folia medica

Folia Medica 67(3)
DOI: 10.3897/folmed.67.e152461

Original Article

Evaluation of the impact of sex on some biochemical markers in end-stage renal disease patients on hemodialysis (comparison between hyperuricemia and normouricemia)

Rawaa Hadi Shareef[1], Bashaer M. Muhammad-Baqir[2], Evan Noori Hameed[2], Mustafa H. Ahmed[3]

1 *Department of Pharmacology and Toxicology, Faculty of Pharmacy, University of Kufa, Iraq*
2 *Department of Clinical Pharmacy, Faculty of Pharmacy, University of Kufa, Iraq*
3 *Al-Sader Teaching Hospital – Specialist Center for Nephrology and Kidney Transplantation, Iraq*

Corresponding author: Rawaa Hadi Shareef, Department of Pharmacology and Toxicology, Faculty of Pharmacy, University of Kufa, Al-Matar street, 54001, Kufa, Iraq; Email: rawaah.alsaabary@uokufa.edu.iq

Received: 9 March 2025 ♦ **Accepted:** 22 March 2025 ♦ **Published:** 16 May 2025

Citation: Shareef R, Muhammad-Baqir B, Hameed E, Ahmed M. Evaluation of the impact of sex on some biochemical markers in end-stage renal disease patients on hemodialysis (comparison between hyperuricemia and normouricemia). Folia Med (Plovdiv) 2025;67(3):e152461. doi: 10.3897/folmed.67.e152461.

Abstract

Introduction: Chronic kidney disease is characterized by the damage or dysfunction of the kidneys for a duration of at least three months, depending on its cause. End-stage kidney disease is defined by a glomerular filtration rate (GFR) of less than 15 mL/min/1.73 m^2 or the need for long-term renal replacement therapy irrespective of GFR.

Aim: The aim of this study was to evaluate the impact of sex on the uric acid, albumin, urea, and creatinine levels, and the prevalence of hyperuricemia in end-stage renal disease patients.

Materials and methods: This cross-sectional study was conducted at Al-Hakeem General Hospital in Al-Najaf, Iraq, from October 2023 to April 2024. The study included 50 patients with chronic renal failure or end-stage renal disease. The following data were collected for each patient: age, sex, cause of end-stage disease, duration of dialysis, number of sessions, and adequacy of dialysis. In addition, biochemical markers were analyzed.

Results: The study demonstrated that 35 patients (20 male and 15 female) had hyperuricemia, a condition characterized by elevated uric acid levels in the blood. A statistically significant difference was observed between male and female patients, with male patients demonstrating considerably higher uric acid levels compared to their female counterparts. Additionally, a statistically significant difference ($p<0.05$) was observed between hyperuricemic and normouricemic groups, indicating an increase in the mean levels of serum urea, albumin, and uric acid in the hyperuricemia patients when compared with the normouricemic patients.

Conclusion: Hyperuricemia was highly prevalent in end-stage renal disease patients. Patients with hyperuricemia had significantly higher serum albumin levels than those without, and a significant positive correlation was found between uric acid and blood glucose levels in the hyperuricemic group.

Keywords

albuminuria, chronic kidney disease, creatinine, uric acid

Introduction

Chronic kidney disease (CKD) can be regarded as a global public health problem for a number of reasons. These include its high prevalence, poor response to treatment, and high treatment costs. Furthermore, CKD has been identified as a major contributor to the overall morbidity and mortality rates associated with non-communicable diseases.[1] This condition is characterized by the impairment or deterioration of kidney function over a period of many months (three or more), depending on the underlying cause. The progression of this disorder is marked by the emergence of multiple complications, with severity and prevalence increasing in advanced stages.[2] The progression of CKD is staged, as illustrated in **Fig. 1**, and these stages are associated with an elevated risk of developing major complications.

The stages and prognosis of CKD, as shown in **Fig. 1**, are based on the glomerular filtration rate and albuminuria. These stages serve to enhance the risk correlation for the major complications associated with CKD which have the potential to adversely impact patients' quality of life and result in elevated morbidity and mortality rates. The onset of end-stage renal disease (ESRD) is characterized by a GFR of less than 15 mL/min/1.73 m^2 or the need for long-term renal replacement therapy, irrespective of GFR.[4]

Hemodialysis is considered to be the most common method used to remove many of the toxic waste products when kidneys become unable to do their functions.[5] It is a necessary technique to remove electrolytes and extra water in blood[6], because accumulation of these substances results in severe abnormalities that could cause death.[7] The relationship between hyperuricemia and CKD has been recognized by nephrologist.[8] Hyperuricemia is an abnormal biochemical condition which occurs in 20%–25% of adult male patients and less in female patients and can be defined as exceeding urate concentration above limit of solubility (about 6.8 mg/dL or 400 μmol/L).[9] There are many factors participating or causing hyperuricemia such as genetic factors and environmental factors and comorbid diseased related factors. So, hyperuricemia is the result of excess urate production, reduced intestinal secretion of urate[10], impaired renal clearance[11], or a combination of these factors[12].

For many years, studies demonstrated that hyperuricemia impairs kidney function through uric acid retention, but in 2002, a study by Kang et al., which induced hyperuricemia in experimental rats, revealed that the condition caused an increase in renal renin and cyclooxygenase 2 expression in many vessels, mainly pre-glomerular arterial vessels, increased uric acid, and induced oxidative stress and endothelial dysfunction, and these effects resulted in systemic and glomerular hypertension and contributed to the progression of CKD.[13] Additionally, the uric acid was found to cause epithelial to mesenchymal transition in the tubular cells which contributed to the progression of re-

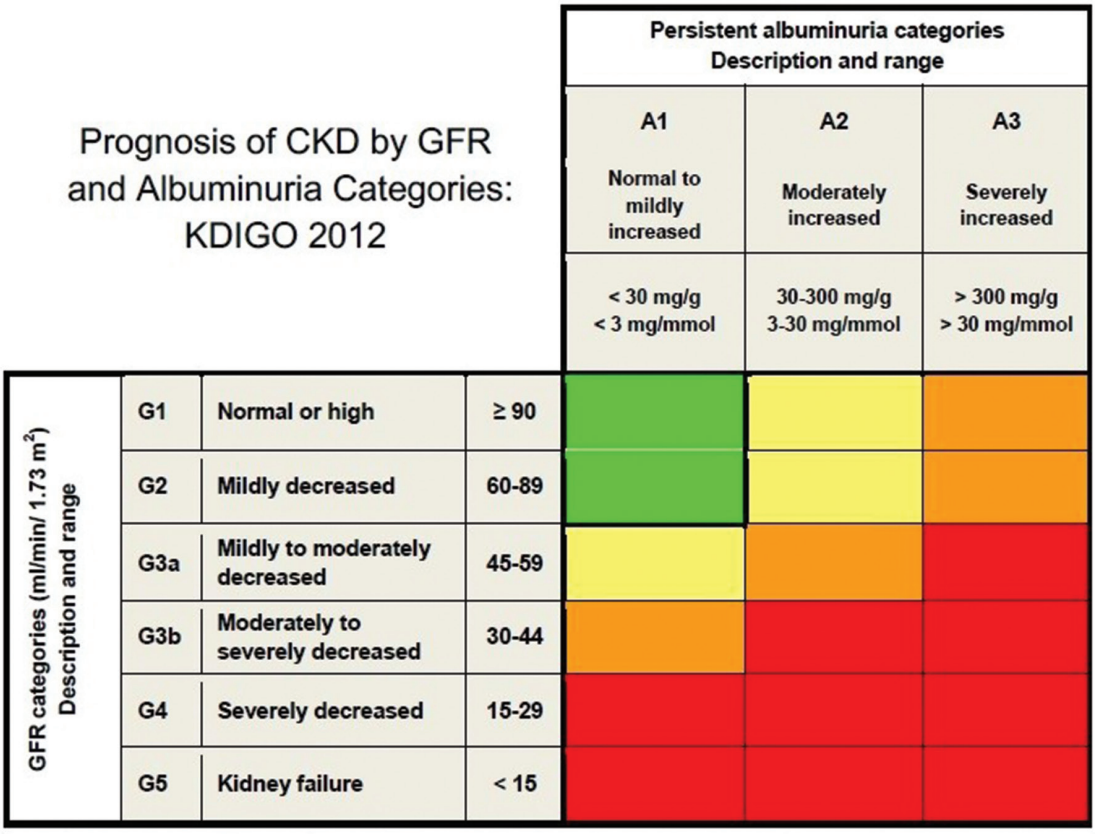

Figure 1. Staging of chronic kidney disease.[3] CKD: chronic kidney disease; GFR: glomerular filtration rate.

nal fibrosis.[14] So, hyperuricemia can be considered as an independent risk factor for CKD and progression to end-stage renal disease by increasing renal renin, promoting renal vasoconstriction, and inhibiting nitric oxide release.[15] Many studies have found that the levels of serum uric acid are increasing in parallel with the reduction of the eGFR, and this occurs in about 40%–60% of stage 1-3 CKD patients and increases to about 70% in patients with stage 4 or 5 of chronic kidney disease.[16]

Aim

The aim of this study was to evaluate the impact of sex on the levels of uric acid, albumin, urea, creatinine, and the prevalence of hyperuricemia in end-stage renal disease patients.

Materials and methods

Patients collection

This cross-sectional study was conducted at Al-Hakeem General Hospital in Al-Najaf City, Iraq, from October 2023 to April 2024. A total of fifty patients (32 men and 18 women) with chronic renal failure at end-stage renal disease planned for hemodialysis program were enrolled in this study. Patients' age ranged from 18 to 78 years. They were diagnosed with chronic kidney disease based on the glomerular filtration rate as estimated by the Cockcroft-Gault equation and the Modification of Diet in Renal Disease study equation. Each patient admitted to the hospital was provided with this information and analysis: the patient's name, age, sex, the underlying cause of the end-stage disease, the duration of dialysis, the number of sessions, the adequacy of dialysis (KtV), blood urea, serum creatinine, serum albumin, serum uric acid, and the presence of hepatitis B and C. In addition to these data, patient case notes were meticulously recorded and utilized for the purpose of data collection. All patients included in this study were administered a detailed questionnaire and provided written informed consent.

Materials

The hemodialysis machine utilized was the Gambro AK 200 ULTRAS model, manufactured in Sweden. The short-term dialysis catheter kit was the Niagara model, produced by the company Gambro, with the Slim-Cath component assembled in Mexico. The lidocaine hydrochloride injection, with a concentration of 20 mg/mL, was sourced from the United Kingdom. The human kits of urea, creatinine, albumin, and uric acid (Human, Germany) were utilized. The Human ELA test kit of viral screening test: anti-hepatitis C virus antibody (Anti HCV Ab), hepatitis B surface antigen (HBsAg), and human immunodeficiency virus (HIV) (Foresight, USA) was employed.

Statistical analysis

Data were analyzed using SPSS v. 28 (Chicago, USA) and Microsoft Excel 2019. The Kolmogorov-Smirnov test was employed to assess the distribution of the variables. Variables with a normal distribution were compared between groups using independent t-test, with all data expressed as the mean ± standard deviation (SD). Nominal variables were presented as frequencies and percentages and were compared between the two groups using the chi-square test. Pearson's correlation coefficient analysis was performed to assess the relationship between the variables. Finally, linear regression analysis was used to identify independent factors. The significance of the observed differences was set at $p<0.05$.

Results

A comprehensive study was conducted on a cohort of patients suffering from end-stage renal disease. The patients' demographic characteristics, including age, sex, weight, the cause of their ESRD, the duration of dialysis, the number of sessions, the adequacy of dialysis, the levels of blood urea, serum creatinine, serum albumin, serum uric acid, and the presence of hepatitis B and C, were thoroughly examined. The present study enrolled 50 patients with end-stage CKD on hemodialysis, with a mean age of 47.3±15.5 years. The findings revealed that there was no statistically significant differences ($p>0.05$) in any of the characteristics among the study population, with the exception of the proportion of male to female patients, as detailed in **Table 1**.

As shown in **Fig. 2**, the results of the study indicated a statistically significant difference ($p<0.05$) in the distribution of hyperuricemia among the study population. Thirty-five patients (70%) exhibited symptoms consistent with hyperuricemia. Conversely, the remaining patients did not exhibit signs of hyperuricemia.

Table 2 shows the comparison between demographic and biochemical parameters in patients with hyperuricemia and those with normouricemia. The findings revealed that the mean age, hemoglobin, creatinine, and glucose levels were not statistically significant between the two groups ($p>0.05$). However, a significant difference was observed between the two groups, indicating an increase in the mean serum urea (167.14±30.89 mg/dl), the albumin (4.2±0.59 g/dl), and uric acid (7.61±0.72 mg/dl) levels in the hyperuricemia patients ($p<0.05$) when compared with the normouricemic patients.

Additionally, a statistically significant difference ($p<0.05$) was observed in the distribution of hyperuricemia among different sexes. Among the 35 patients with hyperuricemia, 20 were male and 15 were female, as illustrated in **Fig. 3** and documented in **Table 3**.

Folia Medica

Table 1. Characteristics of hemodialysis patients

Variables	Mean	SD	Minimum	Maximum
Age	47.3	15.5	18	78
Male	32 (64%)	p=0.045*		
Female	18 (36%)			
Hb (mg/dl)	9.8	2.0	5.6	13.7
Glucose (IU/l)	121.9	68.1	43	432
Urea (mg/dl)	156.6	36.5	75	235
Creatinine (mg/dl)	9.7	2.5	4.7	16.0
Albumin (g/dl)	4.1	0.6	2.5	5.3
Uric acid (mg/dl)	7.0	1.2	4.3	8.8

*Significant differences at p-value <0.05; SD: standard deviation

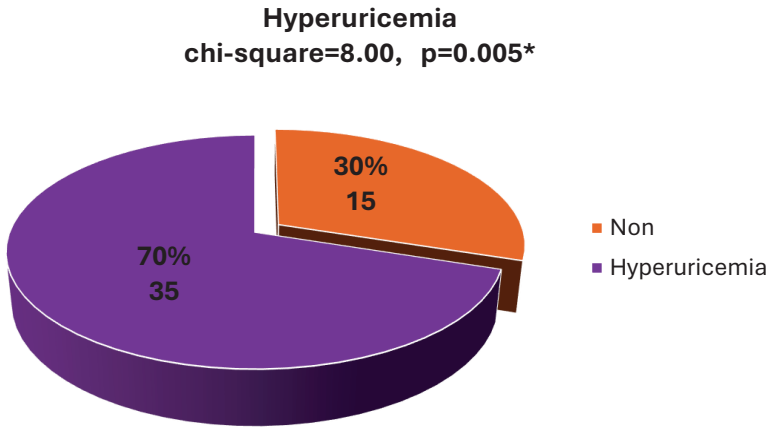

Figure 2. Prevalence of hyperuricemia among study population.

Table 2. Comparison between demographic and biochemical parameters in hyperuricemic and normouricemic patients

Variables	Mean ± SD		p-value
	Normouricemia N=15	Hyperuricemia N=35	
AGE (years)	52.13±18.01	45.29±14.15	0.078
Hb (mg/dl)	9.79±2.33	9.78±1.87	0.494
Glucose (mg/dl)	118.93±58.65	123.14±72.55	0.422
Urea (mg/dl)	131.93±37.59	167.14±30.89	0.001*
Creatinine (mg/dl)	9.27±2.99	9.86±2.35	0.228
Albumin (g/dl)	3.73±0.67	4.2±0.59	0.008*
Uric acid (mg/dl)	5.71±0.87	7.61±0.72	0.0001*

* Significant differences at p-value <0.05; SD: standard deviation

According to sex differences, male patients with hyperuricemia exhibited a significantly higher uric acid level (7.84±0.59) compared to female patients (7.29±0.77) (p=0.023). No other significant sex effects were observed on the other biochemical findings, as demonstrated in **Table 4**.

Regarding the relationship between the biochemical parameters of hemodialysis patients, no significant correlation was observed in any group with respect to any parameter, as shown in **Table 5**, where Pearson correlation results are presented.

Table 6 shows the correlations of serum uric acid levels with the biochemical parameters of CKD patients undergoing hemodialysis. The findings of the multiple linear regression analysis in the normouricemic group indicated absence

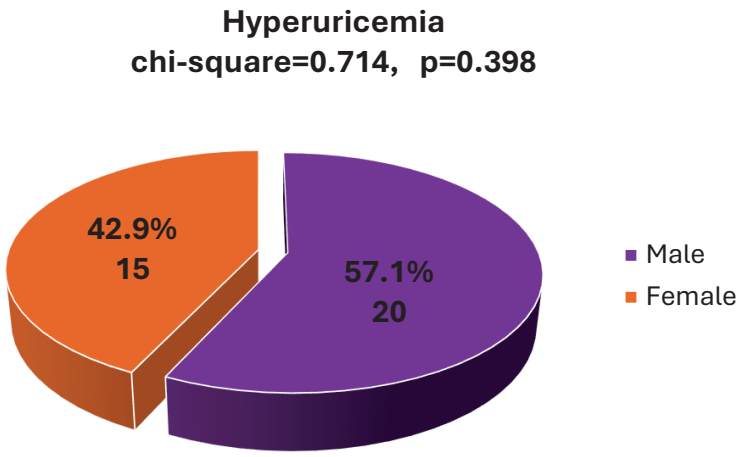

Figure 3. Prevalence of hyperuricemia according to sex.

Table 3. Prevalence of hyperuricemia according to sex

SEX * Hyperuricemia crosstabulation

			Hyperuricemia		Total
			Normouricemia	Hyperuricemia	
Sex	Male	Count	12	20	32
		% within hyperuricemia	80.0%	57.1%	64.0%
	Female	Count	3	15	18
		% within hyperuricemia	20.0%	42.9%	36.0%
Total		Count	15	35	50
% within hyperuricemia			100.0%	100.0%	100.0%

Table 4. Effects of sex on some demographic and biochemical markers in hyperuricemia patients

Variables	Mean ± SD		*p*-value
	Male N=20	Female N=15	
Age (years)	43.55±10.65	47.6±17.96	0.410
Hb (mg/dl)	9.69±1.84	9.9±1.96	0.742
Glu (mg/dl)	126.55±59.88	118.6±88.77	0.754
Urea (mg/dl)	170.85±31.51	162.2±30.38	0.420
Cr (mg/dl)	10.15±2.69	9.47±1.81	0.410
Albumin (g/dl)	4.13±0.59	4.3±0.6	0.407
Uric acid (mg/dl)	7.84±0.59	7.29±0.77	0.023*

* Significant differences at $p<0.05$; SD: standard deviation

of a significant correlation between uric acid levels and the levels of other biochemical parameters. In contrast, the hyperuricemia group exhibited a significant positive correlation between serum uric acid and blood urea levels (β=0.015, p=0.024), uric acid and albumin levels (β=0.752, p=0.025), and uric acid and glucose levels (β=0.006, p=0.020). Additionally, a non-significant negative correlation was observed between uric acid and Hb levels (β=–0.041, p=0.711) and no significant correlation with serum creatinine (β=0.115, p=0.166) within the same group.

Discussion

The present study included 50 patients with end-stage renal disease who received renal replacement therapy with the hemodialysis. About 70% of those patients had asymptomatic hyperuricemia. Hyperuricemia is defined as the concentration of serum uric acid of more than 5.5 mg/dl in children and more than 6.0 mg/dl and 7.2 mg/dl for adult female and male, respectively.[17] Hyperuricemia developed in patients with CKD mainly because of the lowering of renal capability to eliminate toxic waste products, including uric acid[18], where the lower the eGFR, the higher the prevalence of hyperuricemia[19], and this reflects the high prevalence among the patients included in the study since all participants were patients with CKD. This study showed a significant increase in the mean serum level of urea among patients with hyperuricemia. This indicates further worsening of renal functions in patient with hyperuricemia that specify the negative effect of uric acid on kidney function.

Folia Medica

Table 5. Associated between all biochemical parameters in hemodialysis patients

		Pearson correlation					
		AGE	Hb	Glu	Urea	Cr	Album
Variables		**Normouricemia**					
Hb (mg/dl)	*R*	0.403					
	p-value	0.137					
Glu (IU/l)	*R*	0.518*	0.400				
	p-value	0.048	0.140				
Urea (mg/dl)	*R*	0.002	−0.011	0.022			
	p-value	0.993	0.969	0.937			
Cr (mg/dl)	*R*	−0.219	0.082	−0.335	0.560*		
	p-value	0.433	0.770	0.223	0.030		
Albumin (g/dl)	*R*	−0.165	0.400	−0.145	0.252	0.372	
	p-value	0.557	0.140	0.607	0.365	0.172	
Uric acid (mg/dl)	*R*	0.059	0.017	−0.008	0.203	0.441	0.017
	p-value	0.833	0.952	0.978	0.469	0.100	0.952
		Hyperuricemia					
Hb (mg/dl)	*R*	0.259					
	p-value	0.132					
Glu (IU/l)	*R*	−0.299	−0.179				
	p-value	0.081	0.304				
Urea (mg/dl)	R	−0.087	0.358*	−0.300			
	p-value	0.620	0.035	0.080			
Cr (mg/dl)	R	0.011	0.159	−0.425*	0.403*		
	p-value	0.951	0.362	0.011	0.017		
Albumin (g/dl)	R	−0.077	0.412*	−0.293	0.514**	0.383*	
	p-value	0.661	0.014	0.088	0.002	0.023	
Uric acid (mg/dl)	R	−0.514**	−0.127	−0.242	0.326	0.185	0.139
	p-value	0.002	0.468	0.161	0.056	0.286	0.426

Table 6. Linear regression analysis of serum uric acid with biochemical parameters in hemodialysis patients

Hyperuricemia status		**Unstandardized coefficients**		**t**	***p*-value**	**95.0% CI**
		β	**SE**			
Normouricemia	AGE	−0.002	0.031	−0.050	0.963	−0.101-0.098
	Hb (mg/dl)	0.232	0.306	0.758	0.504	−0.742-1.206
	Glu (IU/l)	−0.005	0.011	−0.433	0.694	−0.041-0.031
	Urea (mg/dl)	0.019	0.020	0.963	0.407	−0.045-0.084
	Cr (mg/dl)	−0.044	0.239	−0.185	0.865	−0.805-0.717
	Albumin (g/dl)	0.333	0.591	0.563	0.613	−1.548-2.213
Hyperuricemia	AGE	0.008	0.011	0.732	0.469	−0.015-0.032
	Hb (mg/dl)	−0.041	0.109	−0.374	0.711	−0.262-0.181
	Glu (mg/dl)	0.006	0.002	2.433	0.020*	0.001-0.010
	Urea (mg/dl)	0.015	0.006	2.359	0.024*	0.002-0.028
	Cr (mg/dl)	0.115	0.081	1.416	0.166	-0.050-0.279
	Albumin (g/dl)	0.752	0.321	2.346	0.025*	0.101-1.403

a: dependent variable: uric acid (mg/dl); * Significant differences at *p*-value <0.05; β: size effect; SE: standard error; CI: confidence interval.

Hyperuricemia itself is associated with several comorbidities, including elevated blood pressure and worsening hypertension, as well as diabetes. Both of these conditions have been shown to lead to the development of chronic kidney disease or coronary artery disease. The development of these comorbidities is exacerbated by systemic pro-inflammatory conditions resulting from hyperuricemia, which contributes to the progression of the disease.[20] Endothelial dysfunction, proliferation of vascular smooth muscle cells, and activation of the renin-angiotensin system further exacerbate hypertension.[18] Despite the well-documented deleterious effects of hyperuricemia on health, including its potential role as a leading cause, if not the sole risk factor, for gout[21], as well as its demonstrated J-shaped relationship with mortality[22], there is a notable lack of awareness about hyperuricemia among the Iraqi population.[23] Consequently, this study aims to assess the uric acid levels in patients with chronic kidney disease.

The present study also found that glucose level could predict elevated uric acid level among patients with hyperuricemia, as explained in **Table 6**. The existing literature has previously documented a bidirectional relationship between metabolic syndrome and hyperuricemia.[24] Donkeng et al. also indicated that hyperuricemia was significantly associated with uncontrolled diabetes.[25] Consequently, serum uric acid has been identified as an independent risk factor for incident diabetes, with insulin resistance playing a potentially crucial role in the causal relationship between metabolic syndrome, type 2 diabetes mellitus, and hyperuricemia.[26] The underlying mechanism involves the NOD-like receptor protein 3 inflammasome, which has been demonstrated to induce in vivo and in vitro impairment of insulin signaling, leading to insulin resistance, and resulting in fat accumulation in hepatocytes.[27]

The present study has demonstrated that the number of male patients with hyperuricemia exceeds the number of female patients, a finding which can be attributed to the higher number of male patients who were included in the study. Furthermore, a statistically significant difference was observed in serum uric acid levels between the two groups, as illustrated in **Table 4**. It is well-documented that adult males typically exhibit higher serum uric acid levels, a discrepancy that can be attributed to sex-related biological factors.[28] Moreover, lifestyle differences besides eating habits also have a greater influence on the likelihood of developing hyperuricemia in male patients.[29]

The apparent protective effect observed in female patients may be attributable to estrogen. Estrogen, a well-documented endocrine agent, has been shown to promote the excretion of uric acid. Additionally, estrogen plays a pivotal role in regulating serum uric acid levels.[30] Its actions include a reduction in uric acid accumulation within the walls of blood vessels, which in turn limits endothelial damage in female subjects when compared to male subjects.[31]

This study also indicated that patients with hyperuricemia have significantly higher albuminuria levels than those without hyperuricemia. Bonakdaran et al. also reported that higher serum uric acid concentrations were associated with a greater chance of albuminuria, especially in patients with type 2 diabetes.[32] Similar harmful effects of hyperuricemia were also observed in child patients.[33] This effect could be attributed to impaired function of glomerular podocytes by hyperuricemia.[34] In addition, elevated serum uric acid levels are positively associated with the risk of prehypertension in the general population[35], which could further worsen blood pressure status and albuminuria, consequently further worsening renal function. The findings of this study indicate that higher albuminuria levels can serve as a predictor of greater serum uric acid elevation. Furthermore, an escalating macroalbuminuria level has been shown to augment the prevalence of hyperuricemia among patients, as previously documented.[19]

The patients with hyperuricemia had a strong positive correlation between urea and albuminuria levels within the hyperuricemia group, in addition to a significant positive correlation between creatinine and albuminuria in the same group, which may be due to the greater deterioration in renal function among hyperuricemic patients.

Conclusion

Hyperuricemia is highly prevalent in end-stage renal disease patients on hemodialysis. Male patients are more susceptible to hyperuricemia than female patients. Also, the patients with hyperuricemia have significantly higher albuminuria level than those without hyperuricemia. Regarding the hyperuricemia group, there was a significant positive correlation between the levels of uric acid and blood glucose levels.

Funding

The authors have no funding to report.

Conflict of interest

The authors have declared that no competing interest exist.

Acknowledgements

The authors have no support to report.

References

1. Bikbov B. Core global metrics of chronic kidney disease (CKD) mortality in the GBD 2019 study. Zenodo 2023. doi: 10.5281/zenodo.8312881
2. Fujii H, Joki N. Mineral metabolism and cardiovascular disease in CKD. Clin Experim Nephrol 2017; 21:53–63.

3. Levey AS, Coresh J, Bolton K, et al. K/DOQI clinical practice guidelines for chronic kidney disease: evaluation, classification, and stratification. Am J Kidney Dis 2002; 39(2 Suppl.1):i-ii+S1-S266.
4. Moustafa Y, Kilpatrick M, Schuh M, Robinson MT. Depression in end-stage renal disease# 404. J Palliat Med 2020; 23(12):1681–3. doi: 10.1089/jpm.2020.0561
5. Schilthuizen SF, Batenburg LF, Simonis F, et al., inventors; Netherlands Organization for Applied Scientific Research TNO, assignee. Device for the removal of toxic substances from blood. United States patent US 9,033,908. 2015 May 19.
6. Soykan O, Schu C, Chaffin K, inventors; Medtronic Inc, assignee. Method and device to treat kidney disease. United States patent US 8,641,659. 2014 Feb 4.
7. Singbartl K, Kellum JA. Urinary biomarkers for predicting long-term dialysis. Google Patents. (2014).
8. Pilemann-Lyberg S, Hansen TW, Tofte N, et al. Uric acid is an independent risk factor for decline in kidney function, cardiovascular events, and mortality in patients with type 1 diabetes. Diabetes Care 2019; 42(6):1088–94.
9. Yip K, Cohen RE, Pillinger MH. Asymptomatic hyperuricemia: is it really asymptomatic? Curr Opin Rheumatol 2020; 32(1):71–9.
10. Skoczyńska M, Chowaniec M, Szymczak A, et al. Pathophysiology of hyperuricemia and its clinical significance. Reumatologia 2020; 58(5):312–23. doi: 10.5114/reum.2020.100140
11. Li L, Zhang Y, Zeng C. Update on the epidemiology, genetics, and therapeutic options of hyperuricemia. Am J Transl Res 2020; 12:3167–181.
12. Song J, Jin C, Shan Z, et al. Prevalence and risk factors of hyperuricemia and gout: a cross-sectional survey from 31 provinces in mainland China. J Transl Intern Med 2022; 10:134–45.
13. Choi YJ, Yoon Y, Lee KY, et al. Uric acid induces endothelial dysfunction by vascular insulin resistance associated with the impairment of nitric oxide synthesis. The FASEB Journal 2014; 28(7):3197–204.
14. Srivastava A, Kaze A, McMullan C, et al. Uric acid and the risks of kidney failure and death in individuals with CKD. Am J Kidney Dis 2018; 27(3):362–70. doi: 10.1053/j.ajkd.2017.08.017
15. Nakagawa T, Mazzali M, Kang DH, et al. Hyperuricemia causes glomerular hypertrophy in the rat. Am J Nephrol 2002; 23(1):2–7.
16. Madero M, Sarnak MJ, Wang X, et al. Uric acid and long-term outcomes in CKD. Am J Kidney Dis 2009; 53(5):796–803.
17. Woyesa SB, Hirigo AT, Wube TB. Hyperuricemia and metabolic syndrome in type 2 diabetes mellitus patients at Hawassa university comprehensive specialized hospital, South West Ethiopia. BMC Endocrine Disorders 2017; 17:1–8.
18. Yanai H, Adachi H, Hakoshima M, et al. Molecular biological and clinical understanding of the pathophysiology and treatments of hyperuricemia and its association with metabolic syndrome, cardiovascular diseases and chronic kidney disease. Int J Mol Sci 2021; 22(17):9221.
19. Russo E, Viazzi F, Pontremoli R, et al. Association of uric acid with kidney function and albuminuria: the Uric Acid Right for heArt Health (URRAH) project. J Nephrol 2022; 35:211–21. doi: 10.1007/s40620-021-00985-4
20. Crawley WT, Jungels CG, Stenmark KR, et al. U-shaped association of uric acid to overall-cause mortality and its impact on clinical management of hyperuricemia. Redox Biology 2022; 51:102271.
21. Bardin T, Richette P. Definition of hyperuricemia and gouty conditions. Curr Opin Rheumatol 2014; 26(2):186–91.
22. Petreski T, Ekart R, Hojs R, et al. Hyperuricemia, the heart, and the kidneys – to treat or not to treat? Renal Failure 2020; 42(1):978–86.
23. Jubair SK, Shihab SS, Mousa NA. Awareness of gout and hyperuricemia in a sample of the adult population in Iraq. Al-Anbar Medical Journal 2022; 18(1):27–32.
24. Chen WY, Fu YP, Zhou M. The bidirectional relationship between metabolic syndrome and hyperuricemia in China: A longitudinal study from CHARLS. Endocrine 2022; 76(1):62–9.
25. Donkeng M, Kuaté D, Koudjou PN, et al. Association between hyperuricemia and glycated hemoglobin in type 2 diabetes at the District Hospital of Dschang. Pan Afr Med J 2021; 40(1).
26. Abujbara M, Al Hourani HM, Al-Raoush R, et al. Prevalence of hyperuricemia and associated factors among type 2 diabetic patients in Jordan. Int J Gen Med 2022; 15:6611–9. doi: 10.2147/IJGM.S376857
27. Wan X, Xu C, Lin Y, et al. Uric acid regulates hepatic steatosis and insulin resistance through the NLRP3 inflammasome-dependent mechanism. J Hepatol 2016; 64(4):925–32.
28. Halperin Kuhns VL, Woodward OM. Sex differences in urate handling. Int J Mol Sci 2020; 21(12):4269.
29. Liu L, Lou S, Xu K, et al. Relationship between lifestyle choices and hyperuricemia in Chinese men and women. Clin Rheumatol 2013; 32:233–9.
30. Liu L, Zhao T, Shan L, et al. Estradiol regulates intestinal ABCG2 to promote urate excretion via the PI3K/Akt pathway. Nutr Metab 2021; 18(1):63.
31. Ciarambino T, Crispino P, Giordano M. Hyperuricemia and endothelial function: is it a simple association or do gender differences play a role in this binomial? Biomedicines 2022; 10(12):3067.
32. Bonakdaran SH, Hami M, Shakeri MT. Hyperuricemia and albuminuria in patients with type 2 diabetes mellitus, Iran J Kidney Disease 2011; 5(1):21-4.
33. Noone DG, Marks SD. Hyperuricemia is associated with hypertension, obesity, and albuminuria in children with chronic kidney disease. J Pediatrics 2013; 162(1):128–32.
34. Asakawa S, Shibata S, Morimoto C, et al. Podocyte injury and albuminuria in experimental hyperuricemic model rats. Oxid Med Cell Longev 2017; 2017:3759153. doi: 10.1155/2017/3759153
35. Jiang M, Gong D, Fan Y. Serum uric acid levels and risk of prehypertension: a meta-analysis. Clin Chem Laborat Med (CCLM) 2017; 55(3):314–21.

Table A1. Data we collected for the patients included in the study

case no.	AGE	SEX	R.F	Hb	Glu	Urea	Cr	AIB	U.A
1	64	FEMALE		12.2	103	130	7.3	4.2	5.6
2	59	FEMALE		10.5	138	154	12.2	3.5	7
3	46	MALE		9	82	191	11	4.9	7.3
4	58	MALE		8.4	145	114	10.5	4.2	7.8
5	48	FEMALE		12.3	107	177	11.2	4.8	7.3
6	27	FEMALE		11.6	68	100	12.9	4.1	4.9
7	48	FEMALE		11.8	91	190	9.1	5	7.3
8	71	FEMALE		10.7	96	207	8.3	4.7	6.5
9	61	MALE		8.7	168	160	8.3	3.7	7
10	61	MALE		12.1	245	134	6.1	2.9	5.8
11	45	MALE		8.5	98	150	7	2.8	7.8
12	42	MALE		10.3	87	187	10.3	4.8	7.3
13	54	MALE		8.1	117	198	12.8	4.3	7.8
14	46	MALE		12.8	74	141	10.8	4.8	7.9
15	34	MALE		12.9	106	235	9.7	4.2	8.8
161	57	MALE		8.7	99	142	10.1	4.6	5.6
17	33	MALE		11.8	83	204	13.1	4.9	8.4
18	72	MALE		11.2	82	163	11.6	4.2	6.7
19	43	MALE		7.8	121	166	5.7	3.9	8.5
20	50	FEMALE		8.3	99	178	11.6	5.1	7.3
21	31	FEMALE		6.7	130	135	9.9	4.2	7.4
22	43	FEMALE		13.1	90	205	10.6	5.3	8.7
23	53	MALE		10.3	251	145	7.5	3.9	7.1
24	48	MALE		9.4	164	139	7.3	3.7	7.4
25	15	FEMALE		7.9	73	184	9.4	4.1	8.5
26	33	MALE		10.2	303	160	7.4	3.3	7.3
27	63	FEMALE		9.5	77	136	8.7	4.2	7.9
28	46	FEMALE		8.8	82	110	10	3.2	7.5
29	55	MALE		11	192	138	5.6	4.1	4.7
30	41	FEMALE		8.3	78	189	10	4.5	8
31	10	FEMALE		7.2	432	130	4.9	4	7.2
32	35	MALE		5.6	86	224	14	3.5	5.8
33	73	MALE		9.4	191	106	10	3.5	6.6
34	21	MALE		8.6	80	158	9.8	4.3	6.4
35	58	MALE		13.7	103	150	14	4.2	6.8
36	35	MALE		10.7	113	199	16	4.8	8.4
37	64	FEMALE		11.5	82	138	8	3.8	6.1
38	43	MALE		6.9	83	113	9.4	2.5	6.9
39	55	MALE		8.5	146	75	6	3.5	6
40	44	MALE		9.8	156	164	14	3.8	7.1
41	58	MALE		7	43	87	4.7	2.5	4.3
42	44	MALE		6.3	88	126	9	3.4	8.7
43	31	MALE		11	89	172	7.6	4.5	8.5
44	18	MALE		7	81	162	12	4.4	8.1
45	25	FEMALE		8.7	76	99	8.2	4.3	4.9
46	58	MALE		8.6	77	223	12	3.8	8.3
47	68	FEMALE		11.5	114	134	7.8	4.2	6.3
48	45	MALE		12.1	128	181	10.9	4.5	7.3
49	57	FEMALE		10.4	90	166	10.4	3.9	6.4
50	78	MALE		11.6		160	9.3	3.6	4.6