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ORIGINAL ARTICLE

Epidemiological and Clinical Profile of Hospitalized Children with Moderate and Severe Acute Malnutrition in South India

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Abstract
Objective To evaluate the clinico-epidemiological profile, pattern of infections, feeding practices, socio-demographic risk factors and outcome of hospitalized children with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM).
Methods Cases (children aged 1–60 mo with SAM or MAM) and controls (children with weight for height z score more than −1 SD) were recruited from November 2011 through July 2013. Overall, 126 cases and 126 controls were included.
Results Only 33 % of malnourished children (cases) were exclusively breast fed. Among controls, 71 % were exclusively breast fed for the first 6 mo after birth. Most cases had associated infections (p 0.004) and anemia ($p<0.001$). ROC curve revealed 120 mm mid upper arm circumference (MUAC) as the best cut off for predicting SAM. Mothers' education, pre-lacteal feeds and co-morbidities were independent predictors of malnutrition ($R^2=22.1$ %) by logistic regression.
Conclusions Though 11.5 cm MUAC has been mentioned by WHO as the cut off for identifying SAM, a higher cut off (12 cm) may be required to use it as a screening tool. Mothers' education, pre-lacteal feeds and co-morbidities were found to be independent determinants for malnutrition in the present patient population, indicating the need towards a targeted approach for modifying these factors.

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Keywords Co-morbidities · Moderate acute malnutrition · Mid-upper arm circumference · Severe acute malnutrition

Introduction

Malnutrition is one of the leading causes of under-five morbidity and mortality among children in developing countries. Childhood malnutrition is responsible for 22 % of India's disease burden [1]. According to the National Family Health Survey- 3, under- five mortality is 74 per 1,000 live births and one of the millennium development goals is to reduce it to 38 per 1,000 live births [2]. There is paucity of literature regarding clinical profile and incidence of infections in malnourished children in a hospital based setting, particularly in south India in recent years; hence the present study was conducted.

Material and Methods

This prospective case control study was conducted in the pediatric ward of a tertiary hospital in southern India from November 2011 through July 2013 after obtaining permission from the Institute Ethics Committee.

In this study, according to the diagnostic criteria proposed by the World Health Organization (WHO) [2], severe acute malnutrition (SAM) was diagnosed in children aged 6–60 mo if weight for height was below −3 standard deviation (Z score) of the median WHO growth reference (2006). Presence of bipedal edema (if any) or mid upper arm circumference (MUAC) below 115 mm were considered as additional corroborative evidences (if present) for diagnosis of SAM.

SAM was diagnosed in the age group 1–6 mo as per following criteria:

a) In infants more than 49 cm in length, weight for height less than −3 SD with or without bipedal edema.
b) In infants with length less than 49 cm, visible severe wasting was used to define SAM.

Moderate acute malnutrition (MAM) was defined as weight for height between −2 and −3 SD for age group 1–60 mo.

The primary objectives were to study the epidemiological and clinical profile of hospitalized children with SAM and MAM and to assess the pattern of infections and infestations among them.

The secondary objectives were to assess the feeding practices and socio-demographic risk factors associated with SAM and MAM; to study complications and outcome in hospitalized children with SAM and MAM and to find out the optimal MUAC cut off for predicting SAM.

The inclusion criteria were as follows: Hospitalized children aged 1–60 mo with SAM and MAM were recruited as cases. Children (aged 1–60 mo) with weight for height standard deviation >−1 SD were recruited as controls. Cases satisfying inclusion criteria were recruited from the ward every week on Mondays and on the same admission day; one control for each case was recruited. Controls were not matched with the cases. Children having edema attributable to etiologies other than malnutrition were excluded.

At enrolment into the study, informed consent was taken from the parents and physical examination was conducted to elicit any symptoms and signs of infection. Anthropometric parameters, socio- demographic variables, feeding practices (duration of exclusive breast feeding, age of initiation of complementary feeding, adequacy of complementary feeding as per IMNCI guidelines [3]), clinical profile and basic investigations of the study subjects were recorded in a structured proforma. Anthropometric measurements were recorded by the first author. Body weight was recorded using an electronic weighing machine with accuracy of ±10 g. Height was measured by a stadiometer with accuracy of ±1 cm. MUAC was measured in left upper arm, midway between olecranon process and acromion process with measuring tape with an accuracy of ±1 mm. Head circumference was measured using measuring tape with accuracy of ±1 mm. Weight for height z score was assessed using WHO charts. The measuring equipments were periodically calibrated.

Assuming with 95 % confidence that the incidence of infections among malnourished children is 45 % [4], with a variability (degree of precision) of 10 %, in order to study the incidence of infections among hospitalized children with malnutrition, 96 cases were required to be studied. Accounting for an attrition of 20 %, 115 cases were required to be recruited. An equal number of controls were also required to be recruited to study the risk factors associated with malnutrition.

Student's *t* test was used to compare continuous variables and more than two groups were compared using ANOVA test. Chi-square test/ Fischer's exact test were used for nominal data while Mann–Whitney *U* test or Kruskal Wallis one-way analysis of variance were used for comparing ordinal data among two groups and more than two groups respectively. Predictive risk factors for MAM and SAM were determined by univariate followed by logistic regression analysis.

Results

In the present study, 126 cases and 126 controls were recruited. Among the 126 cases, 78 had SAM and 48 had MAM. Among the 78 children with SAM, 28 were less than 6 mo of age. Among the children with MAM, 9 were less than 6 mo of age. Among the 3,490 children admitted between 1 and 60 mo age group from November 2011 through July 2013, 286 (8 %) expired. Among the expired children, 53 (18 %) had SAM and 14 (4 %) had MAM.

Baseline characteristics and socioeconomic profile of the study subjects are depicted in Table 1. In SAM cases, 28 were in 1–6 mo age group, 17 in 6 mo-1 y group, 26 in 1–2 y group, 6 in 2–3 y group, 1 in 3–4 y group, and none in 4–5 y group. In MAM cases, 9 were in 1–6 mo group, 13 in 6 mo-1 y, 14 in 1–2 y, 5 in 2–3 y, 5 in 3–4 y, 2 in 4–5 y. Among controls, 45 were in 1–6 mo group, 39 in 6 mo-1 y, 16 in 1–2 y, 21 in 2–3 y, 3 in 3–4 y, 2 in 4–5 y.

Among 42 SAM cases with co-morbidities, fourteen cases had cardiovascular co-morbidities [including 8 ventricular septal defect (VSD), 2 patent ductus arteriosus (PDA), 1 single ventricle, 1 total anomalous pulmonary venous connection (TAPVC), 1 tricuspid atresia, 1 atrial septal defect (ASD)]. Eleven children had neurological co-morbidities (5 cerebral palsy, 5 seizure disorder, 1 spinal muscular atrophy). Six cases had renal co-morbidities (1 Bartter syndrome, 1 renal tubular acidosis, 1 acute kidney injury, 2 vesicoureteral reflux, 1 chronic kidney disease). Two children had hemophagocytosis. One child had type 1 diabetes. One child had congenital adrenal hyperplasia. Two were HIV positive. Five children had tuberculosis.

Among 17 MAM cases with co- morbidities, five had cardiovascular co- morbidities (2 PDA, 2 VSD, 1 ASD). Three children had neurological problems (2 seizure disorder, 1 cerebral palsy). Three children had renal co-morbidities (1 acute kidney injury, 1 Pelvic-ureteral junction obstruction, 1 vesicoureteral reflux). Two had hematological co-morbidities (2 hemophagocytosis, 1 thalassemia). Three children had respiratory co-morbidities (2 persistent pneumonia,1 recurrent pneumonia). One child had propionic acidemia.

Table 1 Baseline characteristics and socio economic level of the study subjects

	SAM (n=78)	MAM (n=48)	Controls (n=126)	P value (controls *vs.* SAM plus MAM)
Age (mo) [mean±SD]	11.94±9.58	17.79±12.59	13.23±11.66	0.016
Sex				
Male [No.(%)]	45 (57.7)	20 (41.7)	83 (65.9)	0.015
Female [No.(%)]	33 (42.3)	28 (48.3)	43 (34.1)	
Weight for Height z-score [mean±SD]	−4.7±1.47	−2.51±0.23	−0.25±0.6	<0.001
MUAC for age z-score [mean±SD]	−2.5±1.76	−2.3±1.30	−1.33±1.56	<0.001
Weight for age z-score [mean±SD]	−4.6±1.48	−3.1±1.20	−1.79±1.22	<0.001
Height for age z-score [mean±SD]	−2.3±2.17	−2.0±1.90	−2.39±1.96	0.522
Head circumference for age [mean±SD]	−2.7±2.47	−1.7±1.90	−0.54±2.15	<0.001
Mother's education[$]				
Illiterate [No.(%)]	18 (23.1)	4 (8.3)	9 (7.1)	<0.001
Primary school and middle school [No.(%)]	31 (39.7)	19 (39.6)	8 (6.3)	
High school and Intermediate [No.(%)]	21 (34.6)	24 (50.0)	90 (71.4)	
Graduate and Post graduate, Professional [No.(%)]	8 (11.5)	1 (2.1)	19 (15.1)	
Father's education[$]				
Illiterate [No.(%)]	15 (19.2)	2 (4.2)	11 (8.7)	<0.001
Primary school and middle school [No.(%)]	30 (38.5)	13 (27.1)	4 (3.2)	
High school and Intermediate [No.(%)]	25 (44.9)	30 (62.5)	88 (69.8)	
Graduate and Post graduate, Professional [No.(%)]	8 (10.3)	3 (6.3)	23 (18.3)	
Per capita income (rupees) [mean±SD]	956±573	1,004±591	1,071±672	0.435
Socio economic status[*]				
Class I	0 (0)	0 (0)	1 (0.8)	0.002
Class II	8 (10.3)	8 (16.7)	11 (8.7)	
Class III	33 (42.3)	28 (58.3)	86 (69.8)	
Class IV	36 (46.2)	12 (25)	26 (20.6)	
Class V	1 (1.3)	0 (0)	2 (1.6)	
Sanitation facilities present[#] [No.(%)]	7 (8.9)	6 (13)	10 (7.9)	0.876

[*] Socio economic status was graded using modified Kuppuswamy classification which is on the basis of education, occupation and income

[$] Education was graded in the following manner: 'illiterate' included parents who were not able to put their signature also; 'primary school' till 5th standard; 'middle school' from 5th standard to 8th standard; 'high school' included 9th and 10th standard; 'intermediate' included 11th and 12th standard

[#] If the house had separate or common toilets and open air defecation was not practiced, sanitation facilities were said to be present

Infections and infestations in the study subjects are summarized in Table 2. Five children in severe acute malnutrition group had tuberculosis while there were none in other groups. Among the children with tuberculosis, one was HIV positive, one had blood culture positive for *Acinetobacter baumanii* and one had tracheal aspirate positive for *Pseudomonas aeruginosa*. One child with malaria in MAM group was positive for *Plasmodium vivax*. Blood culture was positive in 3 cases. The organisms identified were *Acinetobacter baumanii, Staphylococcus aureus and Klebsiella pneumoniae.*

Feeding practices of the study subjects are shown in Table 3. Only 32 and 33 % of the SAM and MAM cases respectively had received exclusive breast feeding till 6 mo of age.

Among the study subjects, 63 % of the cases and 43 % of controls were admitted for pneumonia; 14 % of cases were admitted for diarrhea. 9 % of children were admitted for evaluation of failure to thrive. Urinary tract infections, malaria, tuberculosis, febrile seizure, seizure disorder, bronchiolitis were the other indications for admission.

When 115 mm was taken as the cut off for predicting SAM, sensitivity was 44.9 %, specificity was 94.74 %, positive predictive value was 84.62 %, negative predictive value was 72.73 % and likelihood ratio was 8.53. An ROC curve was plotted and it revealed 12 cm as the ideal cut off for predicting SAM. The area under the ROC curve as shown in Fig. 1 was 0.334 with a 95 % CI of 0.222–0.446. Table 4 shows the sensitivity and specificity of various cut-offs.

Anemia was present in 69.2 % of children with SAM, 70.8 % of children with MAM and 42.1 % of controls (p<0.001). Hypothermia was the most common complication in children with SAM accounting for 11.5 % followed by hypokalemia in 6.4 %. History of previous admission was present in 48 % of cases and 20 % of controls (p<0.001). There were 8 deaths in SAM group, 2 in MAM group and 5 in

Table 2 Infections and infestations in the study subjects

	SAM (n=78) [No.(%)]	MAM (n=48) [No.(%)]	Controls (n=126)	P value (control *vs.* SAM plus MAM)
Total infections	19 (24.4)	10 (20.8)	10 (7.9)	0.004
Blood culture positive	2 (2.6)	1 (10.0)	0 (0)	0.213
Urine culture positive	1 (1.3)	1 (2.1)	1 (0.8)	0.779
Tracheal aspirate positive	1 (1.3)	0 (0)	0 (0)	0.326
Malaria	0 (0)	1 (2.1)	0 (0)	0.118
Tuberculosis	5 (6.4)	0 (0)	0 (0)	0.003
HIV positive	2 (2.6)	0 (0)	0 (0)	0.106
Culture negative sepsis	11 (14.1)	7 (14.6)	9 (7.1)	0.186
History of worm infestations	3 (3.8)	1 (2.1)	2 (1.6)	0.583

the control group (p 0.154). The duration of hospital stay was significantly more in SAM group (p<0.001).

The predictors of SAM on univariate analysis were mother's education, father's education, socio- economic status, feeding practices, history of previous admissions, associated co-morbidities, and presence of anemia. The predictors of MAM on univariate analysis were age, sex, mother's education, father's education, associated vitamin deficiencies, history of previous admissions, associated co- morbidities, and presence of anemia. Mothers' education, pre lacteal feeds and co-morbidities were found to be independent predictors of malnutrition on logistic regression (Table 5).

Discussion

The clinical profile of 78 children with SAM and 48 children with MAM was studied and their clinical and epidemiological profile was compared with controls. Only 2 children in SAM group had edematous malnutrition. Edematous malnutrition has been reported commonly from Africa [5, 6]. Secondary malnutrition was more common in children with SAM and MAM in the index study. Poor maternal education and poor socioeconomic status were found to be associated with malnutrition, as in some other studies [7, 8]. Pneumonia and diarrhea were the most common indications for hospitalization in all groups. In an Indian study by Singh et al., out of 108 children <6 mo with SAM, 35.2 % presented with acute diarrhea [9].

In the present study, infections (both suspected and culture positive) were present in 24.4 % of children with SAM, 20.8 % in MAM and 7.9 % of controls. In a prospective study of bacterial isolates and antibiotic sensitivity in Gambian children with SAM [7], out of 140 cases, 38 children had a pathogen isolated from blood culture.

In children aged less than 6 mo age, more children among controls were exclusively breast fed compared to children

Table 3 Feeding practices in study subjects

Feeding Practices (<6 mo)	*SAM (n= 28) [No. (%)]*	*MAM (n= 9) [No. (%)]*	*Controls (n= 45) [No. (%)]*	*P value (controls vs. SAM plus MAM)*
Prelacteal feeds given	7 (25)	1 (11)	1 (2)	**0.005**
On exclusive breast feeding*	9 (32)	3 (33)	32 (71)	**0.020**
On mixed feeding	10 (35)	5 (55)	8 (18)	**0.031**
On replacement feeding	7 (25)	1 (11)	4 (8)	**0.033**
Early initiation of complementary feeding	2 (7)	0 (0)	1 (2)	**0.019**
Complementary feeding practices (>6 mo)	*SAM (n= 50) [No. (%)]*	*MAM (n= 39) [No. (%)]*	*Controls (n= 81) [No. (%)]*	*P value (controls vs. SAM plus MAM)*
Whether initiated on complementary feeding [No.(%)]	46 (92)	32 (82)	76 (93)	0.108
Age of initiation of complementary feeding [mean±SD]	7.04±2.31	6.59±1.49	6.84±1.32	0.512
Adequate complementary feeds$ [No. (%)]	42 (84)	27 (69)	74 (91)	**0.008**
Bottle feeding [No. (%)]	31 (39.7)	22 (46)	45 (35.7)	0.757

* 'Exclusive breast feeding' implies that the child is on only breast feeds and not given anything in addition

$ Based on the IMNCI criteria for adequate complementary feeding –solid/semisolid/soft food- one '*katori*' serving 3 times/d if breast fed or 5 times/d if not breast fed among 6–12 mo age group children; one and half '*katori*' serving 5 times/d in>12 mo old [3]

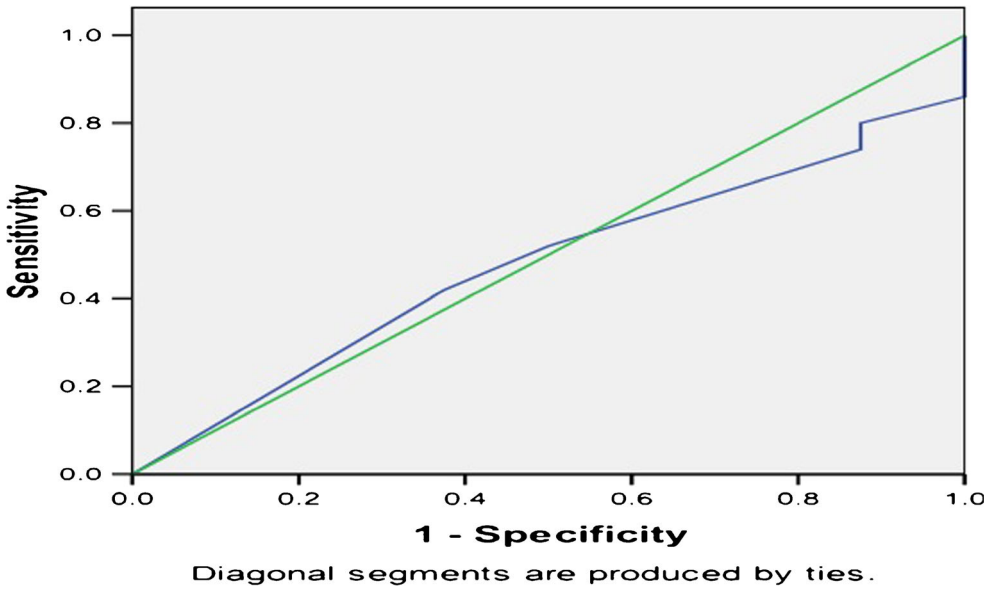

Fig. 1 ROC curve for mid upper arm circumference

having SAM or MAM. More malnourished children were on mixed feeding. Early initiation of complementary feeding was present in 7 % of children with SAM, and 2 % of controls. According to NFHS-3 survey, less than half of children under six months of age are exclusively breastfed and exclusive breastfeeding drops to 28 % for children aged 4–5 mo [4]. The authors acknowledge that the recall period for breastfeeding practices was quite long for majority of the enrolled subjects. The adequacy of complementary feeding [3] was better in controls than SAM and MAM group. Bottle feeding was found more common among children with malnutrition, as in previous studies [10].

The authors evaluated the usefulness of MUAC in predicting SAM. The study revealed that 120 mm would be the cut off for identifying all cases. Anthropometric data from a survey of 1,879 children in Madhya Pradesh [11] revealed low sensitivity (17.5 %) and positive predictive value (30.4 %) of MUAC at the recommended cut-off of 115 mm for identifying SAM and emphasized the need for higher cut off. In a study by Kumar et al. in which validity of MUAC for screening undernutrition was assessed, optimum cut off levels of MUAC were higher than the conventional cut off points for detection of under-nutrition among children [12]. Sensitivity and specificity were optimum at 13.5 cm for detection of wasting in this study. However, in studies at Finland [13] and Bangladesh [14], MUAC less than 11.5 cm was found to be useful as a single criterion for identifying malnutrition. In children above 2 y of age, for detection of severe wasting (weight for height<70 % of the median), Gayle et al. have reported 8 % sensitivity of MUAC<12.5 cm with 98 % specificity; and for moderate wasting (weight for height <80 % of the median), sensitivity of MUAC 13.5 cm was 62 % with 91 % specificity [15]. MUAC has been considered to correlate better with lean mass ratio (LMR is the ratio of estimated mass of limbs to estimated mass of trunk) [16]. Further, pediatric body composition data is not yet available for Indian populations.

In the present study there was 10.3 % mortality in SAM, 4.2 % in MAM and 3.9 % among controls. The median case fatality rate was 3.5 % in SAM, reaching 50 % in edematous malnutrition [17] in an earlier study. The risk of mortality in acute malnutrition is directly related to severity. Moderate wasting is associated with a mortality rate of 30–148 per 1,

Table 4 Usefulness of mid upper arm circumference (MUAC) measurements in predicting severe acute malnutrition (SAM) (>6 mo age group)

	MUAC (in mm)				
	110	115	120	125	130
Sensitivity (%)	38.78	44.90	65.31	79.59	91.84
Specificity (%)	96.20	94.74	90.79	73.68	40.79
Positive predictive value (%)	86.36	84.62	82.05	66.10	50.00
Negative predictive value (%)	71.70	72.73	80.80	84.85	88.57
Likelihood ratio	10.21	8.53	7.09	3.024	1.55

Table 5 Logistic regression analysis for predictors of malnutrition (R^2=22.1 %)

Variables	Odds ratio	95 % CI		*P* value
Mother's education	2.23	1.95	2.627	**.020**
Pre lacteal feeds	4.05	3.84	6.68	**.008**
Co-morbidities	13.46	8.16	16.44	**<0.001**

[Nagelkerke R^2 =22.1 %]

000 children per year [18, 19] and severe wasting is associated with a mortality rate of 73–187 per 1,000 children per year [18].

Anemia, hypothermia [19] and hypoglycemia were commonly encountered complications as in some previous studies [5, 19]. Immunization status was complete in 74.4 % of SAM, 85 % of MAM and 92 % of controls. Recurrent infections may have necessitated repeated admissions and precipitated malnutrition in these children. It is also notable that sanitation facilities were present only in 8.9, 13 and 7.9 % of SAM, MAM and controls respectively, despite the fact that 88 % of fathers and 86 % of mothers had a high school or above education, and only 22 % belonged to Class IV or V socioeconomic status. Most of them practiced open air defecation. This highlights the importance of improving sanitation facilities.

Risk factors for malnutrition have been variable in different studies, due to heterogeneity of patient populations [20–22]. In a study by Saito et al. in rural South India, female gender, and father's occupation as a laborer were the risk factors for malnutrition [23]. In a cross sectional study done in Central India [24], the important correlates of malnutrition were the age of child, age of mother less than 20 y at her first pregnancy, not feeding colostrum, calorie deficit diet, anemia and morbidities like diarrhea and acute respiratory illnesses. In a case control study in north India by Mishra et al. with 76 SAM cases, multivariate analysis revealed that the risk of SAM was independently associated with illiteracy among mothers, incomplete immunization, practice of bottle feeding, consistency of complementary feeding, deprivation of colostrum and receipt of prelacteal feeds at birth [25]. In the index study the authors found mother's education, pre lacteal feeds, and co-morbidities to be independent variables predicting malnutrition. Although several studies have reported a prevalence of illness-related or secondary malnutrition of 6–51 % in hospitalized children, this condition is probably under-recognized [6, 26–28].

Conclusions

Though 11.5 cm has been given by WHO as the cut off for identifying SAM, a higher cut off (12 cm) may be required to identify all cases that are found using weight for height z score criteria. Mothers' education, pre-lacteal feeds and co-morbidities were found to be independent determinants for malnutrition in the index patient population, indicating the need towards a targeted approach for modifying these factors.

Contributions RUD, SK and BVB were involved in management of the patients. RUD collected the data, reviewed the literature and drafted the manuscript. SK and BVB reviewed the literature and critically revised the manuscript. AS was involved in protocol preparations and analysis of data. All authors approved the final version of the manuscript. BVB shall act as guarantor of the paper.

Conflict of Interest None.

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