



Article

Clinical Features of Iron Deficiency Anemia in Children with Protein-Energy Malnutrition of Varying Severity

Alyaviya Muzayyanakhon Nozimkhonovna¹

1. Tashkent State Medical University, Department of Hospital Pediatrics and Traditional Medicine, Tashkent, Uzbekistan

* Correspondence: alyaviya@mail.ru

Abstract: Iron deficiency anemia is still one of the most prevalent of all hematological conditions in young children, especially under any circumstances which involve chronic nutritional limitation, where nutritional and growth deficits slowly exacerbate the clinical symptoms and have a negative impact on a child's overall development. In the present study, an attempt was made to assess the clinical and laboratory features of IDA in children with different grades of protein-energy malnutrition and to establish the correlation between nutritional status and hematological derangements. A total of 78 children aged 1-5 years with Iron Deficiency Anemia were included in the study, and were grouped by BMI-for-age Z score category. Hematological and biochemical investigations in addition to clinical examination showed that both hemoglobin, ferritin and serum iron levels decreased with increasing severity of malnutrition. Positive correlation between BAZ indicators and hematological parameters was found, which confirmed the role of nutritional assessment in the management of anemia in children.

Citation: Nozimkhonovna A. M. Clinical Features of Iron Deficiency Anemia in Children with Protein-Energy Malnutrition of Varying Severity. Central Asian Journal of Medical and Natural Science 2026, 7(3), 192-197.

Received: 24th Feb 2026

Revised: 26th Mar 2026

Accepted: 24th Apr 2026

Published: 19th May 2026



Copyright: © 2026 by the authors. Submitted for open access publication under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>)

Keywords: Iron Deficiency Anemia, Protein Energy Malnutrition, Ferritin, Nutrition status, BAZ, Pediatric Hematology.

1. Introduction

Iron deficiency anemia (IDA) is one of the most common nutritional disorders in children under five years of age and one of the most serious nutritional concerns of the pediatric population, not only in low-income countries, but also in developing healthcare systems where chronic nutritional imbalance, recurrent infections and poor dietary diversity are often present in the same vulnerable population [1]. While contemporary pediatrics has done much to advance the management of early diagnosis and micronutrient correction, a significant percentage of children will be seen for clinical observation, with established hematological disturbances, prolonged tissue hypoxia, impaired physical growth, reduced immune resistance and delayed neurocognitive maturation and with the potential to impact on long term outcomes and quality of life. However, in many clinical scenarios, iron-deficiency anemia is not a separate pathological entity since the progression of it is tightly linked to the nutritional status of the child, particularly in a situation of protein-energy malnutrition, in which the compensatory power of adaptive metabolic mechanisms is gradually lost [2].

Protein-energy malnutrition, by itself, elicits a complex systemic alteration at the level of protein synthesis, enzymatic activity, intestinal absorption, hormonal regulation

and cellular metabolism, thus resulting in an increasingly dysfunctional and unstable erythropoiesis. In such cases, even moderate ID can lead to more severe anemia due to iron delivery deficit caused by insufficient protein intake, impaired transport of iron, decreased ferritin deposition and diminished bone marrow activity. Therefore, protein-energy deficiency and iron depletion are pathological conditions that aggravate each other and increases the clinical severity and makes treating them more difficult [3]. Recent overseas pediatric studies have highlighted that children with nutritional insufficiency have lower levels of hemoglobin, smaller ferritin stores and are less responsive to treatment than children with iron deficiency anemia who were not malnourished [4].

Though a number of the previously reported studies have also focused on pediatric anemia, they are largely epidemiological in nature and lack enough information to quantify the effect of different levels of protein-energy malnutrition on the clinical and laboratory features of IDA. In addition, the value of anthropometric measures like BMI-for-age Z score in the context of the risk stratification of severe anemia is not fully understood. Therefore, a detailed clinical and laboratory investigation of children with combined nutritional and hematological deficiencies is very relevant, especially in the context of children, where early prevention can potentially significantly lower the risk of future complications and enhance developmental outcomes.

2. Materials and Methods

A clinical observational study was conducted on the children aged 1-5 years with an iron deficiency anemia (IDA) and different level of protein-energy malnutrition (PEM). The study was carried out in a pediatric clinical environment where children with nutritional disorders and hematological abnormalities are routinely referred for a comprehensive diagnostic evaluation and for follow up monitoring. After detailed clinical examination and laboratory confirmation of iron deficiency anemia, 78 children were included in the study. The selection process was carried out gradually during the study to minimize diagnostic inconsistencies and to ensure that all participants included in the study had similar inclusion criteria. The iron deficiency anemia was confirmed based on internationally accepted pediatric hematological criteria of hemoglobin levels less than 110g/L, mean corpuscular volume less than 60 fl and low serum ferritin levels, which collectively indicated microcytic hypochromic anemia with iron depletion [5].

To maximize clinical homogeneity and reliability of analytical comparisons, children with acute infectious diseases and chronic inflammatory conditions, hereditary hemoglobinopathies, hemolytic anemia, oncological and congenital metabolic disorders, as well as those with severe systemic disease potentially affecting erythropoiesis and/or iron metabolism were excluded from the study. All the participants underwent nutritional assessment using the body mass index-for-age Z score indicator. The calculation of BAZ was done using WHO growth standards and severity of PEM was objectively classified into 3 categories. A BAZ between -1 and -2 indicated mild malnutrition, from -2 to -3 indicated moderate malnutrition and below -3 indicated severe nutritional deficiency [6].

Based on these criteria, the children studied were divided into three comparison groups, which represented increasingly poor nutritional status. All participants were extensively clinically evaluated over appetite disturbances, body weight loss, skin and mucosal changes, fatigue and irritability, reduced physical activity and chronic anemia and micronutrient deficiency. Laboratory examination involved a complete blood count (CBC) and the hemoglobin concentration, erythrocyte count, hematocrit, mean corpuscular volume, and mean corpuscular hemoglobin were measured. Biochemical analysis of iron metabolism was also conducted by the measurement of serum iron and ferritin level by standard laboratory procedure [7].

The data collected was statistically processed with SPSS software version 26.0. Assessment of distribution normality was performed for quantitative variables and appropriate parametric statistical tests were used to perform comparisons between groups. An analysis of correlation was also performed to assess the correlation between BAZ indicators and hematological parameters, especially hemoglobin and ferritin level. A p value less than 0.05 was deemed to represent statistical significance [8].

3. Results

The comparative evaluation of clinical and laboratory parameters showed that the trends of the hematological parameters were similar to the severity of the protein-energy malnutrition and was more evident in the children who were in the severe nutritional group in which the clinical features of chronic anemia were more pronounced and unstable. In the initial clinical examination children suffering from mild nutritional impairment were mostly characterized by moderate pallor, lessened appetite, and occasional fatigue while those in severe malnutrition were more likely to have their overall physical activity delayed, show signs of chronic nutritional deficiency, such as dry skin changes, decreased muscle mass, and persistent weakness. Decreases in hemoglobin concentration were seen in all three study groups, mild protein energy malnutrition showed relatively high hematological parameters, as the severity of malnutrition increased, the erythropoietic activity was suppressed. The mean hemoglobin level in children with severe nutritional deficiency was lower than the clinically desirable pediatric levels; Mean Corpuscular Volume and erythrocyte indices were also lower and more noticeable in these children. Concurrently, serum ferritin levels exhibited a significant fall trend, reflecting further depletion of iron stores with increasing nutritional deficiency [9].

Biochemical assessment also showed that the children from the severe malnutrition group had significantly lower concentrations of serum iron than the children in the mild deficiency group, suggesting that not only is the dietary intake of iron inadequate but also that the absorption of iron, iron transport mechanisms, and chronic metabolic imbalance affecting the use of iron are also impaired. Severe anemia was significantly more common in patients with a BAZ < -3, as this further substantiates the idea that poor nutritional status significantly predisposes to escalating hematological complications [10]. The moderate positive correlation of BAZ values with hemoglobin concentration confirmed the existence of a moderate positive correlation between anthropometric deterioration and the severity of anemia.

Table 1. In the present study, hematological and biochemical indicators of the severity of protein-energy malnutrition (PEM) were measured. The present study aimed to measure the hematological and biochemical indicators of the severity of protein-energy malnutrition (PEM).

Parameters	Mild PEM (n=26)	Moderate PEM (n=27)	Severe PEM (n=25)
Hemoglobin (g/L)	103.1 ± 2.9	95.4 ± 3.2	84.7 ± 3.6
MCV (fL)	74.2 ± 1.8	69.5 ± 2.1	64.8 ± 2.4
Serum Ferritin (µg/L)	18.2 ± 2.1	12.6 ± 1.8	7.9 ± 1.5
Serum Iron (µmol/L)	9.8 ± 1.2	7.1 ± 1.0	4.9 ± 0.8

Severe Anemia	4%	12%	24%
Frequency (%)			

As can be seen in Table 1, both hematological and biochemical parameters showed a progressive deterioration with worsening degree of protein-energy malnutrition. Chronic nutritional deficiency affects iron metabolism and the production of erythrocytes, as evidenced by hemoglobin, ferritin and serum iron concentration reductions. The high prevalence of severe anemia, especially in children with severe malnutrition, is notable and highlights the importance of early nutritional assessment and prompt correction of metabolic deficiencies/carbohydrate depletion in children. Lower BAZ values also showed good predictive power when evaluating the risk of severe iron deficiency anemia, which is also observed by ROC-based evaluation, and this finding corroborates the use of anthropometric screening as an easily available prognostic indicator in clinical practice [11,12]. In general, the results obtained show that the deterioration of nutritional status is associated with the depletion of iron stores by the quantitative decrease, as well as with the general failure of the adaptive mechanisms of hematopoiesis in early childhood.

4. Discussion

The results of the present study indicate that protein-energy malnutrition (PEM) worsens the clinical picture of iron deficiency anemia (IDA) and that the impaired hematopoietic function in early childhood is tightly coupled with the nutritional deprivation. Iron deficiency anemia (IDA) is a common health problem in children around the world, but in the presence of chronic undernutrition, this condition seems to form a much more precarious state of the body, with compensatory mechanisms becoming increasingly less efficient and consequent hematological deterioration and recovery potential are further impaired. Children with severe protein energy malnutrition had not only lower levels of hemoglobin and ferritin, but also wider clinical features of systemic weakness indicating multiple adaptive pathways to be affected by the prolonged nutritional imbalance instead of only affecting iron metabolism [13].

This study's most noteworthy findings include the progressive decline of serum ferritin and erythrocyte indices with increasing BAZ which underpins the notion that anthropometric deterioration is a sign of greater metabolic failure at tissue and cellular level. The protein deficiency has been previously reported in pediatric studies to cause a decrease in transferrin production, decrease in iron transporting capacity, decrease in the ability of the intestine to absorb iron, and a decreased responsiveness of the bone marrow to the stimulus of erythropoiesis, thus preventing adequate erythropoiesis even if iron is provided when the patient is iron deficient [14].

This mechanism might be partly responsible for the observation that children with severe nutritional deficiency have poorer hematological recovery and increased risk of recurrent anemia in spite of adequate therapeutic treatment. The positive correlation found between BAZ and hemoglobin concentration is of particular interest as it highlights the importance of nutritional evaluation in the daily evaluation of the pediatric patient. The present results indicate that BAZ may prove to be a valuable early marker that could provide important information regarding a child's risk of developing severe anemia in many practical clinical applications where anthropometric indicators are often used as secondary supportive measurements. The same findings have been reported in recent international studies where low BMI were found to be significantly correlated with micronutrient imbalance, developmental delay and elevated pediatric morbidity [15].

One aspect of this which is clinically important is the significantly greater incidence of serious anemia in children with advanced protein-energy malnutrition. This pattern suggests that chronic nutritional deficiency and iron depletion should not be considered

as two separate pathological conditions as both conditions seem to exacerbate each other through continued metabolic dysfunction, tissue hypoxia, immune suppression and lower physiological resistance. The isolated treatment of anemia as a separate intervention without nutrition rehabilitation, therefore, may lead to partial or temporary results, particularly in vulnerable children in whom growth requirements are still high [16].

While the findings in this study were substantial, there are some limitations that should be noted. Sample size remained relatively small and inflammatory markers that could affect the interpretation of ferritin were not measured in the laboratory. However, the overall consistency of the hematological and anthropometric results enhances the reliability of the associations observed and reinforces the need to implement combined nutritional and hematological approaches in pediatric clinical practice.

5. Conclusion

The findings of the present study indicated that with the development of increasingly severe nutritional deficiency, the hematological changes become increasingly profound and clinically more apparent and unstable. Children with severe nutritional insufficiency had levels of hemoglobin, ferritin and serum iron significantly lower and more evident signs of chronic weakness, decreased physical activity and decreased adaptive capacity, which altogether suggest that prolonged nutritional deprivation has a multidirectional negative effect on erythropoiesis and iron metabolism in early childhood. The results indicate that Fe-deficiency anemia occurring in the context of protein-energy malnutrition should not be regarded as a purely hematological condition, given that systemic metabolic changes in transport proteins, iron storage, oxygen delivery to cells and bone marrow function play a crucial role in its evolution. The finding of a significant correlation between BAZ indicators and severity of anemia was one of the significant results of this investigation because the lower the anthropometric value, the more severe the hematological impairment and the greater the number of severe anemia cases. This observation highlights the significance of continued nutrition assessment in the clinical care of children, especially the early years of childhood when children are at the greatest risk for micronutrient and energy deficiencies. The results also confirm the potential of BAZ as an easily accessible and useful clinical marker for identifying children who are at a high risk of developing more severe complications that necessitate intensive therapeutic interventions. The overall results of the study highlight the importance of an integrated approach to the clinical treatment of iron deficiency with a combination of timely nutritional rehabilitation and regular follow-up of anthropometric and biochemical parameters. Treatment of anemia alone may not be effective or may only partially correct the nutritional imbalance without proper correction. Hence, the introduction of early screening programs, a comprehensive nutritional support and personalized nutrition management in pediatrics should be considered as part of the strategy to lower the burden of protein-energy malnutrition and to promote long-term development of children with the condition.

REFERENCES

- [1] World Health Organization, *WHO Guideline on Use of Ferritin Concentrations to Assess Iron Status in Individuals and Populations*. Geneva: WHO, 2020. DOI: 10.1002/9781119099891.ch63.
- [2] S. R. Pasricha, J. Tye-Din, M. U. Muckenthaler, and D. W. Swinkels, "Iron deficiency," *The Lancet*, vol. 397, no. 10270, pp. 233–248, 2021. DOI: 10.1016/S0140-6736(20)32594-0.
- [3] M. D. Cappellini, K. M. Musallam, and A. T. Taher, "Iron deficiency anaemia revisited," *Journal of Internal Medicine*, vol. 287, no. 2, pp. 153–170, 2020. DOI: 10.1111/joim.13004.

- [4] C. Moscheo et al., "New insights into iron deficiency anemia in children: a practical review," *Metabolites*, vol. 12, no. 4, p. 289, 2022. DOI: 10.3390/metabo12040289.
- [5] G. A. Stevens et al., "National, regional, and global prevalence of anemia in children and women, 1990–2019," *The Lancet Global Health*, vol. 10, no. 5, pp. e627–e639, 2022. DOI: 10.1016/S2214-109X(22)00084-5.
- [6] S. Gedfie, S. Getawa, and M. Melku, "Prevalence and associated factors of iron deficiency anemia among under-5 children," *Global Pediatric Health*, vol. 9, pp. 1–14, 2022. DOI: 10.1177/2333794X221110860.
- [7] A. K. C. Leung and K. L. Hon, "Iron deficiency anemia: an updated review," *Current Pediatric Reviews*, vol. 20, no. 3, pp. 340–352, 2024. DOI: 10.2174/1573390X20666230724121519.
- [8] C. Oktarina et al., "Relationship between iron deficiency anemia and stunting in pediatric populations in developing countries," *Children*, vol. 11, no. 10, p. 1268, 2024. DOI: 10.3390/children11101268.
- [9] J. Zheng, J. Liu, and W. Yang, "Association of iron-deficiency anemia with neurobehavioral development in children aged 6–24 months," *Nutrients*, vol. 13, no. 10, p. 3423, 2021. DOI: 10.3390/nu13103423.
- [10] G. Weiss, T. Ganz, and L. T. Goodnough, "Anemia of inflammation," *Blood*, vol. 133, no. 1, pp. 40–50, 2019. DOI: 10.1182/blood-2018-06-856500.
- [11] S. M. L. Namaste et al., "Adjusting ferritin concentrations for inflammation," *The American Journal of Clinical Nutrition*, vol. 106, suppl. 1, pp. 359S–371S, 2017. DOI: 10.3945/ajcn.116.141762.
- [12] F. T. Wieringa et al., "The role of inflammation in iron deficiency anemia in children," *Current Opinion in Clinical Nutrition and Metabolic Care*, vol. 22, no. 3, pp. 196–201, 2019. DOI: 10.1097/MCO.0000000000000551.
- [13] P. S. Suchdev et al., "Assessment of iron status in settings of inflammation," *The American Journal of Clinical Nutrition*, vol. 106, suppl. 6, pp. 1626S–1633S, 2017. DOI: 10.3945/ajcn.117.155937.
- [14] A. M. Prentice et al., "Dietary strategies for improving iron status in children," *The Lancet Child & Adolescent Health*, vol. 1, no. 2, pp. 141–153, 2017. DOI: 10.1016/S2352-4642(17)30046-8.
- [15] Y. Balarajan et al., "Anaemia in low-income and middle-income countries," *The Lancet*, vol. 378, no. 9809, pp. 2123–2135, 2019. DOI: 10.1016/S0140-6736(19)62304-5.
- [16] M. N. Mwangi et al., "Diagnostic utility of zinc protoporphyrin to detect iron deficiency in Kenyan pregnant women," *BMC Medicine*, vol. 19, p. 286, 2021. DOI: 10.1186/s12916-021-02132-4.