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HEMATOLOGICAL PROFILE AND PLATELET INDICES AS INFLAMMATORY BIOMARKERS IN PREGNANT WOMEN WITH *TOXOPLASMA GONDII* INFECTION: A CONTROLLED CLINICAL STUDY AT AL-ZAHRAA TEACHING HOSPITAL

Marwa Ahmed Meri*[1], Ansaf Saleh Abar[2], Rafal Haider AL-Ebrahemi[3]

[1,2]Ministry of Education/Directorate of Education of Al-Najaf Governorate.
[3]General Directorate of Education/ Open Educational College/Center of Najaf.

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***Corresponding Author: Marwa Ahmed Meri**
Ministry of Education/Directorate of Education of Al-Najaf Governorate.
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ABSTRACT

Background and Objective: Toxoplasma gondii still poses a serious parasitic risk during pregnancy due to its ability to disturb maternal physiological balance and alter fetal development. This clinical study focused on determining the hematological changes associated with T with high precision. The study investigates Toxoplasma gondii infection in pregnant women attending Al-Zahraa Teaching Hospital – Iraq. Women with chronic comorbid conditions were excluded to determine the specific effect of the parasite. Thus, 60 married females between 18 years to 40 years of age were taken for the study which comprised 30 infected women and 30 healthy controls. **Materials and Methods:** This study was done using an observational case-control design during March-September 2025. T. The presence of IgG and IgM antibodies confirmed the existence of gondii through ELISA. The measurement of complete blood count parameters and platelet indices was done using an automatic Hematology Analyzer. SPSS version 26.0 was used for statistical analysis. To compare the groups independent t-test was used and a statistical measurement of p value lower than 0.05 was considered significant. **Results:** Evidence of a systemic inflammatory response was shown by the infected group. The average white blood cell count was significantly higher among the infected women as compared to their healthy counterparts, i.e. 11.4 ± 2.1 and 8.2 ± 1.4 $\times 10^3/\mu L$ ($p < 0.05$). This growth was largely due to significant increase of lymphocytes. Conversely, the infected group exhibited significant reductions in erythroid parameters. The average hemoglobin level of infected women (10.1 ± 1.2 g/dL) was significantly lower than that of the control women (12.4 ± 0.9 g/dL) ($p < 0.0001$). There was a major drop in packed cell volume. While total platelet count was not significantly different between the two groups, the average platelet volume and platelet distribution width significantly increased among infected women ($p< 0.05$) There are chances of thrombo-inflammatory activity and raise in platelet turnover. **Conclusions:** These results reveal that T. gondii can significantly disrupt hemato-logical stability during pregnancy. The infection seems to induce a functional type of anemia and fosters a unique pattern of white blood cell mobilization. Narrowing of platelet distribution width as well as rise in platelet volume suggests that the platelet indices may serve as new and affordable biomarkers of systemic inflammation in gestational toxoplasmosis. To support heightened awareness of complications related to infection, detailed hematological profiling should be included in routine prenatal care in the Iraqi clinical setting.

KEYWORDS: *Toxoplasma gondii*, Pregnancy, Hematological Alterations, Al-Zahraa Teaching Hospital, Platelet Indices, Gestational Anemia.

1. INTRODUCTION

Infectious diseases of pregnancy are primarily caused by infectious agents capable of crossing the placental barrier. Among these, Toxoplasma gondii is considered one of the most clinically relevant worldwide. As a required intracellular apicomplexan protozoan, Toxoplasma gondii is biologically very plastic as it can infect virtually all warm-blooded animals, including nearly 30% of humans worldwide (Dubey, 2021; Robert-Gangneux & Dardé, 2012). Toxoplasmosis is still prevalent among the childbearing population in the Middle East, especially Iraq due to the contamination of the environment, consumption of undercooked meat, and the presence of the definitive host felines in urban and rural settings (Al-Habbib et al., 2023; Salman et al., 2021).

The effects of Toxoplasma gondii infection during pregnancy are multi-faceted. Pregnancy itself impart a distinctive immunological status characterized by a shift towards Th2-type cytokine dominance to permit fetal allograft tolerance (Mor & Cardenas, 2010). Toxoplasma gondii disturbs this balance by provoking a vigorous Th1-type inflammatory response due to the release of IL-12 and IFN-γ. Even though this response is important to blockade the conversion from tachyzoites to latent bradyzoites, at the same time induces a systemic inflammatory process threatening the placental and fetal development (Yarovinsky, 2014; Montoya and Liesenfeld, 2004).

Changes in maternal physiology in humans are subtly echoed by markers of hematology. The complete blood count, otherwise known as CBC, is not just any other laboratory test but a reflection of the endeavor of the hematopoietic system to combat systemic inflammation - Hassan et al. (2024) Toxoplasma gondii infection has been shown to cause blood changes. The acute phase is characterized by the white blood cell (WBC) lineages, namely the mobilization of neutrophils, lymphocytes and monocytes when the innate immune system tries to defeat the parasite (Dando et al., 2021; Al-Mulla, 2022). Furthermore, chronic infections have been associated with persistent lymphocytosis which can also serve as a diagnostic marker in resource-limited clinical settings (Al-Jammali, 2019).

The erythroid lineage is also very severely affected. Anemia during pregnancy is a common physiological occurrence but Toxoplasma gondii may worsen it significantly. The parasite struggles for essential nutrients hijacked by its host, particularly iron and vitamin B12, the latter causing functional iron deficiency via hepcidin activation during inflammation (Zaki, 2023; Kadhim, 2022).A considerable drop in haemoglobin (Hb) and packed cell volume (PCV) commonly occurs, resulting in impaired oxygen transportation to the fetus (Al-Khazaali, 2020). Furthermore, current research has started to delve into the role of platelets as immune cells. Alterations in platelet indices, including mean platelet volume (MPV) and platelet distribution width (PDW), have recently been recognized as an indicator of a systemic inflammatory response and endothelial activation in toxoplasmosis (Shoker, 2021; Oz, 2014).

At Al-Zahraa Teaching Hospital in Iraq, there is a critical need for robust data that permits the control of confounding factors in drawing inference about the effects of Toxoplasma gondii. Several prior studies did not possess strict exclusion criteria and included people suffering from chronic metabolic or autoimmune diseases that change hematological profiles by default (Elsheikha et al., 2020; Al-Mayali, 2023). The present study will conduct a case-control study among 60 pregnant women (30 infected vs. 30 healthy) who are strictly free from chronic co-morbidities, as detailed below: It will analyse the hematological profiles in toxoplasmosis. These data collected from March to September 2025 would aid in the formulation of more accurate diagnostic protocols and better perinatal management in the region (Villard et al., 2016; Bhopale, 2003).

2. MATERIALS AND METHODS

2.1 Study Design and Ethical Considerations

This was an observational case-control study, performed at Al-Zahraa Teaching Hospital from 1 March 2025 to 1 September 2025 . Ethical approval was obtained from the hospital's Scientific Committee and health authorities. As per declaration of Helsinki (World Medical Association, 2013), all participants were provided with and gave written informed consent before enrolment. Strict confidentiality was maintained for all personal data.

2.2 Participants and Selection Criteria

Pregnant women aged between 18 and 40 years were taken as study subjects total 60. Divided into two equal volunteer groups.

1. The infected group (n=30) comprised pregnant women with serologically confirmed Toxoplasma gondii infection (positive for IgG and/or IgM).
2. Group of Toxoplasma Control (n=30) consisted of apparently healthy pregnant women with no clinical or serological evidence of toxoplasmosis.

Exclusion Criteria

In order to eliminate the chances of other non-parasitic factors that could interfere with hematological parameters and to obtain reliable data, certain exclusion criteria were followed. The study excluded pregnant women suffering from chronic metabolic or systemic diseases such as diabetes mellitus, hypertension, or renal disorders. People with genetic or autoimmune blood disorders were also left out. Also, those with acute viral or bacterial co-infections at blood sampling were excluded from the analysis of the study. Furthermore, the exclusion of smokers and women on medication affecting bone marrow activity or hematopoiesis was undertaken (Dubey, 2021; Al-Mulla, 2022).

2.3 Sample Collection and Processing

Under aseptic condition 5 ml of venous blood from each subject was collected in two equal parts for laboratory investigation. The first portion (2.5 ml) was transferred to the EDTA tubes and was used directly for CBC analysis. The second part (2.5 ml) was placed in plain tubes without anticoagulant and allowed to clot at room temperature Subsequently, the samples were spun at 3,000 revolutions per minute for 10 minutes. The serum was stored at −20°C until used in the subsequent serological testing (Montoya & Liesenfeld, 2004).

2.4 Laboratory Investigations

2.4.1 Serological Screening

Diagnosis of *Toxoplasma gondii* infection was performed using the Enzyme-Linked Immunosorbent Assay (ELISA) technique. Ready-to-use diagnostic kits were utilized to detect anti-Toxoplasma IgG and IgM antibodies according to the manufacturer's protocols (Villard et al., 2016).

2.4.2 Hematological Analysis

Complete blood count parameters were evaluated using an automated hematology analyzer. The assessed parameters included:

- Total and differential white blood cell (WBC) counts.
- Hemoglobin (Hb) concentration and packed cell volume (PCV).
- Erythrocyte indices: mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC).
- Platelet count and platelet indices, including mean platelet volume (MPV) and platelet distribution width (PDW) (Zaki, 2023; Shoker, 2021).

2.5 Statistical Analysis

Data were analyzed using the Statistical Package for Social Sciences (SPSS version 26.0). Results are presented as mean ± standard deviation (SD). The independent t-test was used for statistical differences between infected and control groups. Statistical significance was set at $p < 0.05$ (Hassan et al., 2024).

3. RESULTS

3.1 Demographic Characteristics of the Study Population

The study sample consisted of 60 pregnant women. No significant difference was noted between the infected group (27.4 ± 5.8) and the control healthy pregnant women group (26.9 ± 6.2) ($p < 0.05$). This guarantee of parity stops age-induced physio-changes from interfering with study hematological findings.

3.2 Analysis of Leukocyte Parameters

The total white blood cell (WBC) count of the Toxoplasma gondii-infected group was significantly higher than that of the control group ($p < 0.05$). Infected participants experienced a significant amount of lymphocytosis and monocytosis, which reflects the maternal immune activation on tachyzoites.

Table 1: Analysis of White Blood Cell Count in Infected Group.

Parameter	Infected Group (n = 30)	Control Group (n = 30)
Total WBC ($10^3/\mu L$)	11.4 ± 2.1	8.2 ± 1.4
Lymphocytes (%)	38.6 ± 4.2	29.1 ± 3.5
Monocytes (%)	8.2 ± 1.1	5.4 ± 0.8
Neutrophils (%)	52.1 ± 5.5	64.8 ± 4.9

* Statistically significant difference ($p < 0.05$).

3.3 Erythroid Lineage and Anemic Markers

The infected group had a significant decrease in the erythroid parameters results. Infected pregnant women had lower mean concentrations of Hemoglobin and Packed cell volume compared to uninfected pregnant women ($p < 0.05$). This means that the parasite has a direct or indirect impact on red cell mass or iron bioavailability.

Table 2: Erythroid Indices in Infected and Healthy Pregnant Women.

Parameter	Infected Group (n = 30)	Control Group (n = 30)
Platelet Count ($10^3/\mu L$)	215 ± 45	248 ± 38
MPV (fL)	11.8 ± 1.2	9.4 ± 0.7
PDW (%)	16.4 ± 1.5	13.2 ± 1.1

* Statistically significant ($p < 0.05$).
NS = Not significant.

4. DISCUSSION

The findings of this clinical trial at Al-Zahraa Teaching Hospital indicate that Toxoplasma gondii infection in pregnant women induces a systemic body change and this was confirmed by significant changes in hematology. In light of the controlled population of 60 individuals (30 infected and 30 healthy controls), without chronic comorbidities, it is likely that the pathology is only due to the effect of the parasite on the maternal hematopoietic system (Dubey, 2021; Al-Mulla, 2022).

4.1 Immunological Orchestration and Leukocyte Dynamics

This increase in overall white blood cells (WBC) levels, comprising lymphocytosis and monocytosis ($p < 0.05$), indicates a directed immune response of the mother. In the acute phase of toxoplasmosis, the innate immune cells of the host (monocytes), the prime producers of IL-12 that activate a Th1-type response, are exploited by the tachyzoites as "Trojan horses" for systemic dissemination (Dando et al., 2021; Yarovinsky, 2014).

The increase of lymphocyte subsets, CD8+ T-cells, and natural killer (NK) cells is the adaptive answer which secretes the master dose interferon-gamma (IFN-γ), which is the main handle on intracellular parasite

replication inhibition (Robert-Gangneux & Dardé, 2012; Montoya & Liesenfeld, 2004). These findings are consistent with Iraqi studies that have noted a persistent inflammatory leukogram in infected gestating women, reflecting the ongoing struggle between fetal tolerance and parasitic clearance (Salman et al., 2021; Al-Habbib et al., 2023; Al-Jammali, 2019).

4.2 Pathophysiology of Erythroid Suppression

Clinical evaluation showed a significant drop in hemoglobin (Hb) and packed cell volume (PCV) in the infected group ($p < 0.01$). The relationship observed is a result of the development associated with toxoplasmosis chronic infection and anemia. Toxoplasma gondii takes up large quantities of host nutrients, especially iron and cholesterol, which supports the rapid growth of tachyzoites (Zaki, 2023; Bhopale, 2003). Infected individual's have increased metabolic demand which might hinder erythroid parameters.

Other than that, inflammation caused by parasites triggers hepcidin production in the liver. Enhanced levels of ferroportin induce sequestration of iron within macrophages, thereby limiting its transport to the bone marrow. Consequently, iron becomes less available for erythropoiesis (Kadhim, 2022; Hassan et al., 2024).

Anemia may also result from systemic oxidative stress caused by infection. Oxidative damage can shorten the lifespan of the circulating red blood cells (RBCs) aggravates physiological anaemia seen in the second and third trimester of pregnancy (Al-Khazaali, 2020; Mor & Cardenas, 2010; Elsheikha et al 2020).

4.3 Platelet Indices and Thrombo-Inflammation

The stability of total platelet counts alongside significantly increased mean platelet volume (MPV) and platelet distribution width (PDW) ($p < 0.05$) highlights the role of platelets as active immune mediators. Larger platelets (high MPV) are more enzymatically active and contain higher concentrations of pro-inflammatory granules (Shoker, 2021). The interaction between *Toxoplasma gondii* and the vascular endothelium promotes a pro-coagulant and pro-inflammatory environment, leading to the consumption of older platelets and a compensatory release of younger, larger ones from the bone marrow (Oz, 2014; Villard et al., 2016). This "thrombo-inflammatory" signature suggests that *Toxoplasma gondii* may alter placental microcirculation, which could be a contributing factor to the adverse pregnancy outcomes often associated with this parasite (Al-Mayali, 2023; World Medical Association, 2013).

4.4 Synthesis of Findings and Clinical Perspective

The hematological changes provided a clearer perspective of the interaction between the mother and the parasite. Our findings suggest that (Toxoplasma gondii), unlike previous studies that took underlying health conditions into account, considerably alters hematological balance (Al-Saeed et al., 2023; Yarovinsky, 2014). The CBC tests when combined with serological ELISA tests provide the clinicians at Al-Zahraa Teaching Hospital with a more power approach to assess the severity of infection (Villard et al., 2016; Robert-Gangneux & Dardé, 2012). This study has demonstrated clear hematological shifts however; the long-term effects on newborns are unknown and need future longitudinal follow-up (Al-Mulla, 2022; Dubey, 2021; Zaki, 2023).

CONCLUSION

The assessments done at Al-Zahra Teaching Hospital showed that Toxoplasma Gondii infection in pregnant women may significantly disturb the hematological stability of mother despite absence of chronic comorbid conditions. According to the results, the parasite is a strong biological stressor that disturbs normal maternal homeostasis in pregnancy.

The leukocyte activation pattern was unique to the infection as well. In pregnant women diagnosed with the infection, the lymphocyte and monocyte counts were elevated, indicating an active immune response against the parasite. The change in hematology parameter indicating lymphocytosis and monocytosis may serve as supportive evidence of pregnancy immune response to infection.

Also, this study indicated a distinct decrease in important erythroid parameters. Women with infection had significantly lower hemoglobin levels and packed cell volume than T. Gondii infection might intensify the anemia observed during pregnancy. The parasite might affect fetal nutrition and contribute to anemia via a nutritional deficiency or competition between parasite and host for iron or other essential nutrient sources.

While the total platelet count was mostly in the reference range, platelet indices markedly changed. Rise in mean platelet volume and platelet distribution width indicates increased platelet activation and turnover. Probably due to inflammatory and thrombotic reactions to a vascular stress caused by the parasite.

In conclusion, results indicate that CBC can be valuable as a tool for diagnosis and monitoring in clinical practice. Due to a wide availability and low cost of CBC testing, it may also provide detailed hematological information alongside serological testing. The combination of both methods enhances clinical follow-up of gestational toxoplasmosis, particularly in healthcare services with limited resources.

6. RECOMMENDATIONS

Toxoplasma gondii-infected pregnant women should have serological testing plus regular hematological monitoring according to experts. During prenatal care, it is advisable to measure the complete blood count (CBC)

and platelet indices to enhance the evaluation of infection.

Infected pregnant women should receive adequate iron and nutritional supplementation. With appropriate measures, the decrease in the erythroid parameters can be reduced and risk of severe gestational anaemia can be reduced.

In the future study, use molecular diagnostic method real-time PCR. Can assess parasite load and clarify its relationship with hematological alterations observed during infection.

Monitoring of hematological markers should be longitudinal across the three trimesters. Monitoring these parameters over time may help in determining whether they can predict vertical (transplacental) transmission of parasite.

Public health programs must sensitize the community regarding the means of T. gondii transmission. An educational campaign to avoid undercooked meat and limit contact with cats can help promote safe food practices.

Future studies should explore whether maternal blood changes relate to neonatal blood profiles. Assessing neonatal CBC can aid in the early identification of congenital toxoplasmosis.

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