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Original Article

Paediatrics Section

Haemogram and Iron Profile in Children Suffering from Severe Acute Malnutrition at a Tertiary Care Centre, Bhopal: A Cross-sectional Study

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ABSTRACT

Introduction: There is a high global prevalence of malnutrition in India, with anaemia and infection being the major co-morbidities in these patients. Iron deficiency is one of the most common causes of anaemia worldwide, which has its complications. However, data regarding haematological and iron profiles among Severe Acute Malnutrition (SAM) children in India is very limited.

Aim: To study the iron profile and haemogram in children with SAM and its comparison with various associated complications.

Materials and Methods: This observational cross-sectional study was conducted in the Department of Paediatrics, Gandhi Medical College, Bhopal, Madhya Pradesh, India, from March 2021 to September 2022. Children aged between six months to five years, fulfilling the World Health Organisation (WHO) criteria of SAM in the present study were included and clinical and haematological data were collected, including growth parameters, haemogram, peripheral smear, Red Blood Cell (RBC) indices, reticulocyte counts, and iron profile. Categorical variables were analysed using the Chi-square test or Fisher's-exact test. Continuous variables were assessed using the Analysis of Variance (ANOVA) or t-test.

Results: 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.

Conclusion: Anaemia was observed to be highly prevalent in SAM children with complications. The most common type of anaemia was microcytic hypochromic, followed by macrocytic type. Serum iron levels were significantly lower in SAM patients with complications (p-value <0.001).

Keywords: Iron deficiency anaemia, Macrocytic anaemia, Protein energy malnutrition, Serum ferritin

INTRODUCTION

Malnutrition continues to be a major health problem in developing countries and an important risk factor for infections [1]. Poor nutrition leads to various forms of malnutrition, contributing to the global disease load and mortality in children [1]. SAM continues to be one of the major global health problems affecting 6.7% of children under five years of age with mortality higher in SAM than in well-nourished children. Moreover, it has proven to be a significant impediment to achieving the fourth millennium development goal [2]. In children aged 6 to 59 months, SAM is defined as Mid-Upper Arm Circumference (MUAC) <115 mm or weight for height of <- 3SD z-score below the median or the presence of bipedal oedema [3].

SAM causes a variety of pathophysiological alterations in the body's systems, including severe haematological abnormalities. Anaemia has been found to be more prevalent in SAM patients [4]. Iron deficiency is one of the most prevalent causes of anaemia in SAM. Iron is essential for various processes, including haematopoiesis and oxidative phosphorylation, which are thus deranged in SAM patients. Likewise, transferrin plays a role in disease resistance in children. Nutritional deficiency affects immune function and reduces the effectiveness of the host defence causing infection and iron loss, contributing to the morbidity and mortality of children with SAM [5]. In India, there is a lack of studies on haematological and iron profiles in SAM children. Therefore, the present study was conducted to evaluate and compare these data with various complications in patients of SAM.

MATERIALS AND METHODS

An observational cross-sectional study was conducted in the Department of Paediatrics, Gandhi Medical College, Bhopal, Madhya Pradesh, India, during a period of 18 months from March 2021 to September 2022 after obtaining Ethical clearance from the Institutional Ethical Committee of the Gandhi Medical College, Bhopal (Letter No. 27161/MC/IEC/2021; dated 25/08/2021). Informed consent was taken from the parent/guardians of the child.

Inclusion criteria: Children aged between six months to five years, meeting the WHO criteria of SAM [3], also the children with clinical features like respiratory tract infections, sepsis, generalised oedema, low appetite, hypoglycaemia, hypothermia, vomiting, diarrhoea, severe dehydration, and severe anaemia, requiring inpatient treatment were considered SAM with complications and those children who had bilateral pitting oedema labelled as oedematous SAM [6] were included in the study.

Exclusion criteria: SAM children with primary systemic diseases, haemoglobinopathies, congenital haematological disorders and those with non consenting parents were excluded from the study.

Sample size calculation: A total of 175 children with SAM, who presented in the Department, within the study duration, were enrolled in the study by purposive sampling.

Study Procedure

Each child was assessed by taking a detailed history from the mother/caregiver and by performing a physical examination including complete anthropometric parameters like:

Weight for age was recorded accurately in minimal clothing by an analogue weighing machine and infants were weighted by a digital weight machine. Height for age was measured using a stadiometer and the length of infants was measured by an infantometer. MUAC was measured using a non-stretchable tape, after marking a mid-point of the left arm while the child holds the arm by his side. Head circumference was measured by non-stretchable tape by crossed tape method from the occipital protuberance to the supraorbital ridges on the forehead. Weight-for-height was also calculated.

Blood samples (5 mL) were drawn under aseptic precautions and sent for haemogram, Erythrocyte Sedimentation Rate (ESR), PCV, peripheral smear, RBC indices, reticulocyte counts, and Iron profile such as serum iron, TIBC, Transferrin saturation, and serum ferritin. Haematological indicators were measured using fully automated cell counters. The measurement of serum-based biochemical indicators such as serum iron and TIBC was done by colourimetry. Protein-based indicators such as serum ferritin were measured by immunoassay [6].

These parameters were compared between SAM children with and without complications. Anaemia is defined as a haemoglobin level below two standard deviations from the population mean [7]. In children aged six months to 59 months, the haemoglobin thresholds (g/dL) to define the severity of anaemia as per the WHO are severe anaemia (<7), moderate anaemia (7-9.9), mild anaemia (10-10.9) and no anaemia (>11). The peripheral smear findings were classified as per the morphological classification of anaemia (Macrocytic Normochromic showing macrocytes, Microcytic Hypochromic showing microcytes, Microcytic Normochromic showing microcytes with normal colour, Normocytic Normochromic showing normal RBCs and dimorphic picture showing both macrocytes and microcytes) [8].

STATISTICAL ANALYSIS

Data were recorded in Microsoft Excel sheets and statistical analysis was performed by the Statistical Package for Social Sciences (SPSS) version 25.0 (SPSS, Chicago, Illinois). Continuous variables were presented as mean±SD, and categorical variables were presented as absolute numbers and percentages. Data were checked for normality before statistical analysis. A descriptive analysis was performed to obtain the general characteristic of the study population. Categorical variables were analysed using the Chi-square test or Fisher's-exact test. Continuous variables were assessed using the ANOVA or t-test. A p-value of <0.05 was considered statistically significant.

RESULTS

A total of 175 children with SAM were analysed. In the present study, 95 (54%) patients were boys and rest were girls. The majority of the SAM children, 79 (45.1%) belonged to the group between 1-2 years and the least children belonged to the 4-5 years age group [Table/Fig-1]. Out of 175 SAM children, 10 (5.7%) had oedematous SAM. Out of 175 SAM children, 77 (44%) were with complications. The most common complication was an acute respiratory infection in 30 (38.9%), followed by acute gastroenteritis in 17 (22.1%) [Table/Fig-2].

In the present study, the majority of SAM children with complications had severe anaemia in 40 (51.9%) followed by moderate anaemia in 26 (33.8%). On the other hand, among those without complications, 77 (78.6%) had mild anaemia and the rest had no anaemia [Table/Fig-3].

Age groups	Gender		Total n (%)
	Girls, n (%)	Boys, n (%)	
6 months to 1 year	17 (21.3%)	20 (21.1%)	37 (21.1%)
>1-2 years	33 (41.3%)	46 (48.4%)	79 (45.1%)
>2-3 years	19 (23.8%)	18 (18.9%)	37 (21.1%)
>3-4 years	9 (11.3%)	11 (11.6%)	20 (11.4%)
>4-5 years	2 (2.5%)	0 (0 %)	2 (1.1%)
Total	80	95	175

[Table/Fig-1]: Age and gender distribution of patients with SAM.
Data are expressed as number of patients (percentage)

Complication	Number of patients (n)	Percentage
Acute respiratory infection	30	38.9
Acute gastroenteritis	17	22.1
Sepsis	14	18.2
Tremours	7	9.1
Seizures	5	6.5
Hypoglycaemia	2	2.6
Dysentery	2	2.6
Total	77	100.0

[Table/Fig-2]: Complications in patients with SAM (n=77).
Data are expressed as no. of patients (percentage)

Severity of anaemia	Complicated, n (%)	Uncomplicated, n (%)	p-value
Severe	40 (51.9)	0	**<0.001**
Moderate	26 (33.8)	0	
Mild	11 (14.3)	77 (78.6)	
No anaemia	0	21 (21.4)	
Total	77 (100)	98 (100)	

[Table/Fig-3]: Distribution of severity of anaemia in SAM patients n=77 (with complication) and n=98 (without complications).
Data are expressed as number of patients (percentage), Chi-square test was used; Bold p-value are significant

The mean Hb (p<0.001), PCV (p<0.001), RBC (p<0.001), MCH (p=0.011) and MCHC (p=0.004) was significantly lower in SAM children with complication than those without complication. The total leukocyte count (p<0.001) was significantly increased in SAM with complication than without complication [Table/Fig-4]. The serum iron (p<0.001) and transferrin saturation (p=0.005) were significantly lower in SAM with complication whereas total iron-binding capacity (p=0.001) and serum ferritin (p<0.001) were significantly higher in SAM with complications as compared to those without complications [Table/Fig-5].

Parameters	Status of complications	Mean±SD	SEM	p-value
Haemoglobin (g/dL)	Complicated	9.126±1.84	0.2149	**<0.001**
	Uncomplicated	10.821±1.26	0.1279	
Total leukocyte count (/µL)	Complicated	13572.99±5715.263	651.31	**<0.001**
	Uncomplicated	6866.84±1899.445	191.87	
Platelet count (lakhs/µL)	Complicated	1.9961±0.42718	0.048	0.305
	Uncomplicated	1.9281±0.43995	0.044	
ESR (mm/hr)	Complicated	15.10±1.667	0.190	0.091
	Uncomplicated	15.65±2.581	0.261	
Packed cell volume (%)	Complicated	25.31±2.957	0.337	**<0.001**
	Uncomplicated	27.60±2.846	0.287	
Red blood cells (millions/µL)	Complicated	3.910±0.3844	0.043	**<0.001**
	Uncomplicated	4.106±0.2784	0.028	
MCV (fL)	Complicated	83.83±14.835	1.691	0.282
	Uncomplicated	81.38±14.978	1.513	

MCH (pg)	Complicated	22.14±6.327	0.148	**0.011**
	Uncomplicated	28.61±2.650	0.268	
MCHC (g/dL)	Complicated	31.57±3.246	0.370	**0.004**
	Uncomplicated	32.81±2.332	0.236	
RDW (%)	Complicated	12.931±1.1290	0.128	0.256
	Uncomplicated	13.104±0.8801	0.088	
Reticulocyte count (%)	Complicated	1.473±0.3814	0.0435	0.125
	Uncomplicated	1.393±0.3037	0.0307	

[Table/Fig-4]: Comparison of haemogram with the status of complications.
ESR: Erythrocyte sedimentation rate; MCV: Mean corpuscular volume; MCH: Mean corpuscular haemoglobin; MCHC: Mean corpuscular haemoglobin concentration; RDW: Red cell distribution width; Data are expressed as number of patients (percentage), t-test was used

Parameters	Status of complications	Mean±SD	SEM	p-value
Serum iron (µg/dL)	Complicated	33.81±23.030	2.625	**<0.001**
	Uncomplicated	46.87±24.866	2.512	
Total iron-binding capacity (µg/dL)	Complicated	438.00±98.390	11.213	**0.001**
	Uncomplicated	391.97±73.882	7.463	
Transferrin saturation (%)	Complicated	30.96±9.557	1.089	**0.005**
	Uncomplicated	34.96±8.952	0.904	
Serum ferritin (ng/mL)	Complicated	188.26±79.739	9.087	**<0.001**
	Uncomplicated	70.99±36.258	3.663	

[Table/Fig-5]: Comparison of iron profile with the status of complications.
Data are expressed as no of patients (percentage), t-test was used

Serum ferritin was significantly increased in SAM with complications as compared to those without complications (p<0.001) however, no significant difference was obtained when SAM children with complications were compared for the severity of anaemia. This highlights that serum ferritin increases in complicated cases, but anaemia status does not significantly alter its level [Table/Fig-6].

In the present study, the authors reported that the majority of the SAM children were male and had an age between 1-2 years (45.1%) showing preferential attention-seeking behaviour of male children and the most common complications along with anaemia were acute respiratory infection (38.9%) followed by acute gastroenteritis (22%) and sepsis (18.2%). A study by Kumar R et al., reported that out of 104 malnourished SAM children, 54% had diarrhoea and 27.8% had acute respiratory tract infections [10]. In the present study, 10 (5.7%) children had oedematous SAM and weight for height <-3SD was recorded in 160 (91.4%) children. The results are in line with a study from Ethiopia by Fekadu H et al., which showed that a considerably high proportion (38.8%) of children were seriously malnourished (MUAC <12.5 cm) [11]. MUAC of a child has a strong statistical association with the wasting of children. They reported that out of 150 children, 41.78% were below standard meaning wasting.

The authors in the present study, found that out of 87% of the SAM children with anaemia, the majority had severe anaemia (51.9%) whereas 33.8% had moderate anaemia and 14.3% had mild anaemia with microcytic hypochromic (35%), macrocytic hypochromic anaemia (33.8%) was more prevalent following the study by Thakur N et al., which reported that contrary to the previous studies performed nutritional anaemia in malnourished children implies mostly iron-deficiency anaemia, the study also showed SAM children to have megaloblastic anaemia [12].

A study by Kumar R et al., reported that SAM patients had lower mean haemoglobin, PCV, and RBC indices and a higher mean value of total leukocyte and platelet counts [10]. The present study also found that the mean Hb (p<0.001), PCV (p<0.001), RBC (p<0.001), MCH (p=0.011) and MCHC (p=0.004) was significantly lower in SAM with complications as compared to those without complications. The authors found that total leukocyte count (p<0.001) was raised in SAM with complications as compared to those without complications which were in line with the studies done by Isezuo K et al., and Basheir HM and Hamza KM [13,14].

Parameters	Complicated SAM (N=77)			Uncomplicated SAM (N=98)	p-value
	Mild anaemia (n=11)	Moderate anaemia (n=26)	Severe anaemia (n=40)	Mild anaemia (n=77)	
Serum ferritin (ng/mL)	181.31±42.18	180.51±72.34	183.76±93.76	64.49±37.12	**<0.001**
Serum iron (µg/dL)	44.0±21.79	37.69±23.57	26.541±20.82	41.22±22.86	**<0.001**

[Table/Fig-6]: Comparison of serum iron and ferritin with the severity of anaemia.
Data are expressed as no of patients (percentage), t-test was used. p-value between complicated and uncomplicated

SAM children with complications had microcytic hypochromic picture in 27 (35%), followed by macrocytic normochromic 26 (33.8%), dimorphic picture 9 (11.7%), and microcytic normochromic anaemia 7 (9.1%) while SAM without complications, patients mostly had normocytic normochromic 28 (38.8%), macrocytic normochromic 32 (32.7%), microcytic hypochromic 31 (31.6%) microcytic normochromic 4 (4.1%) and dimorphic picture 3 (3.1%) [Table/Fig-7].

Peripheral smear study	Complication status		Total (N=175)	p-value
	Complicated (n=77)	Uncomplicated (n=98)		
Dimorphic picture	9 (11.7%)	3 (3.1%)	12 (6.9%)	**0.001**
Macrocytic normochromic	26 (33.8%)	32 (32.7%)	58 (33.1%)	
Microcytic hypochromic	27 (35%)	31 (31.6%)	58 (33.14%)	
Microcytic normochromic	7 (9.1%)	4 (4.1%)	11 (6.3%)	
Normocytic normochromic	8 (10.4%)	28 (28.6%)	36 (20.6%)	

[Table/Fig-7]: Comparing types of anaemia with the status of complications.
Data are expressed as no of patients (percentage), Chi-square test was used

DISCUSSION

World Health Organisation estimated that under the age of five years, 27% of children are malnourished in developing nations. Even though the prevalence of childhood malnutrition is decreasing, countries in South Asia still have the highest number of malnourished children [9].

The present study found that serum iron and transferrin saturation were significantly lower (p<0.001) in SAM with complications compared to SAM without complications whereas total iron-binding capacity and serum ferritin were significantly higher which matched with the study results by Islam N et al., [15]. In the present study, serum ferritin is increased in SAM with complications cases as it is a marker of inflammation and recognised as an acute phase reactant protein and anaemia status does not alter its level significantly. However, serum iron was lowest in severe anaemia as compared to moderate and mild anaemia hence complications in SAM patients affect the serum iron level as per the severity of the anaemia. The authors found that microcytic hypochromic (35%) and macrocytic hypochromic anaemia (33.8%) were more prevalent in complicated cases than in uncomplicated SAM patients with normocytic normochromic anaemia, which was in accordance with previous studies [10,12].

Limitation(s)

The follow-up of included children was not done to screen the reversibility of deranged parameters as they were discharged and referred to Nutrition Rehabilitation Centres (NRCs) and others had an unfavourable outcome.

CONCLUSION(S)

In present study, the anaemia was highly prevalent in SAM children with complications requiring hospital admission. The most common type of anaemia was microcytic hypochromic, followed by macrocytic type among SAM patients with complications. Serum iron levels were significantly lower in SAM patients with complications. We recommend that an iron profile must be done along with a routine haemogram, so that type and severity of anaemia could be identified along with the status of complications so that appropriate intervention could be done in the management, supplementation, and diet given to these children for a better improvement in their outcome.

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