ORIGINAL RESEARCH

Hematological profile of normal pregnant women in Lagos, Nigeria

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Background: Hematological profile is considered one of the factors affecting pregnancy and its outcome. Anemia is the most common hematological problem in pregnancy, followed by thrombocytopenia. Leukocytosis is almost always associated with pregnancy. The study reported here was designed to evaluate the overall mean values of seven major hematological parameters and their mean values at different trimesters of pregnancy.

Subjects and methods: This examination was a cross-sectional study of 274 pregnant women who registered to attend the Lagos University Teaching Hospital or Lagos State University Teaching Hospital antenatal clinics between their first and third trimester. Blood (4.5 mL) was collected from each participant into a tube containing the anticoagulant ethylenediaminetetraacetic acid (EDTA). A full blood count was performed on each sample and the results were analyzed.

Results: Overall, the values obtained were (mean ± standard deviation [SD]): hematocrit level, 30.16% ± 5.55%; hemoglobin concentration, 10.94 ± 1.86 g/dL; white blood cells, 7.81 ± 2.34×10⁹; platelets, 228.29 ± 65.6×10⁹; cell volume 78.30 ± 5.70 fL, corpuscular hemoglobin, 28.57 ± 2.48 pg; and corpuscular hemoglobin concentration, 36.45 ± 1.10 g/dL. When grouped by trimester, the mean ± SD value of packed cell volume at first trimester was 32.07% ± 6.80%; of second trimester, 29.76% ± 5.21%; and of third, 33.04% ± 3.88%. The mean ± SD hemoglobin concentration values were 11.59 ± 2.35 g/dL, 10.81 ± 1.72 g/dL, and 10.38 ± 1.27 g/dL for women in their first, second, and third trimester, respectively. Mean ± SD white blood cell concentration for first, second, and third trimesters were 7.31 ± 2.38×10⁹, 7.88 ± 2.33×10⁹, and 8.37 ± 2.15×10⁹, respectively, while the mean ± SD platelet values for first, second, and third trimesters were 231.50 ± 79.10×10⁹, 227.57 ± 63×10⁹, and 200.82 ± 94.42×10⁹, respectively. A statistically significant relationship was found to exist between packed cell volume and white blood cell count with increase in gestational age ($P = 0.010$ and 0.001, respectively). However, there was no statistically significant association between platelet count and increase in gestational age ($P = 0.296$).

Conclusion: These findings reinforce the need for supplementation and provide additional information on hematological reference values in pregnancy in Nigeria.

Keywords: anemia, thrombocytopenia, hematology, normal pregnancy, trimester

Background

Hematological profile is measured all over the world to estimate general health, because it is a reliable indicator and is a simple, fast and cost-effective test.[1] In addition, the hematological profile is considered to be one of the factors affecting pregnancy and its outcome.[2,3] During pregnancy, changes occur and can be observed in hematological indices such as red blood cell (RBC) count, hemoglobin (Hb) concentration, platelet (PLT) count, and white

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blood cell (WBC) count. Some of these are decreased – for example, RBC and PLT counts – partly as a result of the physiological hemodilution that occurs in pregnancy,[4,5] while others are increased, such as the WBC count.[6]

RBC changes in pregnancy

In pregnancy, plasma volume increases 25%–80% between the sixth and twenty-fourth week of gestation.[7] However, the increase in RBC mass has been found to be approximately 30% between the twelfth and thirty-sixth week of gestation when iron and folate are supplemented.[8] The discrepancy between the rate of increase in plasma volume and that in RBC mass leads to physiological anemia. In late pregnancy, plasma volume increases at a slower rate, inducing a slight rise in hematocrit level. These physiological changes during pregnancy make it difficult to define normal hematological reference intervals for pregnant women.[1]

Anemia is the most common hematological problem in pregnancy.[9] In iron-affluent pregnant women, "anemia" is defined as Hb < 110 g/L[10,11] or less than the fifth percentile of the distribution, based on age and stage of pregnancy.[12] Anemia contributes to low birth weight and miscarriages and is also a primary cause of low immunity in both the mother and the child, which makes them vulnerable to several infections.[13] Malaria infection causes 3%–5% of maternal anemia and, worldwide, about 50 million women are exposed to malaria, especially in highly endemic regions like Nigeria.[14,15]

PLT changes in pregnancy

The PLT count is slightly lower in pregnant than in non-pregnant women.[16] Most studies report an approximate 10% lower PLT level at term compared with at pre-pregnancy.[17,18] However, van Buul et al[19] reported an increase in PLT count in pregnancy. The majority of pregnant women still have levels within the normal range; however, if the pre-pregnancy level is borderline or there is a more severe reduction, this may fall below the normal range. The mechanisms for this are thought to be due to dilution effects and accelerated destruction of PLTs passing over the often scarred and damaged trophoblast surface of the placenta.[20] PLT counts may also be lower in women with twin compared with singleton pregnancies, possibly due to greater thrombin generation.[21] Although most cases of thrombocytopenia in pregnancy are mild, with no adverse outcome for mother or baby, occasionally a low PLT count may be part of a complex disorder with significant morbidity and be (rarely) life-threatening.

Overall, about 75% of cases of PLT changes are due to gestational thrombocytopenia, 15%–20% secondary to hypertensive disorders, 3%–4% due to an immune process, and the remaining 1%–2% comprises rare constitutional thrombocytopenias, infections, and malignancies.[22]

WBC changes in pregnancy

Previous studies have reported that pregnancy is usually accompanied by leukocytosis, but the full sequential changes of the various cell types responsible for this observed leukocytosis have not been clearly determined in all geographical locations and physiological conditions.[23–25] As such, the establishment of reference values of hematological indices in pregnancy is considered important.

The study reported here was designed to evaluate the values of seven major hematological parameters (packed cell volume [PCV], Hb, WBC, PLTs, mean cell volume [MCV], mean corpuscular hemoglobin [MCH], and mean corpuscular hemoglobin concentration [MCHC]) at different trimesters of pregnancy in women reporting for antenatal care at tertiary health care centers in Lagos.

Subjects and methods
Study population

The study reported here was a cross-sectional study of 274 pregnant women who attended either the Lagos University Teaching Hospital or Lagos State University Teaching Hospital antenatal clinics (situated at Ifako Ijaive and Isolo General Hospitals). During the study period between February 2012 and September 2012, all pregnant women who gave informed consent and satisfied the study inclusion criterion (normotensive blood pressure < 140/90 mmHg) were recruited into the study. Pregnant women with any of the following conditions were excluded from the study: bleeding disorders, splenomegaly, connective tissue disease such as systemic lupus erythematosus, hypertension, human immunodeficiency virus (HIV), and hepatitis B infection. In addition, women on non-steroidal anti-inflammatory drugs such as aspirin were also excluded.

Demographic data and information on drug history were collected directly from the recruited participants, and additional data – such as HIV/hepatitis B status – were extracted from clinical notes. All study participants were on routine ferrous sulfate (200 mg three times daily), folic acid (5 mg daily), and vitamin B complex (one taken three times daily) tablets.

Ethics

The research was approved by the ethics review committees of both the Lagos University Teaching Hospital and the Lagos State University Teaching Hospital.

Sample collection

A blood sample (4.5 mL) was withdrawn from each participant with minimal stasis from the antecubital vein using a dry, sterile disposable syringe and needle. The blood was dispensed into tubes containing the anticoagulant ethylenediaminetetraacetic acid (EDTA). The specimens were labeled with the subject's age, and identification number. The EDTA samples were kept at room temperature until processing, which occurred within 4 hours of collection.

Laboratory analysis

Full blood count was performed using a KN-21N Hematology Analyzer (Sysmex, Kobe, Japan), a three-part auto analyzer able to test 19 parameters per sample including Hb concentration, PCV, RBC concentration, MCH, MCV, MCHC, WBC count, and PLT count. Standardization, calibration of the instrument, and processing of the samples were done according to the manufacturer's instructions.

Procedures

Each blood sample was mixed well and then approximately 20 μL was aspirated by allowing the analyzer's sampling probe into the blood sample and depressing the start button. Results of the analysis were displayed after about 30 seconds, after which the analyzer generated a paper copy of the results on thermal printing paper.

Statistical analysis

Data were analyzed using SPSS (v 16; IBM, Armonk, NY, USA). The descriptive data are presented herein as means ± standard deviation (SD). Pearson's Chi-square test and one-way analysis of variance (ANOVA) were used for analytic assessment and the differences were considered statistically significant when the P value obtained was <0.05.

Results

The mean age of the 274 pregnant women who participated in the study was 30.52 ± 4.6 years (range: 20–46 years old). Most of the participants (165/274; 60.21%) were in their second trimester at the time of the study, while 75 (27.37%) were in their third trimester and 34 (12.40%) were in their first trimester (Table 1). About three-quarters of the participants

Table 1 Participants' (n = 274) trimester and educational level

Trimester, n (%)			Level of education attained, n (%)		
1st	2nd	3rd	Primary	Secondary	Tertiary
34 (12.40)	165 (60.21)	75 (27.30)	7 (2.25)	63 (22.99)	204 (74.45)

(204/274; 74.45%) had had tertiary education, 63 (22.99%) had had secondary education, and seven (2.25%) had had primary education (Table 1).

The overall mean hematocrit level for the study population was $30.16\% \pm 5.55\%$, while mean Hb concentration was 10.94 ± 1.86 g/dL, mean WBC count was $7.81 \pm 2.34 \times 10^9$, mean PLT count was $228.29 \pm 65.6 \times 10^9$, MCV was 78.30 ± 5.70 fL, MCH was 28.57 ± 2.48 pg, and MCHC was 36.45 ± 1.10 g/dL (Table 2).

Grouped according to trimester, those in their first trimester had a mean PCV of $32.07\% \pm 6.80\%$, while it was $29.76\% \pm 5.21\%$ for those in their second trimester, and $33.04\% \pm 3.88\%$ for those in their third. The MCHC values were 11.59 ± 2.35, 10.81 ± 1.72, and 10.38 ± 1.27 g/dL for those in their first, second, and third trimester, respectively. Mean WBC count for the first-, second-, and third-trimester group was $7.31 \pm 2.38 \times 10^9$, $7.88 \pm 2.33 \times 10^9$, and $8.37 \pm 2.15 \times 10^9$, respectively, while the mean PLT count for each group was $231.50 \pm 79.10 \times 10^9$, $227.57 \pm 63 \times 10^9$, and $200.82 \pm 94.42 \times 10^9$, respectively. The MCV for the first-, second-, and third-trimester group was 79.7 ± 0.966, 78.38 ± 5.72, and 70.02 ± 5.4 fL, respectively and the MCH for each group was 28.23 ± 2.40, 28.63 ± 2.50, and 28.18 ± 1.93 pg, respectively. The MCHC for the first-, second-, and third-trimester group was 36.27 ± 1.21, 36.49 ± 1.08, and 31.34 ± 0.75 g/dL, respectively (Table 2).

A statistically significant relationship was found between PCV and WBC count, and increase in gestational age ($P = 0.010$ and 0.001, respectively). However, there was no statistically significant association between PLT count and increase in gestational age ($P = 0.296$) (Table 3).

Comparing PCV with gestational age using Tamhane's T2 post-hoc analysis, the result of the homogeneity test of variance was significant at 0.002, while, with ANOVA, F was found to equal 0.826 and a nonsignificant level of 0.680 was obtained. The homogeneity test of variance between WBC count and gestational age was also at a significant level of 0.048, while, with ANOVA, F was found to equal 1.337 and a nonsignificant level of 0.161 was obtained (Table 3). Finally, a similar result was obtained when PLT count was compared with gestational age, with the homogeneity test of variance returning a significant value of 0.008, while, with ANOVA, F was found to equal 1.613 and a nonsignificant value of 0.054 was obtained (Table 3).

Discussion

The aim of the study was to determine the overall mean values for hematological indices in pregnancy and the

Table 2 Trimester-specific Mean Hematological Values

Parameter	Trimester			
	Overall	1st	2nd	3rd
HCT, %	30.16 ± 5.55	32.07 ± 6.80	29.76 ± 5.21	33.04 ± 3.88
Hb, g/dL	10.94 ± 1.86	11.59 ± 2.35	10.81 ± 1.72	10.38 ± 1.27
WBC count, $\times 10^9$	7.81 ± 2.34	7.37 ± 2.38	7.88 ± 2.32	8.31 ± 2.15
PLT count, $\times 10^9$	228.29 ± 6.56	231.50 ± 79.10	227.57 ± 63.00	200.82 ± 94.4
MCV, fL	78.30 ± 5.70	79.70 ± 0.96	78.38 ± 5.72	70.02 ± 5.40
MCH, pg	28.57 ± 2.48	28.23 ± 2.40	28.63 ± 2.50	28.18 ± 1.92
MCHC, g/dL	36.45 ± 1.10	36.27 ± 1.21	36.49 ± 1.08	31.34 ± 0.75

Note: Data presented are mean ± standard deviation.
Abbreviations: Hb, hemoglobin; HCT, hematocrit; MCH, mean corpuscular hemoglobin; MCHC, mean corpuscular hemoglobin concentration; MCV, mean cell volume; PLT, platelet; WBC, white blood cell.

trimester-specific mean values for hematological indices in pregnant women. We found a progressive decline in Hb concentration from the first to the third trimester, but a drop from first to the second trimester. There was a slight rise in the PCV in the third trimester. These findings corroborate those of a similar study undertaken in Ibadan, south-western Nigeria, by Akingbola et al in 2006,[26] which reported exactly the same pattern. The progressive decline in Hb concentration from the first to third trimester may be due to an increased demand for iron as pregnancy progresses. More iron is required to meet the expansion of maternal Hb mass and the needs of fetal growth. The additional progesterone and estrogen that are secreted by the placenta during pregnancy cause a release of renin from the kidneys. Renin stimulates the aldosterone-renin-angiotensin mechanism, leading to sodium retention and increased plasma volume. The increase in plasma volume is relatively greater than the increase in red cell mass, which results in a fall in maternal Hb, hence the physiological anemia that occurs in pregnancy.

Despite the physiological hemodilution associated with pregnancy, which also contributes to the drop in PCV in the first and second trimester, in late pregnancy, plasma volume increases at a slower rate, inducing a slight rise in hematocrit that may account for the slight rise in PCV in the third trimester.[1]

The increase observed in WBC count from the first to third trimester in this study is consistent with the findings of Akingbola et al[26] and Onwukeme and Uguru.[23] The increase is primarily due to an increase in neutrophils and

may represent a response to stress due to redistribution of the WBCs between the marginal and circulating pools. Pain, nausea, vomiting, and anxiety have been reported to cause leukocytosis in the absence of infection.[27] A rising WBC count in pregnancy is not a reliable indicator of infection in subclinical chorioamnionitis; rather, clinical methods of detection such as maternal pyrexia, offensive vaginal discharge, and fetal tachycardia are better indicators, especially of preterm labor and membrane rupture.[28]

This study also reported a gradual reduction in PLT count as pregnancy advanced, which is also consistent with Akingbola et al's study.[26] Due to hemodilution secondary to expansion of plasma volume, the PLT count in normal pregnancies may decrease by approximately 10%, with most of this decrease occurring during the third trimester,[17,29,30] although the absolute PLT count tends to remain within the normal reference range in most patients.[17,29–31]

After anemia, thrombocytopenia is the second most common hematologic abnormality that occurs during pregnancy.[32] "Thrombocytopenia" is classically defined as a PLT count of less than $150,000 \times 10^9/L$.[22,33] Counts from $100,000$ to $150,000 \times 10^9/L$ are considered mildly depressed; from $50,000$ to $100,000 \times 10^9/L$, moderately depressed; and of less than $50,000 \times 10^9/L$, severely depressed.[34] The overall incidence of thrombocytopenia in pregnancy is 8%, but when patients with obstetric or medical conditions are excluded, the incidence drops to 5.1%.[32]

MCV declined from the first to third trimesters in this study, while MCH remained relatively stable through all trimesters. MCHC was stable in the first and second trimester but dropped in the third. These findings may be a reflection of iron deficiency anemia.

Finally, of note, in line with previous studies on early versus late enrollment into antenatal care, we found that a preponderance of the participants in this study registered for antenatal care in their second trimester, while only

Table 3 Results of Statistical Analysis

Parameters	P	F	Significant value
PCV vs gestational age	0.010	0.826	0.680
WBC count vs gestational age	0.001	1.337	0.161
PLT count vs gestational age	0.296	1.613	0.054

Abbreviations: PCV, packed cell volume; PLT, platelet; WBC, white blood cell; vs, versus.

12.4% of participants had registered early for antenatal care. This finding is in keeping with various studies from different regions in Nigeria that have reported that most pregnant women registered when their pregnancy was beyond 20 weeks.[35–38]

A limitation of this study was the lack of a control group of unsupplemented women. However, such a group may not have gained ethical approval, considering the high prevalence of anemia in our environment. Another important limitation of this study may have been the reliability of the information provided by participants and data extracted from clinical notes.

Conclusion

The findings of this study reinforce the need for supplementation and provide additional information on hematological reference values in pregnancy in Nigeria.

Disclosure

The authors declare no conflicts of interest in this work.

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