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Raghda Hameed Jasim
Medical Laboratories Techniques Department, College of Health and Medical Techniques, Al-Mustaqbal University, 51001, Babylon, Iraq, raghda.hameed.jasim@uomus.edu.iq

Rasha Hussain Aouda
Medical Laboratories Techniques Department, College of Health and Medical Techniques, Al-Mustaqbal University, 51001, Babylon, Iraq, rasha.hussein.oudah@uomus.edu.iq

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ORIGINAL STUDY

Evaluation of RBC Indices and Significance of Mentzer Index for Differentiation Between Iron Deficiency Anemia and Beta Thalassemia Trait

Raghda Hameed Jasim, M.B.Ch.B-F.I.B.M.S *, Rasha Hussain Aouda

Medical Laboratories Techniques Department, College of Health and Medical Techniques, Al-Mustaqbal University, 51001, Babylon, Iraq

ABSTRACT

Background: Anemia is a global public health problem affecting developed and adversely affecting developing countries. About 1.62 billion peoples are affected worldwide, currently pregnant women are the most vulnerable population corresponding to 24.8%. **Objective:** To evaluate RBC indices and significance of Mentzer index for differentiation between Iron deficiency anemia and Beta thalassemia trait. **Patients and methods:** Cross sectional study was conducted in Babylon Maternity and Pediatrics Teaching Hospital for a period of 4 months. Data was collected prospectively after approval of the research proposal was gained, the study involved 114 patients that were referred to the Babylon Maternity and Pediatrics Teaching Hospital. **Results:** The average age of IDA patients was 11.79 ± 6.09, while that of BTT patients was 12.15 ± 5.26. There was no significant relationship between the mean age of patients with illness. Those with a Mentzer Index greater than 13 are more likely to have IDA (sensitivity 95.6%) and less likely to have beta thalassemia (specificity 95.6%). Patients with a Mentzer Index <13 are more likely to have βTT (sensitivity 72.7%) and non-probability of IDA (specificity 72.7%). **Conclusion:** Clinicians face a dilemma distinguishing between iron deficiency anemia and beta thalassemia in anemic patients since diagnostic tests are not inexpensive to the majority of the population. The Mentzer Index can be used as a screening test for iron deficiency anemia, with sensitivity and specificity of 95.6% and 72.7%, respectively, and for beta thalassemia. Those with a Mentzer Index <13 can undergo Hb electrophoresis for confirmation.

Keywords: Iron deficiency anemia, Beta thalassemia trait, Mentzer index, RBC indices, Hematopathology, Diagnostic accuracy

1. Introduction

1.1. Background

Anemia is a global public health issue that impacts both industrialized and underdeveloped countries. Globally, around 1.62 billion individuals are impacted, with pregnant women accounting for 24.8% of the total vulnerability [1, 2].

1.2. Epidemiology

Anemia is most common in impoverished countries, with several causes. Anemia incidence varies by socioeconomic position, cultural variables, nutritional inadequacies, repeated pregnancies, poor contraceptive prevalence, infections, and haemoglobinopathies are additional contributors [3].

1.3. Iron deficiency anemia clinical presentation and complication

Iron deficiency anemia is the most common form worldwide, and pregnant women are particularly at risk, especially given the significant risk even during their first pregnancy [4]. In underdeveloped nations, pregnant women with iron deficiency are at high risk

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* Corresponding author.
E-mail addresses: Raghda.Hameed.Jasim@uomus.edu.iq (R. H. Jasim), rasha.hussein.oudah@uomus.edu.iq (R. H. Aouda).

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for serious morbidity and death [5]. The less severe types of anemia are "silent," meaning they don't show any signs. Fatigue, weakness, lightheadedness, sleepiness, and a loss of natural skin color (in fair-skinned individuals) as well as lips, tongue, and nails are signs of the severe type of anemia.

Anemia, regardless of severity, is the second most common cause of maternal death among Asian populations, accounting for 12.8% of all maternal deaths [5]. Additionally, anemia accounts for 20% of maternal fatalities, and it is associated with an additional risk factor that contributes to 50% of all maternal deaths [6].

The primary causes of anemia-related deaths are excessive blood loss during or after delivery, which lowers hematological reserves and increases susceptibility to infection. Severe anemia, on the other hand, is characterized by a hemoglobin (Hb) level of less than 4 g/dl, which is linked to a significant risk of cardiac failure and death, especially during or shortly after delivery [7].

About 30% of people worldwide suffer from iron deficiency anemia (IDA), which is the most prevalent hematological condition in newborns and children and is caused by a shortage of iron necessary for hemoglobin synthesis. An estimated 1.5% of people worldwide are thought to carry the genes for β-thalassemia. Reduced hemoglobin (Hb) production and reduced globin chain synthesis cause thalassemia to manifest as hypochromic microcytic anemia [8].

1.4. Beta thalassemia trait (β-TT)

The most prevalent kind of hereditary hemoglobinopathy. Southeast Asia, the Mediterranean area, Southwest Europe, the Middle East, and Central Africa are also popular places for people with β-TT, with an estimated 50% of the world's population living in this region [9]. Additionally, β-TT is present in persons who have no obvious ethnic connection to the illness because of the migration and marrying of many ethnic groupings. Beta thalassemia trait (β-TT) carriers typically don't have any symptoms [9].

A range of illnesses known as thalassemia syndromes are distinguished by the absence or reduction of one or more globin chains. Almost all of Southeast Asia, the Mediterranean, the Middle East, northern Africa, and India are among the places where beta-globin gene cluster mutations occur at high rates (>1%) [10].

Despite the low frequency of these mutations in northern European and North American populations, they are distributed globally as a result of extensive immigration [11].

In Iraq, the prevalence of thalassemia was around 75% of all hemoglobinopathies, with beta-thalassemia major accounting for 67% of all thalassemia types [12].

Beta-globin chain synthesis is either missing or reduced in beta-thalassemia disorders. A total or nearly complete loss of beta-globin results in beta-thalassemia major, which causes severe anemia that is dependent on transfusions. Ineffective erythropoiesis is the fundamental pathophysiology of beta-thalassemia disorders. Defects in the start or stop of transcription, aberrant RNA splicing or cleavage, substitutions, and frame shifts brought on by a range of gene or regulatory element alterations are the causes of beta-thalassemia [13].

1.5. Thalassemia classification

The two types of thalassemia are phenotypic (silent carrier, B Thalassemia minor, β Thalassemia intermedia, and β Thalassemia major) and genotypic (heterozygous beta-thalassemia, also known as beta-thalassemia trait) [14, 15].

The genotype is the primary determinant of the severity of the clinical presentation and laboratory results in thalassaemia syndrome. During their first year or two of life, people with Coolley's anemia, also known as thalassaemia major, have a severe and sometimes fatal form of anemia. In order to rectify their anemia and decrease their high degree of inefficient erythropoiesis, the patients need ongoing transfusion treatment in order to survive infancy 3. Genetic conditions known as beta-thalassaemia major and intermedia are linked to substantial morbidity and a shortened life expectancy [16].

Prenatal screening by blood counts and hemoglobin analysis should be provided to women who are at risk of becoming carriers due to their ethnic origin and family history. They should also be offered genetic counseling [17].

1.6. Aim of study

The goal of this research is to assess RBC indices and the importance of the Mentzer index in distinguishing between beta thalassemia trait and iron deficiency anemia.

2. Patients and methods

2.1. Cross-sectional research design

2.1.1. Methodology

For four months, the study was carried out at Babylon Maternity and Pediatrics Teaching Hospital. After

Table 1. The mean age of study sample.

Variable	IDA	BTT	P Value
Mean age (years)	11.79 ± 6.09	12.15 ± 5.26	0.811

the research proposal was approved, data was gathered prospectively from 114 patients who had been sent to the Babylon Maternity and Pediatrics Teaching Hospital.

2.2. Statistical analysis

After being converted into a Microsoft Excel work sheet, the survey data is forwarded for additional statistical analysis. The statistical analysis was conducted using the Statistical Package for Social Sciences (SPSS) version 27 software. The data were displayed as tables and figures using basic measures of frequency, percentage, mean, and standard deviation. All statistical comparisons were two-tailed, and the alpha level of significance of 0.05 was taken into consideration for statistical significance; a P value of <0.05 indicates significance. The Students-t-test or Paired-t-test for differences of paired observations was used to determine the significance of the difference.

2.3. Results

The mean age ± S.D of IDA patients was 11.79 ± 6.09, while the mean age ± S.D of BTT was 12.15 ± 5.26. There was no statistical association between mean age of patients with disease (Table 1).

There was statistical association between CBC parameters and type of disease in which p value less than 0.05, while patients hemoglobin not reach to statistical significant (Table 2).

IDA patients their Mentzer Index >13 in (88) patients and (6) patients their Mentzer Index <13, while in BTT (16) patients their Mentzer Index <13 and (4) patients their Mentzer Index >13 (Table 3). At 95.6% sensitivity and 95.6% specificity, individuals with a Mentzer Index greater than 13 are most likely to have iron deficiency anemia and no chance of beta thalassemia trait. With a sensitivity of 72.7% and a specificity of 72.7%, individuals with a Mentzer Index of less than 13 are more likely to have beta thalassemia trait and no-probability of iron deficiency anemia (Table 4).

3. Discussion

Ninety-four (82.45%) of the 114 patients in this study were diagnosed with iron deficiency anemia (IDA), and twenty (17.54%) were diagnosed with beta-thalassemia trait (βTT). This is likely to be the case in other studies, where 93% of the 100 subjects were diagnosed with IDA and 7% with beta-thalassemia trait (βTT) [24]. It has long been necessary to distinguish between IDA and βTT in patients with hypochromic microcytic anemia because multiple studies have shown that coexisting iron deficiency anemia (IDA) directly affects HbA2 synthesis, leading to confusing levels of HbA2 in beta-thalassemia trait (βTT), and that continued iron therapy will not improve the MCV in these patients [25]. Hb A2 measurement by Hb electrophoresis, peripheral blood film examination, iron profile investigation (serum ferritin, iron, TIBC), and transferrin saturation are required to distinguish between βTT and IDA. However, it is preferable to rely on straightforward and readily available information because it is comparatively costly and time-consuming. MCH and MCHC levels, two other metrics, did not significantly differ between the two groups. While serum ferritin levels are greater in βTT patients, they were strikingly low in IDA patients. Our findings are consistent with those of previous studies [26].

To differentiate between IDA and βTT, CBC provides red cell distribution width (RDW), which can be utilized in conjunction with a derived value [27]. RDW is an indicator of anisocytosis. In IDA, its value is elevated, whereas in βTT, it is either slightly

Table 2. Complete blood count (CBC) parameters in both the iron Deficiency anemia (IDA) and beta-thalassemia trait (βTT).

	IDA (NO.94)		βTT (NO.20)		
CBC parameters	Range	Mean ± SD	Range	Mean ± SD	p-value
Hemoglobin(g/dl)	6.1–9	7.76 ± 2.15	6.3–9.7	9.70 ± 3.81	0.067
RBC (1012/l)	2.34-7.9	7.25 ± 38.03	5.1–7	4.94 ± 1.40	0.001
MCV	60.3–76.4	75.65 ± 14.85	50.9–55.80	55.60 ± 20.62	0.001
MCH	16.2–26.9	26.74 ± 11.84	13.7–25.8	24.76 ± 13.74	0.004
MCHC	22.86–96.9	68.15 ± 99.2	24.3–47.3	46.11 ± 67.95	0.001
Ferritin	679–1908	17.88.11 ± 1738.11	800–2356	2278.16 ± 2266.7	0.03
RDW	13.2–24.9	23.56 ± 14.17	10.5–19.6	18.98 ± 5.09	0.008
RDWI	354–570	566.4 ± 480.23	102–201	198.23 ± 50.89	0.001

Table 3. Mentzer Index in cases of iron deficiency anemia and beta thalassemia trait.

Variables	Mentzer Index >13	Mentzer Index <13	Total
IDA	88	6	94
BTT	4	16	20
Total	92	22	**114**

Table 4. Sensitivity and specificity of Mentzer Index for iron deficiency anemia and beta thalassemia trait.

Variables	Sensitivity	Specificity
IDA	95.6%	72.7%
BTT	72.7%	95.6%

elevated or close to normal [27]. We found a significant correlation (p-value < 0.05) between RDW and the kind of sickness. Other investigations also reported similar findings [28]. Iron deficiency anemia (IDA) and beta thalassemia trait differentiation has also been reported using a number of indices employing basic blood count values, however it has not been found to be 100% specific or 100% sensitive. But only observed that Mentzer Index has obtained extraordinary sensitivity and specificity among all relevant indices [29].

It was discovered in this study as well that the Mentzer Index was utilized as a screening tool to distinguish between βTT and IDA. In their investigation, Munir AH et al. also demonstrated this [30]. This study discovered that people with a Mentzer Index greater than 13 are most likely to have iron deficiency anemia (IDA), which has a 95.6% sensitivity and a 95.6% specificity, meaning they have no chance of having beta thalassemia in their bodies. In contrast, women with a Mentzer Index of less than 13 who have microcytic hypochromic anemia in utero are more likely to have beta thalassemia trait (βTT), which has a 72.7% sensitivity, and non-probability of iron deficiency anemia (IDA), which has a 72.7% specificity. Therefore, the Mentzer Index is more accurate in identifying iron deficiency anemia and ruling out beta thalassemia in the process.

These results are consistent with a research conducted in India by Bose S et al. [29]. Additionally, this analysis concurs with prior research that discovered With a sensitivity of 91% and a specificity of 91%, individuals with a Mentzer Index greater than 13 are most likely to have iron deficiency anemia and a non-probability of beta thalassemia trait. On the other hand, women who have microcytic hypochromic anemia in utero and whose Mentzer Index is less than 13 are more likely to have beta thalassemia trait (βTT), which has an 83% sensitivity and an 83% specificity, and no chance of IDA [24].

4. Limitations of study

Additional red blood cell indices and a larger sample size are needed to distinguish iron deficiency anemia from beta thalassemia trait.

5. Conclusion

Clinicians find it difficult to distinguish between iron deficiency anemia and beta thalassemia trait in anemic patients because most people do not think the diagnostic tests are credible. With a sensitivity and specificity of 95.6% & 72.7% for IDA and 72.7% & 95.6% for βTT, the Mentzer Index can be used as a screening test. Those whose Mentzer Index is less than 13 must undergo Hb electrophoresis for confirmation.

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