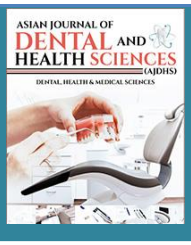

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Asian Journal of Dental and Health Sciences

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Open Access Review Article

Clinical Utility of Mentzer Index in Pregnancy Anemia Screening Programs: A Narrative Review

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Article Info:

Article History:

Received 10 Nov 2024
Reviewed 25 Dec 2024
Accepted 16 Jan 2025
Published 15 March 2025

Cite this article as:

Obeagu EI, Clinical Utility of Mentzer Index in Pregnancy Anemia Screening Programs: A Narrative Review, Asian Journal of Dental and Health Sciences. 2025; 5(1):40-44

DOI: http://dx.doi.org/10.22270/ajdhs.v5i1.118

Abstract

Anemia in pregnancy is a prevalent condition that can lead to severe complications for both mothers and their fetuses. Differentiating between the causes of anemia, particularly iron deficiency anemia (IDA) and thalassemia traits, is crucial for appropriate treatment. The Mentzer Index (MI) is a simple, cost-effective tool used to distinguish between these two common causes of microcytic anemia by comparing the mean corpuscular volume (MCV) to the red blood cell (RBC) count. This review explores the clinical utility of the MI in pregnancy anemia screening programs, highlighting its advantages, limitations, and potential role in improving diagnosis and management. The Mentzer Index has proven to be an effective first-line diagnostic tool, especially in resource-limited settings where advanced testing may not be readily available. By providing a straightforward method to differentiate IDA from thalassemia traits, the MI helps prevent the inappropriate use of iron supplements, which can exacerbate complications in individuals with thalassemia. Additionally, its simplicity allows for its incorporation into routine prenatal care, improving the efficiency of anemia screening programs and facilitating early intervention. Despite its benefits, the MI has limitations, including its reduced accuracy in pregnancy due to physiological changes and mixed anemia.

Keywords: Mentzer Index, pregnancy anemia, anemia screening, clinical utility, iron deficiency anemia

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Introduction

Anemia during pregnancy is a common and significant public health concern, affecting a substantial proportion of pregnant women worldwide. It is associated with numerous adverse outcomes for both the mother and fetus, including maternal fatigue, increased risk of preterm birth, low birth weight, and even maternal and infant mortality in severe cases. According to the World Health Organization (WHO), anemia affects around 40% of pregnant women globally, with iron deficiency anemia (IDA) being the most prevalent cause. Anemia in pregnancy is particularly common in low-resource settings where dietary deficiencies, parasitic infections, and limited access to healthcare services contribute to its high prevalence.[1-2] The causes of anemia in pregnancy are diverse and include iron deficiency, vitamin B12 and folate deficiencies, anemia of chronic disease, and genetic disorders such as thalassemia. Iron deficiency anemia (IDA) is the most common etiology, arising due to increased iron requirements during pregnancy that exceed the available iron stores. Thalassemia, a group of inherited blood disorders characterized by abnormal hemoglobin production, is also prevalent in certain populations. Microcytic anemia, which presents with low mean corpuscular volume (MCV), is often seen in both IDA and thalassemia, making differential diagnosis challenging. Therefore, accurate identification of the underlying cause of anemia is essential for effective treatment and management.[3-4]

Differentiating between IDA and thalassemia is crucial because the treatment approaches for these two conditions differ significantly. While IDA is treated with iron supplementation, thalassemia requires different management, such as folic acid supplementation and, in some cases, blood transfusions. Misdiagnosis and inappropriate treatment, such as the use of iron supplementation in individuals with thalassemia, can lead to complications such as iron overload. This makes the ability to differentiate between these two conditions an essential aspect of anemia management during pregnancy. In this context, the Mentzer Index (MI) has emerged as a simple and effective tool to help healthcare providers distinguish between IDA and thalassemia traits.[5] The Mentzer Index is a calculation derived from a complete blood count (CBC), using the ratio of the mean corpuscular volume (MCV) to the red blood cell (RBC) count. A lower MI value (typically less than 13) suggests thalassemia traits, whereas a higher value (greater than 13) is indicative of IDA. This

straightforward formula is easy to calculate and does not require specialized equipment, making it an ideal tool for use in primary care settings, especially in resource-limited environments. Its simplicity, combined with the ability to distinguish between two of the most common causes of microcytic anemia, makes the MI an attractive option for anemia screening in pregnant populations.[6-7] Despite the advantages of the Mentzer Index, it is not without limitations. The MI may not be as reliable in certain circumstances, such as when a pregnant woman has mixed anemia, where both iron deficiency and thalassemia traits coexist. Additionally, physiological changes during pregnancy, such as an increase in blood volume and alterations in red blood cell production, can affect the accuracy of the MI. Therefore, while the MI is a valuable screening tool, it should not be used in isolation. It must be combined with other diagnostic tests and clinical assessments to ensure a comprehensive diagnosis.[8-9] The clinical utility of the Mentzer Index in anemia screening during pregnancy is particularly relevant in low-resource settings where access to more advanced diagnostic tests, such as hemoglobin electrophoresis or genetic screening, may be limited. In these contexts, the MI offers a practical, affordable, and effective method for identifying women at risk of iron deficiency or thalassemia. The incorporation of the MI into routine prenatal care can enhance early detection and management of anemia, potentially improving maternal and fetal outcomes. However, further research is needed to assess its performance in diverse populations and to optimize its use in pregnancy anemia screening programs.[10-11]

Anemia in Pregnancy

Anemia in pregnancy is a widespread condition that poses significant risks to both maternal and fetal health. It is defined as a reduction in hemoglobin levels, which can result from a variety of underlying causes. Pregnant women are particularly vulnerable to anemia due to increased physiological demands, such as the expansion of blood volume, increased iron and folate requirements, and changes in red blood cell production. As a result, anemia during pregnancy is associated with numerous complications, including fatigue, weakness, preterm labor, low birth weight, and in severe cases, maternal and fetal death. The World Health Organization (WHO) estimates that anemia affects around 40% of pregnant women worldwide, with the prevalence varying by region, socioeconomic status, and access to healthcare.[12-13] The causes of anemia in pregnancy are diverse and can be broadly categorized into nutritional deficiencies, chronic diseases, and genetic disorders. The most common cause of anemia in pregnancy is iron deficiency anemia (IDA), which occurs when there is insufficient iron to meet the increased demand during pregnancy. This is often exacerbated by poor dietary intake, malabsorption, or blood loss. Other causes include folate deficiency, vitamin B12 deficiency, and anemia of chronic disease, which is seen in conditions like chronic infections or autoimmune disorders. In certain populations, genetic disorders such as thalassemia and sickle cell disease can contribute to anemia, leading to microcytic or normocytic anemia, respectively.[14-15]

Anemia during pregnancy can have serious consequences for maternal health. It increases the risk of preterm delivery, low birth weight, and postpartum hemorrhage. For the fetus, it can lead to intrauterine growth restriction, low birth weight, and developmental delays. Severe anemia has also been associated with an increased risk of maternal mortality, especially in low-resource settings where access to healthcare may be limited. Furthermore, maternal anemia can compromise the oxygen-carrying capacity of the blood, which in turn affects the oxygen supply to both the mother and the fetus, leading to potential developmental and health issues.[16] In addition to these risks, anemia in pregnancy can have long-term implications for both the mother and child. Women who experience anemia during pregnancy are more likely to suffer from postpartum anemia, which can delay recovery and impact overall health. For children, early exposure to maternal anemia has been linked to cognitive and developmental delays. As such, anemia management is crucial not only for the health of the pregnant woman but also for the long-term health and development of the child. Early identification, proper screening, and effective treatment are key to reducing the burden of anemia in pregnancy and improving maternal and fetal outcomes.[17] The identification and management of anemia during pregnancy require accurate diagnosis and differentiation between its various causes. This is crucial for providing the appropriate treatment. For instance, while iron deficiency anemia can be effectively managed with iron supplementation, thalassemia traits require different management strategies. Misdiagnosis and inappropriate treatment, such as administering iron supplements to a woman with thalassemia, can lead to adverse outcomes, including iron overload. As a result, healthcare providers need reliable diagnostic tools to distinguish between the causes of anemia in pregnancy and ensure targeted treatment.[18]

The Role of the Mentzer Index in Pregnancy Anemia Screening

The Mentzer Index (MI) is a valuable diagnostic tool used to differentiate between two common causes of microcytic anemia: iron deficiency anemia (IDA) and thalassemia. During pregnancy, anemia is a prevalent condition that can lead to serious complications for both the mother and fetus. Differentiating between the causes of anemia is crucial, as the treatment for IDA (iron supplementation) differs significantly from the management of thalassemia (which may require folic acid supplementation and careful monitoring to avoid iron overload). The Mentzer Index has become an important part of anemia screening, particularly in resource-limited settings, due to its simplicity, cost-effectiveness, and ability to provide immediate insight into the cause of anemia.[19] The Mentzer Index is calculated by dividing the mean corpuscular volume (MCV) by the red blood cell (RBC) count, which is expressed as a ratio. A lower MI value, generally below 13, is indicative of thalassemia or other

hemoglobinopathies, while a higher MI value, greater than 13, typically suggests iron deficiency anemia. This differentiation is particularly important in pregnancy because iron supplementation, which is effective for treating IDA, can exacerbate iron overload in individuals with thalassemia. The MI is a simple calculation, requiring only basic hematological parameters from a complete blood count (CBC), making it easy to use in clinical practice, particularly in primary care and low-resource settings where advanced diagnostic tools may not be available.[20]

The application of the Mentzer Index in pregnancy anemia screening can improve diagnostic accuracy and allow for more targeted interventions. Early differentiation between IDA and thalassemia can help avoid the inappropriate administration of iron supplements to women with thalassemia, preventing potential complications such as iron overload. Moreover, the MI aids in the identification of women who may require further diagnostic tests, such as hemoglobin electrophoresis or genetic screening, to confirm the presence of thalassemia or other hemoglobinopathies. This allows for more efficient use of healthcare resources and ensures that pregnant women receive the most appropriate and effective treatment for their condition.[21] In the context of pregnancy, where maternal and fetal health is at stake, the role of the Mentzer Index becomes even more significant. Pregnancy is a time of increased iron demand, and iron deficiency anemia is one of the most common conditions affecting pregnant women. By providing a simple and quick means of distinguishing between IDA and thalassemia, the MI enables healthcare providers to initiate the correct treatment earlier, reducing the risk of adverse outcomes. Furthermore, the MI helps clinicians identify women who may benefit from more comprehensive genetic counseling and screening, particularly in regions with higher prevalence rates of thalassemia.[22]

Advantages and Limitations of the Mentzer Index in Pregnancy Anemia Screening

The Mentzer Index (MI) is a practical and cost-effective tool used in the screening of anemia during pregnancy, particularly for distinguishing between iron deficiency anemia (IDA) and thalassemia, two of the most common causes of microcytic anemia. While the MI offers several advantages in clinical practice, it also comes with limitations that need to be considered for accurate and effective application in anemia management. Understanding both its strengths and weaknesses can help clinicians make more informed decisions when using the MI in pregnancy anemia screening.[23]

Advantages

1. **Simplicity and Ease of Use**

One of the key advantages of the Mentzer Index is its simplicity. It is calculated using two basic parameters obtained from a complete blood count (CBC): mean corpuscular volume (MCV) and red blood cell (RBC) count. These parameters are readily available in most clinical settings, making the MI an easy and quick tool to use without the need for complex or expensive diagnostic equipment. This simplicity makes it especially valuable in primary care settings or low-resource environments where access to advanced testing may be limited.[24]

2. **Cost-Effective**

The Mentzer Index is a highly cost-effective method for differentiating between IDA and thalassemia. Unlike more specialized diagnostic tests, such as hemoglobin electrophoresis or genetic screening, which can be costly and may require specialized facilities, the MI relies on parameters that are already part of routine blood tests. This makes it an attractive option for healthcare systems with limited resources, allowing for early and efficient screening of anemia in pregnant women.[25]

3. **Early Differentiation Between IDA and Thalassemia**

The MI is particularly useful in distinguishing between IDA and thalassemia, two conditions that can present similarly with microcytic anemia. Iron deficiency anemia, which is treated with iron supplementation, is the most common form of anemia in pregnancy, while thalassemia requires different management strategies. The MI helps avoid the mismanagement of thalassemia, such as inappropriate iron supplementation, which can lead to iron overload. Early differentiation between these conditions allows for appropriate treatment and reduces the risk of complications for both the mother and fetus.[26]

4. **Applicable in Resource-Limited Settings**

In many low-resource settings, where more advanced diagnostic tests may not be available, the Mentzer Index provides a simple and accessible alternative. It is especially helpful in areas where the prevalence of thalassemia or iron deficiency is high. The ability to perform quick screenings with a basic CBC and interpret the results effectively allows healthcare providers to better manage anemia in pregnant women in these regions, improving maternal and fetal health outcomes.[27]

Limitations

1. **Influence of Pregnancy-Related Physiological Changes**

Pregnancy itself brings about significant physiological changes, such as an increase in blood volume, changes in red blood cell production, and alterations in iron metabolism. These changes can affect the mean corpuscular volume (MCV) and red blood cell (RBC) count, potentially leading to misleading Mentzer Index results. For example, the increase in plasma volume during pregnancy may result in lower RBC concentration and altered MCV values, which can distort the MI calculation and reduce its diagnostic accuracy in pregnant women.[24]

2. **Less Effective in Mixed Anemia**

The MI may be less reliable in cases of mixed anemia, where a pregnant woman has both iron deficiency and thalassemia traits. In such cases, the MI may produce ambiguous results, as both conditions can affect MCV and RBC count. Since the MI is designed to distinguish between iron deficiency and thalassemia specifically, it may not be able to provide a clear diagnosis when both conditions are present, necessitating further diagnostic testing such as hemoglobin electrophoresis or genetic screening for a more definitive diagnosis.[25]

3. **Limited in Severe Cases of Anemia**

In cases of severe anemia, where hemoglobin levels are critically low, the Mentzer Index may not offer reliable results. The formula depends on accurate RBC and MCV measurements, which can be influenced by extremely low or high values of these parameters. For example, in severe iron deficiency anemia, the RBC count may be elevated as a compensatory mechanism, and in severe thalassemia, the RBC count may be disproportionately low. These extreme values can cause the MI to be less accurate in such scenarios.[26]

4. **Not Suitable for All Anemia Causes**

While the Mentzer Index is effective in distinguishing between IDA and thalassemia, it does not provide information on other causes of anemia that may also affect pregnant women, such as vitamin B12 deficiency, folate deficiency, or anemia of chronic disease. Therefore, the MI is only useful for identifying specific types of microcytic anemia and should not be relied upon as the sole diagnostic tool in cases where other etiologies are suspected. A comprehensive approach, including additional testing and clinical evaluation, is necessary to accurately diagnose and treat anemia with multiple underlying causes.[27]

5. **Need for Additional Diagnostic Confirmation**

While the MI is a useful screening tool, it is not definitive. The results should always be corroborated with other diagnostic tests, especially in ambiguous or borderline cases. For instance, confirmation of thalassemia typically requires hemoglobin electrophoresis or genetic testing to accurately identify the specific hemoglobin variant or mutation. Similarly, iron deficiency anemia diagnosis may need additional assessments, such as serum ferritin levels or iron studies, to confirm the deficiency and assess the severity.[27]

Conclusion

The Mentzer Index (MI) serves as a valuable, cost-effective tool in the screening and differentiation of microcytic anemia, particularly for distinguishing between iron deficiency anemia (IDA) and thalassemia in pregnant women. Its simplicity and accessibility make it an ideal choice for use in clinical settings, especially in low-resource environments where advanced diagnostic tests may be limited. By enabling early identification of these two common causes of microcytic anemia, the MI helps guide appropriate treatment strategies, reducing the risk of complications such as iron overload in thalassemia patients.

Conflict of Interest: Author declares no potential conflict of interest with respect to the contents, authorship, and/or publication of this article.

Source of Support: Nil

Funding: The authors declared that this study has received no financial support.

Informed Consent Statement: Not applicable.

Data Availability Statement: The data supporting in this paper are available in the cited references.

Ethics approval: Not applicable.

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