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Original article

Influence of Anemia Status and ABO Blood Group on Hematological Parameters Among Pregnant Women

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ABSTRACT

Pregnancy is a typical physiological condition that involves widespread changes throughout the body and in the blood system. Nevertheless, variations in certain blood-related measurements during this time can impact the mother's health and increase the risk of pregnancy-related complications. The study aims to examine the connection between hematological parameters in pregnant women and the condition of anemia, as well as to explore how these parameters relate to different blood group types. This cross-sectional study was conducted in the Gynecology Department of Tobruk Medical Centre, Tobruk, Libya. All pregnant women who were more than 28 weeks pregnant and at least 18 years old were included in this study. A total of 2141 pregnant women were enrolled. Clinical data for these women were collected using hospital electronic records. Blood samples were tested for complete blood count using the Sysmex Automated Hematology Analyzer, and blood group determination using indirect and reverse grouping tubes. Statistical analysis was performed using SPSS software, with independent samples t-tests comparing various hematological parameters and a p-value used to determine statistical significance. The Fisher–Freeman–Halton was used to analyze the association between two categorical variables, and the Phi coefficient was used to calculate to evaluate the strength of associations. Hemoglobin and hematocrit levels were significantly lower in the anemic group, showing a large difference in hemoglobin (d = 0.82) and a moderate effect for hematocrit (d = 0.43). Platelet counts were higher in 3.9% of anemic women compared to 1.2% of non-anemic women. Although this association was statistically significant (χ^2 = 18.965, p = 0.0001), the Phi coefficient (φ = 0.094) indicates that the relationship is weak. Similarly, there was a statistically significant but weak association between white blood cell (WBC) distribution and anemia (χ^2 = 5.041, p = 0.046; φ = 0.080) with 14.9% of anemic women having elevated WBCs versus 11.9% of non-anemic women. No association was found between ABO blood groups and red blood cell (RBC) or platelet counts, although a weak but statistically significant association was observed with WBC levels (χ^2 = 33.476, p = 0.006; φ = 0.125). The study found that pregnant women with blood group B were more likely to exhibit elevated white blood cell counts, followed by those with blood group O+ and AB+. This paper's findings help improve our understanding of how anemia status and ABO blood group traits affect important blood-related measurements such as white blood cell count, red blood cell count, and platelet count. The results highlight the need for more research in bigger and more varied groups of people to better understand the biological and genetic reasons behind these connections.

Introduction

The hematological profile of a pregnant woman can significantly influence both the progression and outcome of pregnancy. The physiological modifications that take place during gestation and the immediate postpartum period are primarily mediated by hormonal changes [1]. Anemia is the most common hematological issue during pregnancy, followed by thrombocytopenia. Leukocytosis is sometimes associated with pregnancy. Hematological parameters serve as important baseline indicators to assess potential complications during pregnancy [2]. Morphological changes in red and white blood cells can also indicate the presence of anemia or infection. Additionally, a decrease in platelet count may signal an increased risk of eclampsia during pregnancy [3]. Gestational thrombocytopenia requires no specific treatment and corrects itself spontaneously after delivery, but the other etiologies must be excluded, i.e., megaloblastic anemia, immune thrombocytopenia, thrombotic microangiopathy syndromes, eclampsia, and liver disorders, before labeling the patient as gestational thrombocytopenia [4]. In addition to being expressed on the surface of red blood cells, ABO blood type antigens are also found to be expressed on other cell surfaces, such as platelets, white blood cells, and certain types of tissues.

The broad distribution of ABO antigens across cellular and secretory sites is believed to influence an individual's vulnerability to multiple health conditions, including infectious diseases, cancers, and other non-communicable disorders [5]. Interestingly, there have been notable links found between ABO blood groups and various other diseases. These diseases include conditions such as duodenal ulceration, gastric

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carcinoma, and different forms of sepsis [6]. Some studies have reported an increased risk of preeclampsia in women with A or AB blood groups [7].
In view of the inconsistent findings reported in previous studies and the absence of data on this topic within the Libyan population, there is a clear need for further investigation in this area. Therefore, this study aims to investigate the association between hematological parameters and anemia among pregnant women, and to determine the relationship between these parameters and ABO blood group patterns. Understanding these relationships may provide insight into the physiological adaptations and potential hematological risks associated with anemia during pregnancy.

Methods

Study design

A cross-sectional design study was conducted at the Gynaecology Department of Tobruk Medical Centre. All pregnant women >28 weeks of gestation, ≥18 years of age, and planning a vaginal birth in Tobruk Medical Center.

Samples and sampling

In this study, 2141 pregnant women were included. The clinical data of pregnant women were collected through hospital electronic records. Laboratory parameters for pregnancy were measured using EDTA-anticoagulated blood samples. All analyses were performed on a Sysmex hematology analyzer, in order to assess the Hematological changes occurring during pregnancy.ABO blood grouping was carried out by the tube method using commercially prepared antisera: anti-A, anti-B, and anti-AB for the direct grouping, and reagent cells: A cells and B cells for the indirect or reverse grouping.

Statistical analysis

Data were entered and stored using the Statistical Package for the Social Sciences (SPSS) software. Frequencies and percentages were calculated for categorical variables. The t-test assesses whether the mean difference between two groups is statistically significant. The Chi-square test was used to assess the significance of associations and differences between anemia status and various hematological parameters, including WBC distribution. For categorical variables with more than two levels, the Fisher–Freeman–Halton exact test was employed when the assumptions of the chi-square test were not met. A p-value of less than 0.05 was considered indicative of statistical significance. In addition, effect size measures, such as the Phi coefficient, were computed to assess the magnitude and strength of observed associations.

Ethical Considerations

All procedures involving human participants were conducted in accordance with the ethical standards of the research committee.

Results

(Table 1) compares different blood parameters between anemic and non-anemic pregnant women using a t-test. As expected, hemoglobin (g/dL) and hematocrit (Hct) were much lower in the anemic group. The difference in hemoglobin was especially striking (mean 9.89 vs 12.09), with a very large effect size (Cohen's d = 0.82). Hematocrit also showed a significant gap, although with a smaller effect (d = 0.43). This strongly confirms that anemia is associated with reduced red blood cell levels.
For the red blood cell indices (MCV, MCH, MCHC), all were significantly lower in the anemic group. This indicates that not only do anemic women have fewer red blood cells, but the cells they do have are smaller (low MCV), contain less hemoglobin (low MCH), and are less concentrated (low MCHC). The effect sizes here ranged from small to moderate (d = 0.34–0.55), showing consistent differences between the two groups.

Table 1. Independent Samples T-Test Results for Blood Parameters between Anemic and Non-Anemic Pregnant Women

Parameters	Group	*N*	Mean (SD)	*t* (df)	*p-value*	Cohen's *d* (95% CI)
HB(g/dL)	Anemic	1068	9.89 (0.81)	-61.88 (2139)	< .001	0.82 [0.82, 0.83]
	Non-anemic	1073	12.09 (0.83)			
Hct	Anemic	1068	29.57 (2.44)	-9.93 (2139)	< .001	0.43 [0.34, 0.52]
	Non-anemic	1073	35.50 (19.36)			

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	Non-anemic	1073	245.60 (74.36)			
MCV	Anemic	1068	75.04 (7.09)	-7.93 (2139)	< .001	0.34 [0.26, 0.43]
	Non-anemic	1073	80.66 (22.08)			
MCHC	Anemic	1068	33.74 (2.37)	-12.62 (2139)	< .001	0.55 [0.46, 0.63]
	Non-anemic	1073	35.00 (2.22)			
MCH	Anemic	1068	25.72 (8.67)	-8.83 (2139)	< .001	0.38 [0.30, 0.47]
	Non-anemic	1073	28.18 (2.84)			

Association between platelet levels and anemia status among pregnant women

The (Table 2) compares platelet levels between anemic and non-anemic pregnant women and reveals a statistically significant association between anemia status and platelet distribution. Among anemic pregnant women, the vast majority (90.8%) had normal platelet counts, with 5.2% showing low levels and 3.9% showing elevated levels. In contrast, non-anemic women also showed a high percentage of normal counts (91.5%), but they had a slightly higher proportion with low platelet levels (7.3%) and a noticeably lower proportion with high counts (1.2%). The chi-square test confirms that the differences in platelet distribution between the two groups are statistically significant (x^2 = 18.965, p = 0.0001). The Fisher-Freeman-Halton exact test supports this result with the same p-value, indicating robustness even with smaller cell counts. Although the association is statistically significant, the Phi coefficient (Φ = 0.094) suggests that the strength of the relationship is weak.

Table 2. Association between Anemia Status and Platelet Count among Pregnant Women: A Cross-Tabulation and Chi-Square Analysis

Group	Platelet Low	Platelet Normal	Platelet High	Total	x^2, P-value
Anemic pregnant women	56 (5.2%)	970 (90.8%)	42 (3.9%)	1068 (100.0%)	x^2 = 18.965, p= .0001. The Fisher-Freeman-Halton exact test (p= .0001). Phi (Φ) = 0.094
Non-anemic pregnant women	78 (7.3%)	982 (91.5%)	13 (1.2%)	1073 (100.0%)	
Total	134 (6.3%)	1952 (91.2%)	55 (2.6%)	2141 (100.0%)	

Association between WBC levels and anemia status among pregnant women

(Table 3) shows the distribution of white blood cell (WBC) counts among anemic and non-anemic pregnant women. Among anemic women, 85.0% had normal WBC counts, while 14.9% showed elevated levels and only 0.1% had low counts. In comparison, non-anemic women had a slightly higher proportion with normal WBCs (88.1%) and a lower proportion with elevated counts (11.9%). Most of 86.5% of all participants were within the normal range, and 13.4% had high WBC levels, while low counts were extremely rare (0.0%). The chi-square value (x^2 = 5.041) with a p-value of 0.046 indicates a statistically significant difference between the groups. The Fisher-Freeman-Halton exact test yields the same p-value, supporting the significance of the finding. However, the Phi coefficient (Φ = 0.080) reflects a weak strength of association.

Table 3. Association between Anemia Status and WBC Count among Pregnant Women: A Cross-Tabulation and Chi-Square Analysis

Group	Low	Normal	High	Total	x^2, P-value
Anemic pregnant women	1 (0.1%)	908 (85.0%)	159 (14.9%)	1068 (100.0%)	x^2 = 5.041, p= .0.046 The Fisher-Freeman-Halton exact test (p= .046). Phi (Φ) = 0.080
Non-anemic pregnant women	0 (0.0%)	944 (88.1%)	128 (11.9%)	1072 (100.0%)	
Total	1 (0.0%)	1852 (86.5%)	287 (13.4%)	2140 (100.0%)	

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Association between ABO blood group and RBC count

(Table 4) shows the relationship between ABO blood group and red blood cell count, which is categorized as low, normal, or high. The data reveal that there is no significant difference in the distribution of red blood cell counts among the different blood groups. For example, in group A+, about 39.7% had low counts and 60.3% had normal counts, while in group O+, 38% had low counts and 62% had normal counts. The other blood groups showed very close patterns, with no extreme differences. The statistical analyses confirm this finding. The chi-square test did not show a significant association between ABO blood group and red blood cell count (x^2 = 21.80, p = 0.142). Likewise, the Fisher–Freeman–Halton exact test also failed to reach significance (p = 0.107). The Phi coefficient (Φ = 0.10) suggests a very weak connection between blood group and red blood cell count.

Table 4. Chi-Square Crosstabulation of ABO Blood Groups and Red Blood Cell Count

ABO Blood Group	Low	Normal	High	Total	x^2, P-value
A-	38 (41.8%)	53 (58.2%)	0 (0.0%)	91 (100%)	x^2= 21.797, p=0.142. The Fisher-Freeman-Halton exact test (p=0.107). Phi (Φ) = 0.10
A+	262 (39.7%)	398 (60.3%)	0 (0.0%)	660 (100%)	
AB-	8 (40.0%)	12 (60.0%)	0 (0.0%)	20 (100%)	
AB+	53 (43.4%)	69 (56.6%)	0 (0.0%)	122 (100%)	
B-	27 (42.2%)	37 (57.8%)	0 (0.0%)	64 (100%)	
B+	117 (31.4%)	254 (68.1%)	2 (0.5%)	373 (100%)	
O-	46 (41.4%)	65 (58.6%)	0 (0.0%)	111 (100%)	
O+	265 (38.0%)	432 (62.0%)	0 (0.0%)	697 (100%)	
Total	**816 (38.1%)**	**1323 (61.8%)**	**2 (0.1%)**	**2141 (100%)**	

Association between ABO blood group and platelet count

(Table 5) shows the relationship between a pregnant woman's ABO blood group and her platelet count, which can be categorized as low, normal, or high. In every blood group category, more than 88% of the women had normal platelet levels. Only a small percentage showed low or high platelet counts. For example, in group A+, 91.7% had normal counts, 5.9% had low counts, and 2.4% had high counts. Similarly, in group O+, 89.5% were normal, 7.2% low, and 3.3% high. The other groups followed the same general trend, with no striking differences between them. The statistical analysis supports this observation. The chi-square test was not significant (x^2 = 9.72, p = 0.852), and the Fisher-Freeman-Halton exact test also showed no significance (p = 0.889). The Phi value (Φ = 0.067) indicates only a very weak relationship between blood group and platelet count.

Table 5. Chi-Square Crosstabulation of ABO Blood Groups and Platelet Count

ABO Blood Group	Low	Normal	High	Total	x^2, P-value
A-	5 (5.5%)	85 (93.4%)	1 (1.1%)	91 (100%)	x^2= 9.724, p=0.852 The Fisher-Freeman-Halton exact test (p=0.889). Phi (Φ) = 0.067
A+	39 (5.9%)	605 (91.7%)	16 (2.4%)	660 (100%)	
AB-	1 (5.0%)	19 (95.0%)	0 (0.0%)	20 (100%)	
AB+	8 (6.6%)	112 (91.8%)	2 (1.6%)	122 (100%)	
B-	1 (1.6%)	61 (95.3%)	2 (3.1%)	64 (100%)	
B+	20 (5.4%)	345 (92.5%)	8 (2.1%)	373 (100%)	
O-	10 (9.0%)	98 (88.3%)	3 (2.7%)	111 (100%)	
O+	50 (7.2%)	624 (89.5%)	23 (3.3%)	697 (100%)	
Total	**134 (6.3%)**	**1952 (91.2%)**	**55 (2.6%)**	**2141 (100%)**	

Association between ABO blood group and WBC count

The analysis of the association between ABO blood groups and white blood cell (WBC) counts, as presented in Table 6, shows a statistically significant relationship; however, the strength of this association appears to be rather weak. When examining all blood groups collectively, the majority of individuals exhibit a normal white blood cell (WBC) count, accounting for 86.5% of the study population. A smaller proportion (13.4%) shows elevated WBC counts, while virtually none present with low WBC levels. However, a closer look reveals some variation in the distribution of WBC categories across the different blood groups. For example, blood group B has one of the highest proportions of elevated WBCs, with 23.4% of individuals showing high levels. Blood group O+ and AB+ also exhibit noticeable proportions of elevated counts, at 14.8% and 15.6% respectively.

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Conversely, groups such as AB- and A+ have lower proportions of high WBC levels (10.0% and 11.1%, respectively). Notably, low WBC counts were observed only in a single case belonging to the O-group (0.9%), while all other groups had no instances of low levels. The chi-square test ($x^2 = 33.476$, $p = 0.006$) indicates a statistically significant difference in WBC distribution across the ABO groups. The Fisher-Freeman-Halton exact test also supports this finding with a p-value of 0.019. However, the Phi coefficient ($\Phi = 0.125$) suggests that although the association is statistically significant, the effect size is weak, indicating limited practical relevance.

Table 6. Chi-Square Crosstabulation of ABO Blood Groups and White Blood Cell Count

ABO groups	Low	Normal	High	Total	x^2, P-value
ABO groups	0 (0.0%)	2 (66.7%)	1 (33.3%)	3 (100.0%)	$x^2 = 33.476$, p= .0.006 The Fisher-Freeman-Halton exact test (p= .019). Phi (Φ) = 0.125
A-	0 (0.0%)	75 (82.4%)	16 (17.6%)	91 (100.0%)	
A+	0 (0.0%)	587 (88.9%)	73 (11.1%)	660 (100.0%)	
AB-	0 (0.0%)	18 (90.0%)	2 (10.0%)	20 (100.0%)	
AB+	0 (0.0%)	103 (84.4%)	19 (15.6%)	122 (100.0%)	
B-	0 (0.0%)	49 (76.6%)	15 (23.4%)	64 (100.0%)	
B+	0 (0.0%)	332 (89.0%)	41 (11.0%)	373 (100.0%)	
O-	1 (0.9%)	93 (83.8%)	17 (15.3%)	111 (100.0%)	
O+	0 (0.0%)	593 (85.2%)	103 (14.8%)	696 (100.0%)	
Total	1 (0.0%)	1852 (86.5%)	287 (13.4%)	2140 (100.0%)	

Discussion

Monitoring hematological profiles is important for identifying or evaluating health conditions in pregnant women**.** The present hospital-based cross-sectional study focuses on assessing the impact of anemia status on various hematological parameters among pregnant women and evaluating the potential association between these parameters and ABO blood group characteristics.

The present study demonstrated significant variations in several hematological parameters between anemic and non-anemic pregnant women. Hemoglobin and hematocrit levels were markedly reduced among anemic participants, confirming the expected hematological pattern of anemia. Red cell indices (MCV, MCH, and MCHC) were also significantly lower, indicating microcytic and hypochromic changes consistent with iron deficiency. In contrast, total RBC counts showed no significant difference between groups, suggesting compensatory erythropoietic activity and plasma volume expansion during pregnancy. These results are consistent with those reported in Baghdad province [8]. The observed reductions in MCV, MCH, and MCHC among anemic pregnant women can be attributed to iron deficiency, which limits hemoglobin synthesis and leads to the production of smaller, hypochromic red cells.

In the present study, most women in both anemic and non-anemic groups exhibited platelet counts within the normal range. However, a slightly higher proportion of anemic women showed elevated platelet levels (3.9%) compared with non-anemic women (1.2%), while low platelet counts were marginally more frequent among the non-anemic group (7.3% vs. 5.2%). The association between anemia status and platelet distribution was statistically significant ($x^2 = 18.965$, $p = 0.0001$; Fisher's exact test = 0.0001), although the effect size was weak ($\Phi = 0.094$). When all blood groups are considered collectively, 91.2% of participants fall within the normal platelet range, whereas 6.3% show decreased levels and only 2.6% exhibit elevated platelet counts. These findings suggest that factors other than anemia, such as physiological changes during pregnancy or environmental influences, may also contribute to variations in platelet parameters [9]. These findings differ from some earlier reports suggesting a progressive decline in platelet count as pregnancy advances, often attributed to hemodilution and shortened platelet survival [10]. Whereas other studies have documented those anemic pregnant women have a significantly association between anemia status and platelet counts compared to non-anemic pregnant women [11,12,13,14].

Our study found slightly higher percentage of elevated WBCs (14.9%) among anemic women which is statistically significant (: $x^2 = 5.041$, $p = 0.046$) but not strong in effect size (Phi (Φ) = 0.080) reflects a weak strength of association, suggesting that while anemia status is related to WBC distribution, the practical impact of this relationship is limited. Overall, the data suggest minor variations in WBC levels between anemic and non-anemic pregnant women, with elevated WBC counts being slightly more common among those with anemia. This correlates with findings of other studies done in Libya [15-17]. In contrast to our finding, some of the studies demonstrated that anemic pregnant women had significantly lower WBC counts compared to non-anemic pregnant women [18,19].

Overall, the majority of women in both anemic and non-anemic groups demonstrated white blood cell (WBC) counts within the normal physiological range, with only a slightly higher percentage of elevated WBCs observed among the anemic group. Instances of leukopenia were rare. Although the association between

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anemia status and WBC distribution was found to be statistically significant, the effect size was weak, indicating that anemia may influence but does not strongly determine leukocyte levels. This finding contrasts with previous reports indicating a more pronounced leukocytosis during pregnancy, with WBC counts typically increasing from an average of approximately 7,000/μL in non-pregnant women to around 10,500/μL in late pregnancy [20]. Moreover, while previous studies have attributed leukocytosis to elevated estrogen secretion, increased plasma cortisol levels, and higher parity, the current results suggest that these physiological changes may not uniformly affect all pregnant populations [21]. Although the present study shows elevated WBC counts among participants, population-related factors may help explain the overall pattern. Differences in genetic background, nutritional status, and environmental conditions have been reported to influence immune responses, and baseline WBC counts tend to be lower in African populations compared with Caucasians. These factors may therefore contribute to the variations observed in this cohort [22,23].

The ABO blood group system has been widely studied for its association with susceptibility to various diseases. Numerous studies have investigated the influence of ABO blood group on pregnancy and related complications for both the mother and the newborn infant. Regarding the correlation between blood group type and RBC count, in our study, the distribution of RBC counts was similar across all blood groups, and there was no significant link between ABO group and RBC count ($x^2 = 21.797$, $p = 0.142$). Similar results of this finding agree with other similar studies that found no significant impact of ABO blood group on anemia prevalence in pregnant women [24].

This finding was contradictory as the RBC count in pregnant women with AB blood type was significantly higher than in those with A and O blood groups [25,26]. In simple terms, this means that a woman's ABO blood type does not seem to play an important role in determining whether she has a low or normal red blood cell count. The variations seen are small and could be due to chance rather than a real effect.

Regarding the correlation between blood group type and platelet count, the results of our study showed that across all blood groups, the majority had normal platelets (>88%). ABO blood group has no significant effect ($x^2 = 9.72$, $p = 0.852$), and the Fisher-Freeman-Halton exact test also showed no significance ($p = 0.889$). The Phi value ($\Phi = 0.067$). Moreover, individuals with blood group O exhibited marginally lower average platelet counts than their counterparts with blood groups A and B. Multiple studies consistently reveal that there are no significant variations in platelet counts across different ABO blood groups [27,28]. The ABO blood group shows a limited connection with platelet count because the ABO antigens are expressed less strongly on platelets compared to red blood cells. The main factors that control platelet production are thrombopoietin and the activity of the bone marrow. Moreover, physiological changes that occur during pregnancy influence platelet levels in a similar way across all blood groups.

The present study demonstrated a statistically significant variation in WBC distribution among ABO blood groups ($x^2 = 33.476$, $p = 0.006$), further supported by the Fisher-Freeman-Halton exact test ($p = 0.019$). The highest proportion of elevated WBC counts was observed in individuals with blood group B− (23.4%), while AB− and A− groups showed comparatively lower proportions (10.0% and 11.1%, respectively). These insights can help improve health monitoring and risk assessment during pregnancy. These findings are also supported by studies done at Cent South Univ, Xiangya Hosp, China (29). In contrast to these findings, previous research investigating the relationship between ABO blood group and immune or inflammatory markers in reproductive medicine has generally reported no significant correlation between blood type and immune cell profiles, indicating that the ABO system may have minimal direct immunological influence on white blood cell (WBC) levels [30].

Although this study provides valuable insights, it is important to acknowledge its limitations. The study's cross-sectional design prevents the determination of a cause-and-effect relationship between anemia, blood group, and changes in blood cells. Furthermore, since the study was conducted in a hospital setting, the results might not accurately represent the situation in the general population. It is possible that some individuals who had undiagnosed or pre-existing health issues, which could affect their white blood cell levels, were included in the study. Despite attempts to exclude people with known medical conditions, such cases might still have occurred. To gain a better understanding of these associations and validate the results, future research should include long-term, multi-center studies.

Conclusion

In conclusion, the study found that anemia had a noticeable impact on the distribution of platelets and white blood cells, and ABO blood groups had a slight influence on white blood cell counts. However, the overall associations demonstrated limited strength. All hematological parameters should be properly interpreted to recognize and avoid pregnancy-related late complications both in the mother as well as in the fetus. Our study provided valuable results that offer a new foundation for future clinical studies.

Conflict of interest. Nil

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