

Haematological and Biochemical Profiles of Oedematous and Non-Oedematous Severe Acute Malnutrition in Children: A Comparative Hospital-Based Study

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ABSTRACT

Background: Severe acute malnutrition (SAM) may present with or without nutritional oedema and is frequently accompanied by haematological and biochemical abnormalities. However, comparative evidence regarding these laboratory profiles between oedematous and non-oedematous SAM remains limited, particularly in Bangladesh. **Methods & Materials:** This cross-sectional comparative study was conducted in the Department of Pediatrics at the Institute of Child and Mother Health, Matuail, Dhaka, Bangladesh, from July 2023 to June 2024. A total of 51 children aged 6–60 months with SAM were included, comprising 26 with oedematous and 25 with non-oedematous SAM. Sociodemographic and anthropometric characteristics were recorded, and haemoglobin, serum calcium, serum sodium, and serum potassium concentrations were assessed. Continuous variables were compared between groups using an independent-samples t test, with $p < .05$ considered statistically significant. **Results:** The mean age of the participants was 10.67 ± 6.47 months, and 30 (58.8%) were male. Mean MUAC was 107.85 ± 9.51 mm in the oedematous group and 104.20 ± 12.32 mm in the non-oedematous group, with no significant difference. Mean haemoglobin was 9.07 ± 0.86 versus 9.17 ± 2.15 g/dL ($p = .827$), serum calcium was 9.92 ± 1.33 versus 9.58 ± 0.88 mg/dL ($p = .289$), and serum sodium was 135.54 ± 3.06 versus 137.48 ± 4.91 mmol/L ($p = .096$) in oedematous and non-oedematous SAM, respectively. Mean serum potassium was significantly higher in the oedematous group, 4.93 ± 1.04 versus 4.34 ± 1.05 mmol/L, with a mean difference of 0.59 mmol/L ($p = .049$). **Conclusion:** Haemoglobin, serum calcium, and serum

sodium profiles were comparable between oedematous and non-oedematous SAM. A modestly higher serum potassium concentration was observed in oedematous SAM, while the remaining measured parameters showed substantial overlap between the two phenotypes.

Keywords: Severe Acute Malnutrition; Oedematous Malnutrition; Serum Electrolytes; Haemoglobin; Children

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INTRODUCTION

Globally, childhood undernutrition remains an important cause of morbidity and mortality, with the greatest burden continuing to occur in low- and middle-income countries. In a recent systematic review and meta-analysis of 157 studies from developing countries, pooled prevalences of stunting, wasting, and underweight among children under five were estimated at 33%, 12%, and 23%, respectively, while the pooled prevalence of wasting in Asia was 13%^[1]. Among children aged 6–59 months, severe acute malnutrition (SAM) is generally identified by a weight-for-height Z-score below -3 standard deviations, a mid-upper arm circumference below 115 mm, and/or bilateral pitting oedema^[2]. Within Bangladesh, substantial improvement in childhood nutritional status has been documented over successive national surveys, with wasting declining from 16.94% in 2007 to 8.44% in 2017–2018^[3]. However, recent analysis of the Bangladesh Demographic and Health Survey 2022 showed that 22.5% of children under five were stunted, 9.7% were wasted, and 19.5% were underweight, indicating that undernutrition remains an important public health concern^[4]. Among

children requiring hospital treatment, SAM is associated with substantial clinical risk. In a systematic review and meta-analysis of hospitalized children with SAM, mean inpatient mortality was estimated at 15.7%, with diarrhoea, pneumonia, shock, poor appetite, HIV infection, and lower weight-for-height Z-score identified as important mortality-related factors^[5]. Besides anthropometric deficits, alterations in micronutrient and mineral status have been described extensively in severe wasting and nutritional oedema, although the available evidence remains heterogeneous and limited for several nutrients^[2]. In a prospective Ethiopian study, low serum phosphate was frequently observed at admission among children with severe acute undernutrition, and abnormalities persisted in some children during nutritional recovery^[6]. So, assessment of SAM based only on anthropometric measures may not fully represent the associated physiological and biochemical abnormalities. Within the biochemical profile, disturbances of sodium, potassium, calcium, and other electrolytes have been reported commonly. In a hospital-based Pakistani study of 184 children with SAM, electrolyte imbalance was identified in 93.5%, while hypokalaemia,

hypocalcaemia, and hyponatraemia were reported in 79.9%, 71.7%, and 48.9%, respectively^[7]. More recently, hyponatraemia was observed in 55.5% of 110 hospitalized Ethiopian children with SAM and was associated with adverse treatment outcomes^[8]. Among Sudanese children with SAM and acute diarrhoea, hypokalaemia was reported in 70.2%, with higher mortality observed among hypokalaemic than normokalaemic children^[9]. Alongside electrolyte disturbances, anaemia is frequently present. In Pakistan, anaemia was documented in 90.7% of children with SAM, with a mean haemoglobin concentration of 9.0 ± 1.4 g/dL^[10]. Similarly, anaemia was found in 77.3% of children with SAM attending a tertiary paediatric hospital in South India^[11]. Within Bangladesh, anaemia was also found more frequently among stunted than non-stunted children, 56% versus 48%, respectively, and stunting was independently associated with increased odds of anaemia^[12]. Clinically, SAM may present as oedematous or non-oedematous malnutrition, and these phenotypes may differ beyond their external anthropometric appearance. In a Ugandan study, oedematous and non-oedematous children differed in age, breastfeeding status, HIV

infection, infectious symptoms, and household dietary diversity, supporting the presence of distinct clinical and nutritional characteristics between the two phenotypes [13]. Despite the documented frequency of electrolyte abnormalities and anaemia in SAM, comparatively limited contemporary evidence has directly examined haemoglobin, calcium, sodium, and potassium profiles between oedematous and non-oedematous SAM, particularly in Bangladeshi hospital settings. Accordingly, the present study was conducted to compare the haematological and biochemical profiles of children with oedematous and non-oedematous severe acute malnutrition admitted to a tertiary-level healthcare facility in Bangladesh.

METHODS & MATERIALS

This cross-sectional comparative study was conducted in the Department of Pediatrics at the Institute of Child and Mother Health (ICMH), Matuail, Dhaka, Bangladesh, from 1 July 2023 to 30 June 2024. Children aged 6–60 months admitted with severe acute malnutrition (SAM) were enrolled using purposive sampling. SAM was defined according to World Health Organization criteria as a weight-for-length/height Z-score below −3 standard deviations, a mid-upper arm circumference (MUAC) <11.5 cm, or the presence of bilateral pitting oedema. Participants were classified into oedematous and non-oedematous SAM groups according to the presence or absence of nutritional oedema. A total of 51 eligible children were

included, comprising 26 with oedematous SAM and 25 with non-oedematous SAM. Children with heart failure, congenital heart disease, a history of preterm birth or intrauterine growth restriction, congenital or chromosomal abnormalities, cerebral palsy, chronic renal or liver disease, or severe anaemia with haemoglobin <7 g/dL were excluded. Sociodemographic and clinical information was collected using a predesigned structured questionnaire. Anthropometric assessment included body weight, length or height, and MUAC. Weight was measured using an electronic weighing scale; recumbent length was measured using an infantometer in children younger than 2 years, while standing height was measured using a stadiometer in children aged 2 years or older. MUAC was measured using a non-stretchable measuring tape. Haematological and biochemical assessment included haemoglobin concentration, serum calcium, serum sodium, and serum potassium. For the present analysis, serum calcium was expressed in mg/dL and serum sodium and potassium in mmol/L. The primary comparison was between children with oedematous and non-oedematous SAM with respect to these haematological and biochemical parameters. Data were analysed using Statistical Package for the Social Sciences (SPSS), version 27.0 for Windows. Continuous variables were summarized as mean and standard deviation, while categorical variables were presented as frequencies and percentages. Differences in mean MUAC, haemoglobin,

serum calcium, serum sodium, and serum potassium between the oedematous and non-oedematous groups were assessed using an independent-samples *t* test. Mean differences were calculated as the mean value in the oedematous group minus that in the non-oedematous group. A two-sided *p* value < .05 was considered statistically significant. The study protocol was approved by the Institutional Review Board of ICMH, and written informed consent was obtained from the parent or legal guardian of each participant before enrolment and data collection.

RESULTS

A total of 51 children with severe acute malnutrition were included in the study. Of them, 26 (51.0%) had oedematous SAM and 25 (49.0%) had non-oedematous SAM. The overall mean age was 10.67 ± 6.47 months, with participants ranging from 6 to 48 months of age. Male children constituted 58.8% of the study population. Among the participants, 30 (58.8%) were male and 21 (41.2%) were female. Secondary education was the most frequent educational category among fathers, 19 (37.3%), whereas nearly half of the mothers, 24 (47.1%), had education below the primary level. Almost half of the children, 25 (49.0%), resided in urban areas. Regarding household income, 28 (54.9%) belonged to families earning >5,000 to ≤10,000 BDT per month, representing the largest income category (Table I).

Table I
Demographic and socioeconomic characteristics of the study participants (*n* = 51).

Characteristic	n (%) or M (SD)
Age, months	10.67 (6.47)
Age range, months	6–48
Sex	
Male	30 (58.8)
Female	21 (41.2)
Father’s education	
Below primary	15 (29.4)
Primary	16 (31.4)
Secondary	19 (37.3)
Above secondary	1 (2.0)
Mother’s education	
Below primary	24 (47.1)
Primary	18 (35.3)
Secondary	7 (13.7)
Above secondary	2 (3.9)
Residence	
Rural	15 (29.4)
Urban	25 (49.0)
Semi-urban/slum	11 (21.6)
Monthly household income, BDT	
≤5,000	11 (21.6)
>5,000 to ≤10,000	28 (54.9)
>10,000 to ≤25,000	11 (21.6)
>25,000 to ≤50,000	1 (2.0)

Note. BDT = Bangladeshi Taka; M = mean; SD = standard deviation.

Mean MUAC was 107.85 ± 9.51 mm among children with oedematous SAM and 104.20 ± 12.32 mm among those with non-oedematous SAM. Although the mean MUAC was numerically higher in the oedematous group, the difference between the two groups was not statistically significant, $p > .05$ (Table II).

Table II
Nutritional phenotype and mid-upper arm circumference of the study participants.

Variable	Oedematous SAM, n = 26	Non-oedematous SAM, n = 25	p
Participants, n (%)	26 (51.0)	25 (49.0)	—
MUAC, mm, M (SD)	107.85 (9.51)	104.20 (12.32)	> .05

Note. M = mean; MUAC = mid-upper arm circumference; SAM = severe acute malnutrition; SD = standard deviation.

Mean haemoglobin concentration was 9.07 ± 0.86 g/dL in the oedematous group and 9.17 ± 2.15 g/dL in the non-oedematous group, with no statistically significant difference, $p = .827$. Similarly, mean serum calcium was 9.92 ± 1.33 mg/dL among children with oedematous SAM and 9.58 ± 0.88 mg/dL among those with non-oedematous SAM, $p = .289$. Mean serum sodium was lower among children with oedematous SAM than among those with non-oedematous SAM, 135.54 ± 3.06 mmol/L versus 137.48 ± 4.91 mmol/L, corresponding to a mean difference of -1.94 mmol/L; however, this difference did not reach statistical significance, $p = .096$. In contrast, mean serum potassium was 4.93 ± 1.04 mmol/L in the oedematous group and 4.34 ± 1.05 mmol/L in the non-oedematous group. The mean difference was 0.59 mmol/L, and the difference was statistically significant, $p = .049$ (Table III).

Table III
Comparison of haematological and biochemical parameters between children with oedematous and non-oedematous severe acute malnutrition.

Parameter	Oedematous SAM, n = 26, M (SD)	Non-oedematous SAM, n = 25, M (SD)	Mean difference	p
Haemoglobin, g/dL	9.07 (0.86)	9.17 (2.15)	-0.10	.827
Serum calcium, mg/dL	9.92 (1.33)	9.58 (0.88)	0.34	.289
Serum sodium, mmol/L	135.54 (3.06)	137.48 (4.91)	-1.94	.096
Serum potassium, mmol/L	4.93 (1.04)	4.34 (1.05)	0.59	.049

Note. M = mean; SAM = severe acute malnutrition; SD = standard deviation. Mean differences were calculated as the mean value in the oedematous SAM group minus that in the non-oedematous SAM group. Statistical significance was defined as $p < .05$.

DISCUSSION

The present study compared selected haematological and biochemical profiles between children with oedematous and non-oedematous severe acute malnutrition. Among the 51 children, 26 had oedematous and 25 had non-oedematous SAM. Haemoglobin, serum calcium, and serum sodium did not differ significantly between the two groups. However, the mean serum potassium concentration was higher in children with oedematous SAM, 4.93 ± 1.04 mmol/L compared with 4.34 ± 1.05 mmol/L in the non-oedematous group, and the difference reached statistical significance ($p = .049$). Besides, the mean MUAC was slightly higher in the oedematous group, although the difference was not statistically significant. Regarding the haematological profile, haemoglobin concentrations were similar between the oedematous and non-oedematous groups, with mean values of 9.07 ± 0.86 and 9.17 ± 2.15 g/dL, respectively ($p = .827$). A comparable pattern was reported in the Ugandan study by Rytter et al., where haemoglobin concentrations of 8.9 ± 2.2 and 9.2 ± 2.5 g/dL were observed in oedematous and non-oedematous children, respectively, without a significant difference ($p = .46$) [13]. Similarly, in the study by Bachou et al., no significant difference in haemoglobin concentration was reported according to the presence or absence of oedema among severely malnourished children [14]. Therefore, the

present finding supports the observation that the presence of nutritional oedema does not necessarily correspond to a distinct haemoglobin profile. Anaemia may occur across both forms of SAM, and factors other than oedema status are likely to contribute to the reduction in haemoglobin concentration. In the present study, the mean MUAC was 107.85 ± 9.51 mm in the oedematous group and 104.20 ± 12.32 mm in the non-oedematous group, with no statistically significant difference. In the study by Rytter et al. (2015), a higher MUAC was also observed among oedematous children, 12.1 ± 1.4 cm compared with 10.6 ± 0.6 cm among non-oedematous children, although that difference was significant. However, substantial geographical variation in MUAC among children with nutritional oedema was demonstrated in the large analysis by Alvarez et al [15]. Across all included countries, a lower median MUAC was generally observed among children with oedema, whereas the Bangladesh data showed median values of 148 mm and 141 mm among children with and without oedema, respectively. Thus, the relationship between oedema and MUAC appears to vary considerably between populations, and MUAC alone may not distinguish the two clinical phenotypes consistently. For serum calcium, mean concentrations of 9.92 ± 1.33 and 9.58 ± 0.88 mg/dL were observed in the oedematous and non-oedematous groups,

respectively, without a significant difference ($p = .289$). Direct open-access evidence comparing mean calcium concentrations specifically between these two SAM phenotypes remains limited. In a Bangladesh study by Chisti et al., hypocalcaemia was identified in 87 of 333 (26%) severely malnourished children, and mortality was higher among children with hypocalcaemia than among those without hypocalcaemia, 17% versus 5% [16]. However, comparison according to oedema status was not performed in that study. Moreover, available evidence on micronutrient and mineral abnormalities in severe wasting and nutritional oedema has been described as heterogeneous, with important differences in study populations, laboratory definitions, and clinical conditions [2]. So, the absence of a calcium difference in the present study should not be interpreted as evidence that disturbances of calcium metabolism are unimportant in SAM. Serum sodium was modestly lower in children with oedematous SAM, 135.54 ± 3.06 mmol/L, than in children with non-oedematous SAM, 137.48 ± 4.91 mmol/L, but the difference was not statistically significant ($p = .096$). Available studies have not demonstrated a consistent phenotype-specific pattern of serum sodium. In the review by Vresk et al., considerable variation in sodium abnormalities among children with severe wasting and nutritional oedema was reported across settings [2]. Such

heterogeneity is important because serum sodium concentration reflects extracellular sodium and water balance rather than total-body sodium content alone. Accordingly, the present difference of approximately 1.94 mmol/L should be regarded as a non-significant between-group variation rather than evidence of a distinct sodium abnormality in oedematous SAM. The principal biochemical finding was the higher mean serum potassium concentration in oedematous SAM. This observation differs from some published clinical evidence. In the Bangladesh study by Chisti et al., nutritional oedema was independently associated with hypokalaemia among under-five children with diarrhoea and radiological pneumonia, with an adjusted odds ratio of 2.76 (95% CI 1.01–7.51) [17]. However, that population was selected for diarrhoeal disease and pneumonia, and categorical hypokalaemia rather than mean serum potassium was evaluated. Similarly, among Kenyan children with SAM complicated by diarrhoea, hypokalaemia and oedema were separately associated with mortality in the study by Talbert et al. [18]. These observations are clinically important but are not directly equivalent to the present comparison. Moreover, severe hypokalaemia was reported in 18 of 81 (22%) children with SAM in the CAPMAL study, whereas it was absent among the non-malnourished controls [19]. Associated electrocardiographic abnormalities were also observed and improved as potassium concentrations increased. Nevertheless, serum potassium does not necessarily represent total-body potassium stores in severe malnutrition, and substantial depletion may exist despite apparently normal circulating concentrations [2]. Consequently, the higher mean potassium observed in the present oedematous group should not be interpreted as indicating better potassium status. With the probability value close to the conventional level of significance ($p = .049$), the finding is more appropriately considered a modest phenotype-specific difference that requires confirmation in larger studies with detailed assessment of electrolyte status and associated clinical factors.

LIMITATIONS

Given the single-centre cross-sectional design and relatively small sample size, the findings may have limited generalisability and cannot establish causal relationships between SAM phenotype and laboratory abnormalities. Additionally, only selected haematological and biochemical parameters were assessed, and potential influences such as concurrent infection, diarrhoea, hydration status, dietary intake, and micronutrient deficiencies were not examined in detail.

CONCLUSION

Among children with severe acute malnutrition, haemoglobin, serum calcium, and serum sodium concentrations were broadly comparable between oedematous and non-oedematous phenotypes. However, a modestly higher mean serum potassium concentration was observed in children with oedematous SAM, representing the only statistically significant biochemical difference between the groups. These findings indicate substantial overlap in the measured haematological and biochemical profiles of the two SAM phenotypes, while suggesting that potassium status may warrant particular attention in phenotype-specific assessment. Larger prospective studies incorporating detailed electrolyte, micronutrient, clinical, and nutritional assessments are required to clarify the significance and reproducibility of this difference.

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CONFLICT OF INTEREST

None declared

ETHICAL APPROVAL

The study was approved by the Institutional Ethics Committee

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