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Original Research Article

Role of intravenous iron therapy in children with severe acute malnutrition with iron deficiency anemia

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ABSTRACT

Background: Iron deficiency anemia (IDA) is the most common micronutrient deficiency among children under five years of age, with severe acute malnutrition (SAM). The coexistence of SAM and IDA increases the risk of impaired growth, developmental delay, recurrent infections, hospitalization, and mortality. Oral iron supplementation is the standard treatment but is often limited in children with SAM because of poor tolerance, reduced absorption. Intravenous (IV) iron sucrose may provide rapid correction of iron deficiency; however, evidence regarding its safety and efficacy in this population is limited. This study evaluated the safety and efficacy of IV iron sucrose therapy in children with SAM and IDA.

Methods: This observational study was conducted in children under five years, with SAM and diagnosed with IDA. Sample size was 65, after stabilization, eligible and clinically stable children received IV iron sucrose in 50ml normal saline administered over 30 minutes on days 7th, 10th, and 13th as per Ganzoni's formula. Follow-up assessments were performed on day 14, 30, and 45, including anthropometry and hematological parameters. Adverse events were monitored.

Results: A total of 65 children with SAM and IDA were enrolled. Mean hemoglobin (Hb) increased from 6.19 g/dL at baseline to 9.62 g/dL at follow-up. Serum ferritin improved from 28.8 µg/L to 157.49 µg/L. Red cell indices showed significant improvement. No serious adverse reactions were reported.

Conclusions: IV iron sucrose therapy is a safe and effective for correcting IDA in children with SAM, especially where oral iron therapy is poorly tolerated.

Keywords: Severe acute malnutrition, Iron deficiency anemia, Intravenous iron sucrose therapy, Pediatric anemia, Hematological outcomes

INTRODUCTION

Acute malnutrition occurs when the body doesn't receive enough energy or protein, leading to nutritional deficiencies. In many developing regions, primary acute malnutrition is widespread, often stemming from limited access to food and influenced by various economic, social and environmental challenges. Whereas, secondary acute malnutrition emerges due to medical conditions that interfere with nutrient absorption, increase energy demands, or restrict food intake.[1] SAM can be characterized by very low weight for height/length (SD score below -3SD of the median for WHO child growth standards), and/or mid upper arm circumference <11.5 cm, and/or by the presence of bilateral pitting oedema.[2] SAM and anemia are closely linked, influencing each other in significant ways. Childhood anemia can stem from a lack of essential macronutrients, especially protein, while anemia itself can exacerbate malnutrition by hindering protein synthesis and disrupting the body's ability to process and utilize nutrients effectively.[3] WHO

definition of anemia in children that are aged as 6-59 months is defined as a Hb level below 11 g/dl which arises when the body lacks sufficient iron which leads to a decrease in RBC levels/ Hb metrics. If the condition develops gradually, symptoms may be mild, including lethargy, physical weakness, difficulty breathing, and diminished endurance. However, its rapid onset can result in more severe effects such as dizziness, confusion, fainting, or increased thirst. In advanced cases, noticeable pallor becomes evident. Among infants, deficiency of iron can hinder growth and development, with associated signs and symptoms influenced by the root cause.[4,5] This condition frequently arises from inadequate iron intake, blood loss, or problems with iron absorption. Impaired absorption may be associated with gastrointestinal conditions including celiac disease or inflammatory bowel disease, as well as procedures like gastric bypass surgery. In many developing countries, the risk is further increased by malaria, parasitic infestations, and HIV/AIDS that may progress to long term development of iron-deficiency anemia.[5,6] Infants are highly susceptible to iron-deficiency anemia because of their accelerated growth and heightened iron requirements, which may not always be met through diet alone. While infants enter the world with stored iron, these reserves are generally exhausted between four and six months of age. Giving cow milk to toddlers at early onset can also contribute to anemia by causing gastrointestinal blood loss.[7] Certain groups of children are more susceptible to iron-deficiency anemia, including:[8,9] Preterm infants, infants that are underweight at the time of birth, breastfed infants lacking iron supplementation post-6 months, and those fed formula without added iron, those from economically disadvantaged backgrounds, children with special medical conditions, overweight children.[9]

This study evaluated the safety and efficacy of IV iron sucrose therapy in children with SAM and IDA.

METHODS

This observational study was conducted in tertiary care hospital over a period of 18 months and obtaining written permission from the institutional ethics committee. Total 65 childrens with severe acute malnourished aged six months to five years with IDA without any serious complications were included, informed parental consent was taken before the study. SAM with thalassemia, sickle cell anemia, septicemia and diarrhea were excluded.

Data collection and procedure

All parents were informed in their local language, and written consent was obtained for further treatment. The antenatal history of the mother was recorded. Vital signs, including heart rate, respiration, blood pressure, capillary refill time, temperature, and SpO_2, were assessed in all children. General examination, including height, weight, mid-upper arm circumference (MUAC), and standard deviation (SD) score, was conducted. Systemic examination was performed**.**

Investigations, including Hb, CBC, indices, mean corpuscular volume (MCV), mean corpuscular Hb (MCH), mean corpuscular Hb concentration (MCHC), and serum ferritin, were carried out.

IDA was confirmed by the presence of microcytic hypochromic anemia, low MCH, MCV, MCHC, and low serum ferritin.

SAM was diagnosed based on weight-for-height measurement (WHO charts), SD score < -3 SD, and/or MUAC ≤11.5 cm, and/or pitting edema on limbs, with the presence of any of these criteria confirming SAM, history of allergy to any medications was obtained.

An IV iron sucrose test dose of 0.5 mL in 20 mL normal saline was administered over 15 minutes, followed by the total iron sucrose dose diluted in 50 mL normal saline over 2 to 4 hours. The dose was calculated using the Ganzoni formula, with the total required iron dose divided over three days and administered on days 7, 10, and 13.

Ganzoni formula for iron requirement

Iron need (mg) = body weight (kg) × (target Hb - actual Hb g/dL)×2.3 + depot iron store need (500 mg or 15 mg/kg for children<35 kg).

Any adverse reactions, such as anaphylaxis, fever, rash, headache, or edema, were documented and managed accordingly.

Parenteral iron sucrose was administered again on the 7th, 10th, and 13th days of admission.

Blood tests were conducted on discharge (14th day). Follow-ups for SAM patients were scheduled in the outpatient department (OPD) or the Nutrition Rehabilitation Center (NRC) on the 15th and 30th of each month for three follow-ups. Hb, MCV, MCH, MCHC, and serum ferritin levels were monitored, and records were maintained to assess the effect of iron sucrose administration.

On discharge oral iron is started in dose of 3 mg /kg for 3 months.

Statistical analysis

The data was stored in a Microsoft excel spreadsheet, and analysis was performed using appropriate software. Data was represented in the form of tables and graphs. Frequency, percentage, and descriptive statistics were used to summarize the data.

To assess the normality of the data, the Shapiro-Wilk test was applied. Differences between continuous normally

distributed variables were analyzed using a t test, while the Mann-Whitney U test was used for non-normally distributed variables. The chi-square test or Fisher's exact test was utilized to determine associations between nominal or ordinal variables. The following parameters were analyzed: Length of hospital stay, complications of iv iron sucrose, relief from symptoms, Hb, CBC, serum ferritin, re-admission rates (within 45 days of discharge), age distribution and gender variation.

Hb levels and IV iron sucrose effects recorded on the 7th, 10th, and 13th days of admission were analyzed using ANOVA. A p value of less than 0.05 was considered statistically significant.

Sample size

A total of 65 patients were studied. Therefore, the sample size of this study is determined using the following formula.

To determine the sample size of this study we have considered Hb level as the primary outcome variable. In a previous study conducted by Khan et al they found that the mean (±SD) Hb level of study group (SAM) patients at the time of admission.[10]

Sample size formula

$$n = \frac{2(Z_{\alpha/2} + Z_{\beta})^2 \sigma^2}{d^2}$$

Where,

n=Required sample size, $Z_{\alpha/2} = 1.96$(5% significance level, two-tailed), $Z_{\beta} = 0.84$(80% power), σ=Standard deviation of haemoglobin, d=Expected mean difference in haemoglobin, assumptions-Significance level (α)=0.05, Power $(1 - \beta)$ = 80%,

$$Z_{\alpha/2} = 1.96$$

$$Z_{\beta} = 0.84$$

Standard deviation (σ) = 1.80 g/dl and expected mean difference (d) = 0.88 g/dl

Calculations

$$n = \frac{2(1.96 + 0.84)^2 (1.8)^2}{(0.88)^2}$$
$$= \frac{2(2.80)^2 (3.24)}{0.7744}$$
$$= \frac{2(7.84)(3.24)}{0.7744}$$
$$= \frac{50.8032}{0.7744}$$
$$= 65.00$$

Therefore, n=65 participants.

RESULTS

At baseline, the mean haemoglobin (Hb) concentration was 6.19±1.26 g/dl, indicating moderate to severe anaemia. Mean serum ferritin was 28.87±1.67 µg/L. The red cell indices-MCV (58.44±6.71 fL), MCH (21.89±2.51 pg), and MCHC (28.49±3.11 g/dl) were all markedly reduced, consistent with microcytic hypo chromic anaemia. Following initiation of IV iron therapy, there was a progressive improvement in all haematological parameters (Table 1). By day 14, Hb had increased to 6.77±1.05 g/dL, serum ferritin to 108.41±42.17 µg/l and red cell indices showed early upward trends. At one month, Hb increased to 7.03±0.96 g/dL, serum ferritin 128.59±30.74 µg/L, and further gains in MCV, MCH, and MCHC were noted. This improvement continued over subsequent follow-up visits (Table II). By the second month, mean Hb was 7.74±0.96 g/dl, increasing to 9.62±1.11 g/dl by the third month (Table 3). Serum ferritin peaked at 157.49±55.84 µg/l at the final visit. Red cell indices had normalized by the third month (MCV 88.23±7.21 fL, MCH 29.58±2.33 pg, MCHC 33.89±1.29 g/dl) (Figure 1). Repeated-measures analysis demonstrated that changes in Hb, serum ferritin, and all red cell indices over time were statistically highly significant ($p<0.001$).

These findings support the efficacy of IV iron therapy in correcting anaemia and restoring hematologic indices in children with SAM and IDA.

Follow-up evaluations

Patients were scheduled for follow-up assessments at 15-, 30-, and 45-days post-discharge. However, due to socioeconomic constraints and logistical barriers-particularly in the rural population-some patients presented later than scheduled, with follow-up durations ranging from 37 to 71 days. Despite this variability, all follow-up assessments consistently demonstrated continued improvement in anthropometric and hematologic parameters. Haemoglobin levels showed a progressive rise, and iron indices improved steadily over time, indicating successful resolution of IDA. Additionally, no child required readmission, and none experienced a relapse into SAM during the follow-up period

Adverse reactions

Mild adverse effects were observed in four patients. Two patients developed transient low-grade fever, which resolved with antipyretics within 24 hours (Figure 2). One patient experienced a mild, generalized rash that responded to oral antihistamines.[11,12] Another patient had a single episode of vomiting, which was effectively managed with an oral antiemetic. No serious or anaphylactic reactions were reported.[22,23]

Table 1: Baseline haematological and biochemical parameters of children with SAM and IDA.

Haematological parameters	Mean	SD	Minimum	Maximum
Hb (gm/dl)	6.23	1.02	3.2	8.9
Serum ferritin (µg/l)	28.8	11.67	5	56
MCV (fl)	58.44	6.57	37	74
MCH (pg)	22.00	2.91	11	28
MCHC (g/dl)	28.80	3.20	18	34

Table 2: Longitudinal changes in haematological parameters in children with SAM and IDA, level of MCV, MCH, and MCHC.

Time point	MCV/SD	MCH/SD	MCHC/SD
Admission	58.44/6.71	21.89/2.51	28.49/3.11
14th day	61.11/6.25	22.49/2.1	29.26/2.45
1st month (F1)	68.72/9.36	24.72/2.91	31.39/2.36
2nd month (F2)	78.92/9.34	27.32/2.96	32.65/1.74
3rd month (F3)	88.23/7.21	29.58/2.33	33.89/1.29
P value	<0.001	<0.001	<0.001

*All parameters increased from admission over three months and p value was significant are shown.

Table 3: Longitudinal changes in haematological parameters in children with SAM and IDA, haemoglobin levels.

Time points	Hb/SD (g/dL)
Admission	6.19/1.26
14th day	6.23/1.02
1st month (F1)	7.04/0.95
2nd month (F2)	7.76/0.94
3rd month (F3)	9.46/1.11
P value	<0.001

*Haemoglobin increased from 6.19 gm/dl to 9.46 gm/dl with significant p value is shown in above.

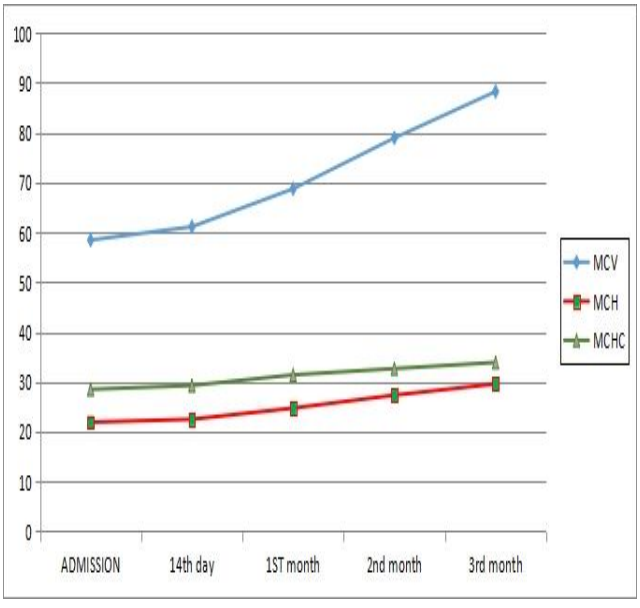

Figure 1: Line diagram showing indices over 3 months.

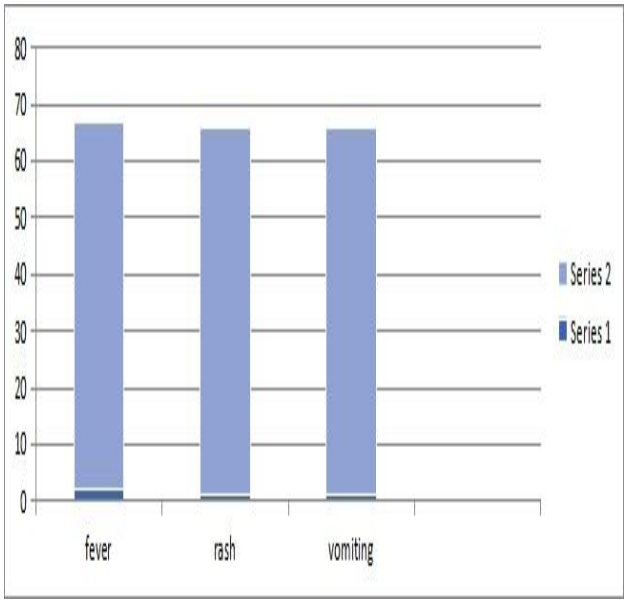

Figure 2: Side effects of IV iron sucrose.

Indices MCV, MCH, MCHC increased significantly over 3 months shown in the above line diagram Figure 1.

Very mild side effects were seen like two patients had mild fever, one patient had mild rash and one had vomiting which were managed with oral medications is shown in above bar diagram Figure 2.

DISCUSSION

The age distribution revealed that the majority of children belonged to the younger age groups. Specifically, 27 children (41.54%) were aged less than 12 months, and 32 children (49.23%) were in the age group of 13 to 36 months. Only 6 children (9.23%) were between 37 and 60 months of age. The mean age of the study population was 17.67 months with a standard deviation of 9.95 months.

Gender distribution in the present study showed, among 65 children enrolled. The 34 (52.31%) were males and 31 (47.69%) were females, indicating a slight male predominance. The male-to-female ratio was approximately 1.1:1, suggesting a nearly equal gender distribution.

In the current study, the majority of participants (46 children, 70.77%) were from rural areas, while only 19 children (29.23%) belonged to urban settings.

The baseline anthropometric assessment of the children enrolled in the study revealed significant levels of undernutrition. The mean weight at admission was 5.75 kg, with a standard deviation (SD) of 1.37 kg. The minimum recorded weight was 2.7 kg, and the maximum was 11 kg, indicating a wide range of nutritional deficits among the participants.

The mean height at admission was 71.46 cm (SD±8.41 cm), with the shortest child measuring 60 cm and the tallest 97 cm. These values reflect the presence of both stunting and wasting among the children. The mean mid-upper arm circumference (MUAC) was 10.51 cm (SD±0.64 cm), ranging from 9 cm to 12.5 cm. MUAC values below 11.5 cm are indicative of SAM, and the data confirm that all enrolled children met the anthropometric criteria for SAM

The mean blood sugar level (BSL) was 99.4mg/dL with a wide standard deviation of ±28.2, ranging from 60 to 168 mg/dL, with some children possibly presenting with stress-induced hyper-glycemia.[13,14]

In the present study on the role of IV iron therapy in children with SAM and IDA, the distribution of blood groups among the 65 participants was evaluated. The most common blood group observed was O+, found in 20 children (30.77%), followed closely by B+ in 19 children (29.23%). The A+ blood group was present in 16 children (24.62%), while AB+ was the least common, seen in 10 children (15.38%). At admission, the mean weight of the study population was 5.88±1.51 kg, the mean height was 71.4±8.41 cm, and the mean MUAC was 10.51±0.61 cm, consistent with severe malnutrition. At discharge, weight had increased to 6.11±1.30 kg and MUAC to 10.65±0.73 cm, indicating measurable nutritional improvement. As expected over the short study duration, height showed minimal change, with a mean of 71.1±8.62 cm. Follow-up assessments demonstrated progressive improvement in all anthropometric parameters.[15] By day 14, the mean weight had increased to 6.54±1.39 kg, with MUAC remaining stable at 10.61±0.66 cm. By the end of the first month, mean weight had risen to 6.94±1.52 kg, MUAC to 11.02±0.78 cm, and height to 72.4±8.6 cm. This upward trend persisted through the second and third months, with mean weights of 7.31±1.36 kg and 7.94±1.43 kg, respectively. Corresponding MUAC values improved to 11.28±0.84 cm and 11.57±0.96 cm, while height increased to 73.6±9.1 cm and 74.02±9.32 cm. Statistical analysis confirmed that changes in weight, height, and MUAC over time were highly significant ($p<0.001$ for all parameters.[16,17]

IV iron sucrose therapy

After stabilization, IV iron sucrose was administered in three divided doses, calculated individually using the Ganzoni formula. Ganzoni formula for iron requirement in (mg)=Body weight in kg×(Target Hb-actual Hb g/dl)×2.3+depot iron store needed (500 mg or 15 mg/kg for children<35 kg).[18] Total dose calculated is divided in 3 equal doses. Each dose was diluted in 50 mL of normal saline and infused over 30 to 45 minutes alternate days for 3 days. Vital parameters were monitored throughout the infusion, and any infusion-related adverse events were documented.[19]

Post-IV iron management and discharge

Following IV iron administration, patients were transitioned to oral iron supplementation (3 mg/kg/day) for three months to maintain the iron reserves.[21] At the time of discharge, comprehensive assessments were performed, including anthropometric measurements (weight, height, and mid-upper arm circumference [MUAC]) and hematologic parameters (Hb, serum ferritin, MCV, MCH, MCHC). A significant improvement was noted in serum ferritin levels, Hb concentration, and red cell indices, along with measurable gains in weight, height, and MUAC.

Anemia remains one of the most prevalent and debilitating complications among children with SAM, often compounding the already high morbidity and mortality associated with this vulnerable group. In the context of SAM, correction of anemia is particularly challenging due to multiple factors-poor dietary intake, impaired nutrient absorption, recurrent infections, and the limitations of conventional oral iron therapy, including poor tolerance, low adherence, and delayed hematologic response. Against this backdrop, the present study evaluated the role of IV iron therapy for anemia correction in children with SAM, assessing both its efficacy in improving Hb levels and its acceptability in terms of adherence.[22,23]

The findings from this study are promising and clinically relevant. Administration of IV iron in SAM patients resulted in a clear and measurable improvement in Hb

concentration over the study period, suggesting that this approach can address iron deficiency more rapidly and effectively than oral supplementation in this population. Notably, IV iron sucrose was well tolerated, with no serious adverse events recorded, indicating that when administered under strict medical monitoring, IV iron is safe even in children with compromised nutritional and physiological reserves. The parenteral route also bypassed key barriers that undermine the success of oral iron therapy in SAM, such as gastrointestinal intolerance, refusal due to poor palatability, and the irregular intake often seen in hospitalized malnourished children, leading to near-universal adherence in our cohort.

Correction of anemia in these children has the potential to enhance oxygen delivery, improve physical activity and alertness, support immune recovery, and possibly accelerate nutritional rehabilitation. While these secondary benefits were not the primary focus of this study, they represent important areas for future research, as the overall functional recovery of SAM patients extends far beyond laboratory parameters.

From a public health perspective, the results of this study highlight the value of integrating IV iron therapy into treatment protocols for SAM patients with moderate to severe anemia, especially in settings where oral therapy adherence is poor and rapid correction is clinically desirable. This is particularly relevant in resource-limited contexts, where prolonged hospital stays are costly, and early recovery can reduce the burden on healthcare systems. However, these findings should be interpreted with an understanding of the study's limitations, including the relatively small sample size and the absence of long-term follow-up to assess sustained hematologic improvement and relapse rates.[24-27]

CONCLUSION

In conclusion, IV iron therapy emerges from this study as a practical, effective, and well-tolerated treatment for anemia in children with SAM, especially where oral iron therapy is poorly tolerated, offering both clinical and logistical advantages. Its use could represent a paradigm shift in the management of anemia in this high-risk group, provided that further multicentric trials confirm its efficacy and safety across diverse healthcare settings. By enabling faster correction of anemia and ensuring high adherence, IV iron therapy has the potential to improve the trajectory of recovery for SAM patients, transforming what has long been a persistent obstacle in their rehabilitation into a manageable and promptly addressed component of care.

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