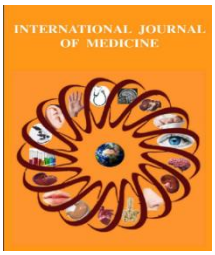
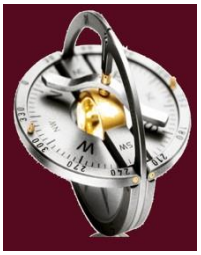


International Journal of Medicine
ISSN (P): 1468-3814; ISSN (e): 2667-7008

https://www.theinternationalmedicine.com



Volume: 7(4) 2025

Original Research

Association of Serum Uric Acid with Severity of Hypertension and Cardiometabolic Risk Among Adult Patients Attending a Tertiary Care Hospital: An Observational Study.

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Received: 11-03-2025 / Accepted: 15-04- 2025

Abstract
Background: Hypertension is one of the major modifiable risk factors for cardiovascular and renal morbidity worldwide. Serum uric acid has increasingly been recognized as a possible marker associated with hypertension, metabolic abnormalities and target-organ damage. Hyperuricemia may contribute to endothelial dysfunction, oxidative stress, renal microvascular injury and activation of the renin-angiotensin system. *Objectives:* To assess serum uric acid levels among adult patients with hypertension and to evaluate their association with severity of hypertension, metabolic risk factors and selected indicators of target-organ involvement. *Materials and Methods:* This hospital-based observational study included 250 adult patients with diagnosed hypertension attending the Department of General Medicine of a tertiary care hospital. Demographic characteristics, duration of hypertension, body mass index, blood pressure, diabetes status, lipid profile, renal function and serum uric acid were recorded. Patients were categorized according to blood pressure severity. Hyperuricemia was defined according to laboratory reference limits. The association of serum uric acid with hypertension severity, diabetes mellitus, obesity, dyslipidemia and renal dysfunction was assessed using appropriate statistical tests. *Results:* The mean age of the study population was 56.8 ± 11.9 years, and 138 (55.2%) participants were males. Hyperuricemia was observed in 102 (40.8%) patients. Mean serum uric acid increased progressively with increasing severity of hypertension, from 5.4 ± 1.2 mg/dL among patients with controlled or lower-grade hypertension to 7.1 ± 1.5 mg/dL among those with more severe hypertension. Hyperuricemia was significantly more frequent among patients with obesity, diabetes mellitus, dyslipidemia and reduced estimated glomerular filtration rate. Patients with hyperuricemia also demonstrated a higher prevalence of left ventricular hypertrophy and microalbuminuria compared with those having normal serum uric acid levels. Serum uric acid showed a positive correlation with systolic blood pressure and serum creatinine. *Conclusion:* Elevated serum uric acid is common among patients with hypertension and is associated with greater blood pressure severity, adverse metabolic profiles and markers suggestive of target-organ involvement. Serum uric acid may serve as a useful adjunctive risk marker in the comprehensive evaluation of hypertensive patients, although prospective studies are required to determine its independent causal role.

Keywords: *Hypertension; serum uric acid; hyperuricemia; cardiovascular risk; renal dysfunction; metabolic syndrome; target-organ damage.*

INTRODUCTION

Hypertension is a major contributor to cardiovascular disease, chronic kidney disease, stroke and premature mortality. Despite improvements in diagnosis and treatment, a substantial proportion of affected individuals continue to have inadequate blood pressure control and remain at increased risk of target-organ complications.

The pathogenesis of essential hypertension is complex and involves genetic, environmental, metabolic, renal and vascular mechanisms. In recent years, serum uric acid has gained considerable attention as a potential marker and possible mediator of cardiovascular and renal risk.

Uric acid is the final oxidation product of purine metabolism in humans. Hyperuricemia may develop due to increased production, reduced renal excretion or both. It frequently coexists with hypertension, obesity, metabolic syndrome, insulin resistance, chronic kidney disease and cardiovascular disease.

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DOI: 10.61336/im/25-04-05

Experimental and clinical observations suggest that uric acid may influence vascular function through oxidative stress, endothelial dysfunction, reduced nitric oxide availability, activation of the renin-angiotensin system and renal arteriolopathy. These mechanisms may contribute to increased systemic vascular resistance and sodium sensitivity.

Several epidemiological studies have reported an association between elevated serum uric acid and incident hypertension. Hyperuricemia has also been associated with poor blood pressure control, chronic kidney disease and cardiovascular outcomes. However, whether uric acid plays an independent causal role or primarily acts as a biomarker of underlying metabolic and renal dysfunction remains debated.

Routine measurement of serum uric acid is inexpensive and widely available in clinical practice. Evaluation of its association with blood pressure severity and cardiovascular risk factors may therefore have practical relevance, particularly in patients with multiple metabolic comorbidities.

The present study was undertaken to evaluate serum uric acid levels in hypertensive adults and to determine their association with severity of hypertension, metabolic risk factors and selected markers of target-organ involvement.

AIM AND OBJECTIVES

Aim

To study the association between serum uric acid and severity of hypertension among adult patients attending a tertiary care hospital.

Objectives

1. To determine the prevalence of hyperuricemia among hypertensive patients.
2. To compare serum uric acid levels according to severity of hypertension.
3. To assess the association between hyperuricemia and obesity, diabetes mellitus, dyslipidemia and renal dysfunction.
4. To evaluate the relationship of serum uric acid with selected indicators of hypertensive target-organ involvement.

MATERIALS AND METHODS

Study Design

Hospital-based observational cross-sectional study.

Study Setting

Department of General Medicine, Shri Balaji Institute of Medical Sciences, Raipur, Chhattisgarh, India.

Study Population

Adult patients with previously diagnosed or newly detected hypertension attending the outpatient or inpatient services of the Department of General Medicine were considered for inclusion.

Sample Size

A total of **250 patients** satisfying the eligibility criteria were included in the analysis.

Inclusion Criteria

Patients aged ≥18 years with hypertension diagnosed according to accepted clinical criteria and willing to undergo the required clinical and laboratory evaluation were included.

Exclusion Criteria

Patients with acute gout, current urate-lowering treatment, active malignancy, pregnancy, severe acute illness, dialysis-dependent renal failure or conditions likely to markedly alter serum uric acid levels were excluded.

Clinical Assessment

A detailed history was obtained regarding duration of hypertension, antihypertensive medications, diabetes mellitus, smoking, alcohol use and other comorbidities.
Height and weight were measured and body mass index was calculated as weight in kilograms divided by height in meters squared.
Blood pressure was recorded using a validated sphygmomanometer after appropriate rest. Multiple readings were taken when required and averaged for analysis.

Laboratory Evaluation

The following investigations were recorded:

- Serum uric acid
- Fasting blood glucose
- HbA1c where available
- Serum creatinine
- Estimated glomerular filtration rate
- Serum total cholesterol
- LDL cholesterol
- HDL cholesterol
- Triglycerides
- Urine albumin or albumin-creatinine ratio where available

Electrocardiography and echocardiography were performed where clinically indicated to assess evidence of left ventricular hypertrophy.

Definition of Hyperuricemia

Hyperuricemia was defined according to the upper reference limit used by the institutional laboratory, with sex-specific cut-offs applied where appropriate.

Statistical Analysis

Data were analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation, while categorical variables were summarized as frequency and percentage.
Comparisons between two groups were performed using Student's t-test or Mann-Whitney U test as appropriate. Analysis of variance was used for comparison across multiple categories. Chi-square test was used for categorical variables.

Pearson or Spearman correlation analysis was used to evaluate associations between serum uric acid, blood pressure and biochemical parameters. A p-value <0.05 was considered statistically significant.

RESULTS

Baseline Characteristics

A total of 250 hypertensive patients were included. The mean age was 56.8 ± 11.9 years. There were 138 (55.2%) males and 112 (44.8%) females.

Table 1. Baseline characteristics of the study population

Characteristic	Value
Total participants	250
Mean age, years	56.8 ± 11.9
Male	138 (55.2%)
Female	112 (44.8%)
Mean BMI, kg/m²	27.1 ± 4.2
Diabetes mellitus	94 (37.6%)
Dyslipidemia	116 (46.4%)
Obesity	83 (33.2%)
Chronic kidney disease	38 (15.2%)
Current smoking	49 (19.6%)
Mean duration of hypertension	7.4 ± 5.1 years

Serum Uric Acid Profile

The mean serum uric acid concentration in the overall study population was **6.2 ± 1.5 mg/dL**.
Hyperuricemia was present in **102 of 250 patients (40.8%)**.

Table 2. Serum uric acid status

Serum uric acid category	n (%)
Normal serum uric acid	148 (59.2%)
Hyperuricemia	102 (40.8%)
Total	**250 (100%)**

Association with Hypertension Severity

A progressive increase in serum uric acid levels was observed with greater blood pressure severity.

Table 3. Serum uric acid according to hypertension severity

Hypertension category	Number	Mean serum uric acid (mg/dL)
Controlled/lower-grade hypertension	82	5.4 ± 1.2
Moderate hypertension	98	6.2 ± 1.3
Severe/uncontrolled hypertension	70	7.1 ± 1.5

The difference in serum uric acid across the three categories was statistically significant (**p<0.001**).

Relationship with Cardiometabolic Risk Factors

Hyperuricemia was more commonly observed among patients with obesity, diabetes mellitus and dyslipidemia.

Table 4. Association of hyperuricemia with metabolic and renal risk factors

Risk factor	Hyperuricemia n (%)	Normal uric acid n (%)	p-value
Obesity	46 (45.1%)	37 (25.0%)	0.001
Diabetes mellitus	47 (46.1%)	47 (31.8%)	0.024
Dyslipidemia	58 (56.9%)	58 (39.2%)	0.007
Reduced eGFR	28 (27.5%)	10 (6.8%)	<0.001

Association with Selected Target-Organ Markers

Evidence of target-organ involvement was more frequent among patients with hyperuricemia.

Table 5. Hyperuricemia and selected target-organ markers

Parameter	Hyperuricemia n=102	Normal uric acid n=148	p-value
Left ventricular hypertrophy	36 (35.3%)	28 (18.9%)	0.004
Microalbuminuria/proteinuria	31 (30.4%)	22 (14.9%)	0.004
Reduced eGFR	28 (27.5%)	10 (6.8%)	<0.001

Correlation Analysis

Serum uric acid demonstrated a positive correlation with systolic blood pressure and serum creatinine.

Table 6. Correlation of serum uric acid with selected parameters

Parameter	Correlation coefficient (r)	p-value
Systolic blood pressure	0.36	<0.001
Diastolic blood pressure	0.24	<0.001
Serum creatinine	0.42	<0.001
BMI	0.29	<0.001
Triglycerides	0.21	0.002
eGFR	−0.39	<0.001

DISCUSSION

The present study demonstrates a high prevalence of hyperuricemia among patients with hypertension and suggests a significant relationship between serum uric acid concentration and severity of hypertension.

Approximately two-fifths of hypertensive patients in the present study had hyperuricemia. Importantly, serum uric acid increased progressively across categories of blood pressure severity. Patients with more severe or poorly controlled hypertension had substantially higher serum uric acid levels compared with patients with better blood pressure control.

The association between uric acid and hypertension has been reported in both epidemiological and mechanistic studies. Elevated uric acid

may contribute to vascular dysfunction by reducing endothelial nitric oxide availability, increasing oxidative stress and stimulating inflammatory and renin-angiotensin pathways. In addition, uric acid-associated renal microvascular changes may promote sodium retention and salt-sensitive hypertension.

Hyperuricemia was also more frequent among obese participants in the present study. Obesity and hyperuricemia frequently coexist because insulin resistance may reduce renal urate excretion. Dietary patterns, increased purine turnover and metabolic dysfunction may further contribute.

A significant association was also observed between hyperuricemia and diabetes mellitus. Insulin resistance represents a potential biological link between increased serum uric acid, hypertension and metabolic disease. Hyperinsulinemia may increase proximal tubular sodium and urate reabsorption, thereby contributing to both elevated serum uric acid and increased blood pressure.

Dyslipidemia was more common among patients with hyperuricemia, further supporting the clustering of uric acid abnormalities with adverse cardiometabolic risk profiles.

One of the strongest associations in our study involved renal dysfunction. Patients with reduced estimated glomerular filtration rate were considerably more likely to have hyperuricemia. This association is biologically expected because the kidney represents the major route of uric acid excretion. Reduced renal function can therefore increase serum uric acid. Conversely, experimental evidence has suggested that uric acid may itself contribute to renal microvascular injury.

The positive correlation between serum uric acid and serum creatinine and the inverse relationship with estimated glomerular filtration rate reinforce the close interaction between uric acid metabolism and renal function.

Another important observation was the higher prevalence of left ventricular hypertrophy among patients with hyperuricemia. Long-standing hypertension is a major determinant of left ventricular hypertrophy, and higher serum uric acid may identify patients with a greater cumulative cardiovascular risk burden.
Similarly, albuminuria was more frequently detected among hyperuricemic patients. Albuminuria is an important marker of hypertensive renal injury and generalized endothelial dysfunction. The coexistence of hyperuricemia and albuminuria may therefore identify patients at elevated cardiovascular and renal risk.

Recent clinical literature continues to debate whether uric acid is simply an associated biomarker or a causal therapeutic target in uncomplicated hypertension. Mendelian randomization studies and trials of urate-lowering therapy have provided inconsistent evidence regarding a direct causal cardiovascular benefit.

Consequently, treatment of asymptomatic hyperuricemia solely for the purpose of lowering blood pressure cannot currently be recommended routinely. Nevertheless, measurement of serum uric acid may provide additional information regarding cardiometabolic and renal risk in hypertensive patients, particularly when interpreted alongside renal function, obesity, diabetes and lipid abnormalities.

The present findings support a comprehensive approach to hypertension management. Rather than focusing only on blood pressure values, clinicians should evaluate associated metabolic abnormalities, kidney function and early target-organ involvement.

LIMITATIONS

The present study has several limitations. It was conducted at a single tertiary care center, which may limit generalizability. Its cross-sectional design does not establish a causal relationship between hyperuricemia and hypertension.

Serum uric acid may be influenced by diet, alcohol intake, renal function and medications, and residual confounding may therefore remain. Detailed dietary purine intake and urinary uric acid excretion were not assessed in all participants.

Furthermore, target-organ investigations such as echocardiography and quantitative urine albumin assessment may not be uniformly available in every participant.

Prospective longitudinal studies are needed to evaluate whether serum uric acid independently predicts cardiovascular and renal outcomes among hypertensive patients.

CONCLUSION

Hyperuricemia is frequently observed among adult patients with hypertension and is associated with increasing severity of blood pressure elevation, obesity, diabetes mellitus, dyslipidemia and impaired renal function.

Patients with elevated serum uric acid also demonstrate a higher prevalence of selected markers of target-organ involvement, including left ventricular hypertrophy and albuminuria.

Serum uric acid may therefore be considered a useful adjunctive marker during cardiovascular and renal risk assessment in patients with hypertension. However, elevated uric acid should be interpreted in the context of associated metabolic and renal abnormalities, and further prospective research is required to clarify its independent causal significance.

DECLARATIONS

Informed Consent

Written informed consent should be obtained from participants where applicable according to the approved study protocol.

Funding

No external funding.

Conflict of Interest

The authors declare no conflict of interest.

Authors' Contributions

All authors contributed to study conception, clinical interpretation, review of the manuscript and approval of the final version.

Data Availability

Study data may be made available by the corresponding author upon reasonable request and subject to institutional and ethical regulations.

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