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Comparative Analysis of Oxidative Stress and Inflammatory Marrs in Patients with Cardiovascular Diseases: The Role of FGF23, CXCL10, and 8-OHdG

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Abstract: **Background:** Cardiovascular diseases (CVDs) are one of the world's leading causes of death, thus finding a novel, trustworthy biomarker for early intervention is crucial. With an emphasis on oxidative stress and inflammation, this study attempts to evaluate the diagnostic value of two inflammatory markers in CVD patients: FGF23, CXCL10, and 8-ohdG. **Materials and Methods:** A case- control research was conducted at Abu Dsheer Laboratory in Iraq between March and July 2024, with 45 CVD patients and 45 matched healthy controls. ELISA kits (Elabscience, USA) were used to measure the serum levels of FGF23, CXCL10, and 8-OHdG in patients and controls. Using SPSS v26, clinical and demographic data were statistically analyzed using the independent t-test, Mann-Whitney U, and Spearman's correlation. **Results:** All three biomarkers (FGF23, 72.47 versus 28.79 pg/mL, CXCL10, 219.40 compared 42.95 pg/mL, and 8-OHdG, 529.32 versus 103.62 ng/mL) were higher elevated in those with cardiovascular disease than in controls ($p < 0.001$). Additionally, a high connection ($\rho=0.878$) was found between CXCL10 and 8-OHdG, indicating a mutual dependence. CXCL10 ($\rho=1.000$) and 8-OHdG ($\rho=0.878$) were enhanced in CVD patients with FGF23 ($p<0.001$). Age, sex, BMI, and blood types did not significantly correlate ($p>0.05$), suggesting that CVD is particular.**Conclusion:** The FGF23, CXCL10, and 8-OHdG pathways that link oxidative stress and inflammation may be powerful biomarkers for cardiovascular disease. These biomarkers have greater clinical usefulness since they are not influenced by any demographic factors. It is necessary to assess these biomarkers' therapeutic potential as well as their prognostic value for clinical outcome.

Keywords: Oxidative Stress, Inflammatory Markers, Cardiovascular Diseases, FGF23, CXCL10, 8-OHdG.

INTRODUCTION

One leading healthcare issue that is faced globally is cardiovascular diseases (CVDs), which cause morbidity and mortality. According to an estimate by the American Heart Association (AHA), over 19.4 million people passed away in 2021 from CV diseases. That is one-third of total mortality in the world, which are staggering figures. Additionally, worldwide more than 612 million people suffer from cardiovascular diseases (Martin, S. S. *et al*., 2025). Iraq is facing the same grave situation. In Iraq, more than half of all deaths are attributed to non-communicable diseases, according to the World Health Organization, and of those deaths, almost 40 percent are due to cardiovascular diseases (Merzah, M. 2025). Conditions like obstruction of coronary arteries, heart failure, arrhythmias, and cardiac or cerebral strokes are often referred to as “silent” because they usually become evident only after an acute heart attack or stroke event. Since these have a generally latent and silent character (3), identifying them proactively is vital (Thiriet, M. 2019).

Warnings about smoking, inactivity, and high blood pressure damaging the heart and fitness have been around for years (Bays, H. E. *et al*., 2021; Bays, H. E. *et al*., 202). Newer evidence has emerged recently, suggesting that chronic inflammation, dysregulation of the immune system, and oxidative-stress-induced damage are some underlying mechanisms that also seem to be important (Henein, M. Y. *et al*., 2022). Dysfunction of endothelial cells results in increased oxidative stress and inflammation in the vessel wall, both of which will, in turn, promote further endothelial dysfunction, thus enhancing the atherosclerosis process in a feed-forward manner (Qaddoori, H. T. *et al*., 2024). The results obtained provide a basis for forming new biomarkers that may lead to early diagnosis and better therapeutic options. Researchers are most interested by FGF23 and CXCL10. The immune chemokine (Karimabad, M. N. *et al*., 2021) CXCL10 recruits inflammatory cells to damaged cardiac tissues.

FGF23 is mainly engaged in the metabolism of phosphate and vitamin D, but in excess, it exerts cardiotoxic effects (Latic, N., & Erben, R. G. 2021). Measuring the circulating concentrations of such markers may uncover some of the key inflammatory pathways implicated in inflammatory CVD.

The ability to measure 8-OHdG, which is a well-established oxidative DNA damage biomarker, is also important (Caballero-Sánchez, M. D. *et al*., 2022). 8-OHdG is known to enhance systemic oxidative stress, which is a major cause of atherosclerosis and endothelial dysfunction (Yan,

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R. *et al*., 2024). Measurement of both markers due to their complex interaction may present other informative and credible pathophysiological profiles in cardiac patients.

The study is comparing the levels of serum FGF23-CXCL10 and 8-OHdG between patients with CVD and healthy individuals. Besides assessing the differences among groups, we look at the possible associations with some demographic (age, sex) and clinical (BMI, blood group) factors. As a result, novel methods for risk stratification and preemptive intervention could lead to better cardiovascular health in the population.

MATERIALS AND METHODS

Study Design and Ethical Considerations

In the year 2024, the case-control study with prospective elements was carried out at Abu Dsheer Laboratory, Baghdad. All study participants provided written informed consent, and the approved study protocol (2025ZMK958) was evaluated by the institutional review board and found in a bound volume of approved studies.

Participant Selection

We screened 90 consecutive patients referred to the laboratory for cardiac diagnostic work-ups for inclusion in the study. Those who were excluded were immunocompromised, unable to communicate, pregnant, younger than 18 years of age, and anemic (female hemoglobin < 11.5 mg/dL). The final analysis involved 45 patients with cardiovascular disease confirmed by angiography and 45 matched healthy controls without clinical or laboratory evidence of heart disease. Demographic and clinical variables, blood group, and clinical measurements like height, weight, and body mass index were collected using a structured questionnaire and chart review.

Sample Collection and Processing

Standard techniques for phlebotomy were employed to collect fasting venous blood samples for participants. A blood sample of 5 mL from each participant was collected. The sample was spun at 3000 rpm for 15 minutes to centrifuge for serum isolation. The serum that was separated was put in aliquots and kept at -80ºC until the analysis of the respective biomarker.

Biochemical AnalysesFGF23, CXCL10, and 8-OHdG were serum biomarkers that were quantified using ELISA kits from Elabscience, Houston, TX. Procedures were conducted in accordance with the guidelines that were provided.

- FGF-23 (Catalog #E-EL-H5134)
- CXCL10 (Catalog #E-EL-H0204)
- 8-OHdG (Catalog #E-EL-0028)

All assays were performed in duplicate by a blinded technician to minimize observer bias.

Statistical Analysis

SPPS version 26 was utilized for data analysis. Continuous data was summarized as mean SD, and categorical data was presented in frequencies and percentages. Kolmogorov-Smirnov tests were employed to examine normality. Group comparisons were done using independent t-tests for parametric data, Mann-Whitney U tests for non-parametric data, and chi-square tests for categorical variables. Relationships between the clinical and demographic variables and the biomarkers were examined using Spearman's correlation. A p-value of less than 0.05 was considered statistically significant.

RESULTS

This section displays the primary results of our comparative study on cardiovascular biomarkers. In Table 1, we assessed the age, body mass index (BMI), and three biological markers (FGF23, CXCL10, and 8-OHdG) in the total participant sample (n=90) and in two subgroups: cardiac patients and healthy controls. The entire study population's average age was 30.6 years, with an average BMI of 21.31 kg/m². The biomarker analysis yielded average results of 50.63 ng/mL for 8-OHdG, 131.17 pg/mL for CXCL10, and 316.47 pg/mL for FGF23. Although we noted no significant differences in age or BMI between the groups ($p > 0.05$), perhaps the most remarkable finding was the strikingly elevated levels of all three biomarkers in cardiac patients compared to the healthy controls ($p < 0.001$).

Table 1: Comparison of Demographic and Biomarker Variables Between Cardiac Patients and Healthy Controls (n=90)

Variable	Group	N	Min	Max	Mean	SD	p-value
Age (years)	Patient	45	16	42	30.00	6.684	0.373
	Control	45	17	44	31.31	7.188	
BMI (kg/m²)	Patient	45	12.9	29.5	21.54	4.296	0.907
	Control	45	9.0	32.4	21.09	6.760	
FGF23 (pg/mL)	Patient	45	38.88	97.28	72.47	15.624	<0.001

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	Control	45	15.36	40.35	28.79	6.425	
CXCL10 (pg/mL)	Patient	45	42.54	280.76	219.40	47.044	<0.001
	Control	45	22.69	60.97	42.95	9.869	
8-OHdG (ng/mL)	Patient	45	102.63	677.36	529.32	113.495	<0.001
	Control	45	54.74	147.10	103.62	23.809	

In Table 2, we explain how sex and blood groups are distributed in relation to being a cardiac patient or a healthy control. As to the results, in the patient group, females accounted for 53.3% and males for 46.7%; in the control group, the distribution was 60% female and 40% male. Nonetheless, the chi-square test showed no significant differences between the two groups in sex distribution ($p = 0.527$). Concerning blood groups, type O was the most predominant in both groups (44.4% in patients and 48.9% in controls). The rest of the blood groups (A, B, and AB) had almost the same distribution between the two groups. The chi-square test of independence did not reveal significant differences in blood group distribution ($p = 0.974$).

Table 2: Distribution of Sex and Blood Groups in Cardiac Patients and Healthy Controls

Variable		Total (n=90)	Patient (n=45)	Control (n=45)	p-value
Sex	Male	39 (43.3%)	21 (46.7%)	18 (40.0%)	0.527
	Female	51 (56.7%)	24 (53.3%)	27 (60.0%)	
Blood Group	A	12 (13.3%)	6 (13.3%)	6 (13.3%)	0.974
	B	21 (23.3%)	11 (24.4%)	10 (22.2%)	
	AB	15 (16.7%)	8 (17.8%)	7 (15.6%)	
	O	42 (46.7%)	20 (44.4%)	22 (48.9%)	

In order to study the possible relations between some biological markers and demographic variables, we conducted a Spearman's correlation analysis. As for our results, we found an extraordinarily strong and significant association, statistically speaking, between the levels of FGF23 and CXCL10 ($\rho = 1.000$, $p < 0.001$). In addition, strong significant correlations were found for FGF23 versus 8-OHdG ($\rho = 0.878$, $p < 0.001$) and for CXCL10 versus 8-OHdG ($\rho = 0.878$, $p < 0.001$). In contrast, both age and body mass index did not exhibit any significant associations ($p > 0.05$) (Table 3).

Table 3: Distribution of Sex and Blood Groups in Cardiac Patients and Healthy Controls

Variable	Correlation	Age	BMI	OH-8	CXCL10	FGF23
Age	r	1.000	-.065	-.153	-.021	-.021
	p-value	.	.542	.150	.847	.847
	N	90	90	90	90	90
BMI	r	-.065	1.000	.037	.090	.090
	p-value	.542	.	.728	.397	.397
	N	90	90	90	90	90
8-OHdG	r	-.153	.037	1.000	.878**	.878**
	p-value	.150	.728	.	.000	.000
	N	90	90	90	90	90
CXCL10	r	-.021	.090	.878**	1.000	1.000**
	p-value	.847	.397	.000	.	.000
	N	90	90	90	90	90
FGF23	r	-.021	.090	.878**	1.000**	1.000
	p-value	.847	.397	.000	.000	.
	N	90	90	90	90	90

In order to assess the possible effect of sex and blood group on the levels of biomarkers, we performed appropriate analyses. For sex-based comparisons, we used the Mann-Whitney U test, and for blood group comparisons, we used the Kruskal-Wallis test for groups A, B, AB, and O. Based on our analyses, males and females did not differ significantly in FGF23, CXCL10, or 8-OHdG levels ($p = 0.721$, 0.721, and 0.490, respectively). Also, we did not observe any statistically significant differences in these biomarkers across the blood groups ($p > 0.95$).

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Altogether, these results indicate that, in our study population, sex and blood group have no considerable impact on the levels of biomarkers measured (Table 4).

Table 4: Comparison of Biomarker Levels by Sex and Blood Group

Variable	Sex Test Statistic (Z / U)	Sex (p-value)	Blood Group Test Statistic (H / df)	Blood Group (p-value)
8-OHdG	Z = -0.690, U = 896.5	0.490	H = 0.305, df = 3	0.959
CXCL10	Z = -0.357, U = 937.0	0.721	H = 0.225, df = 3	0.974
FGF23	Z = -0.357, U = 937.0	0.721	H = 0.225, df = 3	0.974

The Mann–Whitney U test was used to compare male and female groups (Z and U statistics reported).
The Kruskal–Walli's test was used to compare blood group categories (H and df reported).
No statistically significant differences were observed for any comparisons ($p > 0.05$).

DISCUSSION

The results of this study verify that patients with heart disease had far higher blood levels of FGF23 than people in good health. This finding supports the comprehensive study carried out by Batra *et al*. (2016), which established the connection between FGF23 and various cardiovascular problems, including chronic endocrine blood vessel malfunctions, myocardial infarction, persistent hypertension, cardiac wall hypertrophy, and even premature death (Batra, J. *et al*., 2016). One such example of a regulatory protein is FGF23, which keeps the body's phosphate and vitamin D levels in balance (Portales-Castillo, I., & Simic, P. 2022). Interestingly, some new research suggests that this factor's steady rise may eventually have a direct impact on the heart and blood arteries, including the promotion of pathological cardiac muscle growth and chronic vascular function. Decline. Our findings do confirm this hypothesis, and at this point, it is evident that FGF23 may serve a useful role as a diagnostic and prognostic marker to evaluate the advancement of heart diseases in the coming years.

In this study, another striking observation was the marked increase of CXCL10 levels in cardiac patients relative to the healthy control group. This finding is in agreement with other researchers who noted the increase of inflammatory markers CXCL10, CCL20, and CCL22 in cardiac patients (Karimabad, M. N. *et al*., 2021; Li, R., & Frangogiannis, N. G. 2021, Korbecki, J. *et al*., 2022). CXCL10, or IP-10, is a cytokine whose production as well as secretion increases due to immune stimulation, particularly caused by the immune hormone interferon-gamma (Schnabel, C. L. *et al*., 2019). This chemokine is very important in the recruitment of immune cells such as macrophages and T-lymphocytes to inflammatory lesions. In patients suffering from cardiac diseases, the elevated levels of this chemokine may indicate a form of severe multi-organ inflammation, which is one of the marked risk factors contributing and accelerating atherosclerosis, ischemic heart disease, and ischemic heart failure. In addition to these, there is scientific proof that suggests CXCL10 is important in the process of inflammatory vascular disease, contributing to the destabilization and subsequent rupture of atherosclerotic plaques (Altara, R. *et al*., 2016; Gencer, S. *et al*., 2021). Together these findings provide strong support that CXCL10 may serve as both a biomarker and a novel therapeutic target in inflammatory cardiovascular diseases. Our study findings emphasize the evidence of CXCL10-dependent inflammation in these diseases.

The study also revealed that the CXCL10 levels of cardiac patients were substantially greater than those of the healthy control group. This outcome is in line with recent research showing elevated levels of the inflammatory markers CXCL10, CCL20, and CCL22 in heart patients (Korbecki, J. *et al*., 2022; Li, R., & Frangogiannis, N. G. 2021; Korbecki, J. *et al*., 2022). When the immune system is aroused, particularly by the immune hormone interferon-gamma, the cytokine CXCL10, commonly referred to as IP-10, is generated and secreted more frequently (Schnabel, C. L. *et al*., 2019). T-lymphocytes and macrophages are among the immune cells that are drawn to inflammatory lesions by this chemokine. One of the major risk factors for atherosclerosis and ischemic heart disease is severe multi-organ inflammation, which may be indicated by elevated levels of this chemokine in individuals with heart issues. The inquiry yields significant findings. On the 8-OHdG biomarker. Patients with cardiovascular diseases had significantly greater levels of this marker as opposed to the rest. 8-OHdG is a product of oxidative stress on DNA and an important marker for systemic oxidative stress(Di Minno, A. *et al*., 2016; Galenko, O. *et al*.,

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2019). Its increase among cardiac patients indicates an increased free radical oxidative injury among destructively acting processes that may harm vascular tissues, enhance inflammation, and eventually foster the onset or progression of cardiovascular problems. These findings are exactly in line with older studies that stressed the harmful effects of oxidative stress on the vascular system and on the heart muscle in the case of a heart attack. The 2024 systematic review by Vanreusel and others confirmed the impact of stress on physiological processes in the pathological processes of some organs and systems but stressed the need for new markers for better forecasting in the remaining patients (Vanreusel, I., *et al*., 2024). The strong 8-OHdG and heart disease association that we found supports the possibility that the marker can be used to estimate not only the level of a patient's cardiac disease but also to monitor treatment response.

Age and body mass index (BMI) were examined, and neither the patient nor the control groups showed any significant changes in these parameters. Additionally, the distribution of genders among the groups was balanced. Additionally, we did not find any significant or meaningful associations between the biomarker levels (FGF23, CXCL10, and 8-OHdG) and the demographic parameters age, weight, and sex.

The variations are unlikely to be caused by demographics because the biomarker levels indicate heart disease. This finding's therapeutic value lies in its consistency and dependability, independent of the environment. Demographics most likely have no bearing on the utility of these biomarkers as precise predictors of the severity of cardiovascular disease.

Additionally, we looked at how blood types A, B, AB, and O were distributed in heart patients and healthy controls. Contrary to certain predictions, the two groups did not vary statistically ($p = 0.794$). This implies that in this cohort, there was no independent correlation between any of the ABO blood groups and a higher or lower risk of heart disease. This conclusion is consistent with other blood group studies that have questioned the effect of blood group on cardiovascular disorders (22). However, a number of studies, including a sizable systematic review and meta-analysis, had found that people in group A had a little higher risk of coronary artery disease (OR = 1.14; $p = 0.01$), whereas people in group O had lower chances (OR = 0.85; $p = 0.0008$) (23). These differences could be due to differences in sample size and population of the studies.

Although we found no correlation between blood group and levels of inflammation or oxidative damage biomarkers, our study cannot fully rule out a function of blood group in cardiovascular susceptibility due to a limited sample size. Our results showed that the existence of cardiac illness, rather than blood type, was the primary cause of the variations in FGF23, CXCL10, and 8-OHdG levels. According to the finding, blood group may be a weak risk factor in some populations, and changes in blood group may represent the more direct pathophysiological mechanism of cardiovascular disease rather than its lack of harmful consequences.

In conclusion, our study is the first to demonstrate that patients with heart disease have considerably higher levels of the biomarkers FGF23, CXCL10, and 8-OHdG than controls. Thepotential utilization of these markers for diagnosis and prognosis is underscored by the findings. Nonetheless, the clinical usefulness of these tools will need to be confirmed in further large-scale, multicenter, longitudinal studies controlling for potential confounders. The consistent co-elevation of these three inter-related biomarkers in our patients raises the possibility of a synergistic role in CV pathophysiology. Further investigation is needed to explore this matter. Incorporation into routine practice will require further validation, using standard protocols in diverse patients and disease stages; nevertheless, our results support the clinical utility of these markers.

CONCLUSION

Research indicates that cardiovascular disease exhibits strong associations with FGF23, CXCL10, and 8-OHdG, which may prove to be reliable biochemical markers of cardiac dysfunction. A significant finding of this study is the consistent nature of gene expression profiles across all patients. The study detected no differences in gene profiles with respect to age, sex, BMI, and blood group. This means that the expression of these biomarkers is related to the fundamental mechanisms of the disease rather than any demographic or other factors. The three markers show a close relationship, suggesting that inflammation and oxidative stress are interconnected diseases that can progress heart disease. These findings point to the existence of valuable diagnostic possibilities, but studies with wider and more heterogeneous populations will

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help clarify their true clinical significance and therapeutic relevance. With great potential, these links may pave the way for more targeted, useful approaches for estimating cardiovascular risk, as well as patient care.

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Ethical approval
The study was approved by the Ethical Committee of the College of Medicine, University of Diyala. Written informed consent was obtained from all participants prior to enrollment. **Code No.2025ZMK958. Date:30 sep 2025**

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