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Research Article

ANALYSIS OF MENTZER INDEX IN CHILDREN PRESENTING WITH MICROCYTIC HYPOCHROMIC ANEMIA: A CROSS-SECTIONAL STUDY

ARINDAM GHOSH*, DEBDEEP DASGUPTA, SUSUMNA BISWAS

Department of Physiology, Bankura Sammilani Medical College and Hospital, Bankura, West Bengal, India.
***Corresponding author: Arindam Ghosh; Email: arindam01998@gmail.com**

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ABSTRACT

Objective: The objective of the study was to analyze Mentzer index in pediatric patients presenting with microcytic anemia.

Methods: This was a cross-sectional study conducted in the Department of Physiology of a tertiary care medical institute. One hundred and twenty children below the age of 12 years and having microcytic hypochromic anemia were included in this study on the basis of predefined criteria. Mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), MCH concentration (MCHC), and Mentzer index were analyzed from complete blood count reports. Those with a Mentzer index more than 13 were advised further workup to rule out possibility of thalassemia. SPSS 22.0 software was used for statistical analysis and $p<0.05$ was taken as statistically significant.

Results: Out of 120 studied cases, there were 71 (59.17%) boys and 49 (40.83%) girls. There was a male predominance among the studied cases with M: F ratio being 1:0.69. The mean age of boys (8.12±3.13) and girls (7.82±2.98) was found to be comparable with no statistically significant difference. Fatigue was the most common complaint, with 52 boys (73.24%) and 36 girls (73.47%) reporting it. Pallor was observed in 51 boys (71.83%) and 35 girls (71.43%). MCV, MCH, and MCHC values were comparable in boys and girls whereas red cell distribution width was higher in girls as compared to boys and the difference was statistically significant ($p=0.02$). Most of the patients (92.5%) had a Mentzer index of more than 13; however, 7.5% of cases were found to have a Mentzer index below 13. Patients with a Mentzer index <13 were advised further investigations to rule out other causes of microcytic hypochromic anemia including beta-thalassemia.

Conclusion: The Mentzer index provides a simple and effective tool for differentiating between iron deficiency anemia and thalassemia, especially in resource-limited settings, enhancing diagnostic accuracy and improving patient outcomes.

Keywords: Microcytic hypochromic anemia, Mentzer index, Iron deficiency anemia, Thalassemia.

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INTRODUCTION

Anemia is defined as a condition characterized by a deficiency in the number of red blood cells (RBC) or their hemoglobin (Hb) content, leading to a reduced oxygen-carrying capacity of the blood. This deficiency results in various physiological impairments depending on the severity and duration of anemia [1]. Anemia is a significant public health issue worldwide, particularly affecting children and pregnant women. In pediatric populations, anemia is especially concerning due to its potential impact on growth, cognitive development, and overall health. The World Health Organization (WHO) sets Hb thresholds for diagnosing anemia, which varies by age, sex, and physiological status, such as pregnancy [2].

Anemia is particularly common in the pediatric age group for several reasons. During periods of rapid growth, such as infancy and adolescence, the body's demand for iron and other nutrients essential for Hb production increases substantially. Infants and young children are especially vulnerable due to their high iron requirements for growth and development [3]. In many low- and middle-income countries, dietary deficiencies are prevalent, leading to inadequate intake of iron, Vitamin B12, folate, and other micronutrients essential for hematopoiesis. Furthermore, infections, both acute and chronic, contribute significantly to the high prevalence of anemia in children. Infections can lead to anemia through various mechanisms, including direct destruction of RBCs, increased blood loss, and chronic inflammation, which can interfere with iron metabolism and erythropoiesis [4].

Morphological classification of anemia provides critical clues to its etiology and guides further diagnostic evaluation. The primary morphological types of anemia are microcytic hypochromic anemia, normocytic normochromic anemia, and macrocytic anemia. Microcytic hypochromic anemia is characterized by smaller-than-normal and paler RBCs, often indicative of iron deficiency or thalassemia. Normocytic normochromic anemia, where RBCs are of normal size and color but reduced in number, is commonly seen in chronic diseases, acute blood loss, and hemolysis. Macrocytic anemia, marked by larger-than-normal RBCs, typically results from deficiencies in Vitamin B12 or folate [5].

Microcytic hypochromic anemia is particularly prevalent in pediatric populations. The most common causes of microcytic hypochromic anemia in children are iron deficiency and thalassemia [6]. The pathophysiology of microcytic hypochromic anemia involves several mechanisms. In iron deficiency anemia (IDA), the lack of iron leads to impaired Hb synthesis, resulting in the production of smaller and paler RBCs. Iron is a crucial component of Hb, and its deficiency disrupts the normal process of erythropoiesis, leading to the production of microcytic and hypochromic erythrocytes. In thalassemia, genetic mutations result in the defective production of globin chains, which are essential components of the Hb molecule. This defect leads to ineffective erythropoiesis, increased destruction of erythroid precursors in the bone marrow, and the production of microcytic hypochromic RBCs [7].

Two common causes of microcytic hypochromic anemia in children, IDA, and beta-thalassemia, have distinct pathophysiological

mechanisms and clinical implications. IDA results from insufficient iron to meet the demands of Hb synthesis. This can be due to inadequate dietary intake, malabsorption, or chronic blood loss [8]. In children, iron deficiency can lead to impaired cognitive and motor development, increased susceptibility to infections, and overall growth retardation. Thalassemia, a hereditary hemoglobinopathy, results in the reduced or absent synthesis of one or more of the globin chains that constitute Hb. Depending on the type and severity of the mutation, thalassemia can range from mild, asymptomatic carriers to severe forms requiring regular blood transfusions and extensive medical care. While iron supplementation is necessary in the treatment of IDA, its administration in thalassemia can lead to dangerous iron overload [9].

The Mentzer index, calculated as the mean corpuscular volume (MCV) divided by the RBC count, is a valuable tool in differentiating between IDA and thalassemia in children presenting with microcytic hypochromic anemia. A Mentzer index >13 suggests IDA, while a value <13 is indicative of thalassemia. This index is particularly useful in clinical settings where advanced diagnostic facilities may not be readily available, providing a simple yet effective means to guide initial diagnostic and therapeutic decisions [10].

Despite the widespread use of the Mentzer index and its established role in the differential diagnosis of microcytic hypochromic anemia, there remains a significant knowledge gap regarding its sensitivity and specificity across diverse pediatric populations. We undertook this study to analyze the Mentzer index in children presenting with microcytic hypochromic anemia.

METHODS

This was a cross-sectional study conducted in the department of physiology of a tertiary care peripheral*medical college situated in a state of eastern India. One hundred and twenty patients with microcytic hypochromic anemia were included in this study on the basis of predefined inclusion and exclusion criteria. The duration of the study was 1 year. Sample size was calculated on the basis of pilot studies done on the topic of pathophysiology and etiological causes of microcytic anemia. Keeping power (1-Beta error) at 80% and confidence interval (1-Alpha error) at 95%, the minimum sample size required was 105 patients; therefore, we included 120 cases having microcytic hypochromic anemia in our study.

The detailed history including dietary history was obtained from parents or guardians of cases. Presenting complaints were also asked for and noted. Complete blood count reports of the patients were analyzed. As the first step, severity of anemia was determined. Anemia was diagnosed based on the WHO criteria [11]. Specifically, children with a Hb level below 12 g/dL were considered anemic. Severe anemia was identified with an Hb level below 7 g/dL, moderate anemia with Hb levels between 7 g/dL and 9.9 g/dL, and mild anemia with Hb levels from 10 g/dL to 11.9 g/dL. The Mentzer index was calculated in all cases by dividing the MCV in femtoliters by the RBC count in millions per microliter, using data from complete blood count reports. Following the initial diagnosis of anemia and calculation of the Mentzer index, a detailed analysis of the peripheral blood smear was conducted for all patients. The peripheral smears were examined for RBC size, shape, and color, focusing particularly on identifying features indicative of microcytic hypochromic anemia. Only patients with microcytic hypochromic anemia were included in the study.

Statistical analysis was performed using SPSS version 22.0 software. Quantitative data were expressed as mean and standard deviation, while qualitative data were represented using incidence and percentage tables. For the analysis of quantitative data, an unpaired t-test was utilized, and the Chi-square test was applied to qualitative data. $p<0.05$ was considered statistically significant.

Inclusion criteria

The following criteria were included in the study:

1. Children having microcytic hypochromic anemia on peripheral smear
2. Age <12 years
3. Guardians ready to give informed consent to be part of the study.

Exclusion criteria

The following criteria were excluded from the study:

1. Age above 12 years
2. Refusal to give informed and written consent to be part of the study by guardians
3. Patients with comorbid hematological conditions such as leukemia, lymphoma, multiple myeloma, and aplastic anemia
4. Other types of anemia such as autoimmune hemolytic anemia and megaloblastic anemia.
5. History of blood transfusion in the recent past that is likely to affect the Mentzer index.

RESULTS

Out of 120 studied cases, there were 71 (59.17%) boys and 49 (40.83%) girls. There was a male predominance among the studied cases with M:F ratio being 1:0.69 (Fig. 1).

The analysis of the age distribution among boys and girls in the studied cases showed that for children <4 years old, there were 12 boys (10.00%) and 7 girls (5.83%). In the 4–7 years age group, there were 29 boys (24.17%) and 20 girls (16.67%). Among children aged 8–10 years, there were 17 boys (14.17%) and 12 girls (10.00%). In the 11–12 years age group, there were 13 boys (10.83%) and 10 girls (8.33%). The mean age of boys (8.12±3.13) and girls (7.82±2.98) was found to be comparable with no statistically significant difference ($p=0.59$) (Table 1).

The analysis of the presenting complaints among boys and girls revealed that fatigue was the most common complaint, with 52 boys (73.24%) and 36 girls (73.47%) reporting it. Pallor was observed in 51 boys (71.83%) and 35 girls (71.43%). Anorexia affected 40 boys (56.34%) and 28 girls (57.14%). Breathlessness was reported by 20 boys (28.17%) and 14 girls (28.57%), while irritability was noted in 15 boys (21.13%) and 10 girls (20.41%). PICA was the least common, affecting 12 boys (16.90%) and 9 girls (18.37%). The presenting complaints were comparable in boys and girls with no statistically significant difference ($p>0.05$) (Table 2).

The analysis of the severity of anemia among boys and girls indicated that mild anemia (10–11.9 g/dL) was the most prevalent, affecting 35 boys (29.17%) and 27 girls (22.50%). Moderate anemia (7–9.9 g/dL)

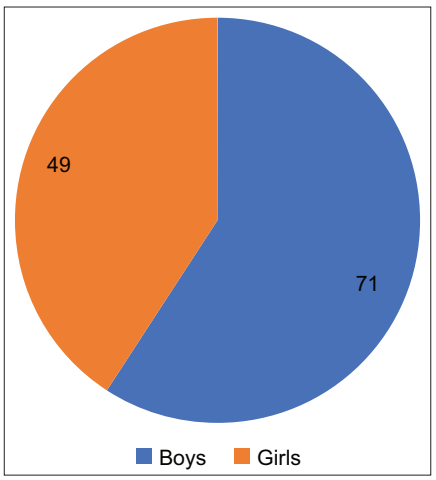

Fig. 1: Gender distribution of the studied cases

Table 1: Gender-wise age distribution of studied cases

Age distribution	Boys		Girls	
	Number of cases	Percentage	Number of cases	Percentage
Less than 4 years	12	10.00	7	5.83
4–7 years	29	24.17	20	16.67
8–10 years	17	14.17	12	10.00
11–12 years	13	10.83	10	8.33
Total	71	59.17	49	40.83
Mean age (years)	8.12±3.13		7.82±2.98	

p=0.5997 (not significant)

Table 2: Presenting complaints in studied cases

Presenting complaints	Boys		Girls		Significance
	Number	Percentage	Number	Percentage	
Fatigue	52	73.24	36	73.47	p>0.05
Pallor	51	71.83	35	71.43	p>0.05
Anorexia	40	56.34	28	57.14	p>0.05
Breathlessness	20	28.17	14	28.57	p>0.05
Irritability	15	21.13	10	20.41	p>0.05
PICA	12	16.90	9	18.37	p>0.05

was observed in 21 boys (17.50%) and 14 girls (11.67%). Severe anemia (<7 g/dL) was found in 15 boys (12.50%) and 8 girls (6.67%) (Table 3).

Boys had a MCV of 69.36 fL (±4.44), mean corpuscular hemoglobin (MCH) of 21.97 pg (±3.97), MCH concentration (MCHC) of 28.15 g/dL (±2.98), and red cell distribution width (RDW) of 15.87% (±2.12). In comparison, girls had an MCV of 73.00 fL (±4.03), MCH of 23.09 pg (±3.24), MCHC of 27.09 g/dL (±3.10), and RDW of 16.81% (±2.46). MCV, MCH, and MCHC values were comparable in boys and girls, whereas RDW was higher in girls as compared to boys, and the difference was statistically significant (p=0.02) (Table 4).

Mentzer index of all patients was studied. It was found that most of the patients (92.5%) had a Mentzer index of more than 13 thereby suggesting that the primary pathology was likely to be iron deficiency; however, 7.5% of cases were found to have a Mentzer index below 13 making it necessary to advice further investigations such as iron studies and Hb electrophoresis to rule out other causes of microcytic hypochromic anemia including beta-thalassemia. Therefore, those patients with Mentzer index were advised to temporarily stop iron supplementation, and further, investigations were advised before resuming iron supplementation [Table 5].

Table 3: Severity of anemia in studied cases

Severity of anemia	Boys		Girls	
	Number	Percentage	Number	Percentage
Mild (10–11.9 g/dL)	35	29.17	27	22.50
Moderate (7–9.9 g/dL)	21	17.50	14	11.67
Severe (<7 g/dL)	15	12.50	8	6.67
Total	71	59.17	49	40.83

DISCUSSION

IDA as well as thalassemia usually present as microcytic hypochromic anemia [11]. Given the distinct pathophysiological mechanisms and management strategies required for these conditions, accurate differentiation is the cornerstone of management. Misdiagnosis of thalassemia as IDA can lead to inappropriate iron supplementation, resulting in harmful iron overload in thalassemia patients [12]. Mentzer index can be used for such differentiation in resource-limited settings, providing an accessible means to guide initial diagnostic and therapeutic decisions. Integrating simple yet effective screening tests such as the Mentzer index into routine clinical practice will prevent the adverse consequences of iron supplementation in thalassemia and improve patient outcomes [13]. In our study, most of the patients (92.5%) had a Mentzer index of more than 13; however, 7.5% of cases were found to have a Mentzer index below 13.

Tabassum *et al*. conducted a cross-sectional study to observe the role of the Mentzer index in differentiating IDA and beta-thalassemia trait (β TT) in pregnant women [14]. The study was conducted from October 2020 to March 2021, including 100 antenatal women with Hb <11 g/dL. The Mentzer index was calculated and diagnoses were confirmed by serum iron studies and Hb electrophoresis. Results showed a Mentzer index sensitivity and specificity of 91% and 83% for IDA, and 83% and 91% for β TT, respectively. On the basis of these findings, the authors concluded that the Mentzer index can be used as a discriminatory test for IDA and β TT, facilitating better patient compliance and cost-effectiveness. Similar findings were also reported by the authors such as Amer [15] and Hoffmann *et al*. [16].

Shah *et al*. conducted a cross-sectional and observational study to evaluate the reliability of the Mentzer index in differentiating beta-thalassemia trait (β TT) from IDA [17]. The study included 59 patients diagnosed with IDA and 59 patients diagnosed with β TT from August 2019 to July 2020, using simple random sampling. The Mentzer index correctly identified 95.76% of patients. Sensitivity and specificity for β TT were 93.2% and 98.3%, respectively, and for IDA, 98.3% and 93.2%, respectively. On the basis of these findings, the authors concluded that the Mentzer index is a reliable screening method, especially in resource-poor settings, though further confirmation by gold standard tests is recommended. The findings and conclusion of this study were similar to our study our study also identified 7.5% of cases with Mentzer index less than 13 who were being given iron supplementation presuming the anemia to be secondary to iron deficiency. Similar findings were also reported in the studies conducted by Bhargava *et al*. [18] and Sherali *et al*. [19].

Due to the high prevalence of IDA and thalassemia among individuals with normal Hb values, applying the Mentzer index across the entire population might give false-positive results. However, when the Mentzer index is determined specifically in children with microcytic (low MCV) and hypochromic (low MCH and MHC) anemia, it may reliably differentiate the cases with IDA and thalassemia [20].

Table 4: MCV, MCH, MCHC, and RDW in studied cases

Gender	Number of cases	MCV (fL)	MCH (pg)	MCHC (g/dL)	RDW (%)
Boys	71	67.86±4.44	20.97±3.97	26.15±2.98	15.87±2.12
Girls	49	69.02±4.03	21.09±3.24	25.09±3.10	16.81±2.46
p-value		0.14	0.86	0.06	0.02*

MCV: Mean corpuscular volume, MCH: Mean corpuscular hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, RDW: Red cell distribution width

Table 5: Mentzer index in studied cases

Mentzer index	No of cases	Percentage
Mentzer index 13 or above	111	92.5
Mentzer index below 13	9	7.5
Total	120	100

CONCLUSION

IDA and thalassemia both present as microcytic hypochromic anemia but require distinct management strategies. Misdiagnosis can lead to inappropriate treatments, such as iron overload in thalassemia patients. The Mentzer index offers a simple, effective tool for differentiation, particularly in resource-limited settings, improving diagnostic accuracy and patient outcomes.

CONFLICTS OF INTEREST

None.

REFERENCES

1. Chaparro CM, Suchdev PS. Anemia epidemiology, pathophysiology, and etiology in low-and middle-income countries. Ann N Y Acad Sci. 2019;1450(1):15-31. doi: 10.1111/nyas.14092, PMID 31008520
2. Hamed E, Syed MA, Alemrayat BF, Tirmizi SH, Alnuaimi AS. Haemoglobin cut-off values for the diagnosis of anaemia in preschool-age children. Am J Blood Res. 2021;11(3):248-54. PMID 34322287.
3. Gallagher PG. Anemia in the pediatric patient. Blood. 2022;140(6):571-93. doi: 10.1182/blood.2020006479, PMID 35213686.
4. Wiciński M, Liczner G, Cadelski K, Kołnierzak T, Nowaczewska M, Malinowski B. Anemia of chronic diseases: Wider diagnostics-better treatment? Nutrients. 2020;12(6):1784. doi: 10.3390/nu12061784, PMID 32560029.
5. Clinton O, Micheal K, Namyalo Angella K, Mary M, Mike M, Muwanguzi E, *et al*. Anaemia, morphological classification and its associated risk factors among lactating mothers at Mbarara City Council Health Centre IV, Southwestern Uganda. J Blood Med. 2022;13:473-81. doi: 10.2147/JBM.S367453, PMID 36081646.
6. Aydogan G, Keskin S, Akici F, Salcioglu Z, Bayram C, Uysalol EP, *et al*. Causes of hypochromic microcytic anemia in children and evaluation of laboratory parameters in the differentiation. J Pediatr Hematol Oncol. 2019;41(4):e221-3. doi: 10.1097/MPH.0000000000001382, PMID 30557168.
7. Schrier SL. Pathophysiology of thalassemia. Curr Opin Hematol. 2002;9(2):123-6. doi: 10.1097/00062752-200203000-00007, PMID 11844995.
8. Aksu T, Ünal Ş. Iron deficiency anemia in infancy, childhood, and adolescence. Turk Arch Pediatr. 2023;58(4):358-62. doi: 10.5152/TurkArchPediatr.2023.23049, PMID 37357449.
9. Mishra AK, Tiwari A. Iron overload in Beta thalassaemia major and intermedia patients. Maedica (Bucur). 2013;8(4):328-32. PMID 24790662.
10. Lawrie D, Glencross DK. Use of the Mentzer index will assist in early diagnosis of iron deficiency in South African children. S Afr Med J. 2015;105(9):702-3. doi: 10.7196/samjnew.8589, PMID 26636161.
11. Chaudhry HS, Kasarla MR. Microcytic hypochromic anemia. In: StatPearls. Treasure Island, FL: StatPearls Publishing. Aug 14, 2023.
12. Bayanzay K, Alzoebie L. Reducing the iron burden and improving survival in transfusion-dependent thalassemia patients: Current perspectives. J Blood Med. 2016;7:159-69. doi: 10.2147/JBM.S61540, PMID 27540317 [published correction appears in J Blood Med. 2016 Oct 21;7(7):233-4. doi: 10.2147/JBM.S120071. doi: 10.2147/JBM.S120071].
13. Powers JM, Daniel CL, McCavit TL, Buchanan GR. Deficiencies in the management of iron deficiency anemia during childhood. Pediatr Blood Cancer. 2016;63(4):743-5. doi: 10.1002/pbc.25861, PMID 26728130.
14. Tabassum S, Khakwani M, Fayyaz A, Taj N. Role of Mentzer index for differentiating iron deficiency anemia and beta thalassemia trait in pregnant women. Pak J Med Sci. 2022;38(4 Part-II):878-82. doi: 10.12669/pjms.38.4.4635, PMID 35634613.
15. Amer J. A retrospective study using Mentzer index for prevalence of iron deficiency anemia among infants visiting maternal centers at the age of one year. Anemia. 2022;2022:7236317. doi: 10.1155/2022/7236317, PMID 35386733.
16. Hoffmann JJ, Urrechaga E, Aguirre U. Discriminant indices for distinguishing thalassemia and iron deficiency in patients with microcytic anemia: A meta-analysis. Clin Chem Lab Med. 2015;53(12):1883-94. doi: 10.1515/cclm-2015-0179, PMID 26536581.
17. Shah TP, Shrestha A, Agrawal JP, Rimal S, Basnet A. Role of Mentzer index for differential diagnosis of iron deficiency anaemia and beta thalassemia trait. J Nepal Health Res Counc. 2023;21(1):99-102. doi: 10.33314/jnhrc.v21i1.4479, PMID 37742157.
18. Bhargava M, Kumar V, Pandey H, Singh V, Misra V, Gupta P. Role of hematological indices as a screening tool of beta thalassemia trait in eastern Uttar Pradesh: An institutional study. Indian J Hematol Blood Transfus. 2020;36(4):719-24. doi: 10.1007/s12288-020-01282-z, PMID 33100716.
19. Sherali A, Ahad A, Tikmani SS, Sohail S. Screening of iron deficiency anemia in children using Mentzer index in Pakistan: A cross sectional study. Glob Pediatr Health. 2023;10:1-5. doi:10.1177/2333794X221130986
20. Suman FR, Teja R, Magdalene J, Bisht T, Varadharajan S, Lakshmi U, *et al*. Screening for beta thalassemia carrier state among women attending antenatal clinic in a tertiary care centre and framing a model program for the prevention of beta thalassemia. Cureus. 2022;14(2):e22209. doi: 10.7759/cureus.22209, PMID 35308710.