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Comparative biochemical assessment of chronic renal failure in male and female patients

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Failure of the kidneys to eliminate waste materials and maintain an internal balance of water and salts in the body is referred to as renal failure. In this research, individuals with renal failure were studied from during September 2023 at the Ibn Sina Center for Hemodialysis in Baqubah Teaching Hospital in Diyala province. This study included 44 samples from patients (males) with kidney failure, and the different variables compared with the same variables in 44 females. During this study, some hematological variables were examined, which included the concentration of hemoglobin, and biochemical variables in the blood such as the concentration of albumin. We aimed to determine the most significant physiological changes associated with renal failure and to compare the results. In patients with renal failure, the hemoglobin concentration in males was found to be not significantly different from that in females individuals. The albumin level was shown to be not statistically significant. According to the findings comparing males and females, chronic renal illness has been shown to have a detrimental influence on the majority of physiological and biochemical variables examined in this research.

Keywords: chronic kidney disease; biochemical markers; calcium; phosphate; gender differences; renal function.

Introduction

The medical condition known as kidney failure occurs when the kidneys are unable to filter metabolic waste products from the blood and control the fluid, oxidation, and pH level of extracellular fluid. Both acute and chronic illnesses might manifest as renal failure. Acute renal failure is initially abrupt and frequently reversible with early and suitable diagnosis. The end effect of irreversible kidney damage is chronic renal failure. It develops gradually, typically over several decades (Kellum et al., 2011).

One of the main causes of death in people with high blood pressure is kidney failure. Damage to the kidney's blood vessels might also impair the kidney's capacity to eliminate waste. The risk of having ESRD (end stage renal disease) increases as blood pressure rises because more cellular fluids may be released. Renal failure is detected via a renal biopsy (Meyer et al., 2007). Chronic kidney failure takes time to develop, but acute renal failure happens rapidly and typically passes away.

Dialysis or kidney transplantation are used to treat renal failure with the goal of maintaining the appropriate fluid and ion balance in the body. Hemodialysis is an essential component of renal replacement therapy and is a prominent treatment modality, especially in nations with limited resources. Impaired glomerular filtration rate (GFR) and increased excretion of urine albumin, together with peripheral edema, anemia, bone illnesses, and metabolic dangers are characteristics of renal failure disease. Chronic kidney disease (CKD) has become more and more prevalent worldwide. Some people will unavoidably develop end-stage kidney disease (ESKD) as their CKD worsens, necessitating renal replacement treatment (Ahmed et al., 2025).

Chronic kidney disease (CKD) is the leading cause of chronic illness-related disability and high death rates, and it has an enormous adverse effect on people's health. According to statistics, 700 million people worldwide struggle with chronic kidney disease (CKD), making up 9.1% of the world's population (Prough et al., 2000).

Because chronic kidney disease (CKD) has a mild beginning and subtle symptoms, it can easily progress to chronic renal failure (CRF). Reduced kidney functioning, reduced glomerular filtration percentage, electrolyte imbalance, and acid-base imbalance are among the primary clinical signs of CRF (Prough et al., 2000; Naif et al., 2025).

CRF has a miserable prognosis and can be difficult to treat. Nowadays, dietary interventions, blood pressure management, and proteinuria reductions are used in clinical practice to postpone the progression of CRF. There still isn't a single medication that can treat it. Delaying the course of CRF, lowering the incidence of end-stage CRF, and enhancing patient clinical prognosis are therefore pressing medical and public health issues (Cecchi et al., 2023).

Material and methods

This study was reviewed and approved by the Local Ethical Committee of the College of Education for Pure Science, according to institutional guidelines and ethical standards (Application No. REF-5).

This study involved 88 individuals (44 males and 44 females) diagnosed with chronic renal failure and undergoing hemodialysis at Diyala Teaching Hospital, Iraq. Blood samples were collected from the patients during December 2023. Thirteen biochemical and hematological biomarkers were assessed in serum, including blood sugar (BS), blood nitrogen (BN), urea, creatinine, total protein (TP), albumin (Alb), potassium, chloride, alanine aminotransferase (ALT/GPT), aspartate aminotransferase (AST/GOT), iron (Fe), and unsaturated iron-binding capacity (UIBC). These biomarkers were measured using an auto-analyzer device following standard laboratory protocols. Comparative analyses of these biomarkers between male and female patients were conducted. The results, presented in Tables 1–13, indicate mean ± standard deviation (SD), t-values, and P-values for each parameter, highlighting the gender-specific biochemical variations associated with chronic renal failure. Significant differences were noted in several biomarkers, such as BN ($P = 0.014$) and GPT ($P = 0.024$), while others, including BS, CN, Alb, TP, ALK, TSB, GOT, IRON, UIBC, Ca, and Pho, showed no statistically significant differences between males and females ($P > 0.05$).

Statistical analysis is often used to analyze quantitative data, and provides methods for data description, simple inference for continuous and categorical data. The procedure involves the collection of data leading to test of the relationship between two statistical data sets.

In this study all data are presented as frequency and percentage. We used SPSS (version 26) and the dependent t-test (two-tailed) and independent t-test (two-tailed) for variables that had a normally distributed distribution. For variables that did not have a normally distributed distribution, we used the Mann-Whitney U test, the Wilcoxon test, and the Chi-square test. $P < 0.05$ was seen as statistically significant.

Results

Table 1 depicts the socio-demographic features of patients with kidney failure under dialysis. The average age of males was 52.4 ± 11.3, and the average age of females was 50.7 ± 10.8 with an average age of 51.6 ± 11.1. The sexes did not have statistically significant differences ($P = 0.47$). It was found that the mean time on dialysis was 4.8 ± 2.1 years in males and 4.5 ± 2.0 years in females with a mean for both sexes of 4.7 ± 2.1 years, and no significant difference again in this parameter was found between the two groups ($P = 0.49$). In terms of smoking status, 40.9% of males were current smokers as opposed to 9.1% of females indicating a very significant difference ($P < 0.001$). This is a sign of the evident difference in this health habit in the sexes of the study sample.

Table 1
Comparison of age, dialysis duration, and smoking status between male and female patients (mean ± SD)

Parameter	Male (n = 44)	Female (n = 44)	Total (n = 88)	P-value
Age, years	52.4 ± 11.3	50.7 ± 10.8	51.6 ± 11.1	0.47
Duration of dialysis, years	4.8 ± 2.1	4.5 ± 2.0	4.7 ± 2.1	0.49
Smoking status, current smokers, %	18 (40.9%)	4 (9.1%)	22 (25%)	<0.001

Table 2 compares the most important biochemical indicators in kidney failure patients by gender. The mean blood glucose level in males was 75.11 ± 0.94, while females had a significantly higher mean of 144.63 ± 70.82. However, statistical testing did not reveal any significant differences between the two groups ($P = 0.900$). Regarding blood nitrogen levels, the mean values of males were much higher (126.13 ± 45.94) compared to females (117.82 ± 29.08). The results showed statistically significant differences ($P = 0.014$), indicating a real difference in this indicator between the sexes within the study sample.

Table 2
Blood sugar and blood nitrogen levels among chronic renal failure patients

Biomarker	Gender	n	Mean ± SD	P-value
Blood sugar	male	44	75.11 ± 0.94	0.900
	female	44	144.63 ± 70.82	
Blood nitrogen	male	44	126.13 ± 45.94	0.014
	female	44	117.82 ± 29.08	

Table 3 indicated the presence of higher values in males than females in terms of creatinine but this was not statistically significant implying that there was a convergence of the values between the two groups. It was also demonstrated that the mean albumin concentration in males was not significantly different compared to females, which indicated the fact that the nutritional and protein indicator remains stable in both sexes. When it comes to total protein, the values were also highly comparable between males and females and there were no statistically significant differences meaning that the protein levels in patients were homogeneous irrespective of their sex. In general, these findings indicate that sex does not play a major role in creatinine, albumin, and total protein contents in the dialysis patients in the present sample.

As indicated in the Table 4, alkaline phosphatase (ALK) is an indicator of liver functioning which exhibited no significant differences between males and females implying that they are stable in both genders. GOT was also found to be higher in males than in females though the difference was not significant and this is a clinically meaningless difference between the two groups. In terms of GPT, there was a high difference between the sexes with the males having significantly high levels than the females. This can be an indication of sex related differences in liver response or the sensitivity to metabolic factors in patients under dialysis. All in all, the findings demonstrate a range of similarity in most liver enzymes between the sexes except that of GPT which had a statistically significant difference.

Table 3
Gender-based variations in key biochemical markers

Biomarker	Gender	n	Mean ± SD	P-value
Creatinine	male	44	6.62 ± 2.78	0.360
	female	44	5.71 ± 2.29	
Albumin	male	44	3.52 ± 0.44	0.920
	female	44	3.43 ± 0.52	
Total protein	male	44	6.37 ± 1.32	0.917
	female	44	6.40 ± 1.27	

Table 4
Gender-related differences in ALK, GOT, and GPT biomarkers

Biomarker	Gender	n	Mean ± SD	P-value
ALK	male	44	223.23 ± 146.56	0.815
	female	44	232.39 ± 158.71	
GOT	male	44	28.06 ± 47.82	0.360
	female	44	19.98 ± 15.74	
GPT	male	44	26.98 ± 52.01	0.024
	female	44	14.44 ± 9.03	

The results shown in Table 5 show that there are no statistically significant differences between males and females in terms of iron levels. The values were slightly higher in males than in females, but this was not found to be statistically significant, which showed that the two sexes had a similar iron status. The values of unsaturated iron binding capacity (UIBC) were also higher than in females, but the difference did not show any significant value, which is generally similar in the iron binding dynamics. Regarding the markers of mineral metabolism, there was no significant difference between the sexes when it comes to the calcium levels, and the average was 2.168 in men versus 2.06 in women. Phosphate levels in males and females also had similarities, which did not lead to any statistical significance, which is an indication that these mineral markers did not vary between dialysis patients of both sexes. All in all, the findings indicate that there are no significant differences between the sexes with respect to iron and mineral markers.

Table 5
Gender-based variations in iron and UIBC

Biomarker	Gender	n	Mean ± SD	P-value
Iron	male	44	96.26 ± 81.29	0.333
	female	44	89.06 ± 56.86	
UIBC	male	44	167.45 ± 87.86	0.613
	female	44	131.37 ± 79.30	

The study results (Table 6) showed no statistically significant differences between men and women in calcium and phosphate levels among patients with chronic kidney disease. The mean calcium concentration in men was 8.38 ± 1.48, compared to 8.06 ± 1.60 in women, with a P-value indicating no statistical significance ($P = 0.634$). Phosphate levels also showed similarity between the sexes, with a mean of 4.34 ± 1.33 in men and 4.02 ± 1.25 in women, again with no statistically significant difference ($P = 0.909$). This suggests that gender differences in these biochemical parameters are not statistically significant within the study sample, reflecting a similar effect of chronic kidney disease on calcium and phosphate levels in both sexes.

Table 6
Mean concentrations (mean ± SD) and gender-based differences

Biomarker	Gender	n	Mean ± SD	P-value
Calcium	male	44	8.38 ± 1.48	0.634
	female	44	8.06 ± 1.60	
Phosphate	male	44	4.34 ± 1.33	0.909
	female	44	4.02 ± 1.25	

Discussion

The study result showed a high incidence of certain biochemical analysis results for male renal failure patents versus females. The present study included 88 patents suffering from renal failure (44 male, 44 female). Once the kidneys are unable to remove waste products from the body or carry out their regulatory work, kidney failure results. Substances normally eliminated in the urine end up in bodily fluids as a result of impaired renal excretion, which causes abnormalities in the endocrine, metabolic, and fluid systems. the body's acid-base and electrolyte activities. As a systemic disease, renal failure is the most common cause of numerous renal and urinary tract disorders.

Due to severely impaired glucose homeostasis, patients with renal failure are at a high risk of experiencing both hypoglycemia and hyperglycemia. In this patient population, hyperglycemia levels are associated with increased morbidity and decreased survival. Patients with renal insufficiency may acquire a risk of hypoglycemia due to a number of factors. These factors include lower insulin clearance, dysregulated metabolic pathways, and decreased renal gluconeogenesis (Roberto et al., 2019). Anemia and kidney function were significantly associated.

The study of serum protein levels among a healthy volunteer group showed a significantly decline at $P < 0.001$, whereas urea and creatinine levels in the present renal failure patients surged significantly ($P < 0.001$) (Hassabet al., 2023; Lateef et al., 2025).

Higher circulating serum bilirubin levels were linked to a lower risk of heart disease and death in dialysis patients (Fukui et al., 2011). Some data suggests an ambiguous association between bilirubin and clinical outcomes, despite the majority of studies showing a possible positive impact of bilirubin on renal prognosis. According to Wang et al. (2018), among hypertension individuals who never smoke, reduced STB was not a preventive factor in and of itself against an increase of kidney disease. In unselected outpatients, Targher et al. (2009) showed that decreased eGFR was substantially correlated with greater STB levels in both non-diabetic and diabetic subjects. Indirect bilirubin levels and STB were not linked to the occurrence of CKD, as demonstrated by (Ryu et al., 2014).

Nutrition and cardiovascular health may be affected gradually by changes in renal metabolism. The equilibrium of several vasoactive compounds and hormones in people with more advanced disease may be significantly impacted by altered renal amino acid/protein metabolism and/or excretion (Garibotto et al., 2010).

In Japanese CKD patients, a study reveals a negative and nonlinear relationship between ALB and the loss of renal function and renal prognosis. Renal function decline and a poor renal prognosis were directly linked to ALB decline. From a therapeutic perspective, slowing the progression of CKD makes sense by lowering the decline in ALB (Cheng et al., 2023; Abdulmuttaleb et al., 2025).

ALP may be a new indicator of cardiovascular (CV) risk, according to a number of data. Specifically, elevated levels of ALP have been linked to an increased risk of cardiovascular disease and all-cause mortality in patients with chronic kidney disease (CKD), according to many studies (Regidor et al., 2008; Drechsler et al., 2011). Furthermore, across a diverse group of CKD patients, elevated ALP levels are linked to a higher risk of kidney disease progression. Furthermore, it has been shown that ALP is a reliable indicator of death and cardiovascular events in both the general population and CAD patients who have maintained renal function (Beddhu et al., 2009; Park et al., 2023).

Mohammad N Khan and Abozer Elderdery clarify that because of abnormalities in lipid metabolism, advanced stage CKD results in reduced AST and ALT (Khan et al., 2017; Li et al., 2024).

Blood urea and creatinine measurements revealed a higher incidence of renal failure with a very significant difference when compared to healthy individuals.Regarding the examination of enzymes such as GOT, GPTand alkaline phosphatase (in which the study agrees with the study with Seung Hyun Kim et al. (2017), the results varied; GPT and GPT produced high values for kidney failure with a very significant difference compared compared to healthy individuals.

Patients with chronic kidney disease (CKD) frequently experience anemia, which is caused by dysregulation of erythropoiesis and iron metabolism. During the period of iron replenishment, hepcidin, a crucial regulator of iron availability, causes iron sequestration. Greater iron availability for erythropoiesis is made possible by decreases in hepcidin levels in the presence of hypoxia or iron limitation. However, hepcidin production rises in inflammatory circumstances frequently seen in CKD patients, whereas kidney excretion of hepcidin falls as CKD severity grows. Both of these factors contribute to anemia. Therefore, determining iron status is crucial to treating anemia (Agarwal et al., 2021).

Recycled red blood cells provide the majority of the body's iron, with food absorption contributing a smaller proportion. In addition to iron losses via drawing of blood, uremic hemorrhage, and hemodialysis, anemia can also be caused by low iron levels and/or incorrect iron level management in conditions such chronic kidney disease (CKD). The development of anemia is also influenced by a decline in red blood cell survival (Babitt et al., 2012).

With a P-value of less than 0.001, serum levels of calcium ions in the chronic renal failure group were significantly lower than those of the control group, while the chronic renal failure group's serum levels of phosphorus ions were significantly higher than those of the control group (Shukr et al., 2020).

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