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Hormonal, Hematological, and Coagulation Dysregulation in Women with *Toxoplasmosis* with Associated Miscarriage

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Abstract:
Toxoplasmosis is one of the most important health-threatening diseases with worldwide distribution and global impact, it is caused by *Toxoplasma gondii* (*T. gondii*). This study aimed to evaluate hormonal, hematological, and coagulation parameters in women with *Toxoplasmosis* associated miscarriage and to compare them with healthy controls. A case-control study was conducted on 100 aborted women attending Samarra General Hospital and private outpatient clinics in Samarra-Iraq between September 2025 and February 2026. The participants were divided into two main groups according to the results of serological examination for anti-Toxoplasma IgG and IgM antibodies: Patients group (n=50), and control group (n=50). Hormonal parameters, including prolactin and Growth Hormone, were measured. Hematological test indices such as Hemoglobin (Hb), Hematocrit (HCT), Mean Corpuscular Volume (MCV), Mean Corpuscular Hemoglobin (MCH) were assessed, along with White Blood Cell (WBC) and Platelet counts. Coagulation parameters, including prothrombin time (PT), partial Thromboplastin Time (PTT) and International Normalized Ratio (INR), were also evaluated using Enzyme-Linked Immunosorbent Assay (ELISA). Results show infected women showed higher prolactin level (45.73 ± 10.64 ng/mL) and lower growth hormone (1.325 ± 0.566 ng/mL) compared to

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control groups (38.38 ± 12.22 and 1.826 ± 0.827 ng/mL, respectively). Hematological parameters were reduced in patients, including hemoglobin (12.03 ± 1.67 g/dL), hematocrit (34.64 ± 2.82%), MCV (76.82 ± 9.18 fL), and MCH (26.80 ± 4.88 pg), compared to controls (14.50 ± 1.14 g/dL and 40.70 ± 2.62%). No significant differences were observed in WBC (6.79 ± 1.59 vs. 6.45 ± 1.65 $\times 10^3/\mu L$) and platelets (203.3 ± 41.7 vs. 216.6 ± 48.6 $\times 10^3/\mu L$). Coagulation parameters were elevated in patients, including PT (13.71 ± 0.44 sec), PTT (33.76 ± 2.53 sec), and INR (1.12 ± 0.10), compared to controls (12.52 ± 0.44 sec, 30.04 ± 3.00 sec, and 1.00 ± 0.04). The findings indicate that *toxoplasmosis* related with miscarriage and hormonal imbalances, haematological abnormalities, and coagulation disorders. These alterations may contribute to the pathophysiology of pregnancy loss and highlight the need for comprehensive evaluation in affected women.
Keywords: Miscarriage, *Toxoplasmosis,* ELISA, Hormonal, and Hematological parameters,

Introduction:

Miscarriage is one of the most prevalent complications of pregnancy and it could be estimated that a significant number of women worldwide experienced miscarriage at least once during their lifetime(Dhillon-Smith *et al.*, 2023). Multifactorial causes can lead to miscarriage, including genetic, hormonal, immunological or infectious factors. *T. gondii* is an intracellular protozoan parasite found worldwide and infects a variety of warm-blooded hosts, including humans(Saleem *et al.*, 2022). An estimated 30 percent of the world's population has been exposed to this parasite(Lourido, 2019), with prevalence depending on geographic region, diet and hygiene. *Toxoplasma gondii* is an intracellular pathogen that causes congenital infections when maternal primary infection occurs in pregnancy among infectious agents. *T. gondii* is also associated with fetal loss, congenital abnormalities and recurrent miscarriage since it can transgress the placental barrier, leading to inflammatory and

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immunological alterations(Sanchez & Besteiro, 2021). Hormonal balance is critical for pregnancy to be sustained, with many hormones acting in important regulatory roles throughout implantation, placentation and foetal development. Infection may disrupt the endocrine system and exert a detrimental effect on these processes, leading to complications in pregnancy(Mushtaq Talib Al-Safi, 2025). Additionally, haematological markers are significant reflections of maternal physiological status and immune response(Saleem *et al.*, 2022). Changes in red blood cell indices and haemoglobin concentrations are common in infectious diseases and could reflect a concomitant inflammatory or nutritional deficit which can adversely affect pregnancy outcomes (Jonathan *et al.*, 2021). The coagulation system plays a critical role in maintaining placental perfusion, preventing maternal or fetal hemorrhage/thrombosis (Yin *et al.*, 2018). The dysregulation of coagulation pathways contributes to pregnancy loss, with infections like *toxoplasmosis* potentially exacerbating these changes through inflammatory and endothelial mechanisms (May *et al.*, 2011). Notwithstanding these conclusions, there is a paucity of studies examining the synergistic impact of changes in hormonal, haematological, and coagulation parameters in women experiencing toxoplasma-associated miscarriage. This study aimed to assess these characteristics to enhance comprehension of the mechanisms that may result in pregnancy loss due to *T. gondii* infection.

Materials and Methods

Study Design and Participants

This case-control study was conducted on 100 women with a history of abortion attending Samarra General Hospital and several private outpatient clinics in Samarra-Iraq during the period from September 2025 to February 2026. Blood samples were collected from all participants, and serological examination for *T. gondii* infection was performed using ELISA tests for anti-Toxoplasma IgM and IgG antibodies. According to the study design, participants were divided into two groups: the patients group included women with a history of abortion associated with

toxoplasmosis, while the control group consisted of women with a history of abortion due to causes other than *toxoplasmosis*.

Blood Sample Collection

Five milliliters of venous blood were collected using sterile syringes and transferred into gel tubes. The samples were allowed to clot for 20 minutes at room temperature (25–30°C), then centrifuged at 3000 rpm for 15 minutes to separate the serum. The obtained serum was transferred into Eppendorf tubes and stored at −20°C until used for serological and biochemical analyses.

Ethical approval

This study was reviewed and approved by the Research Ethics Committee of the University of Baghdad, Iraq (approval number: 29275 dated August 11, 2025). Approval was based on the Declaration of Helsinki, ensuring that all procedures followed adhere to international ethical standards for research involving human participants and biological materials. Informed consent was obtained from all patients prior to sample collection.

Serological and Hormonal Assays

Serum Prolactin (PRL) and Human Growth Hormone (hGH) were quantitatively determined using sensitive Microplate Enzyme Immunoassay (ELISA) kits from Monobind Inc., USA. All assays were strictly performed according to the manufacturer's instructions.

Hematological and Coagulation Testing

Complete blood counts, including red blood cell indices (hemoglobin, hematocrit, mean corpuscular volume, and mean corpuscular hemoglobin content), white blood cells, and platelets, were quantitatively assessed using a fully automated hematology analyzer from Sysmex. Coagulation chain variables (i.e., prothrombin time, activated partial thromboplastin time, and international standard ratio) were assessed using a semi-automated coagulation analyzer (SOLEA 100) from BIOLABO (France).

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Statistical Analysis

Software, SPSS version 10 for Windows was used for statistical analysis. Independent samples t-test was performed to compare the arithmetic means between the infected and control groups. Statistical significance was defined as P-value ≤ 0.05.

Results and Discussion

The results presented in Table (1) show that women with abortion associated with *Toxoplasmosis* (patients group) exhibited higher mean concentrations of both IgM and IgG antibodies (0.432 ± 0.112 and 0.478 ± 0.112, respectively) compared with women with abortion due to other causes (control group), who showed lower levels of IgM (0.185 ± 0.095) and IgG (0.224 ± 0.088).

Table (1): Comparison of anti-*Toxoplasma* IgM and IgG antibody concentrations in study groups

Antibody Type	Group	Mean± SD	P-value (Significance)
IgM	Patients	0.432 ± 0.112	P ≤ 0.05
	Control	0.185 ± 0.095	
IgG	Patients	0.478± 0.112	P ≤ 0.05
	Control	0.224 ± 0.088	

Several previous studies have shown strong agreement with the current findings regarding the interpretation of anti-Toxoplasma IgM and IgG antibodies in relation to toxoplasmosis infection. It has been reported that IgM antibodies are reliable indicators of recent or acute infection with *T. gondii*, and their presence is closely associated with active infection during pregnancy, which increases the risk of adverse outcomes such as miscarriage (Nadia *et al*., 2023). In contrast, IgG antibodies are considered markers of past exposure and long-term immune response, as they remain detectable for life and are not necessarily associated with active disease. These interpretations are supported by findings reported by the Centers for Disease Control and Prevention (CDC), which confirmed that IgM reflects recent infection while IgG indicates previous exposure (Tork *et al.,* 2025; Nadia *et al*., 2023). Additional studies have

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also demonstrated that higher IgM levels are commonly observed in women with abortion history, whereas IgG positivity reflects prior infection without active clinical disease, further supporting the results of the present study(Babekir et al., 2022; Sulaiman et al., 2025).

Table 2, showing levels of prolactin and growth hormone in both the patient (women of abortions with *toxoplasmosis*) and control groups, are presented as mean ± standard deviation. The results indicated a statistically significant increase ($P \leq 0.05$) in serum prolactin (PRL) levels in the infected group, reaching 45.73 ± 10.64 ng/mL compared to 38.38 ± 12.22 ng/mL in the healthy control group. Conversely, active *toxoplasmosis* infection led to a statistically significant inhibition ($P \leq 0.05$) of growth hormone (GH) secretion. The mean GH level in women with miscarriages decreased sharply to 1.325 ± 0.566 ng/mL, in contrast to 1.826 ± 0.827 ng/mL in the uninfected control group.

Table 2. Levels of prolactin and growth hormone in patient and controls

Parameter	Patients Group (n=50) (Mean ± SD)	Control Group (n=50) (Mean ± SD)	P-value (Significance)
Prolactin (ng/mL)	45.73 ± 10.64	38.38 ± 12.22	$P \leq 0.05$
Growth Hormone (ng/mL)	1.325 ± 0.566	1.826 ± 0.827	$P \leq 0.05$

Elevation of prolactin (PRL) levels in women of abortions with *toxoplasmosis* is significantly pronounced and reflects the role of PRL as an immune modulator, not only a lactogenic hormone (Dzitko *et al.*, 2010).One published study showed that prolactin is an immunoregulatory hormone involved in the immune response against *T. gondii* by modulating cytokines and immune cells. Another study demonstrated that administering prolactin eliminated the parasite infection, thus indicating an elevation indicates a natural defense mobilization by the body(Atia *et al.*, 2023). In addition, a recent study conducted (Luna Rojas

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et al., 2024) showed that *toxoplasmosis* infection is associated with changes in hormone levels during pregnancy, as prolactin levels were observed to be significantly elevated in infected women and were linked to the immune response against the parasite. A systematic review also indicated that the body may raise prolactin levels as a mechanism to try to fight infection and boost immunity(Hussein & Mohammed, 2022).

The results of the current study indicated significant differences in growth hormone (GH) levels between the patient and healthy groups. The marked decrease in growth hormone can be explained by the effects of chronic inflammation and physiological stress resulting from infection. Inflammatory cytokines inhibit the hypothalamic-pituitary-adrenal (HPA) axis, thus reducing growth hormone secretion(de la Luz Galván-Ramírez *et al*., 2019). Furthermore, growth hormone plays a crucial role in supporting fetal growth and stimulating the production of insulin-like growth factor-1 (IGF-1), which is essential for placental and fetal development (Li *et al*., 2025). Consequently, low growth hormone levels may lead to impaired placental growth and reduced blood flow, directly contributing to pregnancy failure and miscarriage. The results of the current study are consistent with another study he conducted, which showed that infection with *T.gondii* leads to changes in inflammatory cytokines and hormone regulation. These cytokines (such as IL-6 and TNF-α) are known to suppress the hypothalamic-pituitary axis, leading to decreased GH secretion and consequently, changes in immune hormones that contribute to an increased risk of miscarriage(Wang *et al*., 2024).

Table 3 shows the blood test results between patients and healthy individuals. The results demonstrated a significant effect of the parasite on red blood cell parameters. A marked decrease in hemoglobin (HGB) levels was observed ($P \leq 0.05$), with the mean HGB in the infected group being 12.03 ± 1.67 g/dL compared to 14.50 ± 1.14 g/dL in the control group. Similar results were observed for a significant decrease in hematocrit (HCT) to 34.64 ± 2.82% in patients compared to 40.70 ± 2.62% in the control group. In addition, the results strongly indicated

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microcytic anemia associated with active infection in the infected women, due to the marked decrease in mean corpuscular volume (MCV) and mean corpuscular hemoglobin concentration (MCH), which were 76.82 ± 9.18 femtoliters and 26.80 ± 4.88 picograms respectively.

Table 3. Levels of HGB, HCT, MCV, MCH in patient and controls

Parameter	Patients Group (n=50) (Mean ± SD)	Control Group (n=50) (Mean ± SD)	P-value (Significance)
HGB (g/dL)	12.03 ± 1.67	14.50 ± 1.14	$P \leq 0.05$
HCT (%)	34.64 ± 2.82	40.70 ± 2.62	$P \leq 0.05$
MCV (fL)	76.82 ± 9.18	83.56 ± 5.06	$P \leq 0.05$
MCH (pg)	26.80 ± 4.88	29.69 ± 2.39	$P \leq 0.05$

The results of the current study indicate a significant decrease in hemoglobin (Hb), hemoglobin (HCT), circulating cell volume (MCV), and blood cell count (MCH) in women with *toxoplasmosis* accompanied by miscarriage, suggesting microcytic anemia. These changes can be explained by several pathological mechanisms associated with *T.gondii* infection.

The decrease in hemoglobin and hematocrit is attributed to the direct and indirect effects of the parasite on red blood cells. Studies have shown that *toxoplasmosis* infection leads to a decrease in red blood cell count and hemoglobin, and an increase in white blood cells as a result of the inflammatory response (ALmaeahi *et al.*, 2026). The results of the current study are consistent with a study conducted by (Alobaydi, 2011) on pregnant women in Mosul which indicated that infection leads to a significant decrease in hemoglobin (Hb), red blood cell count, and platelets compared to the control group. The occurrence of anemia can be explained by hemolysis resulting from infection, as pathological study has indicated that Toxoplasma can cause hemolytic anemia and morphological changes in red blood cells. Additionally, the chronic inflammation resulting from the infection leads to the release of cytokines

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such as IL-6, which contribute to the inhibition of red blood cell production in the bone marrow (anemia of inflammation(Pereira *et al.*, 2019). However, some studies reported no significant differences in hemoglobin levels among infected individuals, which may be related to variations in study design and population characteristics
(Thapa *et al.*, 2025), and (Davoodi *et al.*, 2026).

The total White Blood Cell (WBC) count showed a slight but statistically non-significant difference ($P > 0.05$), recording ($6.79 \pm 1.59 \times 10^3/\mu L$) in the infected group compared to ($6.45 \pm 1.65 \times 10^3/\mu L$) in the control group. Similarly, the mean Platelet (PLT) count maintained comparable physiological levels in both groups with no significant differences ($203.3 \pm 41.7 \times 10^3/\mu L$ in patients vs. $216.6 \pm 48.6 \times 10^3/\mu L$ in controls).

Results of the present study showed that there were no substantial variations in WBC and PLT counts among women affected by *toxoplasmosis* and control group which is characteristic for immune response to this parasite. The immunity against *T. gondii* is mainly a cellular one dependent more on the activation of T-cells and on cytokine secretion than an increase in total white blood cell count. Immune Response to Toxoplasma: Activation of immune cells with further secretion of IFN-γ was identified in a published study without significant numerical changes in WBC count(Brasil *et al.*, 2017). Additionally, a normal platelet count suggests that the disease has not progressed to a stage where severe systemic inflammatory response or coagulation dysfunction occurs, which are conditions when platelets typically become involved in more advanced and complicated disease stages. Platelet levels a clinical study shows platelets are usually normal in uncomplicated cases of *toxoplasmosis*; only if severe or immunocompromised will there be changes(Ahmadpour *et al.*, 2023). These results are consistent with an Iraqi study that showed no significant differences in white blood cell count between women infected and uninfected with *toxoplasmosis*, indicating that the effect is often functional rather than numerical(Mahdi *et al.,* 2020). While other studies have reported different results, some

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have noted an increase in white blood cell count due to the acute inflammatory response in certain cases(de la Luz Galván-Ramírez *et al*., 2019; Moghaddami *et al.*, 2024), other study have shown a decrease in platelets (thrombocytopenia) in severe or complicated cases (Valizadeh *et al.*, 2022). This variation is attributed to differences in infection severity, patient immunity, and environmental and nutritional factors.

The analysis of the coagulation cascade demonstrated severe hemostatic disruption induced by the parasite. The results revealed a statistically no significant prolongation in the coagulation profile parameters among the infected aborted women. Prothrombin Time (PT) recorded a significant elevation in the infected group (13.71 ± 0.44 sec) compared to the controls (12.52 ± 0.44 sec). The Partial Thromboplastin Time (PTT) also exhibited a significant increase (33.76 ± 2.53 sec) versus the control group (30.04 ± 3.00 sec). Consequently, a significant elevation was observed in the International Normalized Ratio (INR), reaching (1.12 ± 0.10) in infected women compared to (1.00 ± 0.04) in controls as show in Table 4, indicating an active state of consumptive coagulopathy associated with the parasitic miscarriage.

Table 4: Comparison levels PT, PTT, INR between the study Groups.

Parameter	Patients Group (n=50) (Mean ± SD)	Control Group (n=50) (Mean ± SD)	P-value (Significance)
PT (sec)	13.71 ± 0.44	12.52 ± 0.44	Non-Significant
PTT (sec)	33.76 ± 2.53	30.04 ± 3.00	
INR	1.12 ± 0.10	1.00 ± 0.04	

The results of the current study indicate elevated prothrombin time and partial thromboplastin time, as well as an elevated INR, in women with *toxoplasmosis*-associated miscarriage compared to healthy individuals. This is attributed to an imbalance in hematologic balance and the potential progression to consumptive coagulopathy, which may explain the underlying changes in coagulation parameters(Bakir *et al.*, 2025).

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These changes are due to the effect of the *T. gondii* parasite on the vascular endothelium and the immune system(Ahmad *et al*., 2022). The parasite triggers a strong inflammatory response involving the release of cytokines such as TNF-α and IL-6, which in turn activate endothelial cells and release clotting factors, leading to the consumption of these factors and prolonged clotting time(Aldabbagh *et al.*, 2022). Studies have shown that *toxoplasmosis* infection is associated with impaired coagulation due to inflammation and activation of coagulation pathways. Another study has shown that intracellular parasites such as *T. gondii* can cause microvascular damage and induce intravascular coagulation, leading to the consumption of clotting factors and an increase in PT and PTT (Mohamed *et al.*, 2024). This explains the marked increase in INR observed in our study, reflecting an imbalance between clotting factors and anticoagulants. Furthermore, this imbalance may be related to the presence of antiphospholipid antibodies, which have been linked to *toxoplasmosis* infection and miscarriage, leading to impaired coagulation and an increased risk of pregnancy loss, these antibodies may contribute to prolonged clotting times and impaired platelet function, which promotes miscarriage (Aziz *et al.*, 2023).

Conclusion

This study reveals that *Toxoplasmosis* related miscarriage is associated with significant hormonal, haematological, and coagulation changes, including elevated prolactin levels, diminished growth hormone, lowered red blood cell indices, and extended coagulation parameters. *T. gondii* infection might contribute to pregnancy loss through complex interactions such as hormonal imbalance, impaired oxygen delivery and interference with coagulation processes. Although these changes provide important information on the pathophysiology of miscarriage further studies in larger sample sizes are needed to confirm these results. Further investigations should focus on exploring additional immunological and molecular factors, as well as investigating the potential benefits of early

screening and targeted treatment strategies to reduce the miscarriage risks associated with *Toxoplasmosis*.

Conflict of Interest

"The authors declare that there are no conflicts of interest regarding the publication of this manuscript".

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اضطرابات هرمونية ودموية وتخثرية لدى النساء المصابات بالإجهاض المرتبط بداء المقوسات

مستخلص البحث:

داء المقوسات (التوكسوبلازما) يُعد من أهم الأمراض المُهدِّدة للصحة ذات الانتشار العالمي والتأثير الواسع، وينتج عن الطفيلي *Toxoplasma gondii* (*T. gondii*). هدفت هذه الدراسة إلى تقييم الاضطرابات الهرمونية، والدموية، وعوامل التخثر لدى النساء المصابات بداء المقوسات المرتبط بالإجهاض، ومقارنتها مع مجموعة السيطرة السليمة. أُجريت دراسة حالة–سيطرة على 100 امرأة تعرضن للإجهاض راجعن مستشفى سامراء العام وبعض العيادات الخاصة في مدينة سامراء – العراق خلال الفترة من أيلول 2025 إلى شباط 2026. تم تقسيم المشاركات إلى مجموعتين رئيسيتين اعتمادًا على نتائج الفحص المصلي للأجسام المضادة IgG وIgM، حيث شملت مجموعة المرضى (n=50) ومجموعة السيطرة.(n=50) . تم قياس المؤشرات الهرمونية والتي شملت هرمون البرولاكتين وهرمون النمو، إضافة إلى الفحوصات الدموية مثل الهيموغلوبين(Hb) ، ومكداس الدم(HCT) ، وحجم الكريات الحمراء الوسطي (MCV)، وخضاب الكرية الوسطي(MCH) ، فضلاً عن عدد كريات الدم البيضاء (WBC) والصفائح الدموية. كما تم تقييم مؤشرات التخثر والتي شملت زمن البروثرومبين(PT) ، وزمن الثرومبوبلاستين الجزئي(PTT) ، والنسبة المعيارية الدولية(INR) .

أظهرت النتائج ارتفاع مستوى البرولاكتين لدى المصابات (45.73 ± 10.64 ng/mL) وانخفاض هرمون النمو (1.325 ± 0.566 ng/mL) مقارنة بمجموعة السيطرة (38.38 ± 12.22 و1.826 ± 0.827 ng/mL على التوالي). كما لوحظ انخفاض في المؤشرات الدموية لدى المرضى، بما في ذلك الهيموغلوبين (12.03 ± 1.67 g/dL)، ومكداس الدم (34.64 ± 2.82%)، و(MCV 76.82 ± 9.18 fL)، و(MCH 26.80 ± 4.88 pg)

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مقارنة بمجموعة السيطرة (14.50 ± 1.14 g/dL و40.70 ± 2.62%). ولم تُلاحظ فروق معنوية في عدد كريات الدم البيضاء (6.79 ± 1.59 مقابل 6.45 ± 1.65 ×µL/10³) والصفائح الدموية (203.3 ± 41.7 مقابل 216.6 ± 48.6 ×µL/10³). كما أظهرت مؤشرات التخثر ارتفاعًا لدى المرضى، بما في ذلك PT (13.71 ± 0.44 sec) ، و PTT (33.76 ± 2.53 sec)، و INR (1.12 ± 0.10) مقارنة بمجموعة السيطرة (12.52 ± 0.44sec ، و30.04 ± 3.00sec ، و1.00 ± 0.04 على التوالي).
وتشير هذه النتائج إلى أن داء المقوسات المرتبط بالإجهاض يرتبط بحدوث اضطرابات هرمونية وخلل في المؤشرات الدموية وعوامل التخثر، والتي قد تسهم في آلية حدوث فقدان الحمل، مما يؤكد أهمية التقييم الشامل للنساء المصابات.

الكلمات المفتاحية : الإجهاض، داء المقوسات، اختبار الإليزا, متغيرات هرمونية ودموية.