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Comparison of biochemical and anthropometric parameters in complicated and uncomplicated severe acute malnutrition among children aged 6 to 59 months: a cross-sectional study

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Abstract

Aim: The frequency of severe acute malnutrition (SAM) is the highest in India. Although it should receive more attention, severe anemia is one of the comorbidities that increases mortality in children who are severely undernourished. In SAM children, the liver function test (LFT), kidney function test (KFT), and complete blood count (CBC) are deranged, but their correlation with the prognosis is not well defined. The aim was to describe the anthropometric assessment and biochemical profile of children with SAM.

Methods: This cross-sectional cohort study was performed at the Departments of Paediatrics and Biochemistry at G.S.V.M. Medical College, Kanpur, and at the Department of Biotechnology at Amity University Rajasthan, Jaipur. One hundred and six patients with SAM were enrolled; 53 were grouped as complicated SAM (Group 1) (dehydration and severe dehydration) and 53 were diagnosed as non-complicated SAM (Group 2).

Results: Group II had significantly higher mean values for height, weight, mid-upper arm circumference (MUAC), head circumference, and body mass index (BMI) for age percentile compared to Group I, with *P*-values of 0.001. Group I had a significantly lower level of hemoglobin (8.86 g/dL ± 2.21 g/dL) compared to Group II (10.0 g/dL ± 1.83 g/dL) with a *P*-value of 0.003. The difference in the frequency of anemia between the groups was statistically significant, with a *P*-value of 0.026. Anemia significantly increased the risk of complicated SAM with an odds ratio of 2.60 [95% confidence interval (CI), 1.07–6.31, *P* = 0.001].

Conclusions: This study suggests that there may be a significant relationship between anemia and the development of complications in high-risk children with SAM.

Keywords

Severe acute malnutrition, anemia, hemoglobin, anthropometry

Introduction

Severe acute malnutrition (SAM) presents a ubiquitous health dilemma, primarily impacting young children in regions characterized by limited access to adequate nutritional and healthcare infrastructure within low- and middle-income countries. Despite sustained worldwide initiatives, SAM continues to stand as a prominent contributor to the prevalence of morbidity and mortality in the population of children under the age of 5 [1].

Approximately 2.2 million fatalities in the cohort of children under the age of 5 can be ascribed to severe wasting, stunting, and intrauterine growth restriction. Within the developing regions, one out of every five children experiences undernourishment, and this condition is linked to 50% of child mortalities on a global scale [2]. The mortality rate associated with SAM among children below the age of 5 exhibits a range between 30% and 50%, with malnutrition being the primary or contributing factor in the majority of child fatalities with comorbidities [3]. In India, as per the recent National Family Health Survey-5 (NFHS-5) (2019–2021), the prevalence of SAM remains alarmingly high at 7.7%. As per the findings from the NFHS-5 reports concerning the nutritional status of children, it was noted that 35.58% of children below the age of 5 exhibited stunting (signifying reduced height in relation to their age), 19.21% were afflicted by wasting (indicating low weight concerning their height), and 32.16% were underweight (suggesting inadequate weight concerning their age) [4]. "Severe acute malnutrition (SAM) is defined by very low weight for height or length [*z*-score below—3 standard deviation (3SD) of the median World Health Organization (WHO) child growth standards], or a mid-upper arm circumference (MUAC) less than 115 mm, nutritional bipedal oedema, or visible severe wasting." [5]. SAM represents a complex issue encompassing both social and medical dimensions. The child's medical complexities are, to some degree, an outcome of prevailing social problems within the household. When parents or caregivers face challenges in offering appropriate care and nutrition due to factors like insufficient awareness, constrained resources, or interpersonal disputes, it leads to the development of malnutrition [6]. Anemia is defined by a decreased level of hemoglobin in the bloodstream and is associated with micronutrient deficiencies, including vitamins B-12 and B-9, as well as several infectious diseases that primarily affect red blood cells. This hematological disorder can impact individuals across all age groups, but it is the most widespread and severe among women of childbearing age, children below the age of 5, individuals suffering from other illnesses, and those with additional nutritional deficiencies [7]. Common symptoms of anemia include lethargy, tachycardia, and pallor. In 2020, it was estimated that worldwide, there were 149 million children under the age of 5 who experienced stunted growth (shorter than expected for their age), 45 million children who suffered from wasting (being too thin for their height), and 38.9 million who were classified as overweight or obese [8]. Severe anemia plays a substantial role in the morbidity, hospitalization, and mortality of pediatric patients. However, there exists a notable research gap when it comes to understanding its influence on malnutrition-related mortality. In India, a significant portion of children experiences the co-occurrence of SAM and severe anemia, highlighting the need for further investigation [9]. In fact, anemia is the most frequent concomitant medical condition encountered in children with SAM and is sometimes referred to as "complicated SAM", which slows down recovery and raises the risk of mortality when compared to anemic children without SAM and non-anemic children with SAM [10]. The extensive utilisation of suitable anthropometric tools facilitates the prompt and precise diagnosis of SAM. Early identification and management are crucial for reducing mortality and preventing long-term complications associated with SAM and its comorbidities. The timely intervention leads to reduced treatment delays, diminished disease transmission, lower case fatality rates, prevention of adverse outcomes, and an overall enhancement in patient outcomes. Early recognition and dietary modifications can also contribute to decreased mortality and morbidity rates [11]. Liver function tests, kidney function tests, and complete blood counts, together with anthropometric assessments, are abnormal in SAM, although it is unclear how these abnormalities relate to the prognosis. Thus, a study to emphasize its predictive importance was required. The current study was carried out for this aim in the pediatric ward of the G.S.V.M. Medical College, Kanpur, Uttar Pradesh, India.

Materials and methods

This cross-sectional cohort study was performed at the departments of pediatrics and biochemistry at G.S.V.M. Medical College, Kanpur, and at the department of biotechnology at Amity University, Rajasthan, Jaipur. A total of 106 children with SAM were included in the study. Among them, 53 children had additional health problems, i.e., dehydration, and they were grouped as "SAM with complications", who were recruited from the outpatient department (OPD) and inpatient department (IPD) of the hospital. The other 53 children did not have any complications, and they were categorized solely based on their body measurements. These children were referred to as "SAM without complications" samples, and they were approached through house-to-house visits in an area with Anganwadi workers at the community level.

Ethics statement

Ethical approval has been obtained from the Institutional Ethics Committee (IEC), G.S.V.M. Medical College, Kanpur. No. EC/139/August/2021, dated August 25, 2021. The informed consent of all participants was obtained before their involvement in this study, which was carried out in compliance with ethical principles and guidelines. Detailed explanations of the study's goals, methods, potential drawbacks and advantages, confidentiality safeguards, and participant rights were given to participants as part of the permission process. Based on inclusion and exclusion criteria, children were recruited after obtaining consent from their parents or guardians.

Inclusion criteria for subject recruitment

According to WHO criteria for SAM, children aged 6 to 59 months with uncomplicated SAM were approached through house-to-house visits in an area with Anganwadi workers, whereas children with complicated SAM were recruited from the OPD and IPD of the hospital for maximum inclusion of eligible children with the following inclusion criteria:

(1) Weight for height below 3 standard deviations [standard deviation (SD) or *z*-scores].

(2) Malnutrition with bilateral pedal oedema or visible severe wasting.

(3) MUAC < 115 mm.

Exclusion criteria

Children aged < 6 months and > 5 years, with any congenital malformation, chronic diseases like HIV and cancer, and any previous antibiotic use within 14 days.

Baseline information

Children were subjected to detailed anthropometric measurements using the standard protocol recommended [WHO-United Nations International Children's Emergency Fund (UNICEF), 2009]. Demographic data and evaluation of risk factors among SAM children-related information were collected with the help of a pretested questionnaire.

Anemia

Anemia in infants was defined as having hemoglobin levels below 11 g/dL. This cut-off point was chosen since there are no other specific criteria for this age group, and it is commonly used in clinical settings for infants and children under 6 months of age [12].

Sample collection and processing

Blood samples were drawn from study subjects before undergoing any treatment or management strategy. Blood was collected in two different vials: ethylenediaminetetraacetic acid (EDTA) and non-EDTA. The serum was separated by centrifugation. Biochemical estimation of LFT and KFT using the Q-line kit method and hematological analysis (CBC) of whole blood using a cell counter were measured.

Statistical analysis

The data were analysed using the statistical program for social science (SPSS, version 21, IBM Corp., Chicago, USA). Mean, standard deviation, frequency, and percentage were used to present quantitative and qualitative data, respectively. The normality of the data was checked using the Shapiro-Wilk test. Mann-Whitney U test and the chi-square test were employed for non-parametric variables, while student *t*-tests and analysis of variance (ANOVA) were utilized for parametric variables. Binary logistic regression tests were applied to assess the odds ratio. All statistical tests were considered significant at a level of < 0.05.

Results

Demographic and anthropometric data pertaining to the study participants reveal that the mean age in Group I was 15.11 months ± 10.06 months, consisting of 28 males and 25 females. In contrast, the mean age in Group II was 23.36 months ± 12.77 months, with 35 males and 18 females. In total, across both groups, there were 63 males and 43 females. Regarding economic status, it was observed that in Group I, 51 participants fell into the low-income category, while 53 participants in Group II also belonged to the low-income group. However, 2 participants from Group I were categorized as high-income. In the broader context, the majority of participants in both groups were found to belong to the low-income category. In terms of anthropometric measurements, it was observed that Group II exhibited significantly higher values for height, weight, MUAC, head circumference, and body mass index (BMI) for age percentile in comparison to Group I ($P = 0.001$). Additionally, both Group I and Group II demonstrated similar *z*-scores for height for age and weight for height. The mean values for height for age *z*-score were –3.4 ± 0.53 ($P = 0.001$), and for weight for height *z*-score, they were –3 ± 0.00 ($P = 0.001$), respectively. The demographic and anthropometric measurements for study participants are also presented in Table 1.

Table 1. Demographic & anthropometric measurements for study participants

Parameter		Group I (SAM with complications) (mean ± SD)	Group II (SAM without complications) (mean ± SD)	*P* value
Age (month)		15.11 ± 10.96	23.36 ± 12.77	0.01
Gender	Male	28	35	0.06
	Female	25	18	
Economic status	High	2	0	0.24
	Low	51	53	
Height (cm)		69.95 ± 9.37	76.05 ± 9.31	0.001**
Weight (kg)		6.084 ± 1.87	7.599 ± 1.74	0.001**
MUAC (cm)		10.79 ± 1.32	12.72 ± 0.93	0.001**
Head circumference (cm)		41.06 ± 3.52	44.51 ± 4.96	0.001**
Chest circumference (cm)		41.66 ± 4.59	43.05 ± 6.34	0.198
BMI for age percentile		13.01 ± 0.55	11.31 ± 2.20	0.001**
Height for age (*z*-score)		–3.4 ± 0.53	–3 ± 0.00	0.001**
Weight for height (*z*-score)		–3.4 ± 0.53	–3 ± 0.00	0.001**

** *P* value < 0.05 was considered significant; SAM: severe acute malnutrition; MUAC: mid-upper arm circumference

A comparison of blood parameters between the two groups is presented in Table 2. Group I exhibited lower hemoglobin levels at 8.86 g/dL ± 2.21 g/dL, whereas Group II had higher levels at 10.0 g/dL ± 1.83 g/dL ($P = 0.003$). However, the other parameters, such as leukocyte count, platelet count, red blood cell count, mean platelet volume, urea, and creatinine, did not exhibit significant differences between the groups.

In Group I, the levels of direct bilirubin (0.47 mg/dL ± 0.57 mg/dL) were higher when compared to Group II, where they measured at 0.22 mg/dL ± 0.08 mg/dL ($P < 0.001$). Conversely, Group II had higher levels of protein and albumin ($P = 0.002$ and 0.001), while the levels of serum glutamic pyruvic transaminase (SGPT) and serum glutamic oxaloacetic transaminase (SGOT) were lower in Group II ($P = 0.009$ and 0.031).

Table 2. Biochemical assessment of study participants

Parameters	Group I (SAM with complications) (mean ± SD)	Group II (SAM without complications) (mean ± SD)	*P* value
Hb (g/dL)	8.86 ± 2.21	10.00 ± 1.83	0.003**
TLC (cells/mm^3)	15,374 ± 7,455	13,558 ± 3,602	0.723
Platelet count (million cells/mm^3)	0.33 ± 0.15	0.35 ± 0.12	0.393
Red blood cell (million cells/mm^3)	4.26 ± 0.87	4.22 ± 0.43	0.753
Mean platelet volume (fL)	8.99 ± 2.39	8.86 ± 1.22	0.710
Urea (mg/dL)	29.60 ± 13.90	28.30 ± 5.08	0.513
Creatinine (mg/dL)	0.81 ± 0.23	0.82 ± 0.11	0.683
Bilirubin total (mg/dL)	0.69 ± 0.69	0.49 ± 0.12	0.055
Bilirubin direct (mg/dL)	0.47 ± 0.57	0.22 ± 0.08	< 0.001**
Bilirubin indirect (mg/dL)	0.34 ± 0.27	0.27 ± 0.08	0.064
Protein (mg/dL)	6.72 ± 0.80	7.18 ± 0.68	0.002**
Albumin (mg/dL)	4.15 ± 0.52	4.63 ± 0.52	0.001**
SGOT (IU/L)	67.3 ± 87.4	45.7 ± 14.3	0.031**
SGPT (IU/L)	49.6 ± 53.4	31.2 ± 14.4	0.009**

Hb: hemoglobin; TLC: total leukocytes count; SGPT: serum glutamic pyruvic transaminase; SGOT: serum glutamic oxaloacetic transaminase; SAM: severe acute malnutrition; ** *P* value < 0.05 was considered significant

As indicated in Table 3, Group I consisted of 43 individuals with anemia and 10 without anemia, whereas Group II included 33 individuals with anemia and 20 without anemia. The prevalence of anemia was significantly higher in Group I compared to Group II ($P = 0.026$).

Table 3. Anemic and non-anemic individuals in each group

Anemia classification	Group I (SAM with complications)	Group II (SAM without complications)	*P* value
Anemic (Hb < 11.00 g/dL)	43	33	0.026**
Non-anemic (Hb > 11.00 g/dL)	10	20	

Hb: hemoglobin; ** *P* value < 0.05 was considered significant

The results of the regression analysis are presented in Table 4. Regarding the dependent variable, SAM with complications, age did not show a significant association ($P = 0.680$). However, gender exhibited a significant association ($P < 0.01$), with males having 6.122 times higher odds. Additionally, MUAC showed a significant positive association ($P < 0.001$), where a one-unit increase in MUAC was associated with 8.729 times higher odds. Hemoglobin levels were also significantly associated ($P < 0.05$), with a one-unit increase in hemoglobin resulting in 1.368 times higher odds, while holding other variables constant.

Table 4. Multiple logistics regression analysis for complicated SAM

Characteristics	B (β-coefficient)	SE	Odds ratio	95% CI for odds ratio		*P* value**
				Lower bound	Upper bound	
Intercept	–31.635	6.318				0.001**
Age (month)	0.011	0.026	1.011	0.961	1.063	0.68
Gender	1.812	0.699	6.122	1.556	24.086	0.01**
MUAC (cm)	2.167	0.449	8.729	3.618	21.063	0.001**
Hb (g/dL)	0.314	0.146	1.368	1.028	1.820	0.031**

The reference category is uncomplicated SAM. Logistic regression analysis. SE: standard error; CI: confidence interval; MUAC: mid-upper arm circumference; SAM: severe acute malnutrition; ** $P \leq 0.01$ was found significant; blank indicates not applicable

Discussion

The prevalence of SAM in India is alarmingly high, demanding urgent attention. Among the numerous comorbidities that exacerbate the mortality risk in severely undernourished children, severe anemia stands out as a critical concern.

From an intervention development standpoint, it is important to highlight that around 90% of children afflicted by SAM do not present with medical complications. This implies that they can receive care within their local communities, obviating the need for hospitalization. In contrast, those with medical complications necessitate admission to healthcare facilities, as noted in the study by Panda S et al. (2016) [13]. This cross-sectional study was performed to analyse the risk of complicated SAM in anaemic patients. Males are more prominent for uncomplicated SAM compared to females (Table 1). Additionally, we found a significant difference in height, weight, MUAC, head circumference, BMI for age percentile, height for age, and weight for height between Groups I and II. Similarly, In the study conducted by Chiabi A et al. in 2017, it was reported that the median age of the children was nine months, with an almost equal gender distribution, consisting of 50.8% male and 49.2% female participants [14]. The study carried out in Sri Lanka concentrated on a single rural district known as Vavuniya, where more than 70% of children diagnosed with SAM originate from socioeconomically disadvantaged backgrounds. This finding aligns with the results of our own study [9]. Panda S et al. (2016) suggested that the weight for height *z*-score, which indicates both acute and chronic nutritional deficits, described that 4 out of the 5 villages were in a critical stage of malnutrition [13]. In our comparison of the biochemical profiles between Groups I and II (as shown in Table 2), significant disparities were observed in the blood levels of hemoglobin, protein, and albumin. This finding aligns with the research conducted by Kumar D et al. in 2020 [1], where they demonstrated that hyponatremia and hypocalcemia are more prevalent and carry a higher risk of mortality in children with complicated SAM. According to the guidelines (2012) for SAM, approximately 70% of children aged 6 to 59 months who have SAM also experience anemia. Among these children, 26% exhibit mild anemia, 40% have moderate anemia, and 3% have severe anemia [15]. In this study, a higher frequency of anemia in complicated SAM as compared to uncomplicated SAM was found. Similarly, Thakur N et al. (2014) found a significant number of severely anemic patients with SAM, of whom approximately 25% need blood transfusions, suggesting that nutritional anemia is a prevalent concurrent condition in SAM cases that necessitate hospitalisation. Given the close occurrence of megaloblastic anemia and microcytic anemia, it is advisable to consider supplementing with vitamin B12 in conjunction with iron and folic acid [9].

In this study, as depicted in Table 4, we identified significant associations between male gender, MUAC, and hemoglobin levels with the risk of anemia. These findings are in accordance with the research conducted by Takele WW in 2021, which highlighted that anemia among severely malnourished infants and children poses a significant public health concern in the Amhara region. Furthermore, the study by Takele WW in 2021 [7] underscores that infants below the age of 6 months are at a higher risk of developing anemia.

Chowdhury MRK et al. (2020) [16] revealed that around 52.6% of the children (95% CI, 49.8–55.4%) were identified as anemic. Among them, 26.6% (95% CI, 24.0–29.3%) were found to have moderate to severe anemia. The occurrence of anemia exhibited a pronounced increase in children below the age of 11 months, children with low body weight, children whose mothers were underweight, anemic, and had limited formal education, and children living in ecologically demanding environments. A comprehensive analysis considering multiple variables uncovered that children under 11 months of age, those with lower body weight, and those with mothers afflicted by anemia were at an elevated risk of developing moderate to severe anemia. This suggests that these specific factors contribute significantly to the severity of anemia in children.

Conclusions

This study indicates that anemia might have a notable association with or influence on the emergence of complications in high-risk children with SAM. However, larger population studies are necessary to confirm these findings in future prospective studies. To prevent anemia and other related metabolic risk factors, clear prevention strategies should be included and emphasised in clinics' preventive programmes for SAM.

Abbreviations

ANOVA: analysis of variance

BMI: body mass index

CI: confidence interval

MUAC: mid-upper arm circumference

SAM: severe acute malnutrition

SD: standard deviation

WHO: World Health Organization

Declarations

Acknowledgments

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Author contributions

MM: Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Software, Visualization, Writing—original draft, Writing—review & editing. PT: Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing—original draft, Writing—review & editing. PS: Methodology. YKR: Investigation, Methodology, Project administration, Resources, Supervision, Validation, Visualization, Writing—review & editing. DDS: Conceptualization, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Resources, Software, Supervision, Validation, Visualization, Writing—Review & Editing.

Conflicts of interest

The authors declare that they have no conflicts of interest.

Ethical approval

Ethical approval has been obtained from the Institutional Ethics Committee (IEC), G.S.V.M. Medical College, Kanpur. No. EC/139/August/2021, dated August 25, 2021.

Consent to participate

The informed consent of all participants was obtained before their involvement in this study.

Consent to publication

Not applicable.

Availability of data and materials

The raw data supporting the conclusions of this manuscript will be made available by the authors, without undue reservation, to any qualified researcher.

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