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Original Research Article

A COMPARATIVE STUDY OF THE MENTZER INDEX IN DIFFERENTIATING IRON DEFICIENCY ANEMIA AND BETA THALASSEMIA TRAIT IN ADULTS

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ABSTRACT

Background: Iron deficiency anemia (IDA) and beta thalassemia trait (BTT) are common causes of microcytic anemia in adults. Accurate differentiation between these two causes of anemia is essential as their management differs. While hemoglobin electrophoresis is the diagnostic gold standard for BTT its availability is limited in low-resource settings. The Mentzer Index (MCV/RBC count) offers a simple cost-effective screening method. This study is undertaken to evaluate its diagnostic utility in distinguishing IDA from BTT in adults.

Materials and Methods: This retrospective comparative study included 120 adult patients (80 with confirmed IDA and 40 with confirmed BTT) who were evaluated for microcytic anemia between January 2023 and January 2025 at a tertiary care hospital. IDA was diagnosed on the basis of low serum ferritin and iron with high TIBC. BTT was confirmed if patient's HbA2 level was more than 3.5% on hemoglobin electrophoresis. The Mentzer Index (MI) was calculated for all cases with values >13 suggestive of IDA and <13 suggestive of BTT.

Results: Among IDA cases, 92.5% had MI >13, while 87.5% of BTT cases had MI <13 ($p<0.001$). The Mentzer Index showed a high sensitivity (92.5%), specificity (87.5%), positive predictive value (93.7%) and negative predictive value (85.4%) for diffrentiating IDA from BTT. Hemoglobin levels were lower in IDA (8.5 ± 1.2 g/dL) compared to BTT (9.8 ± 1.1 g/dL, $p<0.001$). RBC count was higher in BTT (5.2 ± 0.7 vs. 4.1 ± 0.6 million/µL) whereas RDW was significantly elevated in IDA (17.8 ± 2.2% vs. 14.2 ± 1.8%, $p<0.001$). All hematological parameters showed statistically significant differences between the two groups.

Conclusion: The Mentzer Index is a simple, cost-effective and reliable tool for differentiation between IDA and BTT in adults. Its high sensitivity, specificity, and predictive values make it particularly useful in screening of BTT cases in resource-limited settings.

Keywords: Iron-Deficiency Anemia, Beta-Thalassemia, Mentzer Index, Microcytic Anemia, Hemoglobin Electrophoresis.

INTRODUCTION

Anemia is a significant public health problem affecting nearly one-third of the global population with a substantial burden among adults in developing countries including India. Iron deficiency anemias (IDA) remains the most prevalent form of anemias and is usually caused by inadequate iron intake, chronic blood loss or increased physiological demand.1 In contrast beta thalassemia trait (BTT) is characterized by impaired beta-globin chain production and is frequently encountered in regions with high consanguinity including South Asia, Middle East and parts of Africa. In countries like India BTT affects approximately 3–17% of the population, while the prevalence of IDA in adults often exceeds 30 %.[2] Microcytic hypochromic anemias is the common blood picture in both these

types of anemia yet their management strategies differ significantly. IDA requires iron supplementation whereas BTT necessitates genetic counselling. Differentiating between these conditions is therefore critical particularly in resource-limited settings where unnecessary iron therapy may worsen iron overload in unsuspected carriers of BTT.[[3]

The gold standard for diagnosing BTT is hemoglobin electrophoresis or high-performance liquid chromatography (HPLC). These tests identify elevated levels of HbA2 or other hemoglobin variants. Though these tests have high specificity these techniques cannot be commonly used because they are often unavailable or unaffordable in rural or under-resourced clinical settings due to the high cost of reagents, requirement for specialized equipment and technical expertise.[4] In contrast, the Mentzer Index (MI), a ratio of mean corpuscular volume (MCV) to red blood cell (RBC) count offers a simple and inexpensive screening tool. It can be calculated from the complete blood count (CBC) which is widely available even at the primary care level. An MI value less than 13 suggests BTT, while values greater than 13 favor IDA.[5] In settings with limited access to confirmatory diagnostics the Mentzer Index can serve as a preliminary screening method to determine which patients should be prioritized for hemoglobin electrophoresis thereby optimizing the use of scarce laboratory resources.[6]

Various discriminant indices such as the Shine & Lal Index, Mentzer index and Red Cell Distribution Width Index (RDWI) have been studied as screening methods to differentiate between IDA and BTT.[7] Amongst these indices Mentzer Index remains one of the most widely used because of its simplicity and reliability. However, its diagnostic accuracy has shown to be variable across populations and may be affected by many confounding factors.[8] For instance factors such as age, ethnicity and presence of coexisting illnesses can influence its utility. Despite this, when applied judiciously, the Mentzer Index can reduce the need for unnecessary electrophoretic testing in patients with clear microcytic anemia suggestive of IDA. This may help in identifying high-risk individuals for whom further evaluation is warranted. Especially in resource-constrained regions, this selective approach can reduce the economic burden on health systems and ensure that limited hemoglobin electrophoresis services are used more efficiently.[9]

Despite its longstanding use and simplicity, there remains a knowledge gap in using Mentzer Index as a screening tool in adult populations. This study seeks to analyze its utility as a screening method to differentiate between IDA and BTT in adult population. This is particularly important in resource-limited and developing countries where full access to molecular or electrophoretic testing is not always feasible.[10]

MATERIALS AND METHODS

This was a retrospective comparative study conducted in a tertiary care hospital. The data was collected from medical records of adult patients who had undergone evaluation for microcytic anemia during the period between Jan 2023 and Jan 2025. Institutional ethics committee approval was taken. The sample size was calculated on the basis of formula $N = (Z\ \alpha^2 \times \sigma^2) / d^2$ on the basis of data from previously published studies evaluating the diagnostic utility of the Mentzer Index in differentiating iron deficiency anemia and beta thalassemia trait. Assuming 90% power and 95% confidence interval and using estimates of standard deviation and effect size derived from earlier similar studies. Accordingly, a total of 120 patients were included in the study, comprising 80 patients with confirmed iron deficiency anemia and 40 patients with beta thalassemia trait. Out of these 120 patients comprising 80 patients were having confirmed iron deficiency anemia (IDA) and 40 patients were confirmed to be having beta thalassemia trait (BTT) on the basis of hemoglobin electrophoresis.

Demographic data including age, sex, and relevant community or ethnic background were recorded. Clinical presentation and signs and symptoms such as fatigue, pallor, breathlessness, anorexia and irritability was noted from medical records, Clinical features related to any specific dietary insufficiencies were noted. History of chronic illnesses or menstrual history in female patients that could contribute to iron deficiency was also noted. History of thalassemia or repeated blood transfusion in any of the family members was specifically looked for and recorded. A background of high-risk ethnic communities (such as Sindhi, Gujarati, Bengali, or Punjabi) was also documented when available as these may be associated with a higher prevalence of BTT.

Clinical findings were analysed for presence of signs of anemia such as pallor, koilonychia, glossitis and systemic findings such as splenomegaly which is expected in hemolytic anemia. Cases with co-existing systemic illnesses that could contribute to anemia were analysed carefully. Laboratory data such as complete blood count (CBC), mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH) and red blood cell (RBC) count was noted. Iron studies such as serum ferritin, serum iron, total iron binding capacity (TIBC) was also recorded. In cases of thalassemia trait hemoglobin electrophoresis findings were recorded. The diagnosis of IDA was confirmed based on reduced serum ferritin and serum iron with elevated TIBC. HbA2 levels >3.5% found in hemoglobin electrophoresis were considered diagnostic of BTT. Complete blood count reports of patients were reviewed and Mentzer Index was calculated for all patients using the formula: MCV (fL) divided by RBC count (millions/μL). A Mentzer Index >13 was interpreted as suggestive of iron

deficiency anemia, whereas an index <13 was suggestive of beta thalassemia trait.

All data was anonymized for analysis. Statistical analysis was performed using SPSS version 23.0. Mentzer Index values were compared between 2 group. Quantitative variables such as hemoglobin, RBC count, MCV, MCH, and Mentzer Index were summarized as mean ± standard deviation. Qualitative variables such as gender as well as etiology of anemia was expressed as frequencies and percentages. Group comparisons were done using the unpaired t-test for quantitative data and Chi-square or Fisher's exact test for qualitative data. A p-value < 0.05 was considered statistically significant.

Inclusion Criteria

1. Adults aged above 18 years at the time of diagnosis.
2. Patients previously diagnosed with iron deficiency anemia based on serum iron, ferritin, and TIBC.
3. Patients diagnosed with beta thalassemia trait (HbA2 >3.5%).
4. Availability of complete clinical and laboratory data including RBC indices, iron studies and hemoglobin electrophoresis.

Exclusion Criteria

1. Patients below 18 years of age.
2. Patients with a history of blood transfusion within the last three months prior to data recording.
3. Patients with co-existing hematological disorders such as hemoglobinopathies other than thalassemia, aplastic anemia or other autoimmune and inherited anemias.
4. Patients with incomplete medical records.

RESULTS

The analysis of the gender distribution of the studied cases showed that among the total 120 participants, females slightly outnumbered males, with 61 cases (50.8%) compared to 59 males (49.2%). In the iron deficiency anemias (IDA) group females were slightly more common (52.5%) as compared to males (47.5%). Conversely, in the beta thalassemia trait group males were more common, with 21 cases (52.5%) compared to 19 females (47.5%). However, both the groups were found to be comparable with respect to gender distribution (P>0.05). (Table 1)

The age distribution analysis showed that most participants in both groups were between 18–30 years. In the IDA group, 28 cases (35%) were aged 18–30, followed by 22 (27.5%) in the 31–40 group, 17 (21.2%) in the 41–50 group, and 13 (16.2%) in the 51–60 group. Among those with thalassemia trait, 12 cases (30%) were aged 18–30, 13 (32.5%) were 31–40, 9 (22.5%) were 41–50, and 6 (15%) were 51–60. The mean age was 36.9 ± 11.5 years in the IDA group and 37.3 ± 11.0 years in the thalassemia trait group. Both the groups were comparable in terms of age with no statistically significant difference (P >0.05). (Figure 1)

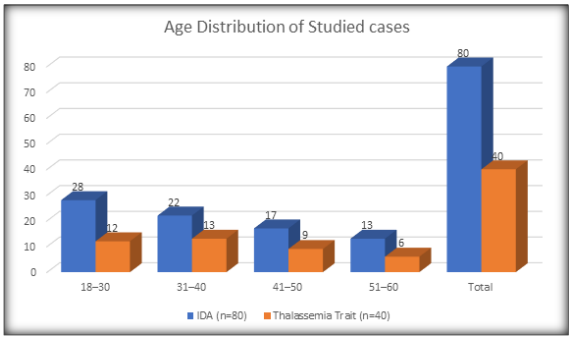

Figure 1: Age distribution of studied cases.

The analysis of hematological parameters revealed significant differences between IDA and beta thalassemia trait: hemoglobin was lower in IDA (8.5 ± 1.2 g/dL vs. 9.8 ± 1.1 g/dL), whereas MCV (68.4 ± 5.6 fL vs. 62.1 ± 4.9 fL) and MCH (22.3 ± 2.1 pg vs. 19.5 ± 2.0 pg) were higher; RBC count was greater in thalassemia trait (5.2 ± 0.7 vs. 4.1 ± 0.6 million/µL), while RDW was higher in IDA (17.8 ± 2.2% vs. 14.2 ± 1.8%). There was a statistically significant difference in all the studied parameters in both the groups (p < 0.001) (Figure 1) (Table 2).

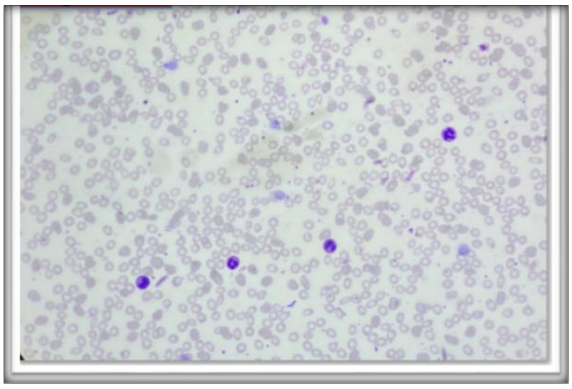

Figure 2: Peripheral smear shows anisopoikilocytic RBC with microscopic and hypochromic morphology, few elongated cells and polychromatophils seen.

The analysis of the Mentzer Index in differentiating iron deficiency anemia (IDA) and beta thalassemia trait revealed a clear distinction between the two groups. Among the IDA cases, a majority of 74 individuals (92.5%) had a Mentzer Index greater than 13while only 6 cases (7.5%) had values below 13. In contrast, among the thalassemia trait group 35 individuals (87.5%) had a Mentzer Index less than 13 whereas only 5 cases (12.5%) had values above 13. Mentzer index was found to be more in IDA group as compared to BTT group and the difference was found to be statistically significant (P< <0.001) (Table 3).

The diagnostic performance analysis of the Mentzer Index showed that it reliably distinguished IDA from beta thalassemia trait, with sensitivity of 92.5% and specificity of 87.5%. The positive predictive value of Mentzer index for diagnosis of IDA was found to be

93.7%, indicating that most individuals with an index >13 truly had IDA. Negative predictive value was found to be 85.4% reflected its accuracy in identifying thalassemia trait when the index was <13 (Table 4).

Table 1: Comparison of gender Distribution in studied cases

Gender	IDA (n=80)	Thalassemia Trait (n=40)	Total (n=120)	p-value
Male	38 (47.5%)	21 (52.5%)	59 (49.2%)	0.69 (NS)
Female	42 (52.5%)	19 (47.5%)	61 (50.8%)	

Table 2: Comparison of various hematological indices in studied groups

Parameter (Mean ± SD)	IDA (n=80)	Thalassemia Trait (n=40)	p-value (t-test)
Hemoglobin (g/dL)	8.5 ± 1.2	9.8 ± 1.1	<0.0001 (HS)
MCV (fL)	68.4 ± 5.6	62.1 ± 4.9	<0.001 (HS)
MCH (pg)	22.3 ± 2.1	19.5 ± 2.0	<0.001 (HS)
RBC Count (mill/µL)	4.1 ± 0.6	5.2 ± 0.7	<0.001 (HS)
RDW (%)	17.8 ± 2.2	14.2 ± 1.8	<0.001 (HS)

Table 3: Distribution of Mentzer Index in Both Groups

Mentzer Index	IDA (n=80)	Thalassemia Trait (n=40)	Total (n=120)	p-value
>13 (Suggests IDA)	74 (92.5%)	5 (12.5%)	79 (65.8%)	<0.001 (HS)
<13 (Suggests Thalassemia)	6 (7.5%)	35 (87.5%)	41 (34.2%)	

Table 4: Sensitivity, specificity, PPV and NPV of Mentzer Index

Parameter	Value (%)
Sensitivity	92.5
Specificity	87.5
Positive Predictive Value (PPV)	93.7
Negative Predictive Value (NPV)	85.4

DISCUSSION

This study examined the diagnostic value of the Mentzer Index (MI) in distinguishing iron deficiency anemias (IDA) from beta thalassemia trait (BTT) in adults presenting with microcytic anemias. A clear separation between the two groups was observed: an MI >13 correctly classified the majority of IDA cases (92.5%), while an MI <13 identified 87.5% of BTT cases. These findings are consistent with earlier studies such as those done by Emmanuel IO et al who documented a high sensitivity and specificity of MI for differentiation between IDA and BTT in antenatal women.[11] Similarly Urrechaga et al in their study identified the Mentzer Index as one of the most reliable discriminant indices for microcytic anemia.[12] Taken together these studies show that the Mentzer index can be used as a screening tool for diagnosis of BTT across different populations. The high predictive values seen in our data (PPV 93.7%, NPV 85.4%) support its role as a pragmatic screening tool.

The hematological differences observed between individuals with IDA and BTT groups were seen corresponding closely with established pathophysiology. Lower hemoglobin levels, reduced RBC counts and elevated RDW among IDA patients were highly suggestive of iron-deficient profiles. On the other hand, higher RBC counts with lower MCV and MCH values in BTT cases were expected as BTT is associated with pathology at the level of erythropoiesis. Similar trends have been documented by Ahmad et al who reported that in adolescent and young adult cohorts RBC count emerged as a particularly reliable discriminator.[13] Katsaros M et al also emphasized that the markedly elevated RDW in IDA, due to anisopoikilocytosis, contrasts with the uniformly microcytic picture of BTT.[14] These patterns, when combined with MI, sharpen diagnostic accuracy and provide clinicians with a cost-effective first-line approach.

Age distribution added another dimension to our findings. In this study we found majority of both IDA and BTT cases were clustered between 18 and 40 years. The mean age was 36.9 ± 11.5 years in the IDA group and 37.3 ± 11.0 years in the thalassemia trait group. Many cases of BTT remained undiagnosed till there 4th decade. These Undiagnosed BTT cases can have broader health and social implications. Marriage of BTT individuals can have the catastrophic consequence of a child being affected by Thalassemia Major. Bordbar E et al reported a predominance of BTT cases in younger adults undergoing premarital and antenatal screening.[15] Givens DI et al likewise noted that IDA remains highly prevalent among young women largely due to menstrual blood loss and inadequate dietary iron.[16] Such overlap increases the risk of diagnostic ambiguity and highlights the value of simple indices like MI in resource-constrained settings where hemoglobin electrophoresis is not readily available.

Despite its strengths, MI is not a confirmatory index. A small subset of IDA patients (7.5%) showed MI <13, and 12.5% of BTT cases fell above the threshold. This reflects the possibility of misclassification. Similar limitations have been described by Hoffmann JJ et al who cautioned against sole reliance on a single index.[17] DeLoughery et al also pointed out that overlap becomes more

pronounced in adults with comorbidities or borderline red cell indices where inflammation or variant thalassemia forms can distort results.[18] These findings indicate that while MI is a useful triage tool confirmatory tests such as serum ferritin or hemoglobin electrophoresis are necessary particularly in cases with atypical presentations.

These findings add to the growing evidence base for the utility of the Mentzer Index in adult populations which have been comparatively less studied than pediatrics age groups. Its high sensitivity and specificity make it a reliable preliminary test in the context of developing countries where resources remain low. However as emphasized by Sain A et al,[19] and Althumairi A et al,[20] larger multicentric studies across diverse ethnic populations are needed to refine cut-off thresholds and validate its broader applicability. Given the global burden of anemias particularly in developing countries incorporating accessible indices such as MI into diagnostic pathways can improve case detection and strengthen public health strategies in combating the menace of anemia.

CONCLUSION

Mentzer Index is a simple, Reliable and inexpensive tool for differentiating iron deficiency anemias (IDA) from beta thalassemia trait (BTT) in adults. With a sensitivity and specificity, it showed strong diagnostic accuracy in distinguishing between the two conditions. The high positive predictive value supports its usefulness in correctly identifying IDA while the negative predictive value underscores its role in excluding BTT. Given its ease of calculation from routinely available CBC parameters the Mentzer Index can be used as a valuable preliminary screening method in resource-limited settings.

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