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Original Research Article

Serum Creatinine and Urine Microalbumin Levels in Patients with Essential Hypertension

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Abstract:

Background: Essential hypertension is a prevalent condition globally and a leading cause of morbidity due to its association with cardiovascular and renal complications. Early detection of renal impairment in hypertensive patients is crucial to prevent progression to chronic kidney disease (CKD). Serum creatinine and urine microalbumin are widely used markers for assessing renal function and detecting early renal damage.

Aim: This study aimed to evaluate serum creatinine and urine microalbumin levels in patients with essential hypertension and to explore their correlation with disease duration and severity.

Methods: A cross-sectional study was conducted over 12 months at the VSS Institute of Medical Sciences and Research, Burla, Odisha, involving 200 hypertensive patients. Participants' demographic and clinical data were collected. Serum creatinine levels were measured using the modified Jaffe method, while urine microalbumin levels were assessed using an immunoturbidimetric method. Statistical analyses were performed using SPSS version 23.0, with Pearson's correlation and t-tests applied to identify associations between variables.

Results: The mean serum creatinine and urine microalbumin levels were 1.15 ± 0.29 mg/dL and 48.6 ± 22.4 mg/L, respectively. Elevated serum creatinine levels were observed in 21% of participants, while 40% had elevated urine microalbumin levels. A significant positive correlation was found between serum creatinine and urine microalbumin levels ($r = 0.51$, $p < 0.001$). Participants with a longer duration of hypertension (>5 years) exhibited significantly higher levels of both markers ($p < 0.05$).

Conclusion: A considerable proportion of hypertensive patients exhibited elevated serum creatinine and urine microalbumin levels, indicating early renal impairment. The strong correlation between these markers emphasizes their utility in detecting renal dysfunction at an early stage.

Recommendations: Routine monitoring of serum creatinine and urine microalbumin levels should be incorporated into the management of hypertensive patients to enable early detection and intervention. Further longitudinal studies are recommended to assess the progression of renal damage and evaluate the impact of targeted therapeutic measures.

Keywords: Hypertension, Serum Creatinine, Urine Microalbumin, Renal Dysfunction, Early Detection

Introduction

A major global public health concern is essential hypertension, which is defined as consistently high blood pressure without a known secondary cause. It is a substantial risk factor for renal failure and cardiovascular diseases (CVD), which are major contributors to morbidity and mortality globally [1]. According to WHO estimates, 1.28 billion persons between the ages of 30 and 79 worldwide suffer from hypertension, with a significant percentage going misdiagnosed and untreated [2]. Renal impairment is one of the most dangerous side effects of hypertension because, if uncontrolled, it can develop into chronic kidney disease (CKD) and end-stage renal disease (ESRD) [3].

The kidneys are both targets and contributors to hypertensive damage, with prolonged elevated blood pressure causing structural and functional abnormalities in renal vasculature and glomeruli. Serum creatinine and urine microalbumin levels are two widely utilized biomarkers for evaluating renal health in hypertensive patients. Serum creatinine, a byproduct of muscle metabolism, reflects the glomerular filtration rate (GFR) and provides an indirect measure of renal function [4]. However, it often remains within normal ranges until significant kidney damage occurs, limiting its sensitivity for early detection of renal impairment.

On the other hand, urine microalbumin is a more sensitive and earlier marker of renal damage.

Microalbuminuria, defined as the urinary excretion of 30–300 mg of albumin per day, signifies increased permeability of the glomerular basement membrane, often indicative of subclinical kidney injury. It has been established as a predictor of both renal disease progression and cardiovascular events in hypertensive patients [5]. Recent studies have shown that microalbuminuria is prevalent in up to 40% of hypertensive patients and is associated with an increased risk of adverse outcomes [6].

The pathophysiological link between hypertension and microalbuminuria involves endothelial dysfunction, oxidative stress, and increased intraglomerular pressure, which collectively contribute to glomerular injury [7]. Identifying and managing microalbuminuria in hypertensive patients is critical, as it offers an opportunity for early intervention. Therapies targeting blood pressure control, including renin-angiotensin-aldosterone system (RAAS) inhibitors, have been effective in reducing microalbuminuria and delaying CKD progression [8]. This study aimed to evaluate serum creatinine and urine microalbumin levels in patients with essential hypertension and to explore their correlation with disease duration and severity.

Methodology

Study Design: This study is a hospital-based cross-sectional study.

Study Setting: The study was carried out at the Department of General Medicine, VSS Institute of Medical Sciences and Research (VIMSAR), Burla, Sambalpur, Odisha, over a period of 12 months, from February 1, 2023, to January 31, 2024.

Participants: A total of 200 patients diagnosed with essential hypertension were enrolled in the study. Participants were selected using simple random sampling to ensure a representative sample.

Inclusion Criteria

- Patients aged between 18 and 70 years.
- Individuals diagnosed with essential hypertension as per standard guidelines.
- Patients willing to provide informed consent.

Exclusion Criteria

- Patients with secondary hypertension.
- Individuals with pre-existing (CKD).
- Patients with diabetes mellitus.
- Those on nephrotoxic drugs or with a history of urinary tract infection in the past three months.
- Pregnant and lactating women.
- Patients who did not provide informed consent.

Bias: To minimize selection bias, random sampling was employed. Efforts were made to reduce measurement bias by standardizing the equipment and calibrating instruments regularly. Observer bias was mitigated by blinding the laboratory personnel analyzing serum creatinine and urine microalbumin levels to the participants' clinical details.

Data Collection: Data were collected using a structured proforma, including demographic information, clinical history, and laboratory investigations. Blood samples were obtained to measure serum creatinine levels, and spot urine samples were collected for the assessment of urine microalbumin levels.

Procedure: Serum creatinine levels were measured using the modified Jaffe method, while urine microalbumin levels were assessed using the immunoturbidimetric method. All tests were conducted in the hospital's central laboratory. Participants' blood pressure was measured in a standardized manner using a calibrated sphygmomanometer.

Statistical Analysis: SPSS software (version 23.0) was used to analyze the data. The data was summarized using descriptive statistics including mean, standard deviation, and percentages. The chi-square test was used to evaluate categorical variables, and the independent t-test or ANOVA was used to compare continuous variables. Pearson's correlation coefficient was used to evaluate the relationships between urine microalbumin levels and serum creatinine levels. Statistical significance was defined as a p-value of less than 0.05.

Results

The study involved 200 participants, 110 (55%) of whom were men and 90 (45%) of whom were women. Participants' ages ranged from 25 to 70 years old, with a mean age of 51.8 ± 11.2 years. The individuals' average duration of hypertension was 6.2 ± 3.9 years.

Table 1: The demographic and clinical characteristics of the participants.

Variable	Overall (N=200)	Male (N=110)	Female (N=90)
Age (years), mean ± SD	51.8 ± 11.2	53.5 ± 10.8	49.7 ± 11.4
Duration of hypertension (years), mean ± SD	6.2 ± 3.9	6.5 ± 4.1	5.8 ± 3.7
Smokers, n (%)	50 (25%)	45 (40.9%)	5 (5.6%)
BMI (kg/m²), mean ± SD	26.8 ± 3.4	27.2 ± 3.5	26.3 ± 3.2

The mean serum creatinine level for all participants was 1.15 ± 0.29 mg/dL. Elevated serum creatinine levels (>1.3 mg/dL in males, >1.1 mg/dL in females) were observed in 42 participants (21%). The mean urine microalbumin level was 48.6 ± 22.4 mg/L, and elevated urine microalbumin levels (>30 mg/L) were detected in 80 participants (40%).

Table 2: The serum creatinine and urine microalbumin levels among participants.

Parameter	Normal Range	Mean ± SD	Elevated Levels (n, %)
Serum Creatinine (mg/dL)	0.6–1.2	1.15 ± 0.29	42 (21%)
Urine Microalbumin (mg/L)	<30	48.6 ± 22.4	80 (40%)

Serum creatinine and urine microalbumin levels showed a strong, substantial relationship (Pearson's correlation coefficient r = 0.51, p < 0.001). This suggests that urine microalbumin levels tended to be higher when serum creatinine levels increased.

Table 3: Correlation Between Serum Creatinine and Urine Microalbumin

Parameter	Correlation Coefficient (r)	p-value
Serum Creatinine vs. Urine Microalbumin	0.51	<0.001

Participants with a longer duration of hypertension (>5 years) showed significantly higher levels of serum creatinine (1.21 ± 0.31 mg/dL) and urine microalbumin (55.4 ± 24.1 mg/L) compared to those with a shorter duration of hypertension (≤5 years) (1.08 ± 0.27 mg/dL and 42.1 ± 20.3 mg/L, respectively; p < 0.05 for both).

Table 4: Serum Creatinine and Urine Microalbumin Based on Duration of Hypertension

Duration of Hypertension	Serum Creatinine (mg/dL), Mean ± SD	Urine Microalbumin (mg/L), Mean ± SD
≤ 5 years	1.08 ± 0.27	42.1 ± 20.3
> 5 years	1.21 ± 0.31	55.4 ± 24.1
p-value	0.015	0.002

Key Findings

Prevalence of Abnormal Levels: Elevated serum creatinine levels were present in 21% of participants, while 40% had elevated urine microalbumin levels, indicating a significant proportion of hypertensive individuals at risk of renal damage.

Gender Differences: Male participants showed slightly higher serum creatinine levels compared to females (p = 0.06, borderline significance).

Duration of Hypertension: Participants with a longer duration of hypertension exhibited significantly higher serum creatinine and urine microalbumin levels.

Discussion

This study evaluated serum creatinine and urine microalbumin levels in 200 patients with essential hypertension to assess early markers of renal dysfunction. The participants had a mean age of 51.8 years, with a slight male predominance (55%). The mean duration of hypertension was 6.2 years, and participants with a longer duration of hypertension (>5 years) demonstrated higher levels of serum creatinine and urine microalbumin, indicating a progressive risk of renal impairment.

The results revealed that 21% of the participants had elevated serum creatinine levels, while 40% exhibited elevated urine microalbumin levels, suggesting that a significant proportion of hypertensive patients are at risk for renal damage. The positive correlation between serum creatinine and urine microalbumin levels (r = 0.51, p < 0.001) underscores the interrelationship between these markers, highlighting the role of hypertension in causing microvascular and renal dysfunction. Participants with a longer duration of hypertension showed significantly higher serum creatinine (1.21 ± 0.31 mg/dL) and urine microalbumin levels (55.4 ± 24.1 mg/L) compared to those with a shorter duration. This finding supports the hypothesis that prolonged hypertension exacerbates renal impairment over time. Gender-specific differences were observed, with males showing slightly higher mean serum creatinine levels, though the difference was not statistically significant.

Microalbuminuria, a condition characterized by small amounts of albumin excretion in urine, has been widely recognized as an early marker of systemic vascular dysfunction and target organ damage in patients with essential hypertension. A study conducted in Western India found a 40% prevalence of microalbuminuria among hypertensive patients, independent of age, sex, and smoking habits. It correlated significantly with cardiovascular morbidities such as left ventricular hypertrophy and diastolic dysfunction, establishing microalbuminuria as a critical predictor of systemic vascular dysfunction [9]. Another investigation in Iraq reported a positive relationship between microalbuminuria and left ventricular hypertrophy in hypertensive patients. The mean albumin-to-creatinine ratio in hypertensive patients was significantly elevated, demonstrating its potential as a biomarker for cardiovascular risk assessment [10]. Research conducted among hypertensive patients in Tibet revealed that higher systolic and diastolic blood pressure, serum uric acid, and total cholesterol levels were associated with increased microalbuminuria. Multivariate analysis showed hemoglobin and systolic blood pressure were significant predictors, underscoring the importance of early intervention in such populations [11]. In a study from Odisha, India, microalbuminuria levels were significantly elevated in hypertensive patients, especially in stage II hypertension. It demonstrated strong correlations with systolic blood pressure, serum creatinine, and lipid parameters, reinforcing its role as a marker for cardiovascular and renal risks [12]. Lastly, a study focusing on normoglycemic hypertensive patients highlighted that 44% of participants exhibited microalbuminuria. It showed significant associations with mean arterial pressure, serum creatinine, and hypertension severity. This study recommended routine screening for microalbuminuria to facilitate early detection of cardiovascular and renal complications [13].

Conclusion

This study demonstrates that elevated serum creatinine and urine microalbumin levels are common in hypertensive patients, with 21% and 40% of participants, respectively, showing abnormal levels. A significant positive correlation between these markers highlights their utility in identifying early renal dysfunction. Prolonged duration of hypertension exacerbates renal impairment, emphasizing the importance of routine monitoring and early intervention to prevent progression to chronic kidney disease. These findings underscore the critical role of integrating renal evaluation into hypertension management.

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