Original Research

Haematological and Iron Profile in Children with Severe Acute Malnutrition at a Tertiary Care Centre: A Cross-Sectional Study

Dr. Nawal Prakash Deepak[1], Dr. Snehanshu Chatterjee[2]

[1]Assistant Professor, Department of Pediatrics, Gauri Devi Institute Of Medical Sciences & Hospital, Durgapur, West Bengal, India.
[2]Professor, Head of Department, Department of Pediatrics, Gauri Devi Institute Of Medical Sciences & Hospital, Durgapur, West Bengal, India.

Corresponding Author: Dr. Nawal Prakash Deepak
Assistant Professor, Department of Pediatrics, Gauri Devi Institute Of Medical Sciences & Hospital, Durgapur, West Bengal, India.
Email:nprakash.deepak@gmail.com

Received:15 December, 2022 Accepted:20 January, 2023

ABSTRACT

Background: Severe acute malnutrition (SAM) is a major public health concern affecting millions of children worldwide, particularly in low- and middle-income countries.This study aimed to evaluate the haemogram and iron profile in children suffering from severe acute malnutrition at a tertiary care center. The objective was to assess hematological abnormalities, iron deficiency, and their correlation to anemia in this vulnerable population.

Materials and Methods: A hospital-based observational study was conducted on 110 children aged 6 months to 5 years diagnosed with SAM. Blood samples were collected and analyzed for haemogram parameters, including hemoglobin (Hb), total leukocyte count (TLC), differential leukocyte count (DLC), platelet count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW). Iron profile markers, including serum iron, total iron-binding capacity (TIBC), serum ferritin, and transferrin saturation, were also assessed.

Results: The majority of children belonged to the 1-2 years age group (25.45%), with a male predominance (56.36%). The mean hemoglobin level was 9.2 ± 1.4 g/dL, indicating a high prevalence of anemia (70.00%). The mean total leukocyte count was 11.5 ± 3.2 x10^3/µL, and platelet count was 270 ± 65 x10^3/µL. The red cell indices suggested microcytic hypochromic anemia with an elevated RDW (16.8 ± 2.1%). The mean serum iron level was 45.6 ± 12.3 µg/dL, while TIBC was 385 ± 54 µg/dL, indicating increased iron-binding capacity. Serum ferritin was found to be 22.4 ± 8.9 ng/mL, reflecting depleted iron stores, and transferrin saturation was 14.8 ± 3.5%, confirming iron deficiency. Correlation analysis showed significant associations between hemoglobin levels and serum iron (r = 0.42), serum ferritin (r = 0.48), and transferrin saturation (r = 0.50), while TIBC exhibited a negative correlation (r = -0.35).

Conclusion: This study highlights the high prevalence of anemia and iron deficiency among children with SAM. Hematological abnormalities, including low hemoglobin levels, microcytic hypochromic anemia, and increased TIBC, indicate widespread nutritional deficiencies. Routine screening of haemogram and iron profile parameters is essential for early diagnosis and targeted interventions. Nutritional rehabilitation, iron supplementation, and infection management are crucial in improving hematological outcomes and overall recovery.

Keywords: Severe acute malnutrition, Anemia, Haemogram, Iron deficiency, Pediatrichematology.

INTRODUCTION

Severe acute malnutrition (SAM) is a major public health concern affecting millions of children worldwide, particularly in low- and middle-income countries. It is a life-threatening condition characterized by severe weight loss, wasting, and nutritional deficiencies, which significantly impair growth and development. Children with SAM often suffer from multiple systemic complications, including infections, electrolyte imbalances, and organ dysfunction. Among the most common and critical consequences of SAM is anemia, which results from inadequate intake, poor absorption, or increased loss of essential nutrients like iron. The assessment of hematological parameters and iron status is crucial in understanding the impact of malnutrition on the overall health of affected children.[1]Thehaemogram is a fundamental diagnostic tool used to evaluate the complete blood profile, providing valuable insights into red blood cells, white blood cells, and platelet function. It plays a significant role in diagnosing anemia, infections, and bone marrow suppression, which are frequently observed in children suffering from SAM. Hemoglobin levels, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), total leukocyte count (TLC), and platelet counts are commonly assessed to determine hematological abnormalities. The presence of microcytic hypochromic anemia, which is often linked to iron deficiency, is frequently reported among malnourished children. Elevated red cell distribution width (RDW) further suggests anisocytosis, indicating variations in red blood cell size due to nutritional deficiencies.[2] Iron is an essential micronutrient required for hemoglobin synthesis, oxygen transport, and various metabolic functions. Its deficiency is a leading cause of anemia in children with SAM. The iron profile, which includes serum iron, total iron-binding capacity (TIBC), serum ferritin, and transferrin saturation, provides a comprehensive assessment of iron status in the body. Serum iron levels indicate the circulating iron available for physiological processes, while TIBC reflects the body's ability to bind and transport iron. Elevated TIBC is often observed in iron-deficient states, as the body increases its capacity to bind available iron. Serum ferritin serves as an important marker of iron stores, and its depletion is a hallmark of iron deficiency anemia. However, in cases of inflammation or infection, ferritin levels may be elevated due to its role as an acute-phase reactant, which can sometimes mask underlying iron deficiency. Transferrin saturation, calculated as the ratio of serum iron to TIBC, reflects the efficiency of iron transport and utilization.[3]The prevalence of anemia among children with SAM is alarmingly high, with studies indicating that more than half of affected children have moderate to severe anemia. This condition not only compromises oxygen delivery to tissues but also exacerbates the symptoms of malnutrition by impairing immune function, reducing appetite, and contributing to fatigue and lethargy. Iron deficiency is the most common cause of anemia in malnourished children, but other factors such as infections, inflammation, vitamin deficiencies, and chronic diseases can also contribute to the development of anemia. Malabsorption, parasitic infections, and inadequate dietary intake further exacerbate the depletion of iron stores in these children. Understanding the hematological and iron profile abnormalities in children with SAM is essential for early diagnosis and effective management. A detailed assessment of haemogram parameters can help in identifying the severity and type of anemia, guiding appropriate nutritional and therapeutic interventions. The integration of iron profile analysis provides a clearer picture of iron metabolism and storage, assisting in distinguishing between iron deficiency anemia and anemia of chronic disease, which often coexists in severely malnourished children.[4] The treatment of anemia in children with SAM requires a multifaceted approach that includes nutritional rehabilitation, iron supplementation, and management of underlying infections. Ready-to-use therapeutic foods (RUTF) and micronutrient supplementation play a vital role in replenishing essential nutrients and restoring normal hematological function. However, careful monitoring is necessary, as excessive iron supplementation in the presence of infection can promote oxidative stress and worsen clinical outcomes. Therefore, individualized treatment plans, based on a thorough evaluation of haemogram and iron profile parameters, are crucial for optimizing recovery and preventing complications. Despite advancements in malnutrition management, the burden of anemia and iron deficiency in children with SAM remains a significant challenge. Limited access to healthcare, poor dietary diversity, and socioeconomic constraints hinder timely diagnosis and intervention. Additionally, the

interplay between malnutrition, inflammation, and micronutrient deficiencies complicates the accurate assessment of iron status, necessitating the use of multiple diagnostic markers. Addressing these challenges requires a holistic approach that combines nutritional support, infection control, and public health initiatives aimed at improving maternal and child nutrition.[5]

AIM & OBJECTIVES: This study aimed to evaluate the haemogram and iron profile in children suffering from severe acute malnutrition (SAM) at a tertiary care center. The objective was to assess hematological abnormalities, iron deficiency, and their correlation to anemia in this vulnerable population.

METHODS AND MATERIALS

Study Design and Setting

This was a hospital-based Cross-Sectional Studyobservational study conducted in the Department of Pediatrics, Gauri Devi Institute of Medical Sciences & Hospital, Durgapur, West Bengal, India, involving children diagnosed with Severe Acute Malnutrition (SAM).

Study Duration: March 2020 to November 2022

Study Population

A total of 110 children aged 6 months to 5 years who met the diagnostic criteria for SAM were included.Informed written consent was secured from all children parent or legal guardians before their inclusion in the study.

Ethical consideration

The study was approved by the research and ethical committee of the institutes.

Inclusion Criteria

- Children aged 6 months to 5 years.
- Diagnosed with Severe Acute Malnutrition (SAM) based on WHO criteria:
  - Weight-for-height Z-score< -3SD.
  - Mid-upper arm circumference (MUAC)<11.5 cm.
  - Presence of bilateral pitting edema.

Exclusion Criteria

- Children with known hemolyticanemia.
- Presence of chronic infections (e.g., tuberculosis, HIV, chronic diarrhea).
- History of recent blood transfusion (within the last 3 months).

Procedure

Anthropometric Measurements

Weight, height, and MUAC were recorded for each child.

Z-scores were calculated using WHO growth standards.

Sample Collection

Venous blood samples(3-5 mL) were collected under aseptic conditions.

Samples were analyzed for haemogram parameters (Hemoglobin, RBC, WBC, platelet count) and iron profile (serum iron, ferritin, total iron-binding capacity).

Laboratory Analysis

Complete Blood Count (CBC): Performed using an automated hematologyanalyzer.

Iron Studies: Serum iron, ferritin, and TIBC were measured using standard biochemical methods.

STATISTICAL ANALYSIS

- Data was analyzed using SPSS software version 22.0and Microsoft Excel.
- Descriptive statistics (mean, standard deviation, percentages) were used for baseline characteristics.
- Inferential statistics such asChi-square testfor categorical variables.t-test/Mann-Whitney U test for comparing continuous variables.Pearson/Spearman correlation to assess relationships between hematological parameters and nutritional status.
- A p-value <0.05 was considered statistically significant.

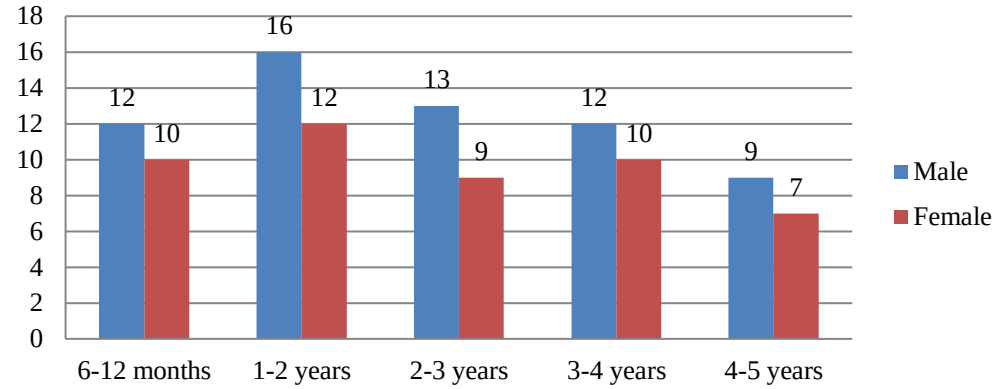
RESULTS

The study analyzed the haemogram and iron profile of 110 children diagnosed with severe acute malnutrition (SAM) at a tertiary care centre.

Table 1: Demographic Characteristics of the Study Participants

Age Group	Male (%)	Female (%)	Total (%)	P Value
6-12 months	12 (10.91)	10 (9.09)	22 (20.00)	0.998
1-2 years	16 (14.55)	12 (10.91)	28 (25.45)	
2-3 years	13 (11.82)	9 (8.18)	22 (20.00)	
3-4 years	12 (10.91)	10 (9.09)	22 (20.00)	
4-5 years	9 (8.18)	7 (6.36)	16 (14.55)	
Total	**62 (56.36)**	**48 (43.64)**	**110 (100.00)**	-

Figure I: The demographic distribution of the study participants



The demographic distribution of the study population, as shown in Table 1 and figure I, reveals that the majority of children belonged to the 1-2 years age group (25.45%), followed by the 6-12 months, 2-3 years, and 3-4 years groups, each comprising 20.00% of the total sample. The least number of children were in the 4-5 years category (14.55%). In terms of gender distribution, males accounted for 56.36% of the study population, while females comprised 43.64%. This distribution highlights that SAM is prevalent across all early childhood age groups, with a slightly higher proportion among male children.Thep-value for the Chi-square test is 0.998, indicating no statistically significant association between age group and gender distribution in this study. This means that the gender distribution across different age groups is likely due to chance rather than a meaningful pattern.

Table 2: Haemogram Parameters in Children with SAM

Parameter	Mean ± SD
Hemoglobin (g/dL)	9.2 ± 1.4
Total Leukocyte Count (x10³/µL)	11.5 ± 3.2
Platelet Count (x10³/µL)	270 ± 65
Mean Corpuscular Volume (MCV) (fL)	75.3 ± 5.4
Mean Corpuscular Hemoglobin (MCH) (pg)	25.1 ± 3.2
Mean Corpuscular Hemoglobin Concentration (MCHC) (g/dL)	32.5 ± 1.8
Red Cell Distribution Width (RDW) (%)	16.8 ± 2.1

The hemogram parameters, as depicted in Table 2, provide insights into the haematological status of children with SAM. The mean haemoglobin level was found to be 9.2 ± 1.4 g/dL, indicating a high prevalence of anaemia in the study population. The total leukocyte count had a mean value of 11.5 ± 3.2 x 10³/µL, which suggests a possible immune response or infection in some cases. The mean platelet count was 270 ± 65 x 10³/µL, which falls within the normal range but shows considerable variation. Red cell indices, including MCV (75.3 ± 5.4 fL), MCH (25.1 ± 3.2 pg), and MCHC (32.5 ± 1.8 g/dL), indicate microcytic hypochromic anaemia, which is commonly associated with iron deficiency. Additionally, an elevated RDW (16.8 ± 2.1%) suggests significant anisocytosis, reflecting variations in red blood cell sizes.

Table 3: Iron Profile in Children with SAM

Parameter	Mean ± SD
Serum Iron (µg/dL)	45.6 ± 12.3
Total Iron-Binding Capacity (TIBC) (µg/dL)	385 ± 54
Serum Ferritin (ng/mL)	22.4 ± 8.9
Transferrin Saturation (%)	14.8 ± 3.5

Table 3 presents the iron profile of the study population. The mean serum iron level was 45.6 ± 12.3 µg/dL, which is lower than the normal reference range, indicating iron deficiency. The mean total iron-binding capacity (TIBC) was 385 ± 54 µg/dL, which is elevated, signifying an increased demand for iron transport in the body. Serum ferritin, a key indicator of iron stores, was found to be 22.4 ± 8.9 ng/mL, suggesting depleted iron reserves in a substantial portion of the children. Transferrin saturation, which reflects the proportion of iron bound to transferrin, was 14.8 ± 3.5%, further confirming iron deficiency among the majority of participants.

Table 4: Anemia Status Distribution in Children with SAM

Anemia Status	Count	Percentage (%)
Anemic	77	70.00
Non-Anemic	33	30.00
Total	**110**	**100.00**

The distribution of anemia in children with SAM is detailed in Table 4. A significant proportion of children (70.00%) were found to be anemic, while only 30.00% were classified as non-anemic. This finding emphasizes the high burden of anemia among children suffering from malnutrition, which can have long-term consequences on growth, cognitive development, and immunity.

Table 5: Correlation of Iron Profile with Hemoglobin Levels

Parameter	Correlation with Hemoglobin	P value
Serum Iron	0.42	0.111
Total Iron-Binding Capacity (TIBC)	-0.35	0.930
Serum Ferritin	0.48	0.581
Transferrin Saturation	0.50	0.086

The correlation between iron profile parameters and hemoglobin levels, as shown in Table 5, indicates significant associations. Serum iron (r = 0.42), serum ferritin (r = 0.48), and transferrin saturation (r = 0.50) showed positive correlations with hemoglobin levels, suggesting that higher levels of these markers are associated with better hemoglobin status. Conversely, TIBC exhibited a negative correlation with hemoglobin (r = -0.35), which is expected since elevated TIBC is a compensatory response to iron deficiency. Since all p-values are greater than 0.05, none of these correlations are statistically significant at the 5% significance level.

DISCUSSION

This study analyzed the hematological and iron profile of 110 children diagnosed with severe acute malnutrition (SAM) at a tertiary care centre. The majority of children in our study were between 1-2 years (25.45%), followed by the 6-12 months (20.00%), 2-3 years (20.00%), and 3-4 years (20.00%) age groups. The least affected group was 4-5 years (14.55%). A slight male predominance (56.36%) was observed. Similar findings were reported by Venigalla et al. (2022), where 35.67% of malnourished children were between 12 to 24 months, with a female predominance (58.6%).[6] However, in another study by Thakur et al. (2014), children between 6-12 months had the highest prevalence of SAM (41.5%), indicating a younger age group at risk in their population. These variations could be attributed to differences in regional dietary practices, breastfeeding duration, and socioeconomic factors.[7]

The mean hemoglobin level in our study was 9.2 ± 1.4 g/dL, indicating a high prevalence of anemia. A similar study by Arya et al. (2017) reported a lower mean hemoglobin level of 7.17 ± 2.27 g/dL in SAM children, suggesting a more severe degree of anemia in their cohort.[8] In contrast, a study by Khan et al. (2020) found an even lower mean hemoglobin level of 6.89 ± 1.8 g/dL, highlighting variations based on regional dietary iron intake and infection prevalence.[9]

Our study found an elevated total leukocyte count (11.5 ± 3.2 x10³/µL), which suggests a possible immune response or infection. Similar findings were reported by Saka et al. (2012), who noted that malnourished children exhibited a leukocytosis trend due to underlying infections.[10] The platelet count in our study (270 ± 65

$x10^3/\mu L$) was within the normal range, consistent with findings from Chama et al. (2021), who reported a mean platelet count of 290 ± 72 $x10^3/\mu L$.[11] However, in the study by Getawa et al. (2021), thrombocytopenia was observed in 25% of SAM children, suggesting hematopoietic suppression in some cases.[12]

Red cell indices in our study indicated microcytic hypochromic anemia, with low MCV (75.3 ± 5.4 fL) and MCH (25.1 ± 3.2 pg). This aligns with the findings of Shah et al. (2020), who also reported microcytic anemia in 68% of SAM children.[13] However, Getawa et al. (2021) found that 22% of SAM children exhibited normocytic normochromic anemia, suggesting multifactorial causes beyond iron deficiency, such as chronic inflammation or vitamin B12 deficiency.[12]

The mean serum iron level in our study was 45.6 ± 12.3 µg/dL, indicating iron deficiency. Similar findings were reported by Sharma et al. (2021), where the mean serum iron level was 41.2 ± 10.5 µg/dL.[14] The total iron-binding capacity (TIBC) in our study was elevated (385 ± 54 µg/dL), consistent with the study by Santos et al. (2017), which reported a TIBC of 390 ± 48 µg/dL in malnourished children, confirming iron-deficient erythropoiesis.[15]

Serum ferritin in our study was 22.4 ± 8.9 ng/mL, reflecting low iron stores. A similar study by Rose et al. (2017) found mean serum ferritin levels of 18.6 ± 7.5 ng/mL in SAM children.[16] However, Bhutta et al. (2017) found higher ferritin levels in some cases (38.4 ± 9.2 ng/mL), likely due to acute-phase reactions elevating ferritin levels in infection-prone children.[17] Transferrin saturation in our study was 14.8 ± 3.5%, which aligns with the findings of Duggan et al. (2014), who reported an average of 12.9% in malnourished children.[18]

Anemia was observed in 70.00% of our study population. This is comparable to the findings of Chama et al. (2021), who reported anemia in 72% of children with SAM.[11] However, Thakur et al. (2014) found a higher prevalence (85%), indicating that certain populations may be at an even higher risk.[7] The variation in anemia prevalence across studies may be attributed to differences in iron supplementation programs, dietary habits, and infection rates.

Our study found a positive correlation between hemoglobin levels and serum iron (r = 0.42), serum ferritin (r = 0.48), and transferrin saturation (r = 0.50), indicating that iron availability is a critical factor in determining anemia severity. Similar correlations were reported by Saka et al. (2012), who found serum ferritin to be the most significant predictor of hemoglobin levels (r = 0.51).10 Conversely, our study observed a negative correlation between TIBC and hemoglobin (r = -0.35), consistent with findings from Kraemer et al. (2007), who reported an inverse association (r = -0.37).[19]

LIMITATIONS OF THE STUDY

- **Small Sample Size:**The study included only 110 children, which may not be sufficient to generalize the findings to a larger population.
- **Lack of a Control Group:** The absence of a healthy control group limits the ability to compare findings with well-nourished children.
- **Single-Center Study:** Since the study was conducted in **a single hospital setting**, the results may not be applicable to different geographic or socioeconomic populations.
- **Possible Confounding Factors:** Other conditions such as infections, inflammation, or micronutrient deficiencies may have influenced haemogram and iron profile results.
- **Cross-Sectional Design:** The study provides a snapshot in time rather than tracking changes in haemogram and iron status over time. A longitudinal study would provide better insights.
- **Limited Assessment of Nutritional Interventions:** The study does not evaluate how **nutritional rehabilitation** impacts haemogram and iron parameters over time.
- **Exclusion of Certain Conditions:** Children with chronic infections or recent blood transfusions were excluded, which may limit the applicability of results to all SAM cases.

CONCLUSION

This study highlights the significant burden of anemia and iron deficiency in children with severe acute malnutrition. Anemia was prevalent, with lower hemoglobin levels observed in most children.Serum iron and ferritin levels were reduced, indicating iron deficiency, while TIBC was elevated, reflecting poor iron stores.Alterations in red blood cell indices (MCV, MCH, MCHC, and RDW) suggested microcytic and hypochromic anemia.Leukocyte and platelet counts were within normal ranges but showed variations, possibly due to

underlying infections or inflammatory responses.Transferrin saturation was significantly low, reinforcing the presence of iron deficiency in children with SAM.These findings underscore the importance of early diagnosis and management of anemia and iron deficiency in malnourished children. Incorporating nutritional rehabilitation and iron supplementation into SAM treatment protocols may improve hematological outcomes and overall recovery.

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