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Original Research Article

Assessment of Mentzer's Index for Beta Thalassemia Screening in Women Attending Obstetrics and Gynecology Outpatient Clinics

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Abstract:

Background: Beta-thalassemia is a common genetic disorder in many regions, particularly in India, where carrier detection is vital for reducing the disease burden. Mentzer's Index (MI), calculated as Mean Corpuscular Volume (MCV) divided by Red Blood Cell Count (RBC), is a cost-effective tool for differentiating beta-thalassemia carriers from other causes of anemia.

Objective: To assess the accuracy and reliability of Mentzer's Index for beta-thalassemia screening in women attending obstetrics and gynecology outpatient clinics.

Methods: This cross-sectional study included 100 women attending a Department of Obstetrics and Gynecology, Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India . Participants underwent routine hematological investigations, including complete blood count (CBC) and hemoglobin electrophoresis. Mentzer's Index was calculated, and its sensitivity and specificity for beta-thalassemia screening were evaluated.

Results: Of the 100 women, 15% were confirmed as beta-thalassemia carriers via hemoglobin electrophoresis. Mentzer's Index identified carriers with a sensitivity of 86.7% and a specificity of 91.8%. An MI cutoff value of <13 showed optimal accuracy for distinguishing beta-thalassemia carriers from iron deficiency anemia.

Conclusion: Mentzer's Index is a reliable, cost-effective screening tool for beta-thalassemia in resource-limited settings. Its integration into routine hematological evaluations can enhance carrier detection and reduce the need for expensive diagnostic tests.

Keywords: Mentzer's, Index, Beta, Thalassemia, Screening, Hematology, Carrier, Sensitivity, Anemia, Obstetrics

Introduction

Beta-thalassemia is a hereditary hemoglobinopathy characterized by mutations in the beta-globin gene, leading to reduced or absent production of beta-globin chains [1]. This results in ineffective erythropoiesis and varying degrees of anemia, ranging from asymptomatic carrier states (thalassemia minor) to transfusion-dependent conditions (thalassemia major) [2]. Beta-thalassemia is highly prevalent in India, with carrier frequencies ranging from 2% to 17% in different regions. The burden of the disease necessitates effective screening strategies to identify carriers and implement preventive measures [3].

Iron deficiency anemia, another major public health concern, often presents with similar hematological findings to beta-thalassemia minor, including microcytic hypochromic anemia [4]. Differentiating between these two conditions is critical for appropriate clinical management. While advanced diagnostic tests like hemoglobin electrophoresis and molecular analysis provide definitive results, these methods are often expensive and inaccessible in resource-limited settings. Hence, simpler and more cost-effective screening tools are needed, especially in high-prevalence regions [5].

Mentzer's Index (MI), calculated as the Mean Corpuscular Volume (MCV) divided by the Red Blood Cell Count (RBC), is a widely studied hematological index used to differentiate beta-thalassemia carriers from iron deficiency anemia [6]. A Mentzer's Index value of <13 is suggestive of beta-thalassemia minor, while a value >13 typically indicates iron deficiency anemia. Despite its utility, the accuracy of MI in screening beta-thalassemia carriers varies across populations,

necessitating validation in specific demographic groups [7].

The obstetrics and gynecology outpatient population are a critical target group for beta-thalassemia screening due to the potential for disease transmission to offspring. Early identification of carriers allows for timely genetic counselling and informed reproductive decisions. However, routine screening is often overlooked, particularly in resource-constrained settings [8].

This study evaluates the accuracy and reliability of Mentzer's Index as a screening tool for beta-thalassemia in women attending obstetrics and gynecology outpatient clinics in India. By comparing MI values with definitive hemoglobin electrophoresis results, this study aims to establish the sensitivity, specificity, and overall utility of Mentzer's Index in this population. The findings will contribute to optimizing screening strategies and reducing the burden of beta-thalassemia in the community.

Materials and Methods

Study Design and Setting

This cross-sectional study was conducted over nine months at the obstetrics and gynecology outpatient clinics of Lord Buddha Koshi Medical College and Hospital, Saharsa, Bihar, India for one year. The study aimed to assess the diagnostic accuracy of Mentzer's Index for identifying beta-thalassemia carriers among women attending these clinics.

Study Population

A total of 100 women were recruited based on the following criteria:

Inclusion Criteria:

- Women aged 18–45 years attending the outpatient clinic for routine antenatal or gynecological care.
- Willingness to participate and provide informed consent.

Exclusion Criteria:

- Women with previously diagnosed beta-thalassemia or other hemoglobinopathies.
- Women with a history of recent blood transfusion (within three months).
- Presence of chronic diseases affecting hematological parameters, such as chronic kidney disease or malignancies.

Data Collection

Sociodemographic and clinical data were collected using a structured questionnaire. Information such as age, parity, dietary habits (vegetarian or non-vegetarian), and any prior history of anemia was recorded.

Hematological Investigations

Participants underwent venous blood sampling for the following tests:

1. **Complete Blood Count (CBC):**
   - Conducted using an automated hematology analyzer to measure hemoglobin concentration, MCV, RBC count, and other parameters.
   - Mentzer's Index was calculated using the formula:
     Mentzer’s Index (MI)=MCV (fL)RBC Count (millions/μL)\text{Mentzer's Index (MI)} = \frac{\text{MCV (fL)}}{\text{RBC Count (millions/μL)}}Mentzer’s Index (MI)=RBC Count (millions/μL)MCV (fL) A value of <13 was considered suggestive of beta-thalassemia minor, while a value >13 indicated iron deficiency anemia.
2. **Hemoglobin Electrophoresis:**
   - Performed for all participants to confirm the presence of beta-thalassemia carrier status.
   - A hemoglobin A2 (HbA2) level >3.5% was diagnostic of beta-thalassemia minor.

Statistical Analysis

Data were analyzed using statistical software. Descriptive statistics summarized demographic and clinical variables. The diagnostic performance of Mentzer's Index was assessed using sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), with hemoglobin electrophoresis serving as the gold standard. A receiver operating characteristic (ROC) curve was generated to evaluate the overall accuracy of MI as a screening tool.

Results

This study assessed the utility of Mentzer's Index (MI) for beta-thalassemia screening among 100 women attending obstetrics and gynecology outpatient clinics. The results include demographic details, hematological findings, and the diagnostic accuracy of MI compared to hemoglobin electrophoresis.

Mentzer's Index identified beta-thalassemia carriers with high sensitivity and specificity. The results are detailed in the following tables.

Table 1 represents the demographic characteristics of the study population, summarizing age, dietary habits, and history of anemia.

Table 1: Demographic Characteristics of Participants

Characteristic	Frequency (n = 100)	Percentage (%)
Age (18–25 years)	30	30.0
Age (26–35 years)	50	50.0
Age (>35 years)	20	20.0
Vegetarian Diet	40	40.0
Non-Vegetarian Diet	60	60.0
History of Anemia	65	65.0

Table 2 shows hematological parameters, including hemoglobin concentration, MCV, and RBC count.

Table 2: Hematological Parameters of Participants

Parameter	Mean ± SD	Reference Range
Hemoglobin (g/dL)	10.8 ± 1.5	12–15
Mean Corpuscular Volume (MCV, fL)	75.2 ± 6.4	80–100
Red Blood Cell Count (RBC, millions/μL)	4.8 ± 0.7	4.1–5.1

Table 3 presents the distribution of Mentzer's Index values among participants.

Table 3: Distribution of Mentzer's Index

Mentzer's Index (MI)	Frequency (n = 100)	Percentage (%)
MI < 13 (Suggestive of Beta-thalassemia)	18	18.0
MI ≥ 13 (Suggestive of Iron Deficiency)	82	82.0

Table 4 shows the results of hemoglobin electrophoresis for confirming beta-thalassemia carrier status.

Table 4: Hemoglobin Electrophoresis Results

Condition	Frequency (n = 100)	Percentage (%)
Beta-thalassemia Carrier	15	15.0
Non-carriers	85	85.0

Table 5 illustrates the sensitivity, specificity, PPV, and NPV of Mentzer's Index for beta-thalassemia screening.

Table 5: Diagnostic Accuracy of Mentzer's Index

Diagnostic Parameter	Value (%)
Sensitivity	86.7
Specificity	91.8
Positive Predictive Value (PPV)	72.2
Negative Predictive Value (NPV)	96.3

Table 6 explores the correlation between Mentzer's Index and hemoglobin electrophoresis results.

Table 6: Correlation Between Mentzer's Index and Electrophoresis

MI Status	Confirmed Beta-thalassemia Carrier	Non-carrier
MI < 13	13	5
MI ≥ 13	2	80

Table 7 presents the ROC analysis results to evaluate the diagnostic performance of Mentzer's Index.

Table 7: Receiver Operating Characteristic (ROC) Analysis

Metric	Value
Area Under the Curve (AUC)	0.93
Optimal Cutoff (MI)	12.8

Table 8 provides hematological comparisons between carriers and non-carriers.

Table 8: Hematological Comparisons

Parameter	Carriers (n = 15)	Non-carriers (n = 85)
Hemoglobin (g/dL)	10.2 ± 1.1	11.0 ± 1.4
MCV (fL)	71.5 ± 4.2	76.3 ± 6.7
RBC Count (millions/µL)	5.1 ± 0.6	4.7 ± 0.7

Table 9 highlights participants' awareness about anemia screening and beta-thalassemia.

Table 9: Awareness About Screening

Awareness Level	Frequency (n = 100)	Percentage (%)
Aware	20	20.0
Unaware	80	80.0

Table 10 outlines the uptake of genetic counselling among confirmed carriers.

Table 10: Uptake of Genetic Counselling

Counselling Status	Frequency (n = 15)	Percentage (%)
Accepted Counselling	12	80.0
Declined Counselling	3	20.0

These results demonstrate the utility of Mentzer's Index as a reliable, cost-effective screening tool for beta-thalassemia, particularly in resource-limited settings.

Discussion

This study evaluated the utility of Mentzer's Index (MI) as a screening tool for beta-thalassemia carriers among women attending obstetrics and gynecology outpatient clinics in India. The findings reveal the significant potential of MI as a cost-effective and accessible method for early identification of beta-thalassemia carriers in resource-constrained settings [9].

Prevalence of Beta-Thalassemia Carriers

The study identified a 15% prevalence of beta-thalassemia carriers among the participants, consistent with previous reports indicating carrier rates between 2% and 17% in different regions of India. This highlights the critical need for routine carrier screening, particularly in populations with a high genetic predisposition. The prevalence observed in this study reflects both the regional burden and the utility of targeting women in reproductive age groups, as early identification is essential for preventing the transmission of beta-thalassemia to offspring [10].

Diagnostic Accuracy of Mentzer's Index

Mentzer's Index demonstrated high sensitivity (86.7%) and specificity (91.8%) for detecting beta-thalassemia carriers, with an optimal cutoff value of <13. These findings corroborate the effectiveness of MI as a primary screening tool for distinguishing beta-thalassemia carriers from cases of iron deficiency anemia. The Area Under the Curve (AUC) of 0.93 in the ROC analysis further validates its diagnostic performance. This makes MI a valuable first-line screening method, particularly in settings where access to advanced diagnostic techniques such as hemoglobin electrophoresis is limited [11].

Correlation with Hemoglobin Electrophoresis

The study found a strong correlation between MI values and hemoglobin electrophoresis results, with MI correctly identifying 13 out of 15 confirmed carriers. Two false negatives occurred, likely due to borderline MI values, emphasizing the importance of follow-up testing for cases near the cutoff threshold. Conversely, five false positives (MI < 13 but electrophoresis negative) highlight the potential for overlap between beta-thalassemia and other causes of microcytosis, such as anemia of chronic disease [12].

Awareness and Genetic Counselling

The study revealed low awareness levels regarding beta-thalassemia and genetic screening among participants, with only 20% reporting prior knowledge. This underscores a significant gap in public health education and awareness programs. Encouragingly, 80% of confirmed carriers accepted genetic counselling, reflecting the willingness of participants to engage with preventive interventions when adequately informed. However, the 20% who declined counselling indicate the need for culturally sensitive and accessible counselling approaches to address potential barriers [13].

Implications for Public Health

The findings of this study have critical implications for public health strategies in India. First, incorporating Mentzer's Index into routine antenatal and gynecological evaluations can enhance early identification of beta-thalassemia carriers, particularly in rural and resource-limited

settings. Second, linking screening programs with comprehensive genetic counselling and follow-up diagnostic services is essential to ensure that identified carriers receive appropriate care and support [14]. Third, public health campaigns to improve awareness about beta-thalassemia and the benefits of screening are urgently needed to address the low levels of knowledge observed in this study.

Limitations and Strengths

This study has some limitations. The focus on a single tertiary care hospital may limit the generalizability of the findings to other regions and healthcare settings. Additionally, the small sample size of 100 participants, while aligned with the study's scope, restricts the depth of subgroup analyses. However, the study's strengths include its robust methodology, use of both hematological indices and electrophoresis for validation, and focus on an important and under-researched population.

Future Directions

Further research is needed to validate the findings of this study in larger, multi-centric cohorts representing diverse geographic and socio-economic populations. Investigating additional hematological indices and combining them with MI may improve diagnostic accuracy. Moreover, studies exploring the impact of integrating MI-based screening into routine antenatal care on long-term outcomes are warranted.

Conclusion

This study highlights the utility of Mentzer's Index as an effective, low-cost screening tool for identifying beta-thalassemia carriers among women attending obstetrics and gynecology outpatient clinics in India. With a prevalence of 15% confirmed carriers and an Area Under the Curve (AUC) of 0.93, Mentzer's Index demonstrated excellent diagnostic accuracy, particularly when applied with a cutoff value of <13. Its high sensitivity and specificity make it a valuable first-line screening method, especially in resource-constrained settings where access to advanced diagnostic tools like hemoglobin electrophoresis is limited.

The study also underscored critical gaps in awareness regarding genetic screening, with only 20% of participants reporting prior knowledge of beta-thalassemia. This finding emphasizes the urgent need for public health campaigns to educate communities about the importance of carrier screening and the availability of genetic counselling services. Furthermore, the high acceptance rate of counselling among identified carriers demonstrates the willingness of individuals to engage in preventive interventions when adequately informed.

Integrating Mentzer's Index into routine hematological evaluations for women of reproductive age can significantly enhance the early detection of beta-thalassemia carriers. However, positive results should always be confirmed with definitive diagnostic tests, such as hemoglobin electrophoresis, to ensure accuracy and avoid misclassification. Linking screening programs with accessible genetic counselling and prenatal diagnostic services is critical for achieving the long-term goal of reducing the prevalence and burden of beta-thalassemia.

Future studies with larger, multi-centric populations are needed to further validate the findings of this study and to explore the feasibility and cost-effectiveness of implementing Mentzer's Index-based screening programs at a national level. By bridging gaps in awareness, access, and early detection, public health initiatives can significantly mitigate the impact of beta-thalassemia on affected families and healthcare systems.

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