



Evaluating the role of immunological and inflammatory markers in infertile female patients in Kirkuk city / Iraq

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Abstract:

Infertility is one of the most complex gynecological diseases in medical sciences, which is defined as a health disorder affecting the reproductive system that leads to the inability to achieve pregnancy after 12 months or more of engaging in marital relations. It is a major health condition affecting a large number of people worldwide. This study was conducted from November 5, 2025, to December 5, 2025, to evaluate the levels of certain immunological and inflammatory variables in the blood serum of 85 women from Kirkuk (patients and healthy women), aged 18-40 years. Fifty-five (50) blood samples were randomly collected from women with confirmed gestational age (3 years of marriage) and 35 blood samples from a control group of healthy women. Several immunological and inflammatory variables were then measured, including interleukin-6, interleukin-10, TNF- α , IFN- λ , catalase, and peroxynitrite. The results showed significant differences between the two groups at a probability level of $P \leq 0.05$.

Key words: Infertility, inflammatory cytokines, IL-6, catalase, peroxynitrite.



Introduction

Infertility is one of the most complex gynecological diseases in medical sciences. It is defined as a health disorder affecting the reproductive system that leads to the inability to achieve pregnancy after 12 months or more of regular sexual intercourse. It is a major health condition affecting a large number of people worldwide. It is a condition with multiple genetic factors, including chromosomal and single-gene changes, which are responsible for 20-30% of infertility cases and are prevalent in 10-15% of the world [1,2]. Several factors lead to infertility, some of which are related to the man, some to the woman, some of which are related to both spouses, and some of which are unknown (Unexplained Factor). The main causes of infertility in the majority of women are (premature ovarian failure, blocked fallopian tubes, poor egg quality, uterine problems, etc.) [3]. In men, infertility is caused by the side effects of certain types of drugs, such as Sulfasalazine, Spironolactone, and Cyclosporine, which in turn lead to secondary infertility when treated with them permanently or temporarily. In addition, chemotherapy treatments for cancer and radiation

therapy are among the treatments that lead to the killing of sperm in males or even the destruction of the tissue responsible for sperm production, depending on the type and amount of dose for chemotherapy, the period of exposure to radiation, and the number of sessions for radiation therapy. This condition is known as arrested spermatogenesis [4]. The basic principle of treating infertility in both sexes is to restore balance within the body after chemotherapy, which is based on hormonal regulation of the menstrual cycle and providing a suitable physiological environment to facilitate pregnancy, embryo implantation, and subsequent pregnancy continuation [5]. Since physiological imbalance causes anovulation, which constitutes 90% of infertility cases, treatment must be applied after proper diagnosis and identification of the causes to restore ovarian function and treat infertility, with clinical focus on developing new treatments to prevent unexplained infertility [6]. Interleukin-6 (IL-6) is a type of inflammatory cytokine produced by many cells in the body. IL-6 plays an important role in follicular growth and regulates cell proliferation or

differentiation, follicular survival or regression, and egg maturation [7]. IL-6 levels in follicular fluid are significantly higher than those in serum [8,9]. In polycystic ovary syndrome, IL-6 levels increase in both serum and follicular fluid due to the increased secretion of granulocytes. Some studies have shown that increased IL-6 levels may be associated with hyperandrogenism and insulin resistance, thus affecting most infertile women [10]. Interleukin-10 is an immune-regulating cytokine responsible for the proliferation of many immune cells. Increased levels of this cytokine occur during lymphomas and melanomas, and it is therefore concluded that it promotes tumor growth [11,12]. In addition, IL-10 is a key cytokine that mediates immune responses specific to *C. trachomatis*. The immunosuppressive IL-10 may reduce disease in the upper genital tract, and when produced in excess or at the wrong time, it can also impair pathogen clearance and cause chronic infection [13]. Tumor necrosis factor- α (TNF- α) is secreted primarily by macrophages, T cells, and cytotoxic T cells. This cytokine promotes chronic inflammation and activates the endothelium [14]. It is considered an

important factor in angiogenesis, which is stimulated by promoting endothelial cell division and influencing pro-angiogenic elements [15]. It is one of the cytokines that plays a significant role in stimulating reactions in advanced stages of inflammation, leading to delayed conception and often unexplained infertility [16]. Interferon gamma is a type of non-immune cytokine with a molecular weight of 34 kDa. It is produced by CD4⁺ T helper cells, CD8⁺ cytotoxic lymphocytes, NK cells (Natural Killer), B cells, natural killer cells, and dendritic cells [17]. The irregular production of these cytokines is associated with several diseases, such as chronic autoimmune diseases, inflammatory bowel disease, and diabetes, in addition to unexplained infertility due to the inflammation they cause [18]. By examining the elevated levels of certain immune cytokines, the current research aims to evaluate the role of some immune and inflammatory markers in infertile women in Kirkuk.

Material and Methods

Collection of specimens

Study Design and Participants

This case-control study was conducted at

Kirkuk General Hospital and several external private medical laboratories in Kirkuk City, Iraq, from November 5, 2025, to December 5, 2025. A total of 85 married women, aged between 18 and 40 years, were enrolled in this study. The participants were divided into two groups:

Patient Group (n=50): Included women diagnosed with unexplained infertility, defined as the failure to conceive after at least three years of regular unprotected intercourse, with no identifiable cause after standard gynecological and endocrinological evaluations. **Control Group (n=35):** Included age-matched healthy fertile women with no history of infertility, chronic diseases, or inflammatory disorders. All participants provided verbal informed consent before enrollment.

Blood Sample Collection and Preservation

Approximately 5 mL of venous blood was drawn from each participant by antecubital venipuncture using sterile disposable syringes. The blood samples were transferred into plain Vacutainer tubes (without anticoagulant) and left to

clot at room temperature for 30 minutes. To separate the serum, the samples were centrifuged at 3,000 rpm for 15 minutes at 4°C. The clear supernatant (serum) was carefully aliquoted into sterile Eppendorf tubes and immediately stored at -80°C for further biochemical analysis, thereby preventing repeated freeze-thaw cycles and preserving protein integrity.

3. Measurement of Immunological and Inflammatory Markers

Serum levels of interleukin-6 (IL-6), interleukin-10 (IL-10), tumor necrosis factor-alpha (TNF- α), and interferon-lambda (IFN- λ) were quantitatively determined using commercial sandwich Enzyme-Linked Immunosorbent Assay (ELISA) kits. The assays were performed strictly according to the manufacturer's guidelines.

Subsequently, several immunological and inflammatory variables were measured (interleukin-6, interleukin-10, TNF- α , IFN- λ , catalase, and peroxynitrite).

Estimating the level of immune and inflammatory variables in the samples under study

Immunological and inflammatory variables, including interleukin-6, interleukin-10, TNF- α , IFN- λ , catalase, and peroxynitrite, were measured in the serum of both patient and healthy groups using enzyme-linked immunosorbent assay (ELISA). This technique relied on the use of calibrated plates consisting of 96 wells pre-coated with antibodies specific to each variable. When serum samples are added, the antigens they contain bind to antibodies fixed to the surface of the well. Then, an enzyme-labeled secondary antibody is added, forming an immunocompetent sandwich ELISA complex. During incubation, the immunocompetent complex aggregates in the titration tubes due to the high-affinity reaction between streptavidin and biotinylated antibody. After equilibrium is reached, the bound antibody fragments separate from the unbound antigens in the washing process. The enzyme activity of the bound antibody fragments is directly proportional to the concentration of

antigens. When stimulated by HRP, the pits appear blue after its addition; then the stop solution is applied to each pit, and the color changes from blue to yellow. The optical density (OD) is measured at a wavelength of 450 nm.

Statistical analysis

Statistical analysis was performed using SPSS software (version 26.0). An independent samples t-test was used to compare means between the two groups for normally distributed variables; Levene's test was performed to check the homogeneity of variances due to the unequal sample sizes (50 vs. 35). All data were expressed as mean $\pm$ SD, and statistical significance was set at $p \leq 0.05$.

Result and Discussion

Analysis of immunological and inflammatory variables in both groups (patients and healthy individuals):

Table (1) shows the mean $\pm$ standard deviation of the immune and inflammatory variables in the two groups (patients and healthy people).

Parameter	Mean $\pm$ SD		P-Value
	Control n=35	INF n=50	
IL -6 (pg/ml)	9.16 $\pm$ 5. 18	14.49 $\pm$ 3.15	0.0001
IL-10 (pg/ml)	32.77 $\pm$ 8.12	20. 65 $\pm$ 6.51	0.0001
TNF- α (pg/ml)	60.18 $\pm$ 4.16	87.17 $\pm$ 5.05	0.0001
IFN- λ (pg/ml)	13.87 $\pm$ 6.49	31.57 $\pm$ 12.23	0.0001
Catalase (IU/L)	0.78 $\pm$ 0.04	0.39 $\pm$ 0.06	0.0001
Peroxy nitrate (μ mol/L)	23. 21 $\pm$ 3.21	44.13 $\pm$ 3. 28	0.0001

The current research results showed significant differences in both groups of infertile patients and healthy women (healthy women) for immune and inflammatory levels, which included

(interleukin-6, interleukin-10, TNF- α , IFN- λ , catalase, in addition to peroxynitrite). At a probability level of $P \leq 0.001$, as shown in the following figures:

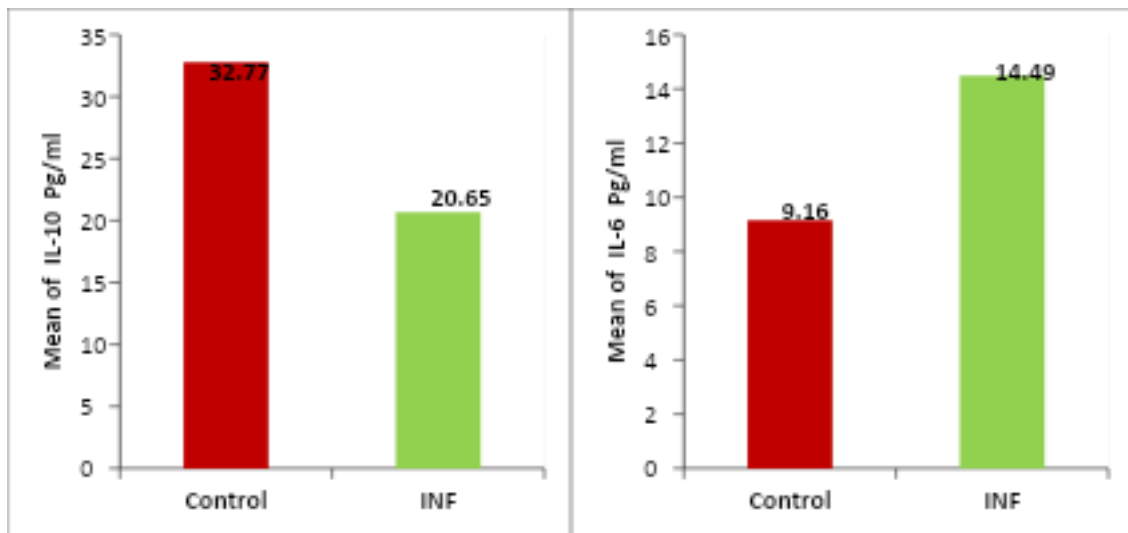


Fig 2: Average of IL-10 in serum under study

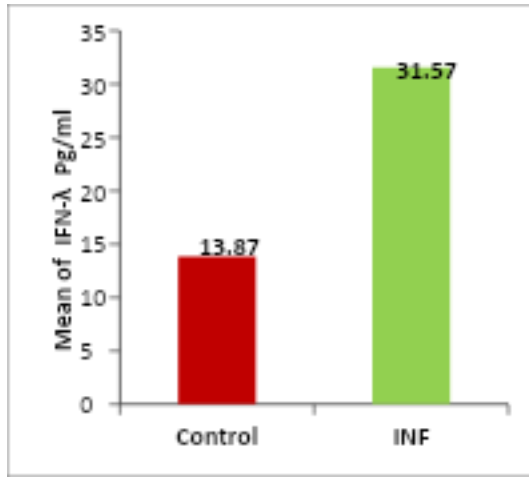


Fig 1: Average of IL-6 in serum under study

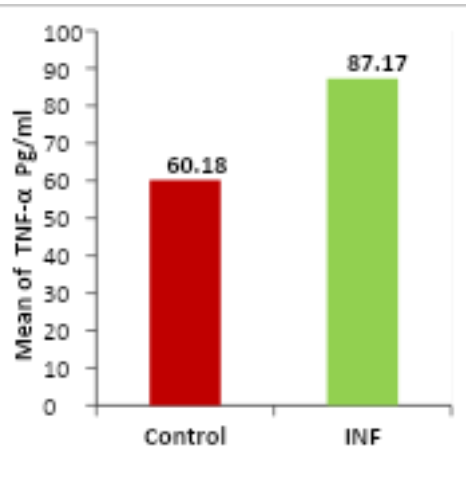


Fig 3: Average of IFN-γ in serum under study

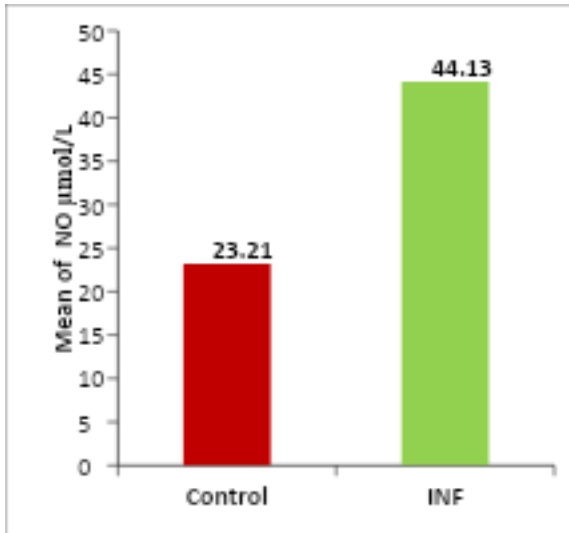


Fig 4: Average of TNF-α in serum under study

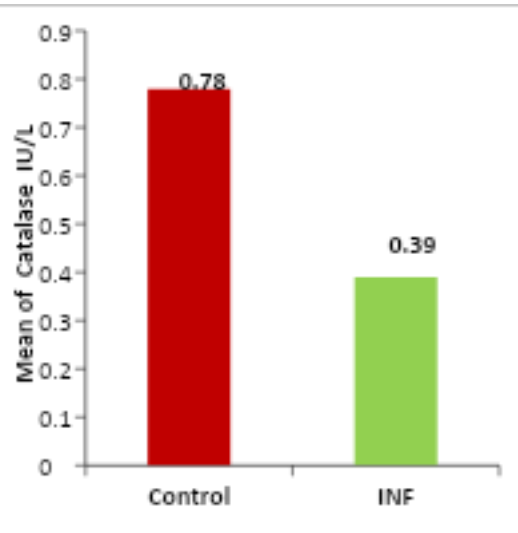


Fig 5: Average of NO in serum under study

Fig 6: Average of Catalase in serum under study

Discussion

The elevated levels of interleukin-6 (IL-6) in infertile women were consistent with the findings of Bingyao et al. [19]

and Giosuè et al.[20]. This elevation is believed to be due to an underlying inflammatory condition associated with fertility disorders, as IL-6 plays a pivotal

role in regulating the immune response within the reproductive environment, being a major inflammatory cytokine capable of interacting with the endometrium, ovaries, and follicular fluid [21]. Furthermore, a marked elevation in IL-6 may reflect chronic, low-intensity immune system activation, whether associated with pelvic inflammatory disease, endometriosis, or polycystic ovary syndrome (PCOS), all common causes of infertility. Studies have shown that increased IL-6 negatively affects endometrial receptivity to embryo implantation by disrupting the balance between inflammatory and anti-inflammatory cytokines, thus impairing the implantation process [22, 23].

The finding of low interleukin-10 (IL-10) levels in infertile women was consistent with the results of Jessica E et al. [24] and Tuğba et al. [25]. The reason for this decrease is believed to be due to immune dysregulation, represented by a disruption of the balance between Th1 and Th2 immune response patterns. Under normal conditions, the uterine environment during implantation tends towards an anti-inflammatory immune pattern (Th2-dominant response), and IL-10 is one of the most prominent

cytokines supporting this pattern. When its levels are low, there is a tendency toward an inflammatory response (Th1), leading to increased secretion of inflammatory cytokines such as IL-6 and TNF- α , which may impair endometrial acceptance of the embryo [26, 27]. IL-10 also plays a crucial role in promoting immune tolerance toward the embryo, which is considered a semi-foreign entity from an immunological perspective; its low levels lead to increased cytotoxic activity of T cells and natural killer cells within the endometrium, which may cause implantation failure or disruption of early pregnancy development [28].

The result of the high level of TNF- α in infertile patients was consistent with the results of both Lin et al. [29] and Ozcelik et al. [30]. This increase is believed to be due to the main role that TNF- α plays in causing endometriosis by altering immune cell function and increasing the levels of pro-inflammatory cytokines in the peritoneal cavity, endometrium, and blood. These immune changes promote the adhesion of ectopic tissues and the spread of endometrial cells (31). The breakdown of endometrial tissue with menstruation is a severe inflammatory

process in those with ectopic tissue outside the uterus, generating the possibility of widespread inflammation of endometrial cells in ectopic sites as seen in endometriosis, which can be activated by elevated estradiol and decreased testosterone, stimulating the activity of inflammatory cytokines, including TNF- α [32].

The elevated IFN- λ levels observed in infertile women were consistent with the findings of Kwak-Kim et al. [33] and Piccinni MP [34]. This elevation is believed to be due to an overactive cellular immune response, which may, in turn, create an unfavorable uterine environment for embryo implantation. Elevated IFN- γ levels may also stimulate chronic inflammatory pathways and oxidative stress, which also affect trophoblast differentiation, negatively impacting pregnancy success [35].

The finding of decreased catalase levels in infertile women was consistent with the results of both Maysaloon [36] and Pyari [37]. This reduction is believed to be attributed to two possible mechanisms: first, increased consumption of catalase to neutralize free radicals and prevent oxidative damage may lead to decreased

enzyme activity, and second, reduced catalase production may result from diminished sensitivity to negative feedback, which occurs as a compensatory response to oxidative stress, whereby antioxidant systems are initially activated; however, over time, the sensitivity of these systems declines, leading to organ damage, which indicates the formation of excessive reactive oxygen species (ROS), accompanied by a decrease in antioxidant defense mechanisms in both the blood and other cellular systems [38].

The elevated level of peroxynitrite observed in infertile patients was consistent with the findings of Rajeshwary [39] and Sahi [40]. This increase is believed to result from the interaction of multiple oxidative stress factors, including environmental exposures, radiation, metabolic byproducts, and comorbidities associated with infertility, such as diabetes, obesity, and cardiovascular diseases [41].

It has been observed that oxidative stress affects female infertility, particularly in cases of unexplained infertility, through various mechanisms,

as elevated reactive oxygen species (ROS) within Graafian follicles cause oocyte damage by overwhelming antioxidant defenses and inducing DNA damage in both oocytes and sperm, thereby impairing fertilization; furthermore, even when fertilization occurs, subsequent oxidative stress may adversely affect embryo implantation, increase the risk of congenital malformations, and contribute to placental abortion [42].

Conclusion

This study concludes that women with unexplained infertility exhibit significant alterations in both immune and oxidative stress markers compared to healthy controls. The elevated levels of pro-inflammatory cytokines (IL-6, TNF- α , and IFN- λ) alongside decreased IL-10 levels indicate a state of chronic low-grade inflammation and immune dysregulation, characterized by an imbalance between Th1 and Th2 immune responses. Furthermore, the reduced catalase activity and increased peroxynitrite levels suggest enhanced oxidative stress and impaired antioxidant defense mechanisms. These findings highlight the potential role of inflammation and oxidative stress in the

pathogenesis of unexplained infertility, as elevated reactive oxygen species (ROS) within Graafian follicles may cause oocyte damage and impair fertilization, while chronic inflammation may negatively affect endometrial receptivity and embryo implantation. In conclusion, the integrated assessment of both inflammatory and oxidative stress biomarkers may provide valuable insights into the underlying mechanisms of unexplained infertility and could serve as potential targets for future therapeutic interventions.

Conflict of interest:

Authors Declare there is no conflict of interest.

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تقييم دور المؤشرات المناعية والالتهابية لدى النساء المصابات بالعقم في مدينة كركوك / العراق

ثناء خليل إبراهيم و زينة عبد المنعم عبد الرزاق

جامعة البصرة، كلية العلوم، قسم علوم الحياة، العراق
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الخلاصة

الخلفية: يُعد العقم أحد أكثر أمراض النساء تعقيداً في العلوم الطبية، ويُعرف بأنه اضطراب صحي يصيب الجهاز التناسلي ويؤدي إلى عدم القدرة على الحمل بعد مرور 12 شهراً أو أكثر من الممارسة الزوجية. وهي حالة صحية رئيسية تؤثر على أعداد كبيرة من الأشخاص حول العالم. أُجريت هذه الدراسة في الفترة من 5 نوفمبر 2025 إلى 5 ديسمبر 2025 لتقييم مستويات بعض المتغيرات المناعية والالتهابية في مصل الدم لدى 85 امرأة من مدينة كركوك (مريضات ونساء سليمات)، تتراوح أعمارهن بين 18 و40 عاماً. تم جمع 50 عينة دم عشوائياً من نساء يعانين من العقم (بمدة زواج تبلغ 3 سنوات)، و35 عينة دم من مجموعة ضابطة (مجموعة مقارنة) مكونة من نساء سليمات. وجرى بعد ذلك قياس عدة متغيرات مناعية والتهابية، شملت: الإنترلوكين-6 (IL-6)، والإنترلوكين-10 (IL-10)، وعامل نخر الورم ألفا (TNF-α)، والإنترفيرون-كاما (IFN-λ)، وإنزيم الكاتاليز (catalase)، والبيروكسي نتريت. وأظهرت النتائج وجود فروق معنوية (ذات دلالة إحصائية) بين المجموعتين عند مستوى احتمالية $P \geq 0.05$.

الكلمات المفتاحية: العقم، السيتوكينات الالتهابية، إنترلوكين-6، إنزيم الكاتاليز، بيروكسي نتريت.