the specificity. This 13-mm increase in WHO's cutoff in our study produces a large improvement in sensitivity (from 13.6% to 50%), with little loss in specificity. This cutoff MUAC enables to have reasonably highest cases of SAM from community. The findings of our study is stressing the urgent need to change the MUAC cutoff for diagnosing severe wasting from <11.5 to 12.8 cm.

The increase in the level of cutoff may have impact on the planning and implementation of nutritional rehabilitation programs in India, especially for tribal children. It may help in early and effective diagnosis of SAM so as to have effective implementation of nutritional rehabilitation program in India. Few researchers suggested increasing the cutoff of MUAC for increasing its capability of diagnosing SAM. A study on sample from wide geographic data has recommended MUAC cutoff around 13.5cm where sensitivity increases to 84.5% and with specificity 76.2%,[9] and another study has suggested to increase cutoff to 12 cm to have best cutoff for increasing the ability of MUAC in Indian children (sensitivity, 74.4%; specificity, 77.8%).[8]

The limitations of this study were that we could not compare the findings of this study with the findings of other studies. First, because, similar studies conducted in Indian tribal setup were not reported. Second, there was inconsistency in standards they used. We worked with smaller sample size. We recommend further studies with larger sample size to accumulate more evidence on the performance of MUAC with larger geographic representation.

Conclusion

The sensitivity of MUAC at cutoff < 11.5 cm is very low. The poor performance in terms of sensitivity and specificity confirms the need to change the MUAC cutoff value from <11.5 cm to 12.8 cm for early, rapid, and accurate diagnosis of SAM in the community. The performance of MUAC at new suggested cutoff improves the screening ability of MUAC. This change is important for early diagnosis of SAM in order to reduce the risk of death of SAM cases in community and for effective management of nutritional rehabilitation programs in India.

References

1. Briend A, Garenne M, Maire B, Fontaine O, Dieng K. Nutritional status, age and survival: the muscle mass hypothesis. Eur J Clin Nutr 1989;43(10):715–26.
2. WHO, UNICEF. *WHO Child Growth Standards and the Identification of Severe Acute Malnutrition in Infants and Children*. A Joint Statement by the World Health Organization and the United Nations Children's Fund. Geneva: WHO, 2009. Available at: http://www.who.int/nutrition/publications/severemalnutrition/9789241598163_eng.pdf
3. Myatt M, Khara T, Collins S. A review of methods to detect cases of severely malnourished children in the community for their admission into community-based therapeutic care programs. Food Nutr Bull 2006;27(3 Suppl):S7–23.
4. Government of India. *Operational Guidelines on Facility Based Management of Children with Severe Acute Malnutrition*. New Delhi: Ministry of Health and Family Welfare Government of India, 2011.
5. Dasgupta R, Sinha D, Jain SK, Prasad V. Screening for SAM in the community: is MUAC a 'simple tool'? Indian Pediatr 2013;50:154–5.
6. Dairo MD, Fatokun ME, Kutti M. Reliability of the mid upper arm circumference for the assessment of wasting among children aged 12-59 months in urban Ibadan, Nigeria. Int J Biomed Sci 2012;8(2):140–4.
7. Berkley J, Mwangi I, Griffiths K, Ahmed I, Mithwani S, English M, et al. Assessment of severe malnutrition among hospitalized children in rural Kenya comparison of weight for height and mid upper arm circumference. JAMA 2005;294(5):591–7.
8. Shekhar S, Shah D. Validation of mid upper arm circumference cut offs to severe wasting in Indian children. Indian Pediatr 2012;49:496–7.
9. Fernández MAL, Delchevalerie P, Van Herp M. Accuracy of MUAC in the detection of severe wasting with the new WHO growth standards. Pediatrics 2010;126(1):e195–201.
10. Prasad V, Sinha D, Sridhar S. Falling between two stools: operational inconsistencies between ICDS and NRHM in the management of severe malnutrition. Indian Pediatr. 2012;49:181–6.
11. Government of India. *Census 2001*. 2001 Available at: URL: www.censusindia.org (last accessed on September 2008).

12. Talapalliwar MR, Garg BS. Nutritional status and its correlates among tribal children of Melghat, central India. Indian J Pediatr 2014;81:1151–7.
13. *National Family Health Survey India (NFHS-3). 2005–2006*. Available at: http://www.nfhsindia.org (last accessed on September 12, 2008).
14. World Health Organization. *Training Course on Child Growth Assessment*. Version 1. Geneva: WHO, 2006. Available at: http://www.who.int/entity/childgrowth/training/module_h_directors_guide.pdf
15. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. World Health Organ Tech Rep Ser 1995;854:1–452.
16. Monika B, Elaine B, de Onis M, Onyango A, Siyam A, Yang H, et al. *WHO Anthro: Beta Version Feb 17th: Software for Assessing Growth and Development of the World's Children*. 2006. Geneva: WHO, 2005. Available at: URL: http://www.who.int/childgrowth/software/en/ (last accessed on March 2009).
17. World Health Organization. *The WHO Child Growth Standards*. Geneva: WHO, 2006. Available at: URL: http://www.who.int/childgrowth/en/ (last accessed on October 23, 2008).
18. Youden WJ. Index for rating diagnostic tests. Cancer 1950; 3(1):32–5.

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