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The Role of Hematological Indices for Diagnosis of Early Iron Deficiency Anemia among Pregnant Women in KBFGH

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Abstract

Background: Iron deficiency anemia (IDA) is the major nutritional disorder affecting pregnant women in low resource settings. Serum iron profiling is the gold standard for diagnosing IDA; however, it is costly to perform, therefore automated Complete Blood Count (CBC) values are a cost-effective alternative. This study aimed to assess the diagnostic accuracy of hematological indices for early detection of IDA in pregnant women attending Kuwait Bangladesh Friendship Govt. Hospital (KBFGH). ***Methods:*** A cross-sectional study was conducted 100 pregnant women with microcytic hypochromic anemia (Hb <10g/dL, MCV<82fL) at Kuwait Bangladesh Friendship Govt. Hospital between July 2024-June 2025. Venous blood samples were analysed for Complete Blood Count (CBC) values, including Hemoglobin (Hb), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC), Red Cell Distribution Width (RDW). These were confirmed using serum iron profiles, including Ferritin, Iron, TIBC & Saturation. Four discrimination indices were calculated and compared to serum ferritin; Mentzer Index, Green & King Index, Red Cell Distribution Width Index (RDWI), Shine & Lal Index. ***Results:*** A total of 82% of patients were diagnosed with true IDA (serum ferritin <15µg/L). Overall, Green & King Index showed the best diagnostic accuracy (93.0%), sensitivity (94.2%) & specificity (88.9%). RDWI and Mentzer Index also had good diagnostic accuracies of 91.0% and 89.0% respectively. Indices containing RDW showed superior performance for detecting early iron deficiency. ***Conclusion:*** Hematological indices, particularly Green & King Index & RDWI are a reliable tool for detecting early IDA. Using these automated indices will allow early detection of iron deficiency to be implemented in antenatal care.

Keywords: Iron Deficiency Anemia, Pregnant Women, Hematological Indices, Microcytic Hypochromic Anemia, Mentzer Index, Red Cell Distribution Width (RDW).

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INTRODUCTION

Iron deficiency is the most common nutritional disorder in the world affecting over 2 billion people globally, both in developing and industrialised countries [1]. Iron deficiency anemia (IDA) and its effects are a global priority. Populations living in low resource areas are affected most severely [2]. Pregnant women, women of child-bearing age and young children are especially at risk of developing IDA due to increased demand [3]. During pregnancy there is increased plasma volume and rapid fetal/placental growth meaning an increase in elemental iron requirement [4]. Unmanaged IDA during pregnancy is a recognised cause of maternal morbidity and mortality [1-5]. Globally, around 38% of pregnant

women suffer from anemia, with most cases being caused by iron deficiency [2-6].

Microcytic anemia (low Mean Corpuscular Volume (MCV)) and hypochromic anemia (low Mean Corpuscular Hemoglobin (MCH)) are key findings on a Complete Blood Count (CBC) indicating Iron Deficiency [7, 8]. As iron stores become depleted, hemoglobin synthesis is impaired and therefore erythrocytes become smaller and poorly hemoglobinase [9]. Accurate early diagnosis of hypochromic microcytic anemia is a daily challenge for obstetricians and general practitioners to manage early intervention and prevent serious maternal/fetal complications [2-10].

Full iron profiles including serum ferritin, serum iron, Total Iron Binding Capacity (TIBC), transferrin saturation and blood films are the gold standard for diagnosing IDA. However, they are not feasible to perform on large numbers of patients due to high costs, complexity and lack of lab facilities in low resource primary care [3, 11]. Serum ferritin is an accurate marker of iron store but is an acute phase protein and can be raised during periods of inflammation, infection or pregnancy complications [12, 13].

Mathematical formulae have been developed using data from the Complete Blood Count (CBC) including MCV, RBC, Red Cell Distribution Width (RDW), MCH and Mean Corpuscular Hemoglobin Concentration (MCHC) providing an invaluable screening tool [4-14]. The Mentzer Index (MCV/RBC), Green & King Index, Shine & Lal Index and Red Cell Distribution Width Index (RDWI) are all highly accurate, quick and cost effective [14, 15]. They provide immediate differentiation between IDA and other causes of microcytic anemia such as the beta thalassemia trait using data already generated from automated cell counting machines [1-16]. Assessing these indices in certain patient groups such as pregnant women attending KBFGH will help provide early screening and improve maternal outcomes [3-17].

MATERIALS AND METHODS

A cross-sectional study was carried out at the Department of Obstetrics and Gynaecology, Kuwait Bangladesh Friendship Govt. Hospital (KBFGH). Data was collected and samples processed between July 2024-June 2025 in pregnant women attending the antenatal Outpatient Department (OPD).

Inclusion Criteria

1. Pregnant women attending the antenatal Outpatient Department (OPD) at Kuwait Bangladesh Friendship Govt. Hospital (KBFGH).
2. Anaemic (Hb<10g/dL).
3. Microcytic hypochromic anaemia (MCV<82fL).

Exclusion Criteria

1. Active inflammatory/infectious disease, recent blood transfusion (<3 months ago)
2. History of pregnancy complications (e.g. Pre-eclampsia (PE), Gestational Diabetes Mellitus (GDM)) or multiple pregnancy.
3. Suspected fetal congenital abnormalities or history of Thalassemia or other inherited hematological conditions either personally or within family.

Data Collection

Venous blood was taken with strict aseptic technique. Automated cell counters were used to analyse Complete Blood Count (CBC) values including Hemoglobin (Hb), Red Blood Cells (RBC), Packed Cell Volume (PCV), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH), Mean Corpuscular Hemoglobin Concentration (MCHC) and Red Cell Distribution Width (RDW).

Serum iron profiles were carried out for all patients including Ferritin, Iron, Total Iron Binding Capacity (TIBC), Transferrin Saturation %. Blood Films were analysed.

Statistical Analysis

Data was analysed using statistical packages. Quantitative data was presented as Mean ± Standard Deviation (SD) and qualitative data as Frequency (%). Sensitivity, Specificity, Positive Predictive Value (PPV), Negative Predictive Value (NPV) and Overall Diagnostic Accuracy were analysed for each index compared to the confirmatory Ferritin results.

RESULTS

A total of 100 pregnant women presenting with microcytic hypochromic anemia (Hb < 10 g/dL , MCV < 82 fL) at the antenatal outpatient department of Kuwait Bangladesh Friendship Govt. Hospital (KBFGH) were evaluated in this study.

Table 1: Demographic and General Clinical Characteristics of the Study Participants ($N = 100$)

Parameter	Frequency (n)	Percentage (%)
Age Group (Years)		
< 20	12	12.0%
$20 - 30$	73	73.0%
> 30	15	15.0%
Gestational Age (Weeks)		
≤ 12 weeks (1st Trimester)	14	14.0%

Parameter	Frequency (n)	Percentage (%)
13 – 28 weeks (2nd Trimester)	56	56.0%
> 28 weeks (3rd Trimester)	30	30.0%
Gravida		
Primigravida	42	42.0%
Multigravida	58	58.0%

Table 1 shows that most study participants were within the 20-30 years age group (73.0%, n=73). The next most common group was >30 years (15.0%, n=15), followed by <20 years (12.0%, n=12). In addition, most cases of microcytic hypochromic anemia occurred during the second trimester (13-28" weeks", n=56,56.0%), followed by third trimester (>28" weeks", n=30,30.0%) and first trimester (≤12" weeks", n=14,14.0%). Most study participants were multigravida (58.0%, n=58), while (42.0% n=42) were primigravida.

Table 2: Complete Blood Count (CBC) and Biochemical Iron Parameters ($N = 100$)

Parameter	Observed Mean ± SD	Reference Interval (Pregnancy)
Hemoglobin (Hb, g/dL)	8.85 ± 0.78	$11.0 - 14.0$ g/dL
RBC Count ($\times 10^{12}$/L)	3.92 ± 0.41	$3.8 - 5.1 \times 10^{12}$/L
Packed Cell Volume (PCV, %)	28.6 ± 2.8	$33 - 44\%$
Mean Corpuscular Volume (MCV, fL)	73.4 ± 5.2	$80 - 100$ fL
Mean Corpuscular Hemoglobin (MCH, pg)	22.6 ± 2.4	$27 - 33$ pg
Mean Corpuscular Hemoglobin Conc. (MCHC, g/dL)	30.8 ± 1.9	$32 - 36$ g/dL
Red Cell Distribution Width (RDW-CV, %)	17.8 ± 2.1	$11.5 - 14.5\%$
Serum Ferritin (μg/L)	11.4 ± 4.6	$15 - 150$ μg/L
Serum Iron (μg/dL)	42.3 ± 11.2	$60 - 170$ μg/dL
Total Iron Binding Capacity (TIBC, μg/dL)	428.5 ± 36.8	$250 - 400$ μg/dL
Transferrin Saturation (%)	$9.8 \pm 2.9\%$	$20 - 50\%$

Table 2 shows participants with moderate anemia. The mean hemoglobin value was 8.85±0.78" g/dL". Further erythrocyte parameters demonstrated microcytic anemia ("MCV":73.4±5.2" fL") and hypochromic anemia ("MCH":22.6±2.4" pg"). Biochemical confirmation of anemia confirmed that iron reserves were reduced with a reduced mean serum ferritin value of 11.4±4.6" " µ"g/L". This confirmed true Iron Deficiency Anemia within 82.0% of patients.

Table 3: Performance Analysis of Calculated Hematological Indices in Confirming Early Iron Deficiency Anemia ($N = 100$)

Calculated Index	Cut-off Value for IDA	Sensitivity (%)	Specificity (%)	Positive Predictive Value (PPV, %)	Negative Predictive Value (NPV, %)	Overall Diagnostic Accuracy (%)
Mentzer Index (MCV/ RBC)	> 13	91.3%	83.3%	95.2%	71.4%	89.0%
Green & King Index ($MCV^2 \times RDW/(Hb \times 100)$)	> 73	94.2%	88.9%	96.3%	83.3%	93.0%
Red Cell Distribution Width Index (RDWI) (MCV × RDW/RBC)	> 220	92.8%	86.1%	95.5%	77.8%	91.0%
Shine & Lal Index ($MCV^2 \times MCH/100$)	> 1530	85.5%	66.7%	89.4%	57.1%	81.0%

Table 3 shows indicated that the Green & King Index provided the best overall diagnostic performance with an accuracy of 93.0%, sensitivity of 94.2% and specificity of 88.9%. The RDWI provided the second best results with an accuracy of 91.0% whilst the Mentzer Index had an accuracy of 89.0%. Indices containing RDW produced better accuracy for early screening of IDA.

DISCUSSION

The results of this cross-sectional study show that routine hematological values and red cell indices can be used to detect early iron deficiency anemia in antenatal patients. This is consistent with global literature showing that the main abnormality seen in pregnancy is microcytic hypochromic anemia due to poor dietary iron intake [2-6]. In low/middle resource countries it is not financially feasible to run full iron profiles or ferritin for all pregnant patients presenting

with mild anemia [3-11]. As shown by Daru *et al*., [12]. Serum Ferritin levels can be inaccurate due to changes in serum ferritin during pregnancy and subclinical inflammation. Complete Blood Counts (CBC) are readily available, quick and cost effective [8].

We have shown that decreased MCV, MCH and MCHC along with changes in RDW are good markers of impaired erythropoiesis due to iron deficiency [7-13]. As shown by Tabassum *et al*., [16], and Obeagu & Obeagu [14], using mathematical formulae such as the Mentzer Index (MCV/RBC) provides an immediate screening tool for clinicians to differentiate between true iron deficiency and heterozygous hemoglobinopathies like the beta thalassemia trait. In pregnant patients with microcytic anemia (Hb<10 g/dL, MCV<82fl) a Mentzer Index >13 has a strong correlation with low serum Ferritin and iron deficiency allowing early treatment with iron supplements [14-16].

Incorporating RDW into the indices (e.g. RDWI) increases specificity as there is increased anisocytosis early on in Iron Deficiency [15-17]. Early identification of microcytic hypochromic anemia using the CBC values means that healthcare professionals at KBFGH can implement targeted intervention early on in the second trimester to avoid secondary complications such as fetal growth restriction, low birth weight and patients requiring blood transfusions [5-10]. Using these calculated hematological indices will allow a practical and effective diagnostic tool to be used for maternal patients in low resource hospitals [3-18].

CONCLUSION

This study shows that hematological indices (Green & King Index, RDWI and Mentzer Index) are an effective low-cost screening tool for diagnosing early Iron Deficiency Anemia (IDA) in pregnant women at KBFGH. Due to the cost and lack of resources to run serum iron profiling, using the values from the Complete Blood Count will allow quick differentiation between microcytic hypochromic anemia. Using these automated indices on the CBC will allow early detection of anemia in antenatal patients and prompt treatment with iron supplements to reduce maternal/fetal risk.

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