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ORIGINAL RESEARCH

Assessment of Haematological and Iron Profile in Children with Severe Acute Malnutrition: A Cross-sectional Study

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ABSTRACT

Background: In developing countries, malnutrition remains a significant health issue and a key risk factor for infections. The present study was conducted to evaluate haematologicaland iron status among severe acute malnutrition (SAM) children.**Materials & Methods:**140 SAM children age ranged 6 months- 7 years of both genders were selected. Parameters such as height, weight, Mid-upper Arm Circumference (MUAC), and head circumference etc. was recorded. Blood samples (5 mL) were collected using aseptic techniques and sent for haemogram, Erythrocyte Sedimentation Rate (ESR), PCV, peripheral smear, RBC indices, reticulocyte counts, and Iron profile including serum iron, TIBC, Transferrin saturation, and serum ferritin were assessed with fully automated cell counters. The haemoglobin thresholds (g/dL) to define the severity of anaemia as per the WHO are severe anaemia.**Results:**Age group (years) 6 months- 2 years had 22 boys and 15 girls, 2-4 years had 18 boys and 24 girls and 4-7 years had 40 boys and 21 girls. The difference was significant (P< 0.05). Complications were acute respiratory infection in 15, acute gastroenteritis in 11, hypoglycaemia in 6, sepsis in 9 and dysentery in 2 patients. The difference was significant (P< 0.05). There was significant difference in haemoglobin (g/dL), total leukocyte count (/µL), packed cell volume (%), MCH, and MCHC in complicated and uncomplicated SAM children (P< 0.05). Among complicated (43) and uncomplicated (97) SAM patients, there was no anaemia in 4 and 56, mild in 8 and 37, moderate in 10 and 4 and severe in 21 and 0 in group I and II respectively. The difference was significant (P< 0.05).**Conclusion:** It was noted that anaemia is very common among SAM children who have complications. In SAM patients with complications, serum iron levels were significantly lower.

Keywords: Malnutrition, Mid- upper arm circumference, Severe acute malnutrition

INTRODUCTION

In developing countries, malnutrition remains a significant health issue and a key risk factor for infections. Inadequate nutrition results in different types of malnutrition, which adds to the global disease burden and child mortality.[1,2] SAM remains one of the significant global health issues, impacting 6.7% of children under five, with mortality rates exceeding those of well-nourished children.[3] It has also been shown to be a major obstacle to the realization of the fourth millennium development goal. In children aged 6 to 59 months, SAM is defined as Mid-upper Arm Circumference (MUAC) <- 3SD z-score below the median or the presence of bipedal oedema.[4,5]SAM leads to a range of pathophysiological changes in the body's systems, which can include serious haematological abnormalities. It has been discovered that anaemia occurs more frequently

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among SAM patients.[6] In SAM, one of the most common causes of anaemia is iron deficiency. Iron is crucial for numerous processes, such as haematopoiesis and oxidative phosphorylation, which are disrupted in SAM patients. Transferrin also contributes to children's resistance to disease.[7] Nutritional deficiency impacts immune function and diminishes the efficiency of host defense mechanisms, leading to infections and iron depletion. This contributes to the morbidity and mortality rates among children with SAM.[8,9]

AIM & OBJECTIVES

The present study was conducted to evaluate haematological and iron profile in children with Severe Acute Malnutrition (SAM).

MATERIALS & METHODS

Study Design

This was a hospital-based, observational cross-sectional study.

Study Place

The study was conducted in the Department of Paediatrics, Government Medical College and Hospital, Purnea, Bihar, India.

Study Duration

The study was carried out over a period of one year and nine months from January 2023 to September 2024).

Study Population

The study population included children aged between 6 months to 7 years diagnosed with Severe Acute Malnutrition (SAM) based on WHO criteria, admitted to the paediatric inpatient department of the tertiary care centre.

Sample Size

A total of 140 children with SAM were enrolled in the study.

Ethical Considerations

Approval was obtained from the Institutional Ethics Committee prior to the commencement of the study. Written informed consent was obtained from the parents or legal guardians of all participants before enrollment.

Inclusion Criteria

- Children aged 6 months to 5 years diagnosed with SAM as per WHO criteria.
- Children presenting with complications such as respiratory tract infections, sepsis, generalised oedema, poor appetite, hypoglycaemia, hypothermia, vomiting, diarrhoea, severe dehydration, and severe anaemia requiring inpatient management.
- Children with oedematous SAM (i.e., bilateral pitting oedema).

Exclusion Criteria

- Children aged below 6 months or above 7 years.
- Children with mild or moderate malnutrition.
- Children with chronic systemic illnesses, congenital haematological disorders, haemoglobinopathies, or evidence of on-going haemolysis.
- Children whose parents/guardians did not consent to participation.

Study Procedure

After obtaining consent, demographic details including name, age, gender, and relevant clinical history were recorded. Anthropometric parameters such as weight, height/length, Mid-Upper Arm Circumference (MUAC), and head circumference were measured using standard methods. Children were clinically examined for features of SAM and associated complications.

Investigations

Venous blood samples (5 mL) were collected under aseptic precautions for the following investigations:

- Haemogram: including total and differential leukocyte count, platelet count, haemoglobin concentration, and RBC indices.
- Peripheral Smear Examination: to classify anaemia morphologically.
- Erythrocyte Sedimentation Rate (ESR)
- Packed Cell Volume (PCV)
- Reticulocyte Count
- Iron Profile:
  - Serum Iron
  - Total Iron Binding Capacity (TIBC)
  - Transferrin Saturation
  - Serum Ferritin

All laboratory parameters were evaluated using fully automated haematology analyzers and biochemistry analyzers available in the hospital's central laboratory.

Outcome Measures

- Prevalence and types of anaemia in children with SAM.
- Correlation between SAM and iron profile derangements.
- Morphological patterns of anaemia based on peripheral smear examination.

Statistical Analysis

Data were recorded in Microsoft Excel sheets and statistical analysis was performed by using Statistical Package for the Social Sciences (SPSS) software version 25.0(SPSS Inc; Chicago, IL, USA). Descriptive statistics were

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used to summarize demographic and clinical characteristics. Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as frequencies and percentages. Categorical variables were analysed using the Chi-square test or Fisher's-exact test. Continuous variables were assessed using the ANOVA or Student's t-test. A p-value <0.05 was considered statistically significant.

RESULTS

Table 1: Age specific and gender-wise distribution of children with Severe Acute Malnutrition (SAM)

Age group (years)	Boy (n, %)	Girl (n, %)	P value
6 months- 2 years	22 (15.71%)	15 (10.71%)	0.05
2-4 years	18 (12.86%)	24 (17.15%)	
4-7 years	40 (28.57%)	21 (15%)	
Total	80(57.14%)	60(42.86%)	

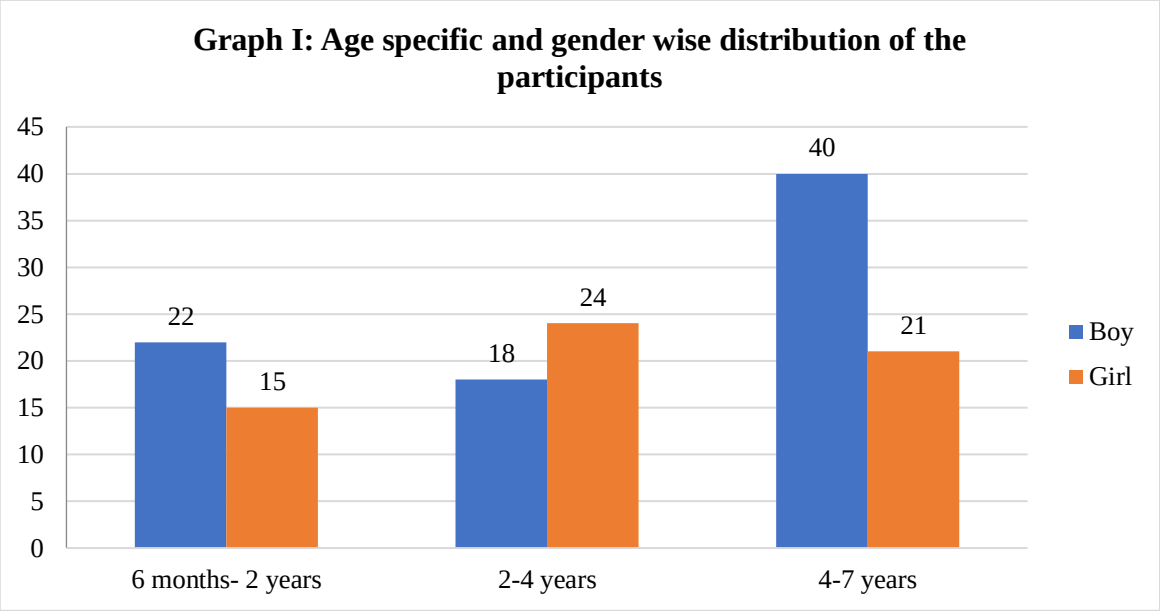

Table 1, graph I shows that age group (years) 6 months- 2 years had 22 boys and 15 girls, 2-4 years had 18 boys and 24 girls and 4-7 years had 40 boys and 21 girls. The difference was significant (P< 0.05). The table presents the gender-wise distribution of 140 children diagnosed with Severe Acute Malnutrition (SAM) who participated in the study. Out of 140 children, 80 (57.14%) were boys and 60 (42.86%) were girls. This indicates a higher proportion of boys affected by SAM compared to girls in this study population.

The p-value of 0.05indicates that the difference in distribution between boys and girls isstatistically significant, meaning there is likely a real difference rather than one due to chance.

Table 2: Complications in patients with Severe Acute Malnutrition (SAM)

Complications	Number (%)	P value
Acute respiratory infection	15(10.7%)	0.05
Acute gastroenteritis	11 (7.9%)	
Hypoglycaemia	6(4.3%)	
Sepsis	9(6.4%).	
Dysentery	2 (1.4%)	

Table 2 shows that complications were acute respiratory infection in 15(10.7%), acute gastroenteritis in 11 (7.9%), hypoglycaemia in 6(4.3%), sepsis in 9 (6.4%).and dysentery in

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2(1.4%) patients. The difference was significant (P< 0.05).The most frequent complication was acute respiratory infection, followed by gastroenteritis and sepsis.The p-value of 0.05indicates that the occurrence of complications is statistically significant, suggesting it is a frequent and notable complication in SAM patients.

Table 3: Comparison of haematological parameters

Parameters	Complicated (n=43)	Uncomplicated(n=97)	P value
Haemoglobin (g/dL)	9.4±1.4	10.3±2.5	0.05
Total leukocyte count (/μL)	13245.2±246.2	6782.4±232.1	0.01
Platelet count (lakhs/μL)	1.8±1.1	1.8±1.1	0.10
ESR (mm/hr)	15.6±2.4	15.9±9.6	0.97
Packed cell volume (%)	24.2±6.8	29.5±4.5	0.02
Red blood cells (millions/μL)	3.8±1.0	4.0±1.6	0.67
MCV (fL)	84.3±11.5	83.2±6.7	0.41
MCH (pg)	21.4±8.5	27.5±2.4	0.02
MCHC (g/dL)	32.5±3.2	33.6±3.3	0.05
RDW (%)	12.6±6.5	13.2±1.8	0.74
Reticulocyte count (%)	1.4±0.6	1.3±1.1	0.82

Table 3 shows that Haemoglobin, TLC, PCV, MCH, and MCHC showed statistically significant differences ($p \leq 0.05$). These values were lower (except TLC, which was higher) in the complicated group, indicating- greater anaemia and higher immune activation (due to infections). Platelet count, ESR, RBC count, MCV, RDW, and reticulocyte count were not significantly different. These parameters may not be strongly affected by the presence or absence of complications in SAM.

Table 4: Distribution of type of anaemia in SAM children

Type of Anaemia	Complicated SAM (n=43)	Uncomplicated SAM (n=97)	P value
No Anaemia	4 (9.3%)	56 (57.7%)	0.05
Mild Anaemia	8 (18.6%)	37 (38.1%)	
Moderate Anaemia	10 (23.3%)	4 (4.1%)	
Severe Anaemia	21 (48.8%)	0 (0.0%)	

Table 4 shows that a large number of children without anaemia (56 out of 97) were from the uncomplicated group, while only 4 children in the complicated group were anaemia-free. This shows that most children with complications had some form of anaemia. Mild Anaemia Observed in 8 children with complications and 37 without. Indicates that mild anaemia is more frequent among uncomplicated cases.Moderate Anaemia seen more commonly in complicated SAM (10 cases) compared to only 4 cases in uncomplicated SAM. Suggests an association between complications and worsening anaemia.Severe Anaemia found exclusively in the complicated group (21 children). No child in the uncomplicated group had severe anaemia. This is a critical finding showing that severe anaemia is strongly linked with clinical complications in SAM. The P value of 0.05 indicates a statistically significant difference between the groups. Children with complicated SAM are more likely to have moderate to severe anaemia, whereas those with uncomplicated SAM are more likely to be non-anaemic or mildly anaemic. This highlights the importance of screening and treating anaemia more aggressively in complicated SAM cases.

DISCUSSION

The World Health Organization estimated that in developing countries, 27% of children under the age of five suffer from malnutrition.[10] Although the rate of childhood malnutrition is declining, South Asian countries continue to have the highest number of children suffering from malnutrition.[11,12] The present study was conducted to evaluate haematological parameters among severe acute malnutrition (SAM) children.

We found that out of 140 children, 80 (57.14%) were boys and 60 (42.86%) were girls. This indicates a higher proportion of boys affected by SAM compared to girls in this study

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population.The findings align with previous studies suggesting that male children are more frequently affected by SAM than females. A similar trend was reported by **Bhutia (2014)**, who observed a male preponderance among SAM children in a national-level survey conducted in India.[13]

Age-wise distribution in our study showed that the highest number of boys (40 out of 80) were in the 4–7 years age group, while girls were more concentrated in the 2–4 years group (24 out of 60). These variations might be linked to developmental vulnerabilities and feeding transitions that occur at different ages. **Victora, C. G., et al.** (2010) found that the early childhood period, particularly the first two years of life, is a critical window for growth and development, and poor nutritional practices during this time can lead to SAM.[14]

Rose et al.[15] studied the iron profile and haemogram in children with SAM and its comparison with various associated complications. Total of 175 children (80 girls and 95 boys) with SAM were enrolled in the study and data was analysed. Anemia was observed in 87% of study population. Most SAM children with complications had severe anaemia (51.9%) with a higher prevalence of microcytic anaemia followed by macrocytic anaemia compared to SAM without complications with normocytic anaemia. On comparing the haemogram, it was revealed that Hemoglobin (Hb), Packed Cell Volume (PCV), Red Blood Cells (RBC), Mean Corpuscular Haemoglobin (MCH), and Mean Corpuscular Haemoglobin Concentration (MCHC) were significantly low in SAM patients with complications. While the iron status of SAM patients with complications revealed low serum iron levels and transferrin saturation while ferritin and Total Iron-Binding Capacity (TIBC) were increased.

We found that complications were acute respiratory infection in 15, acute gastroenteritis in 11, hypoglycaemia in 6, sepsis in 9 and dysentery in 2 patients. **BasheirHM**et al.[16]determined complete blood count of malnourished Sudanese children below 5 years of age. Twenty apparently healthy with matched age subjects were selected as control group. 58% of test group with age below 18 months and 42% above 18 months. Marasmus was observed in 82% of malnourished children. All hematological parameters of malnourished children was significantly different compared to control group. Hemoglobin decreased from 15.12 ±1.1 g/dl in control group to 8.8 ± 2.5 g/dl in test group. Blood platelet count and WBC of test group significantly increased compared to control ($p < 0.00$). WBC increased from 5.1 ± 0.98 × 103 µl in control to 12.2 ±5.2 $\times 10^3$ in test group. Serum iron and serum ferritin of malnourished children significantly decreased compared to control group. Serum iron decreased from 99.3 ± 27.6 µg/ dl to 43.9 ± 32.9 µg/ dl in control and test groups respectively ($p < 0.00$). In conclusion, marasmus is the major type of malnutrition among study group. Malnutrition significantly alters hematological status of test group. Iron deficiency and infections are frequently associated with malnutrition.

We found that there was significant difference in haemoglobin (g/dL), total leukocyte count (/µL), packed cell volume (%), MCH, and MCHC in complicated and uncomplicated SAM children ($P< 0.05$). We found that among complicated (43) and uncomplicated (97) SAM patients, there was no anaemia in 4 and 56, mild in 8 and 37, moderate in 10 and 4 and severe in 21 and 0 in group I and II respectively. **Islam N**et al.[17]assessed the pattern of serum iron profile and red cell indices in children with severe acute malnutrition. Seventy children having severe acute malnutrition were compared with 70 age matched children those had normal growth. Age range of the studied children was 6 months to 59 completed months. Male was found predominant (54.3%) in both study group and comparison group. Mean serum iron, serum ferritin, serum total iron binding capacity and transferrin saturation in severely malnourished children were 45.3±19.3 µg/dl, 26.5±20.0 ng/ml, 246.3±47.5 µg/dl and 16.4±2.0% respectively which were significantly lower than that of healthy children ($p<0.05$). Mean Hb level in children with severe acute malnutrition was found 8.3±1.6 gm/dl which was also found significantly lower than that of normal children ($p<0.05$). Anaemia was found in all (100%) severely malnourished children compared to 25.7% of children in comparison group. Mean MCV, MCH and MCHC in children with severe acute malnutrition was found 71.7±13.5 fl, 24.0±5.8 pg and 31.4±4.0 gm/dl respectively which were significantly lower than that of comparison group ($p<0.05$). Serum iron profile and red cell indices should be routinely done in severely malnourished children for early intervention and management of iron deficiency anaemia.

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LIMITATIONS OF THE STUDY

- The study was limited to a single tertiary care centre, which may affect the generalizability of the findings.
- Being cross-sectional in nature, causal relationships could not be established.
- The impact of therapeutic interventions on haematological and iron parameters was not assessed.
- Dietary history and micronutrient deficiencies beyond iron (e.g., folate, vitamin B12) were not evaluated.
- The shortcoming of the study is small sample size.

CONCLUSION

This study highlights the higher prevalence of SAM was noted among boys, with the age group of 4–7 years being most affected, and respiratory infections were the most common complication.Children with complicated SAM exhibited significantly lower haemoglobin levels, packed cell volume, MCH, and MCHC, alongside elevated total leukocyte counts, indicating the presence of anaemia and an on-going inflammatory or infectious process. The moderate to severe anaemia being significantly more prevalent in the complicated SAM group, while the majority of uncomplicated SAM children were either non-anaemic or had mild anaemia.These findings underscore the importance of early detection and management of haematological abnormalities in children with SAM, especially in those presenting with complications. Integrated nutritional rehabilitation along with appropriate medical management of anaemia and infections is essential to improve outcomes in this vulnerable population.

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