International Journal of Medical Sciences And Clinical Research

VOLUME Vol.06 Issue02 2026
PAGE NO. 146-151
DOI 10.37547/ijmscr/Volume06Issue02-26

Early Biomarkers of Renal Function Decline in Patients with Arterial Hypertension: A Clinical and Laboratory Assessment

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Received: 31 December 2025; **Accepted:** 23 January 2026; **Published:** 28 February 2026

Abstract: Arterial hypertension is a major global health burden and a well-established risk factor for chronic kidney disease (CKD). Early renal impairment in hypertensive patients often remains clinically silent and may not be detected using conventional markers such as serum creatinine alone. Identification of sensitive biomarkers capable of detecting subclinical kidney damage is essential for improving risk stratification and preventing disease progression. Objective:

This study aimed to evaluate early indicators of renal function decline in patients with arterial hypertension and to assess the association between microalbuminuria, estimated glomerular filtration rate (eGFR), and blood pressure control status.

Materials and Methods: A cross-sectional clinical study was conducted involving 162 adult patients diagnosed with essential hypertension. Clinical characteristics, duration of hypertension, blood pressure levels, and laboratory parameters including serum creatinine, eGFR (calculated using the CKD-EPI formula), and urinary microalbumin levels were assessed. Patients were stratified according to blood pressure control and duration of disease. Statistical analysis included correlation analysis, independent t-tests, and multivariate logistic regression.

Results: Microalbuminuria was detected in 34.6% of hypertensive patients, including 18.2% of individuals with controlled blood pressure. A significant negative correlation was observed between duration of hypertension and eGFR ($r = –0.41$, $p < 0.001$). Multivariate regression analysis demonstrated that duration of hypertension and systolic blood pressure were independent predictors of early renal dysfunction.

Conclusion: Microalbuminuria and subtle reductions in eGFR represent sensitive early markers of renal impairment in patients with arterial hypertension. Routine screening of these parameters may facilitate early intervention and reduce the risk of progression to chronic kidney disease.

Keywords: Arterial hypertension; Chronic kidney disease; Early renal dysfunction; Microalbuminuria; Estimated glomerular filtration rate (eGFR); Renal biomarkers; Blood pressure control; Hypertensive nephropathy; Risk stratification.

Introduction: Arterial hypertension remains one of the most prevalent non-communicable diseases worldwide and represents a major contributor to global morbidity and mortality. According to international epidemiological data, more than one billion individuals are affected by elevated blood pressure, and this number continues to rise due to population aging, sedentary lifestyles, and increasing metabolic risk factors. While the cardiovascular consequences of hypertension are widely recognized, its impact on renal structure and function is equally significant and often underestimated. Hypertension is both a cause and a consequence of chronic kidney disease (CKD). Persistent elevation of systemic blood pressure induces progressive structural alterations in renal microcirculation, including endothelial dysfunction, intimal thickening, glomerulosclerosis, and tubulointerstitial fibrosis. These pathological changes

contribute to nephron loss and gradual decline in glomerular filtration rate. Importantly, early renal damage in hypertensive patients is frequently asymptomatic and may remain undetected until substantial functional impairment has occurred. In routine clinical practice, serum creatinine and estimated glomerular filtration rate (eGFR) are commonly used to assess renal function. However, serum creatinine lacks sensitivity for detecting early or subclinical kidney injury, as measurable changes typically appear only after significant nephron loss. Consequently, increasing attention has been directed toward alternative biomarkers capable of identifying early renal dysfunction. Microalbuminuria, reflecting early glomerular endothelial injury and increased vascular permeability, has emerged as a potentially valuable indicator of early hypertensive nephropathy. Several studies have demonstrated an association between uncontrolled blood pressure and the development of microalbuminuria. Nevertheless, evidence remains inconsistent regarding the presence of early renal impairment in patients with apparently controlled hypertension. Moreover, limited data are available concerning the combined predictive value of microalbuminuria and subtle reductions in eGFR in detecting early renal dysfunction in hypertensive populations, particularly in regional clinical settings. Given the progressive and often silent nature of hypertensive kidney damage, early identification of high-risk patients is essential for implementing timely therapeutic strategies aimed at slowing disease progression and reducing cardiovascular complications. Therefore, the aim of the present study was to evaluate early markers of renal function decline in patients with arterial hypertension and to assess the relationship between microalbuminuria, eGFR, and blood pressure control status.

METHODS

A cross-sectional analytical study was conducted between January 2023 and December 2023 at the Department of Internal Medicine of a tertiary care hospital. The study aimed to evaluate early indicators of renal function decline among patients diagnosed with essential arterial hypertension. A total of 162 adult patients aged 30–75 years with a confirmed diagnosis of essential hypertension were enrolled in the study. Hypertension was defined according to current international guidelines as systolic blood pressure ≥140 mmHg and/or diastolic blood pressure ≥90 mmHg, or ongoing antihypertensive therapy.

- Diagnosed essential arterial hypertension
- Disease duration ≥1 year
- Age ≥30 years
- Informed consent provided

Exclusion Criteria

- Known chronic kidney disease stage 3 or higher
- Diabetes mellitus
- Acute infections or inflammatory conditions
- History of primary renal disease
- Pregnancy
- Malignancy

These criteria were applied to minimize confounding factors affecting renal function.

Clinical Assessment

All participants underwent standardized clinical evaluation. Blood pressure was measured using a calibrated automatic sphygmomanometer after 5 minutes of rest in a seated position. The average of two measurements taken 5 minutes apart was recorded. Patients were categorized into controlled and uncontrolled hypertension groups based on guideline-recommended targets. Anthropometric measurements including body mass index (BMI) were recorded. Duration of hypertension and current antihypertensive treatment were documented.

Laboratory Analysis

Venous blood samples were collected after overnight fasting. Serum creatinine levels were measured using an enzymatic method. Estimated glomerular filtration rate (eGFR) was calculated using the CKD-EPI equation. Urinary microalbumin levels were assessed using an immunoturbidimetric assay from a morning spot urine sample. Microalbuminuria was defined as urinary albumin excretion of 30–300 mg/day (or equivalent albumin-to-creatinine ratio).

Outcome Measures

The primary outcome was the presence of early renal dysfunction, defined as:

- eGFR between 60–89 mL/min/1.73 m² and/or

- Presence of microalbuminuria

Statistical Analysis

Data were analyzed using SPSS version 26.0 (IBM Corp., USA). Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Normality of distribution was assessed using the Shapiro–Wilk test. Independent samples t-test was used to compare continuous variables between groups. Pearson correlation analysis was performed to evaluate associations between duration of hypertension, blood pressure levels, and renal parameters. Multivariate logistic regression analysis was conducted to identify independent predictors of early renal dysfunction. A p-value <0.05 was considered statistically significant. The study protocol was approved by the Institutional Ethics Committee. All participants provided written informed consent prior to enrollment. The study was conducted in accordance with the Declaration of Helsinki principles.

RESULTS

A total of 162 hypertensive patients were included in the analysis. The mean age of participants was 56.4 ± 10.8 years. Among them, 94 (58.0%) were female and 68 (42.0%) were male. The mean duration of hypertension was 8.2 ± 4.6 years.

Table 1. Baseline Clinical and Laboratory Characteristics

Variable	Total (n=162)	Controlled HTN (n=88)	Uncontrolled HTN (n=74)	p-value
Age (years)	56.4 ± 10.8	55.1 ± 9.9	58.0 ± 11.5	0.118
Duration of HTN (years)	8.2 ± 4.6	6.9 ± 3.8	9.8 ± 5.1	0.001*
BMI (kg/m²)	28.7 ± 3.9	27.9 ± 3.5	29.6 ± 4.2	0.012*
Systolic BP (mmHg)	148 ± 16	132 ± 8	166 ± 12	<0.001*
Serum Creatinine (µmol/L)	93.2 ± 18.4	88.5 ± 14.9	98.9 ± 20.2	0.003*
eGFR (mL/min/1.73 m²)	82.5 ± 14.1	86.9 ± 11.8	77.2 ± 15.4	0.001*
Microalbuminuria (%)	34.6%	18.2%	54.0%	<0.001*

***Statistically significant**

Early renal dysfunction (eGFR 60–89 and/or microalbuminuria) was detected in 63 patients (38.9%). Notably, 16 patients (18.2%) in the controlled hypertension group also demonstrated microalbuminuria, indicating subclinical renal damage despite adequate blood pressure control.

Pearson correlation analysis revealed:

- Significant negative correlation between duration of hypertension and eGFR (r = –0.41, p < 0.001)
- Positive correlation between systolic blood pressure and urinary microalbumin levels (r = 0.47, p <

0.001)

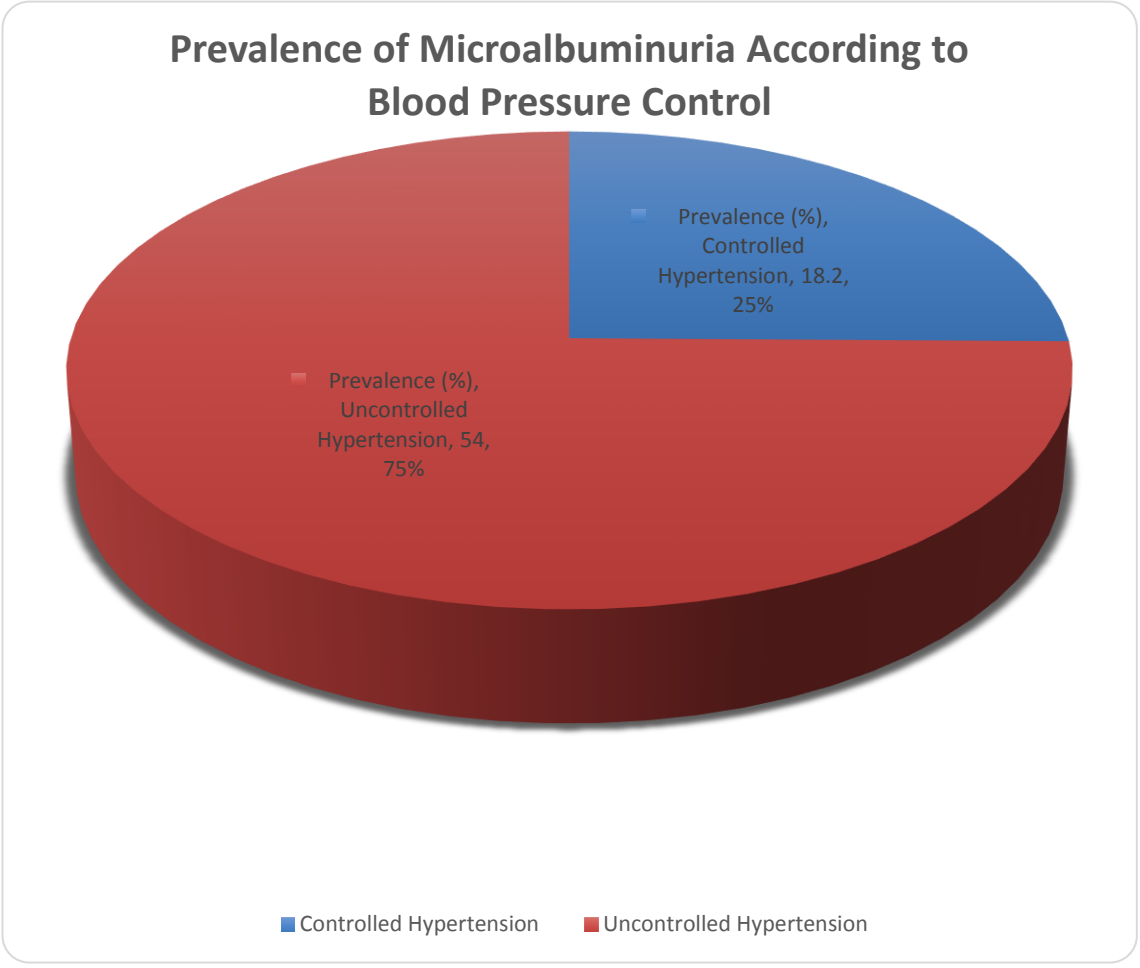
These findings suggest progressive renal impairment with increasing disease duration and poor BP control. Multivariate analysis identified independent predictors of early renal dysfunction.

Table 2. Multivariate Logistic Regression Analysis

Variable	Odds Ratio (OR)	95% CI	p-value
Duration of HTN (>8 years)	2.84	1.52–5.31	0.001*
Uncontrolled systolic BP	3.12	1.71–5.69	<0.001*
BMI (>30 kg/m²)	1.89	1.01–3.54	0.046*
Age (>60 years)	1.42	0.79–2.55	0.237

Uncontrolled systolic blood pressure demonstrated the strongest independent association with early renal dysfunction.

Figure 1. Prevalence of Microalbuminuria According to Blood Pressure Control



- X-axis: Blood Pressure Status (Controlled vs Uncontrolled)
- Y-axis: Percentage of Patients with Microalbuminuria
- Controlled: 18.2%
- Uncontrolled: 54.0%

This diagram visually demonstrates a markedly higher prevalence of microalbuminuria among patients with

uncontrolled hypertension.

(Word yoki SPSS da oddiy bar chart qilasiz — juda sodda, lekin ta'sirli.)

Key Findings Summary

- 34.6% of hypertensive patients had microalbuminuria
- 38.9% had early renal dysfunction
- Duration of hypertension and uncontrolled systolic BP were independent predictors
- Even controlled patients demonstrated subclinical renal damage

DISCUSSION

The present study evaluated early markers of renal dysfunction in patients with arterial hypertension and demonstrated that microalbuminuria and subtle reductions in eGFR are common even in the absence of clinically overt chronic kidney disease. Notably, early renal impairment was identified in nearly 39% of hypertensive patients, emphasizing the silent and progressive nature of hypertensive nephropathy. One of the key findings of this study was the significantly higher prevalence of microalbuminuria among patients with uncontrolled hypertension compared to those with controlled blood pressure. This observation is consistent with previous international studies reporting that sustained systolic pressure elevation contributes directly to glomerular endothelial damage and increased albumin permeability. Elevated intraglomerular pressure leads to structural alterations, including mesangial expansion and basement membrane thickening, which precede measurable decline in serum creatinine. Importantly, our findings also revealed that a considerable proportion (18.2%) of patients with controlled hypertension exhibited microalbuminuria. This suggests that blood pressure normalization alone may not fully eliminate the risk of early renal injury. The persistence of microvascular damage could be attributed to prior long-term exposure to elevated blood pressure or additional subclinical vascular dysfunction. This supports the hypothesis that renal damage may begin early in the disease course and progress independently of short-term blood pressure control. The negative correlation observed between duration of hypertension and eGFR further reinforces the progressive nature of hypertensive renal injury. Prolonged exposure to elevated hemodynamic stress accelerates nephron loss and promotes interstitial fibrosis. Multivariate analysis confirmed that longer disease duration and uncontrolled systolic blood pressure were independent predictors of early renal dysfunction, highlighting the cumulative effect of hemodynamic burden on renal microcirculation. From a clinical perspective, these findings underscore the importance of routine screening for microalbuminuria in hypertensive patients, even when conventional renal parameters appear within normal limits. Early detection allows timely therapeutic interventions, including optimization of antihypertensive therapy, use of renin–angiotensin–aldosterone system inhibitors, and lifestyle modifications aimed at reducing cardiovascular and renal risk. Several limitations should be acknowledged. First, the cross-sectional design does not allow assessment of causal relationships or long-term renal outcomes. Second, the study was conducted in a single tertiary care center, which may limit generalizability. Third, more sensitive biomarkers such as cystatin C or NGAL were not evaluated. Future longitudinal studies with larger sample sizes and extended biomarker panels are warranted. Despite these limitations, the study highlights the clinical relevance of incorporating microalbuminuria screening into routine hypertension management protocols. Early identification of subclinical renal dysfunction may improve risk stratification and guide personalized therapeutic strategies.

CONCLUSION

In conclusion, early renal dysfunction is highly prevalent among patients with arterial hypertension, even in the absence of overt chronic kidney disease. Microalbuminuria and subtle reductions in eGFR were identified as sensitive early indicators of renal impairment, with disease duration and uncontrolled systolic blood pressure emerging as independent predictors. Importantly, the presence of microalbuminuria in patients with controlled hypertension underscores the need for routine renal screening beyond conventional creatinine-based assessment. Early identification and targeted management of subclinical kidney injury may play a critical role in preventing progression to advanced chronic kidney disease and reducing long-term

cardiovascular risk. Integrating microalbuminuria assessment into standard hypertension care protocols should therefore be strongly considered.

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