Original Research

Mentzer Index as a Reliable and Economical Tool for Screening of Beta-Thalassemia Trait

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Abstract

Introduction: Microcytic hypochromic anemia is a distinct morphologic subtype of anemia with variable etiological causes. Mentzer Index is an economical tool derived from hematology analyser readings (MCV/RBC count), which can help in distinguishing Beta thalassemia trait from other causes.

Aims and objectives: The aim of this study was to evaluate the role of Mentzer Index in distinguishing Beta thalassemia trait from other causes of microcytic anemia.

Methods: Five hundred cases of microcytic hypochromic anemia were randomly selected. Relevant clinical history, hemogram, reticulocyte count, iron profiles were documented. Mentzer index was calculated. MCV/RBC count >13 -suggestive of Iron Deficiency anemia. MCV/RBC count<13- suggestive of Thalassemia trait disorders. Hemoglobin electrophoresis were conducted for confirmation. Data was statistically analysed.

Results: Iron deficiency anemia was the most common etiology (85%) followed by anemia of chronic diseases (12.2%). Beta thalassemia trait was detected in 2.2% cases and sideroblastic anemia was detected in 0.6 % cases. In the present study, among the 500 patients, 484 cases had Mentzer>13 while 16 cases had<13.

Conclusion: Diagnosis of microcytic hypochromic anemia requires a standardized diagnostic approach which needs resources. But in resource deficient areas, Mentzer index can be used as a tool in initial screening. This calculation does not put any extra financial burden on poor patients yet provides valuable reliable information.s

Key words: Anemia, Electrophoresis, Hypochromasia, Iron profile, Microcytosis, Thalassemia

Introduction

In India, the prevalence of anemia is high.[1] Anemia can morphologically be classified into three subgroups as-(a) Microcytic hypochromic, (b) Normocytic normochromic and (c) Macrocytic anemia. This classification is based on mean corpuscular volume (MCV), mean corpuscular

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hemoglobin (MCH) and mean corpuscular hemoglobin concentration (MCHC) of complete blood count (CBC) and aids the physician in diagnosis and monitoring of anemia that can be easily cured, such as deficiency of iron and vitamin B-12 or folic acid.[2]

Microcytic anemia (MCV<80 fL) is mainly due to iron deficiency anemia (IDA) followed by other causes like thalassemia or anemia of chronic diseases. [1] The differentiation between thalassemic and non-thalassemic microcytosis has important clinical implications.[3]

Beta-thalassemia trait(BTT) is characterized by mild anemia, with a disproportionate decrease in MCV and MCH, relative erythrocytosis, and a normal RDW. As red cell indices are altered by co-existing disorders, screening for BTT should be considered in any patient with unexplained microcytosis even if the red cell indices are not typical of BTT.[4] Discriminant functions like Mentzer index, Shine & Lal index, and England & Fraser index can be applied though none of them are 100% sensitive or specific.[5,6]

Mentzer index is used in differentiating IDA from beta thalassemia. It depends on two parameters included from the complete blood count. If the quotient of the mean corpuscular volume (MCV, in fL) divided by the red blood cell count (RBC, in millions per microliter).[7,8] The Mentzer Index can be used as a screening test with a sensitivity and specificity of 91% & 83% for iron deficiency anemia and 83% & 91% for beta thalassemia. Those with Mentzer Index < 13 can be subjected to Hb electrophoresis for confirmation. It is found that Mentzer Index has got maximum sensitivity and specificity among all relevant indices.

We chose Mentzer index to evaluate its significance in our setting where thalassemia is not very prevalent. Thus, screening is needed not to miss any hidden case without additional cost. Moreover, formula of Mentxer index is easier and can easily be interpreted.[7]

MCV/RBC count >13 -suggestive of Iron Deficiency anemia

- MCV/RBC count<13- suggestive of Thalassemia trait disorders.

Cases of anemia, in particular, microcytic anemia, has high prevalence in Indian settings. Iron deficiency anemia is a curable disorder.[9] On contrary, Beta thalassemia trait cases are usually asymptomatic to mildly symptomatic. They often go unnoticed and are usually misinterpreted as IDA even by clinicians, due to microcytosis. Hemoglobin electrophoresis (HPLC) usually not requested. These cases have high possibility of getting married and conceive without any genetic familial counseling. this may result in birth of a child with life-long transfusion dependency e.g. Thalassemia major. Here comes the role of Mentzer index. A simple calculation will help in segregation between two type of disorders and can guide that for which cases HPLC to be recommended on priority. [10] Mentzer index calculation can be done in rural and suburban settings. Thus, increasing possibility of early diagnosis and decreasing the burden of a sick baby on family and society.

Material and Methods

The present study was a single center observational cross-sectional study carried out in a tertiary teaching hospital in western Uttar Pradesh. Study duration was of 18 months (for data collection-1year,data analysis -6 months). Ethical approval was taken from the Institutional ethical committee (MMC/IEC/2022/128). The study started in October 2022 and completed in March 2024.

Sample size: sample size = 500. (hospital based study, depending on the last 3 years average.) Sampling technique was simple random sampling.

Inclusion criteria: all cases of anemia showing microcytic hypochromic blood picture on peripheral blood smear with MCV less than 80fl and hemoglobin less than 12g/dl for females and less than 13g/dl for males.

Exclusion criteria: Neonates, pregnant and lactating females (based on history), hematological malignancies, history of blood transfusion in past 4 months.

Statistical analysis: Suitable statistical significance test that was used for statistical analysis along with SPSS17/20 and statistical software. The p-value < 0.05 was considered for statistical analysis.

Study procedure: We included 500 patients in this study who were diagnosed to have anemia as

per WHO guidelines, based on initial hematological screening. Relevant history and clinical details were taken. Blood samples were taken in vacutainers-EDTA, Serum separator tube and plain vial. EDTA samples were used for the smear preparation and run on automated cell counter. The analyzer used in the study was 'Mindray five-part hematology analyzer' based on the principle of Impedance counting**.** Values of Red blood cell count, Hematocrit, Hemoglobin estimation, Red Cell Indices etc. were obtained by automated hematology cell counter.

Mentzer's index [7] was calculated : MCV/RBC count-IDA:>13;BTT<13

High Performance Liquid Chromatography -HPLC was done on D-10 HPLC analyzer. Dual Program is based on chromatographic separation of the analytes by ion exchange high performance liquid chromatography (HPLC).

Reference Range: Normal value of HbA2– less than 3.5%. Normal value of HbF is 0.2– 1.0%

Results

The present study was a single center observational cross-sectional study. Applying the predetermined inclusion criteria, out of 32,446 cases of anemia, 19,472 cases had microcytic anemia i.e. 60% of anemia cases were microcytic anemia. All neonates, pregnant and lactating females (based on history)**,** cases of hematological malignancies, history of blood transfusion in past 4 months were excluded. (7594 cases i.e. 39% were excluded). Out of remaining 11878 cases,500 cases of microcytic anemia were randomly sorted out for study.

A battery of investigations, both routine, and specialized, were done to establish the etiology of microcytic anemia. Clinical history was also taken in account. Complete blood cell counts along with various red cell indices like hemoglobin, RBC count, MCV, MCH, MCHC, RDW were obtained from Mindray five-part hematology analyzer. Mentzer Index, was calculated for screening of thalassemia hemoglobinopathies. Hemoglobin electrophoresis was done for confirmation.

In the present study, patients were ranging from 6 months to 90 years in age of which majority of the cases falling under the age group of 6 month to 10 years (27.2%) and least number of cases, i.e., 5 cases were falling under the age group of 81 years to 90 years (01.0 %). The mean age involved was 27.06 ± 21.95 years. In the present study, out of total 500 cases, 230 (46.0%) were male and 270 (54.0%) were female showing female preponderance with M: F ratio of 1:1.2 **(Table1)**

Table 1: Age wise distribution of cases in study group

AGE GROUP	CASES	MALE	FEMALE	PERCENTAGE
6M -10Y	136	82	54	27.2%
11Y–20Y	130	59	71	26 %
21Y–30Y	58	11	47	11.6%
31Y–40Y	42	11	31	8.4 %
41Y–50Y	44	21	23	8.8 %
51Y–60Y	39	13	26	7.8 %
61Y–70Y	21	12	9	4.2 %
71Y–80Y	25	18	7	4.8 %
81Y–90Y	5	3	2	1 %
TOTAL	500	230	270	100

In the present study, among the 500 patients, 484 cases had MENTZER>13 while 16 cases have <13. (**Table 2)**

Table 2: Distribution of cases in study group according to Mentzer Index (MI)

MENTZER INDEX	CASE	PERCENTAGE
<13	16	3.2 %
>13	484	96.8 %
TOTAL	500	100 %

Sixty one patients have Mentzer score >13 in ACD. In IDA, 6 patients had Mentzer score ≤13, while 419 patients had Mentzer score >13. In SA, only 3 patients had Mentzer score >13. in BTT, out of 11 patients, 10 patients had Mentzer score <13 while only one patient had Mentzer score >13. (**Table 3, Figure 1)**

Table 3: Distribution of cases according to Mentzer Index (MI) in ACD, IDA, SA and BTT

MENTZER INDEX (%)	ACD	IDA	SA	BTT	p value
≤13	0	6	0	10	<0.001*
>13	61	419	3	01	
TOTAL	61	425	3	11	
Mean and SD	22.43± 2.10	21.27± 3.98	17.65± 3.80	12.91± 0.50	
**signifies highly significant p-value<0.05 (Test used: One-way ANOVA)_					

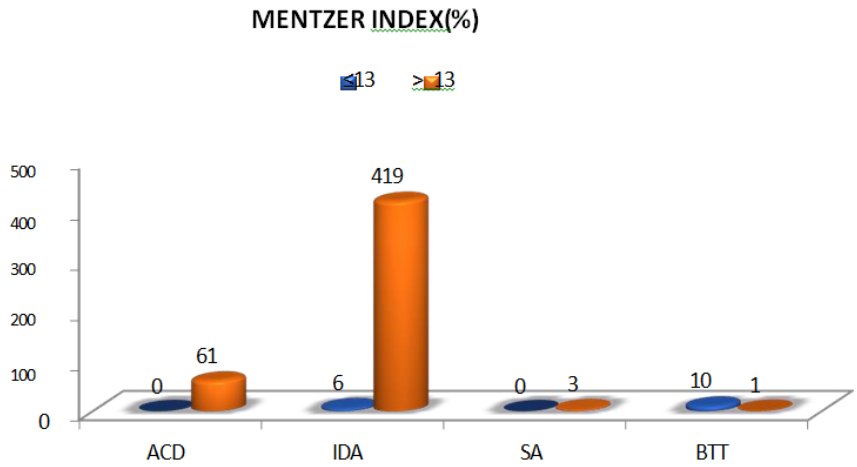

Figure 1: Bar diagram showing distribution of cases according to Mentzer Index (MI) in ACD, IDA, SA and BTT

Hemoblobin electrophoresis was done for all cases. Out of total 500 cases, 11 cases came out to be positive, while 16 cases <13, suggestive of Thalassemia trait disorders. (**Table 4)**

Table 4: Correlation between Hb A2 and Mentzer Index

HbA2	MI-POSITIVE	MI-NEGATIVE
>3.5	10(TP)	01(FN)
<3.5	06(FP)	483(TN)
StatisticValue at 95% CI		
Sensitivity	90.91%	58.72%to 99.77%
Specificity	98.77%	97.35%to 99.55%
Positive-predictive Value (*)	86.92%	74.59%to 93.77%
Negative-predictive Value (*)	99.18%	94.92%to 99.87%
Accuracy(*)	98.13%	96.51%to 99.12%

Discussion

Mentzer WC from Turkey assessed 290 children aged 1 - 16 years and used the red blood cell count, RDW and Mentzer index (mean corpuscular volume/red blood cell count ratio) to differentiate β thalassemia trait from iron deficiency anemia. These results indicated that the Mentzer index was the most reliable indicator, with a sensitivity of 98.7% and specificity of 82.3%. [8]

Similarly, Sundh et al, A value of MI＜13 was highly sensitive in the diagnosis of BTT. MI ＞13 was found to have both high specificity and high sensitivity for diagnosing IDA.[9] Amer also performed a retrospective study on Mentzer index. [11]

In the present study, among the500 patients, 484 cases had MENTZER>13 while 16 cases have <13.

In study done by Aydogan et al , of the 200 enrolled, 107 were male (53.5%). In total 154 had IDA (77%), 27 had β-TT (13.5%), and in 11 (5.5%) both conditions coexisted. Sensitivity and specificity of Mentzer index for the detection of β-TT were 100% and 69.4%, respectively. The positive and negative predictive values of Mentzer index in diagnosing β-TT were 36.6% and 100%, respectively. [12]

Idrees et al. conducted a study on the Mentzer index's sensitivity and specificity in separating iron deficiency anemia from beta- thalassemia minor.371patients (43.14%) had a greater suspicion of beta thalassemia and 489 patients (56.86%) had iron deficiency anemia based on Mentzer index criteria.[13]

According to Vehapoglu et al., the the Mentzer index performs quite well and may be useful, while screening patients for microcytic anemias, [14]

Lafferty et al discovered that the S&L index, MI, and MCV were effective in differentiating between IDA and β-TT minor instances, but the RDW indices proved to be ineffective. [13]

Siswandari et al, in their study showed that the Mentzer index had an 81% negative result rate in persons without thalassemia and a 0.36% accurate diagnosis rate in subjects with beta-thalassemia.[16]

In study done by Bose et al, with a sensitivity of 90%, the Mentzer index was found to be more dependable in identifying real positive instances of iron deficiency anemia, while its specificity of 90% allowed for the identification of true negative cases of beta thalassemia trait. For IDA and β-TT, the positive predictive values were 88.2 percent and 87.1%, respectively. For IDA and β-TT, the negative predictive values were 87.1% and 88.2%, respectively. [17]

In study done by Tabassum et al, Mentzer Index's sensitivity and specificity for IDA are 91% and 83%, respectively, whereas for β TT, they are 83% and 91%. [7] In study done by Sherali et al, in terms of MI, the sensitivity was 80.7%, specificity was 77.7% , PPV was 56.8%, NPV was 91.6%, accuracy was 78.4.[18]

Iqbal et al, concluded that sensitivity and specificity make the Mentzer Index stand out among the many other used indices. The Mentzer index performs exceptionally well and could be helpful in the screening of patients with microcytic anemias.[10] Various mathematical formulae like Mentzer's Index are simpler, cost effective, easy to apply screening tools at outpatient clinics are beneficial to identify thalassemia traits.[15-20]

We considered HPLC as a gold standard in diagnosis of hemoglobinopathies. In our study, HPLC was done for all 500 cases. Maximum number of patients were in second decade of life followed by first decade of life with mean age of 25.5 years. Similar findings have been observed in other studies by Verma et al and Balgir et al.[20,21]

We know that most patients with haemoglobinopathies present in the younger age groups which could be there as on for increased HPLC analysis done in the younger age group. One reason for this could be increased growth requirements in younger patients causing severe symptoms than adults. The majority of the cases in our study were females. Similar distribution of cases was observed in the study by Jain et al. [22]

Table 5: Comparison of sensitivity, specificity, positive and negative predictive value of Mentzer Index on the basis of studies by various researchers.

MentzerIndex	Sensitivity %	Specificity %	Positive Predictive Value %	Negative Predictive Value %
Vehapoglu et al (2014)[14]	98.7	82.3	86.3	98.2
Siswandari et al (2018)[16]	36	81	44	75
Bose et al (2018)[17]	85	90	87.1	88.2
Tabassum et al(2022)[7]	74.81	70.06	78.94	64.96
Sherali et al(2023)[18]	80.7	77.7	56.8	91.6
Iqbal et al(2024)[10]	90.1	90.1	93.8	4.6
Present study	90.91	98.77	86.92	99.18

In our study, we did not get any case of any other hemoglobinopathy except beta thalassemia trait. However, in some studies done in eastern India show higher proportion of sickle cell related haemoglobinopathies. This high rate was possibly because study was done in high prevalence zone for sickle cell haemoglobinopathies. This increased occurrence of sick le cell disease in tribal populations in Eastern India as has been documented in literature.[23,24] In the present study beta thalassemia related haemoglobinopathies show microcytic hypochromic anemia along with anisopoikilocytosis which was comparable with findings in other studies.[25,26]

Conclusion

For discrimination purposes between thalassemia minor and iron deficiency anemia, Mentzer Index formula although , does not provide 100% sensitivity and 100% specificity, and further confirmatory testing is required before a case can be correctly diagnosed, but in resource deficient areas Mentzer index emerges as a great help in initial screening. This calculation does not put any extra financial burden on poor patients yet provides valuable reliable information.

Thus, we concluded that the data derived from RBC parameters provided by the hematology analyzer, could be used as a laboratory- based criterion for the selection of samples for thalassemia testing, with a high degree of accuracy.

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References

1. Brugnara C, Mohandas N. Red cell indices in classification and treatment of anemias: From M. M. Wintrobes's original 1934 classification to the third millennium. Current Opinion of Hematology 2013;20(3): p. 222-3
2. Sharif N, Das B, Alam A. Prevalence of anemia among reproductive women in different social group in India: Cross-sectional study using nationally representative data. PLoSONE. 2023;18(2):e0281015. https://doi.org/10.1371/ journal.pone.0281015
3. Khusum H, Hip H, Schultink W, et al. World Health Organization hemoglobin cut-off points for the detection of anemia are valid for Indonesian population. J Nutr 1999;129(9): p. 1669-74.
4. Ryan K, Bain BJ, Worthington D, James J, Plews D, Mason A, Roper D, Rees DC, de la Salle B, Streetly A, British Committee for Standards in Haematology.Sig nificanthaemoglobinopathies:guidelinesforscreening and diagnosis. Br J Haematol. 2010;149(1):35–49.
5. Bain B J. The α, β, δ ,and γ thalassaemias and related conditions. In: Bain BJ, editor. Hemoglobinopathy diagnosis. 2nd ed. Malden: Blackwell; 2006. p. 63–138.
6. Batebi APA, Esmailian R. Discrimination of beta thalassemia minor and iron deficiency anemia by screening test for red blood cell indices. Turk J Med Sci. 2012;42(2):275–80.
7. 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 Mar-Apr;38(4Part-II):878-882.

8. Mentzer WC Jr. Differentiation of iron deficiency from thalassaemia trait. Lancet.1973Apr21;1(7808):882. doi:10.1016/s0140-6736(73)91446-3. PMID:4123424.

9. Sundh A, Kaur P, Palta A, Kaur G. Utility of screening tools to differentiate beta thalassemia trait and iron-deficiency anemia - do they serve a purpose in blood donors? Blood Res. 2020 Sep 30;55(3):169-174. doi: 10.5045/br.2020.2020219. PMID: 32989178; PMCID: PMC7536563.

10. Iqbal S, Amin W, Arshad S, Ain N .U .Diagnostic accuracy of Mentzer index as a screening tool for the diagnosis of iron deficiency anemia by taking iron profile as gold standard in patients presenting with hypochromic microcytic anemia at tertiary care hospital, Karachi. Biol. Clin. Sci. Res. J., 2024: 669.

11. 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. HindawiAnemia Volume 2022,Article ID 7236317, 5 pages https://doi.org/10.1155/2022/7236317.

12. Aydogan A, Keskin S, Akici F,Salcioglu Z, Bayram C,Uysalol EP,Gucer NT, 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–e223

13. Idrees M., Khan, J.U.A., Riaz H.,Shah M.A.,Shah,H, Hris S. M. (2023). Utilization of Mentzer Index to Discriminate Between Beta Thalassemia Minor and Anemia of Iron Deficiency, Followed by HPLC. Pakistan Journal of Medical & Health Sciences 2023; 17:843-845.

14. Vehapoglu A, Ozgurhan G, Demir AD, Uzuner S, Nursoy MA, Turkmen S, Kacan A. Hematological indices for differential diagnosis of Beta thalassemia trait and iron deficiencyanemia.Anemia.2014;2014:576738. doi:10.1155/2014/576738.Epub2014Apr10.PMID: 24818016;PMCID: PMC4003757

15. Lafferty JD, Crowther MA, Ali MA, et al: The evaluation of various mathematical RBC indices and their efficacy in discriminating between thalassemic and non-thalassemic microcytosis. Am J Clin Pathol 1996; 106: 201 –205.

16. Siswandari W,Rujito L, Indriani V, DjatmikoW. Mentzer Index Diagnostic Value in Predicting Thalassemia Diagnosis. IOP Conf. Series:Earthand Environmental Science 255 (2019) 012004

17. Bose S, Maimoon S. Is Mentzer Index A Reliable Diagnostic Screening Tool For Beta Thalassemia Trait? IOSR Journal of Dental and Medical Sciences (IOSR-JDMS) Volume 17, Issue 7 Ver. 6 (July. 2018), PP 07-11

18. Sherali A, Ahad A, Tikmani SS, Sohail S. Screening of Iron Deficiency Anemia in Children Using Mentzer Index in Pakistan:ACross Sectional Study. Glob Pediatr Health. 2023 Feb 11;10:2333794X221130986. doi: 10.1177/2333794X221130986. PMID:36845556;PMCID:PMC9943956.

19. Siswandari W, Rujito L, Indriani V, Djatmiko W. Mentzer Index Diagnostic Value in Predicting Thalassemia Diagnosis. IOP Conf. Series : Earthand Environmental Science 255 (2019) 012004

20. Verma P, Ghildiyal A, Verma D, Krishna A, Singh S, Kumar A et al. Prevalence of hemoglobinopathies in different regions and castes of Uttar Pradesh, India -A hospital-based study. Asian J Med Sci. 2015;6(5):21- 5.

21. Balgir R.S. The spectrum of hemoglobin variants in two scheduled tribes of Sundargarh district in north western Orissa, India. Ann Hum Biol. 2005;32(5):560-73.

22. Jain P, Gupta M, Dua S, Marwah N, Gill M, Sen R. Prevalence of Various Hemoglobinopathies-An Experience from Tertiary Care Centre. Dicle Med J. 2019;46 (2):269-76.

23. Alam S, Singh A, Chakrabarty S, Mohanty R. Spectrum of hemoglobinopathies in Odisha—an institutional study by CE-HPLC. Int J Med Sci Public Health. 2016;5(2):208-12.

24. Behera SK, Mohanty S, Triya L, Nayak J. Spectrum of hemoglobinopathies in pediatric population in Southern Odisha-an institutional study. J Med Sci Clin Res. 2019;7(7):935-42.

25. Bhalodia JN, Oza HV, Modi PJ, ShahAM, Patel KA, Patel HB. Study of hemoglobinopathies inpatients of anemia using high performance liquid chromatography (HPLC) in Western India. Nat J Community Med. 2015;6(1):35-40

26. Bhuvana, Rajan S. Studies on Beta Thalassemia and other Hemoglobinopathies in the Metropolitan City of Chennai. Int J Biol Sci. 2016;7(1):7-19.