Prognostic Significance of Hyperuricemia in Patients with Chronic Kidney Disease

G'ayratjonova Fotimaxon G'ofurjon qizi

Fergana Medical Institute of Public Health

Abstract

Chronic kidney disease is a progressive pathological condition characterized by a gradual decline in renal filtration function and an increased risk of cardiovascular complications, hospitalization and mortality. Hyperuricemia is frequently observed in patients with chronic kidney disease due to reduced renal excretion of uric acid, impaired tubular transport and metabolic disturbances. In recent years, elevated serum uric acid has been considered not only a biochemical abnormality but also a potential prognostic biomarker associated with renal disease progression, endothelial dysfunction, inflammation, oxidative stress and cardiovascular risk. The aim of this study was to evaluate the prognostic significance of hyperuricemia in patients with chronic kidney disease. The study included patients with different stages of chronic kidney disease who underwent clinical examination, laboratory assessment of serum uric acid, creatinine, urea, estimated glomerular filtration rate, proteinuria, lipid profile, glucose and inflammatory markers. The results showed that hyperuricemia was associated with lower estimated glomerular filtration rate, higher serum creatinine, increased proteinuria, arterial hypertension and greater cardiovascular risk. Patients with elevated uric acid levels had a more unfavorable clinical course and a higher probability of renal function deterioration.

Keywords: *chronic kidney disease, hyperuricemia, uric acid, renal dysfunction, estimated glomerular filtration rate, proteinuria, cardiovascular risk, prognosis.*

Introduction

Chronic kidney disease is one of the most important medical and social problems of modern healthcare. It is characterized by persistent structural or functional abnormalities of the kidneys lasting for more than three months and is commonly associated with a progressive decrease in glomerular filtration rate. Chronic kidney disease may develop as a result of diabetes mellitus, arterial hypertension, glomerulonephritis, chronic pyelonephritis, hereditary kidney disorders, obstructive uropathy and other renal or systemic diseases.

The clinical importance of chronic kidney disease is determined not only by the risk of progression to end-stage renal disease but also by its close association with cardiovascular morbidity and mortality. Even moderate impairment of renal function

increases the risk of arterial hypertension, left ventricular hypertrophy, ischemic heart disease, heart failure, arrhythmias and cerebrovascular complications. Therefore, early identification of factors associated with renal progression and cardiovascular risk is a priority in clinical nephrology.

Hyperuricemia is defined as an increased concentration of serum uric acid. Uric acid is the final product of purine metabolism in humans and is mainly excreted by the kidneys. In chronic kidney disease, reduced renal filtration and impaired tubular secretion lead to accumulation of uric acid in the blood. As kidney function declines, hyperuricemia becomes more frequent and more pronounced.

Traditionally, hyperuricemia has been associated mainly with gout and urate crystal deposition. However, current clinical understanding suggests that elevated uric acid may also be involved in the pathogenesis of renal and cardiovascular damage. Hyperuricemia is associated with oxidative stress, activation of the renin-angiotensin-aldosterone system, endothelial dysfunction, microvascular injury, low-grade inflammation and arterial stiffness.

In patients with chronic kidney disease, hyperuricemia may contribute to further deterioration of renal function. Elevated uric acid can impair endothelial nitric oxide availability, promote afferent arteriolar damage, increase intraglomerular pressure and stimulate inflammatory and fibrotic processes in renal tissue. These mechanisms may accelerate decline in glomerular filtration rate and increase the risk of proteinuria.

At the same time, hyperuricemia is often associated with other metabolic and cardiovascular risk factors, including obesity, insulin resistance, arterial hypertension, dyslipidemia and diabetes mellitus. This makes serum uric acid an important marker of systemic metabolic and vascular disturbances.

Therefore, studying the prognostic significance of hyperuricemia in patients with chronic kidney disease is clinically important. Serum uric acid may help identify patients with a higher risk of renal progression, cardiovascular complications and unfavorable long-term outcomes.

Purpose of the Study

The aim of this study was to evaluate the prognostic significance of hyperuricemia in patients with chronic kidney disease and to determine its relationship with estimated glomerular filtration rate, serum creatinine, proteinuria, arterial hypertension, inflammatory activity and cardiovascular risk.

Materials and Methods

The study included patients diagnosed with chronic kidney disease. The diagnosis was established on the basis of clinical history, laboratory findings, urine analysis, renal ultrasound and persistent decrease in estimated glomerular filtration rate or evidence of kidney damage lasting more than three months.

The examined patients were divided into groups according to serum uric acid level. The first group included patients with hyperuricemia, and the second group included patients with normal serum uric acid concentration. Hyperuricemia was defined as serum uric acid level above 420 μmol/L in men and above 360 μmol/L in women.

Clinical assessment included analysis of complaints, disease duration, blood pressure, body mass index, presence of edema, cardiovascular symptoms, history of gout, diabetes mellitus, arterial hypertension and use of diuretics or other medications that could affect uric acid metabolism.

Laboratory examination included serum uric acid, creatinine, urea, estimated glomerular filtration rate, electrolytes, fasting glucose, lipid profile, C-reactive protein, complete blood count, urinalysis, proteinuria and albuminuria when available. Estimated glomerular filtration rate was calculated using standard clinical formulas.

Patients were also evaluated according to stages of chronic kidney disease. Renal function was classified according to estimated glomerular filtration rate. Proteinuria was assessed as an important marker of renal damage and progression risk.

Cardiovascular status was assessed on the basis of arterial blood pressure, electrocardiography, clinical symptoms and history of cardiovascular disease. Particular attention was paid to arterial hypertension, ischemic heart disease, chronic heart failure and left ventricular hypertrophy.

The prognostic value of hyperuricemia was evaluated by analyzing its relationship with kidney function, proteinuria, blood pressure, inflammatory markers and cardiovascular risk factors. Patients were followed clinically to assess progression of renal dysfunction, need for hospitalization and worsening of comorbid conditions.

Statistical analysis included calculation of mean values, standard deviations and percentage indicators. Correlation analysis was performed to determine the association between serum uric acid and estimated glomerular filtration rate, creatinine, proteinuria and blood pressure. Differences were considered statistically significant at $p<0.05$.

Results

The results showed that hyperuricemia was frequently detected in patients with chronic kidney disease. The prevalence of elevated serum uric acid increased with progression of chronic kidney disease stages. Patients with lower estimated glomerular filtration rate had higher serum uric acid levels.

Patients with hyperuricemia had significantly higher serum creatinine and urea levels compared with patients with normal uric acid concentration. This indicates that hyperuricemia is closely associated with impaired renal filtration and accumulation of nitrogenous metabolic products.

Estimated glomerular filtration rate was lower in patients with hyperuricemia. A negative correlation was observed between serum uric acid and estimated glomerular

filtration rate. As uric acid level increased, glomerular filtration rate decreased. This relationship suggests that hyperuricemia may reflect worsening renal function and may also contribute to renal disease progression.

Proteinuria was more frequently observed in patients with elevated serum uric acid. Patients with hyperuricemia had a higher degree of urinary protein excretion, indicating more pronounced glomerular damage. The combination of hyperuricemia and proteinuria was associated with a more unfavorable renal prognosis.

Arterial hypertension was more common and more difficult to control in patients with hyperuricemia. These patients had higher systolic and diastolic blood pressure values. Elevated uric acid may contribute to endothelial dysfunction, vascular stiffness and activation of the renin-angiotensin-aldosterone system, which may worsen blood pressure control.

Patients with hyperuricemia more frequently had metabolic risk factors such as obesity, dyslipidemia, insulin resistance and diabetes mellitus. Elevated triglycerides, increased low-density lipoprotein cholesterol and reduced high-density lipoprotein cholesterol were more often observed in this group.

C-reactive protein levels were higher in patients with hyperuricemia, suggesting the presence of chronic low-grade inflammation. Inflammatory activity may play an important role in both renal progression and cardiovascular complications.

Cardiovascular complications were more frequent in patients with elevated uric acid. Arterial hypertension, ischemic heart disease, left ventricular hypertrophy and chronic heart failure were more commonly detected in the hyperuricemia group. This confirms the association between hyperuricemia and increased cardiovascular risk in chronic kidney disease.

During clinical observation, patients with hyperuricemia had a higher frequency of renal function deterioration, progression to more advanced stages of chronic kidney disease and repeated hospitalization due to cardiovascular or renal complications.

The most unfavorable clinical profile was observed in patients with the combined presence of hyperuricemia, reduced estimated glomerular filtration rate, increased creatinine, proteinuria and arterial hypertension. These patients represented a high-risk group requiring closer monitoring and more intensive preventive measures.

Discussion

The findings of this study confirm that hyperuricemia has important clinical and prognostic significance in patients with chronic kidney disease. Elevated serum uric acid was associated with impaired renal function, reduced estimated glomerular filtration rate, increased creatinine, proteinuria, arterial hypertension and cardiovascular complications.

The relationship between hyperuricemia and chronic kidney disease is complex and bidirectional. On the one hand, reduced kidney function decreases uric acid

excretion, leading to its accumulation in the blood. On the other hand, elevated uric acid may promote mechanisms that worsen kidney damage.

Hyperuricemia may impair endothelial function by reducing nitric oxide availability. Nitric oxide plays an important role in maintaining vascular relaxation and renal blood flow. When nitric oxide bioavailability decreases, vasoconstriction, renal microvascular damage and glomerular hypertension may develop.

Another important mechanism is activation of the renin-angiotensin-aldosterone system. Elevated uric acid may stimulate vascular smooth muscle cell proliferation and increase intrarenal vascular resistance. This can contribute to arterial hypertension and progressive nephron damage.

Oxidative stress is also closely related to hyperuricemia. Uric acid production through xanthine oxidase activity is accompanied by generation of reactive oxygen species. Increased oxidative stress damages renal tissue, promotes inflammation and accelerates fibrosis.

Proteinuria is a major marker of kidney damage and an important predictor of chronic kidney disease progression. In this study, patients with hyperuricemia had more frequent and more pronounced proteinuria. This may indicate that elevated uric acid is associated with glomerular injury and increased permeability of the filtration barrier.

The association between hyperuricemia and arterial hypertension is also clinically important. Hypertension is both a cause and consequence of chronic kidney disease. When hyperuricemia coexists with hypertension, the risk of renal progression and cardiovascular events increases significantly.

Cardiovascular risk is very high in patients with chronic kidney disease. Hyperuricemia may further aggravate this risk through endothelial dysfunction, inflammation, oxidative stress and vascular stiffness. Therefore, serum uric acid may be considered an additional marker in cardiovascular risk stratification.

However, it is important to note that hyperuricemia may act both as a marker and as a potential mediator of disease progression. Elevated uric acid reflects reduced renal excretion, but it may also contribute to renal and vascular damage. This dual role explains why hyperuricemia has prognostic value.

In clinical practice, assessment of serum uric acid is simple, inexpensive and widely available. Therefore, its inclusion in routine monitoring of patients with chronic kidney disease may help identify high-risk patients. This is especially important in patients with reduced estimated glomerular filtration rate, proteinuria, arterial hypertension, diabetes mellitus and cardiovascular disease.

Management of hyperuricemia in chronic kidney disease should be individualized. Lifestyle modification, dietary control, reduction of purine-rich foods, adequate hydration, correction of obesity and control of blood pressure and glucose

metabolism are important non-pharmacological measures. Pharmacological urate-lowering therapy should be considered according to clinical indications, presence of gout, urate nephropathy and individual risk-benefit assessment.

Thus, hyperuricemia is an important clinical marker that reflects metabolic, renal and cardiovascular disturbances in patients with chronic kidney disease.

Conclusion

Hyperuricemia is frequently observed in patients with chronic kidney disease and is associated with more severe renal dysfunction, reduced estimated glomerular filtration rate, increased serum creatinine, proteinuria, arterial hypertension and higher cardiovascular risk.

Serum uric acid may serve as an additional prognostic biomarker for identifying patients at increased risk of chronic kidney disease progression and cardiovascular complications.

The relationship between hyperuricemia and chronic kidney disease is bidirectional. Reduced renal function leads to uric acid accumulation, while elevated uric acid may contribute to endothelial dysfunction, oxidative stress, inflammation, arterial hypertension and renal fibrosis.

Patients with the combination of hyperuricemia, reduced estimated glomerular filtration rate, proteinuria and arterial hypertension represent a high-risk clinical group requiring close monitoring and comprehensive management.

Regular assessment of serum uric acid, together with creatinine, estimated glomerular filtration rate and proteinuria, may improve risk stratification and help optimize treatment strategies in patients with chronic kidney disease.

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