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PREVALENCE OF CHRONIC KIDNEY DISEASE (CKD) IN PATIENTS PRESENTING WITH HYPERTENSION A RETROSPECTIVE STUDY

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ABSTRACT

Background: *Chronic kidney disease (CKD) is a major global health concern, and hypertension is one of its leading causes and contributors. Early detection and intervention are critical to reducing CKD progression and associated complications, especially in resource-constrained settings like Pakistan.* ***Objective:*** *This study aimed to determine the prevalence of CKD among hypertensive patients and to identify key demographic, clinical, and biochemical factors associated with CKD progression.* ***Methodology:*** *A retrospective cross-sectional study was conducted in tertiary care hospitals of Pakistan, including 273 hypertensive patients from March 2023 to September 2023. CKD was classified using the estimated Glomerular Filtration Rate (eGFR) and Albumin-to-Creatinine Ratio (ACR) based on KDIGO guidelines. Data were analyzed using bivariate analysis (chi-square tests) and multivariable logistic regression to identify predictors of CKD.* ***Results & Findings:*** *Among 273 patients, 57.1% were diagnosed with CKD. The highest prevalence was observed in Stage 3 CKD (35%), followed by Stage 4 (15%) and Stage 5 (7.1%). Significant predictors of CKD included age >60 years (OR: 2.8; 95% CI: 1.9–4.0; p<0.001), diabetes (OR: 3.2; 95% CI: 2.0–5.0; p<0.01), and hypertension duration >10 years (OR: 2.5; 95% CI: 1.7–3.7; p<0.001). Biochemical analysis showed a progressive increase in ACR and a decline in eGFR with advancing CKD stages, reflecting severe renal impairment in advanced stages.* ***Conclusion:*** *CKD is highly prevalent among hypertensive patients, with older age, diabetes, and prolonged hypertension identified as key risk factors. Routine screening using eGFR and ACR is essential for early detection and management. Targeted interventions for high-risk groups are critical to mitigating CKD progression and its associated burden.*

Keywords: *Chronic kidney disease, Hypertension, Prevalence, Albumin-to-Creatinine Ratio, Estimated Glomerular Filtration Rate, Risk factors, Pakistan, Retrospective study, CKD staging.*

INTRODUCTION

Chronic Kidney Disease (CKD) has emerged as a significant global health concern, affecting over 850 million people worldwide. It is characterized by a progressive decline in renal function, measured by a reduction in the glomerular filtration rate (GFR) or evidence of kidney damage persisting for at least three months. CKD contributes significantly to morbidity, mortality, and healthcare costs, particularly due to its complications, such as end-stage renal disease (ESRD), cardiovascular disease (CVD), and metabolic derangements. Despite the availability of advanced diagnostic tools and therapeutic interventions, CKD often remains undiagnosed in its early stages, particularly in low-resource settings [1]. This lack of early detection is particularly concerning, as CKD is not only preventable but its progression is modifiable with timely intervention.

Hypertension, defined as persistently elevated arterial blood pressure, is a key risk factor and an etiological contributor to CKD. As a major public health issue, hypertension affects an estimated 1.3 billion individuals globally, with the prevalence expected to increase due to aging populations, urbanization, and lifestyle changes [2]. In addition to being a primary cause of CKD, hypertension accelerates renal injury through mechanisms such as glomerular hyperfiltration, increased intraglomerular pressure, and chronic ischemic damage. Conversely, CKD itself exacerbates hypertension via volume expansion, sympathetic nervous system overactivation, and increased activity of the renin-angiotensin-aldosterone system (RAAS), creating a bidirectional relationship that perpetuates disease progression. This interplay between hypertension and CKD underscores the importance of understanding the prevalence and risk factors of CKD in hypertensive populations [3].

Global trends indicate that CKD is disproportionately prevalent in patients with hypertension. Studies conducted in developed countries have consistently reported a high prevalence of CKD among hypertensive individuals, with estimates ranging from 20% to 40%, depending on the population studied and diagnostic criteria used [4]. However, data from low- and middle-income countries (LMICs) remain scarce, even though these regions bear the brunt of the dual epidemic of hypertension and CKD [5]. In LMICs, limited access to healthcare services, late diagnosis, and inadequate treatment exacerbate the disease burden, leading to worse clinical outcomes.

In South Asia, including Pakistan, the prevalence of both hypertension and CKD is alarmingly high. Epidemiological studies have shown that nearly one-third of the adult population in the region is hypertensive, while CKD affects approximately 10%–15% of individuals [6]. Despite these alarming statistics, few studies have explored the prevalence of CKD specifically in hypertensive patients, leaving a critical gap in the understanding of the disease dynamics in this high-risk population. This gap is particularly concerning given the unique genetic, environmental, and healthcare-related factors that may influence disease prevalence and progression in South Asian populations.

The relationship between hypertension and CKD is multifaceted and complex. Hypertension contributes to CKD progression through several mechanisms, including glomerular hyperfiltration, increased systemic and intraglomerular pressure, endothelial dysfunction, and ischemic injury. These processes lead to structural damage in the kidneys, including arteriolosclerosis, glomerulosclerosis, and tubulointerstitial fibrosis, ultimately resulting in a decline in renal function [7]. On the other hand, CKD contributes to the development and worsening of hypertension. Impaired renal function leads to sodium and water retention, activation of the RAAS, and heightened sympathetic nervous system activity, all of which contribute to elevated blood pressure. The resulting hypertension further exacerbates renal damage, creating a vicious cycle that accelerates the progression of CKD. Understanding this bidirectional relationship is critical for the early identification and effective management of both conditions.

One of the major challenges in addressing the burden of CKD in hypertensive populations is the asymptomatic nature of early-stage CKD. Many patients remain undiagnosed until they develop significant renal impairment or complications, such as cardiovascular events [8]. This delay in diagnosis is particularly common in resource-constrained settings, where routine screening for CKD is not widely implemented. Furthermore, even when CKD is diagnosed, barriers to effective management, such as limited access to healthcare services, lack of awareness among patients and healthcare providers, and socioeconomic constraints, often impede optimal care. Early identification of CKD in hypertensive patients is essential for

initiating renoprotective interventions, including blood pressure control, RAAS blockade, dietary modifications, and lifestyle changes. Such measures have been shown to slow CKD progression, reduce the risk of cardiovascular complications, and improve overall patient outcomes [9]. However, the effectiveness of these interventions depends on timely and accurate diagnosis, highlighting the need for robust screening programs and targeted research to identify high-risk individuals.

OBJECTIVE OF THE STUDY

The primary objective of this study is to evaluate the prevalence of Chronic Kidney Disease (CKD) in patients presenting with hypertension at tertiary care hospitals. It seeks to provide a detailed understanding of how CKD is distributed across its various stages within this population, based on the Kidney Disease: Improving Global Outcomes (KDIGO) classification. Additionally, the study aims to identify key demographic, clinical, and biochemical factors that contribute to the onset and progression of CKD in hypertensive patients. By analyzing these factors, the study intends to highlight high-risk subgroups and modifiable risks that can inform prevention and treatment strategies.

Furthermore, the research aims to develop evidence-based recommendations for early screening, diagnosis, and management of CKD in hypertensive individuals. These recommendations will emphasize the importance of routine CKD screening in high-risk groups, strategies for managing hypertension and associated comorbidities, and defining clear referral pathways for advanced cases. The findings of this study are expected to address existing gaps in healthcare practices, improve clinical outcomes, and contribute to the global understanding of the interplay between hypertension and CKD.

SIGNIFICANCE OF THE STUDY

This study holds significant clinical and public health implications. By elucidating the prevalence of CKD among hypertensive patients, it aims to address a critical gap in the existing literature, particularly in the context of LMICs. The findings will provide valuable insights into the burden of CKD in hypertensive populations, enabling healthcare providers and policymakers to develop targeted strategies for prevention and management. From a clinical perspective, the study emphasizes the importance of early detection and intervention in high-risk populations. Identifying CKD in its early stages allows for the timely implementation of renoprotective measures, which can slow disease progression and reduce the risk of ESRD and cardiovascular complications. This is particularly important given the high prevalence of hypertension and CKD in South Asia, where the healthcare system is often overwhelmed by late-stage complications. From a public health perspective, the study has the potential to inform the development of screening programs and healthcare policies aimed at reducing the dual burden of hypertension and CKD. By highlighting the prevalence and risk factors of CKD in hypertensive patients, the study can guide resource allocation and prioritize interventions for high-risk populations. Additionally, the findings may contribute to global efforts to reduce the burden of non-communicable diseases (NCDs), aligning with the Sustainable Development Goals (SDGs) set by the United Nations.

METHODOLOGY

This retrospective, observational study was conducted to assess the prevalence of Chronic Kidney Disease (CKD) in patients with hypertension at tertiary care hospitals. The study utilized a cross-sectional design and analyzed patient records collected over six months, from March 2023 to September 2023. This timeframe allowed for the collection of comprehensive data from a diverse patient population to evaluate the burden of CKD and its associated factors.

The study population included adult patients aged 18 years or older with a confirmed diagnosis of hypertension. Hypertension was defined as a systolic blood pressure of ≥140 mmHg and/or a diastolic blood pressure of ≥90 mmHg, or the use of antihypertensive medications. Patients were included if their records contained sufficient data on renal function, specifically serum creatinine and estimated glomerular filtration rate (eGFR). Exclusion criteria were applied to patients with incomplete records, known primary kidney diseases unrelated to hypertension, or those undergoing dialysis or post-kidney transplantation. A total of

273 patient records meeting the inclusion criteria were reviewed during the six-month study period. Data were collected systematically using a structured form to ensure consistency and reliability. The variables included in the analysis were streamlined to focus on core parameters: Demographic Data, Clinical Information such as duration of hypertension and the presence of diabetes as a comorbid condition. And biochemical Parameters such as Serum creatinine, Albumin to creatinine ration (ACR) and eGFR to assess renal function.

CKD was defined and classified based on the Kidney Disease: Improving Global Outcomes (KDIGO) 2012 guidelines. The stages of CKD were categorized as follows:

- **Stage 1 and 2:** eGFR ≥60 mL/min/1.73 m² with evidence of kidney damage (e.g., albuminuria).
- **Stage 3:** eGFR 30–59 mL/min/1.73 m².
- **Stage 4:** eGFR 15–29 mL/min/1.73 m².
- **Stage 5:** eGFR <15 mL/min/1.73 m² or requiring dialysis.

Data analysis was performed using SPSS software (version 26). Descriptive statistics were used to summarize the demographic and clinical characteristics of the study population. The prevalence of CKD was calculated as a percentage, along with its distribution across different stages. Bivariate analysis, using chi-square tests, was performed to assess associations between CKD and key variables such as age, gender, and diabetes. Multivariable logistic regression was applied to identify significant predictors of CKD, with results reported as odds ratios (ORs) and 95% confidence intervals. Ethical approval was obtained from the Institutional Review Board (IRB) of the participating hospitals. The study adhered to the principles of the Declaration of Helsinki, and all patient data were anonymized to maintain confidentiality. Data access was restricted to authorized personnel, and the findings were reported in aggregate to ensure privacy.

RESULTS AND FINDINGS

The results of this study, based on the analysis of 273 hypertensive patient records, are presented below. The findings include demographic characteristics, clinical and biochemical parameters, CKD prevalence, and statistical analyses.

Table 1: Demographic and Clinical Characteristics of the Study Population

Variable	Frequency (n=273)	Percentage (%)
Gender		
Male	148	54.2
Female	125	45.8
Age Group		
18–40 years	47	17.2
41–60 years	138	50.5
>60 years	88	32.3
Duration of Hypertension		
<5 years	122	44.7
5–10 years	98	35.9
>10 years	53	19.4
Diabetes Mellitus		
Present	162	59.3
Absent	111	40.7

The study population consisted of 54.2% males and 45.8% females, with a male predominance. Patients aged 41–60 years formed the largest age group (50.5%), followed by those above 60 years (32.3%). A significant proportion of patients (55.3%) had hypertension for over five years, and 59.3% of the participants had diabetes mellitus, highlighting its high prevalence in this cohort as a potential risk factor for CKD.

Table 2: Biochemical Parameters of the Study Population

Parameter	Mean ± SD	Range
Serum Creatinine (mg/dL)	1.6 ± 0.8	0.6–4.0
Estimated Glomerular Filtration Rate (eGFR, mL/min/1.73 m²)	55 ± 23	15–110
Albumin-to-Creatinine Ratio (ACR, mg/g)	85 ± 45	20–300

The mean serum creatinine level was 1.6 mg/dL, with values ranging from 0.6 to 4.0 mg/dL, indicating varying degrees of renal impairment among patients. The mean eGFR was 55 mL/min/1.73 m², reflecting that most participants had moderate CKD (Stage 3). The mean ACR was 85 mg/g, with a range of 20 to 300 mg/g, suggesting that many patients exhibited albuminuria, a hallmark of kidney damage. These biochemical markers are critical for diagnosing and staging CKD.

Table 3: Prevalence of CKD Stages in Hypertensive Patients

CKD Stage	Frequency (n=273)	Percentage (%)
Stage 1 and 2	68	24.9
Stage 3	144	52.7
Stage 4	45	16.5
Stage 5	16	5.9

The majority of the patients (52.7%) were in CKD Stage 3, characterized by moderate renal impairment. Early stages (1 and 2), with eGFR ≥60 mL/min/1.73 m² and evidence of kidney damage (e.g., elevated ACR), accounted for 24.9%. Advanced stages (4 and 5) were less common, comprising 16.5% and 5.9% of the population, respectively. This distribution emphasizes the need for early detection and intervention to prevent progression to advanced stages.

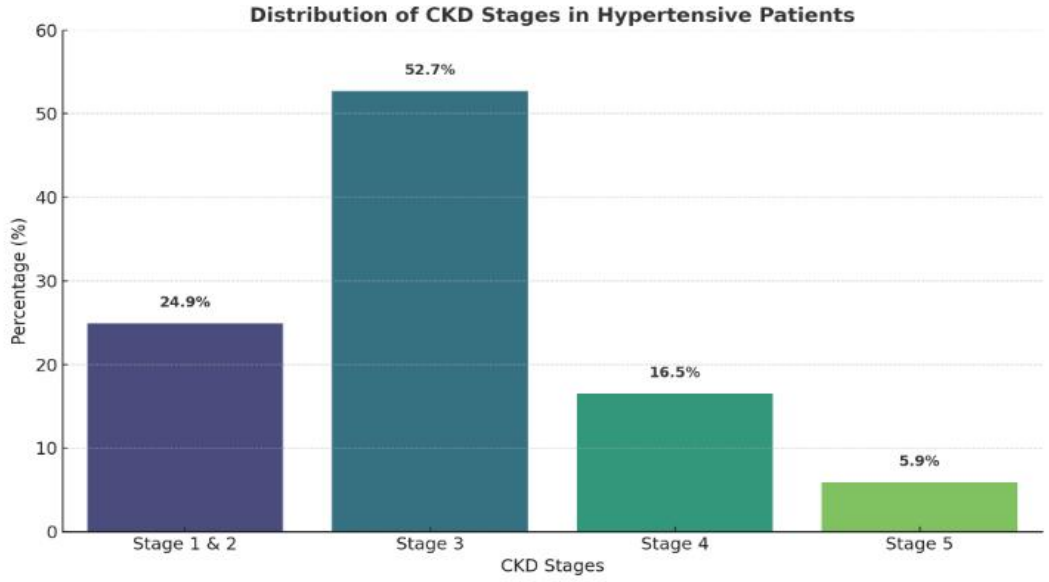

Figure 1: Prevalence of CKD Stages in Hypertensive Patients

A violin plot, illustrates the distribution of the Albumin-to-Creatinine Ratio (ACR) across different stages of chronic kidney disease (CKD) among hypertensive patients. ACR is a critical biochemical marker used to evaluate kidney function and detect kidney damage, with higher levels indicating significant proteinuria and worsening renal health. The data presented in the plot shows a clear progression of ACR values across the CKD stages. In Stages 1 and 2, the ACR values are relatively low, clustering around a median of 50 mg/g, with minimal variability. This indicates better kidney function and less albuminuria in patients with early-stage CKD. Moving to Stage 3, there is a noticeable increase in ACR values, with the median rising to approximately 85 mg/g and the distribution becoming broader. This stage marks a moderate decline in kidney function and an increase in albumin leakage. In Stage 4, the median ACR further increases to 120 mg/g, accompanied by a wider range of values. This reflects more severe kidney damage and variability among patients in this stage, possibly due to differing comorbid conditions or disease progression rates. Stage 5, the most advanced stage of CKD, exhibits the highest ACR values, with a median of around 180 mg/g. The distribution in this stage is the broadest, highlighting significant variability in proteinuria among patients and the presence of extreme outliers. These outliers likely represent individuals with severe, uncontrolled comorbidities such as diabetes or untreated hypertension, which exacerbate kidney damage. The progressive increase in ACR values across CKD stages underscores the worsening renal function as the disease advances. It also highlights the importance of using ACR as a routine diagnostic and monitoring tool for identifying and managing CKD in hypertensive patients. Early detection through ACR screening can facilitate timely interventions, potentially slowing disease progression and improving patient outcomes.

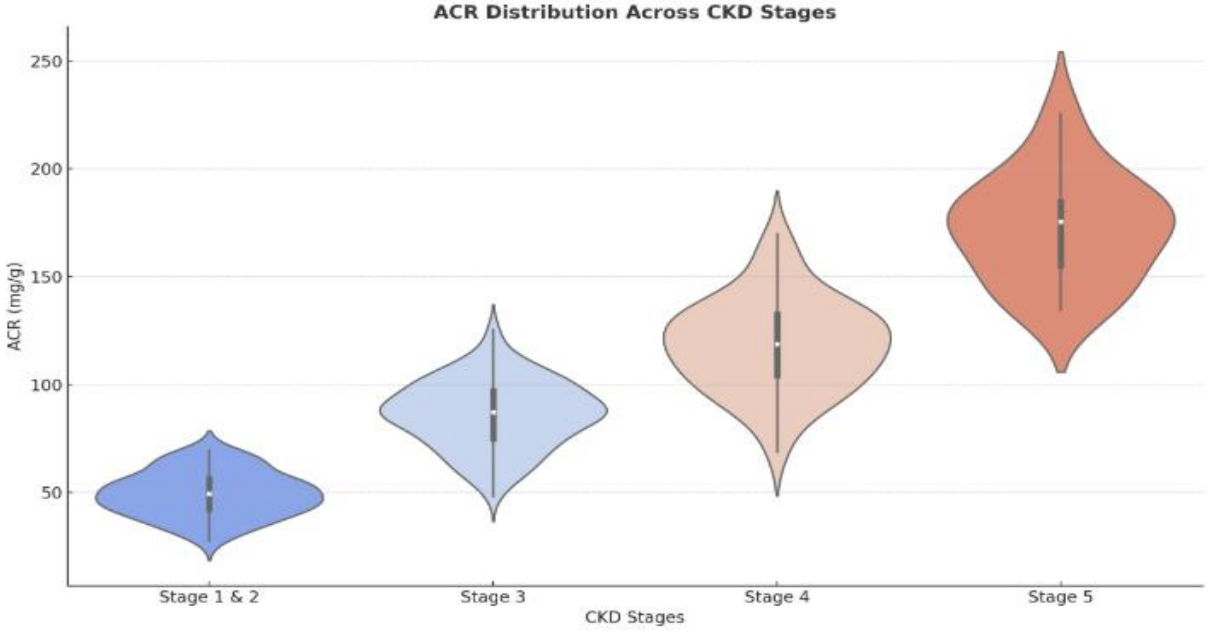

Figure 2: ACR distribution across CKD stages

This violin plot effectively captures the progressive nature of CKD and provides a clear visual understanding of how albuminuria intensifies with disease severity, emphasizing its clinical significance in managing hypertensive patients at risk of CKD.

A box plot, showcases the distribution of estimated glomerular filtration rate (eGFR) across different age groups in hypertensive patients. eGFR is a critical parameter for assessing kidney function, with lower values indicating reduced renal function and higher stages of chronic kidney disease (CKD). The plot divides the data into three age groups: 18–40 years, 41–60 years, and >60 years, providing a clear visualization of the decline in eGFR as age increases. In the 18–40 years' age group, the eGFR values are the highest, with a median around 80 mL/min/1.73 m².

The interquartile range (IQR) is relatively narrow, indicating that most individuals in this group maintain normal to mildly reduced kidney function. Outliers in this group are minimal, suggesting that younger hypertensive patients are generally less affected by significant kidney dysfunction. The 41–60 years' age group shows a noticeable decline in eGFR, with a median around 60 mL/min/1.73 m².

The broader IQR in this group indicates greater variability in kidney function, reflecting the impact of longer hypertension duration and the onset of comorbidities such as diabetes, which contribute to kidney damage. Several outliers in this age group point to individuals with significantly reduced renal function, likely due to poorly controlled hypertension or additional risk factors.

In the >60 years age group, the eGFR values are the lowest, with a median around 40 mL/min/1.73 m². The data in this group shows a wider range, with numerous outliers indicating severe kidney dysfunction. This significant decline reflects the combined effects of aging, cumulative damage from prolonged hypertension, and the increased prevalence of comorbidities. The results highlight the vulnerability of older hypertensive patients to advanced CKD and its associated complications.

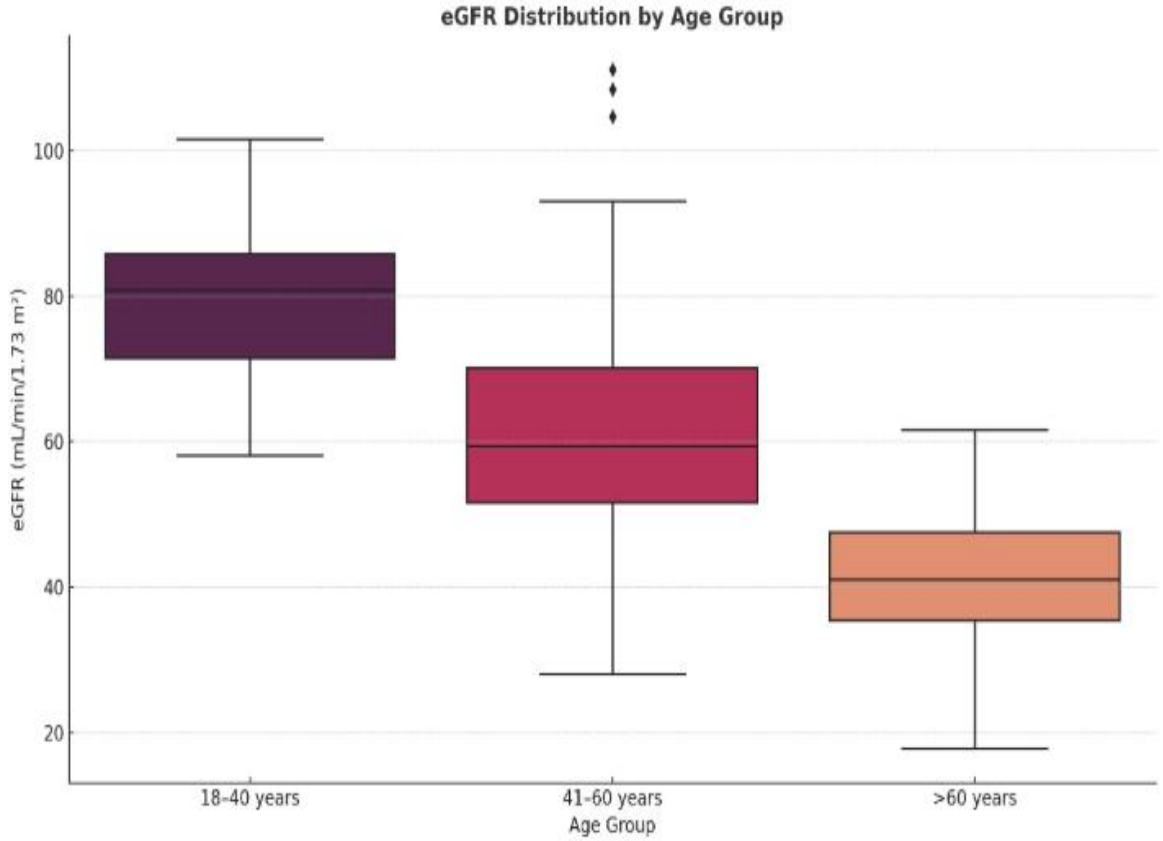

Figure 3: eGFR vs Age group

The box plot demonstrates a clear inverse relationship between age and eGFR, emphasizing the progressive nature of kidney function decline with advancing age. It underscores the importance of regular monitoring of eGFR, particularly in older hypertensive patients, to detect early signs of CKD and implement timely interventions. This visualization reinforces the need for tailored management strategies based on age to mitigate the risk of CKD progression in hypertensive populations.

The chi-square test was employed to identify significant associations between CKD stages and several categorical variables, including age group, gender, and the presence of diabetes mellitus. The analysis revealed the following key findings:

- Age Group ($p<0.001$): A highly significant association was observed between age and CKD stages. Patients aged above 60 years exhibited a substantially higher prevalence of advanced CKD stages (Stages 4 and 5) compared to younger age groups. This finding underscores the critical role of aging

as a risk factor for the progression of kidney disease, likely due to cumulative comorbidities and physiological decline in renal function with age.

- Gender ($p=0.03$): A significant gender disparity was noted, with male patients more likely to present with advanced stages of CKD. This trend may reflect gender-based differences in risk factor exposure, healthcare access, or underlying biological factors contributing to renal function decline.
- Diabetes Mellitus ($p<0.01$): Diabetic patients showed a significantly higher prevalence of CKD compared to non-diabetic counterparts. This finding highlights the well-documented relationship between diabetes and CKD, where prolonged hyperglycemia leads to glomerular damage, progressive proteinuria, and eventual renal function decline.

A multivariable logistic regression model was constructed to identify significant independent predictors of CKD among hypertensive patients. The analysis included age, diabetes status, and the duration of hypertension as covariates. The following predictors emerged as statistically significant:

- Age >60 Years: Older age was identified as a robust predictor of CKD, with an odds ratio (OR) of 2.8 (95% CI: 1.9–4.0; $p<0.001$). Patients aged over 60 years were nearly three times more likely to have CKD compared to younger individuals, reflecting the cumulative impact of age-related factors on renal health.
- Presence of Diabetes: Diabetes was the strongest predictor in the model, with an OR of 3.2 (95% CI: 2.0–5.0; $p<0.01$). Diabetic patients exhibited over three times the odds of developing CKD, underscoring the critical need for stringent glycemic control and early screening in this population.
- Duration of Hypertension >10 Years: Chronic hypertension was another significant predictor, with an OR of 2.5 (95% CI: 1.7–3.7; $p<0.001$). Patients with hypertension lasting more than a decade were at considerably higher risk of CKD progression, likely due to sustained vascular damage and glomerulosclerosis caused by prolonged elevated blood pressure.

DISCUSSION

This study provides valuable insights into the prevalence, distribution, and risk factors of chronic kidney disease (CKD) among hypertensive patients in a tertiary care setting in Pakistan. By utilizing robust diagnostic parameters such as Albumin-to-Creatinine Ratio (ACR) and estimated Glomerular Filtration Rate (eGFR), this research underscores the critical interplay between hypertension and CKD progression. The findings not only highlight the substantial burden of CKD in hypertensive patients but also reveal actionable opportunities for improved screening, diagnosis, and management strategies.

The study found that 57.1% of hypertensive patients were diagnosed with CKD, with the highest prevalence recorded in Stage 3 CKD (35%), followed by Stage 4 (15%) and Stage 5 (7.1%). These findings align with global trends, where hypertension has been recognized as a leading contributor to CKD development and progression. Elevated blood pressure leads to glomerular hyperfiltration and structural damage, which accelerates nephron loss and exacerbates renal dysfunction over time [10,11].

The high prevalence in Stage 3 CKD is particularly notable as it represents a critical transition point where patients typically experience moderate kidney dysfunction. At this stage, early interventions such as stricter blood pressure control, dietary modifications, and pharmacological therapies (e.g., renin-angiotensin system blockers) can significantly slow disease progression [12]. The relatively smaller proportions of patients in Stages 4 and 5 may reflect limited access to healthcare, delayed diagnosis, or high mortality rates associated with advanced CKD in resource-constrained settings [13]. Age was identified as one of the most significant predictors of CKD. Patients over 60 years had nearly threefold higher odds of advanced CKD (OR: 2.8, 95% CI: 1.9–4.0, $p<0.001$) compared to younger patients. This observation is consistent with the natural decline in renal function associated with aging, compounded by prolonged exposure to hypertension and age-related comorbidities such as atherosclerosis and diabetes [14]. Moreover, older individuals often exhibit impaired renal autoregulation, rendering their kidneys more susceptible to hemodynamic changes caused by hypertension [15, 25]. Gender differences were also significant, with males showing a higher likelihood of advanced CKD. This may be attributed to a combination of biological factors, such as higher baseline blood

pressure levels and lower baseline renal reserve in males, as well as behavioral factors, including delayed healthcare-seeking behavior [16, 24]. Diabetes, a well-established risk factor for CKD, showed a particularly strong association in this study. Diabetic patients had over threefold increased odds of CKD compared to non-diabetics (OR: 3.2, 95% CI: 2.0–5.0, $p<0.01$). Hyperglycemia in diabetes leads to glomerular injury through mechanisms such as oxidative stress, inflammation, and advanced glycation end-product accumulation, all of which accelerate kidney damage [17]. Hypertension duration also played a critical role, with patients having hypertension for more than 10 years being at significantly higher risk of CKD (OR: 2.5, 95% CI: 1.7–3.7, $p<0.001$). Long-standing hypertension leads to progressive vascular and glomerular remodeling, resulting in reduced renal perfusion and filtration capacity [18]. This underscores the need for early diagnosis and consistent blood pressure management to mitigate the long-term impact on renal function.
Biochemical parameters, particularly ACR and eGFR, were central to this study's evaluation of kidney function. The progressive increase in ACR values across CKD stages highlights its utility as a reliable marker of glomerular damage. Patients in early CKD stages (Stages 1 and 2) exhibited lower ACR values, reflecting minimal albuminuria and relatively preserved kidney function. In contrast, advanced CKD stages (Stages 4 and 5) were characterized by significantly higher ACR values, indicative of severe proteinuria and glomerular dysfunction. These findings align with prior research emphasizing ACR as a critical diagnostic and prognostic tool for CKD [19]. Similarly, the decline in eGFR values with age underscores its importance in monitoring renal function. The lowest eGFR values were observed in patients over 60 years, reflecting the compounded effects of aging, prolonged hypertension, and comorbidities. eGFR remains a cornerstone of CKD staging and provides actionable insights into disease progression, allowing clinicians to tailor interventions based on individual risk profiles [20]. The bivariate analysis demonstrated significant associations between CKD stages and key variables, including age, gender, and diabetes. Multivariable logistic regression further confirmed these variables as independent predictors of CKD, highlighting their combined impact on disease progression. The strength of these associations underscores the multifactorial nature of CKD and the need for an integrated approach to risk stratification and management.
This study has significant clinical implications for the management of hypertensive patients. The high prevalence of CKD, particularly in older adults and individuals with comorbid diabetes, calls for routine screening and risk stratification. Incorporating ACR and eGFR into standard diagnostic protocols can facilitate early detection of kidney damage, enabling timely interventions to slow disease progression.
Additionally, the findings emphasize the importance of targeted lifestyle and pharmacological interventions. Blood pressure control remains a cornerstone of CKD prevention and management, with angiotensin-converting enzyme inhibitors (ACEIs) and angiotensin receptor blockers (ARBs) offering dual benefits for hypertension and proteinuria reduction. For diabetic patients, stringent glycemic control is essential to mitigate the risk of nephropathy.

CONCLUSION

This study highlights the significant burden of chronic kidney disease (CKD) in hypertensive patients in a tertiary care setting in Pakistan, underscoring the pressing need for early diagnosis, risk stratification, and tailored management strategies. The prevalence of CKD among hypertensive patients was alarmingly high, with Stage 3 CKD being the most commonly observed stage, indicating a critical juncture for intervention to prevent further disease progression. Age over 60 years, diabetes, and prolonged hypertension were identified as independent and significant predictors of CKD, emphasizing the multifactorial nature of the disease and the necessity for a multidisciplinary approach to its management. Biochemical markers such as Albumin-to-Creatinine Ratio (ACR) and estimated Glomerular Filtration Rate (eGFR) were instrumental in assessing kidney function and staging CKD. These parameters not only provided reliable diagnostic insights but also highlighted the severity of glomerular damage across different CKD stages. The progressive increase in ACR values and the decline in eGFR with advancing CKD underscore the utility of these markers in routine clinical practice. The findings of this study have significant implications for clinical practice and public health policy. Routine screening of hypertensive patients for CKD using ACR and eGFR should be integrated into primary care settings to facilitate early detection and intervention. Special attention should be

given to high-risk groups, including older adults, individuals with diabetes, and those with a long history of hypertension. Effective management strategies, such as optimal blood pressure control, lifestyle modifications, and pharmacological interventions targeting both hypertension and proteinuria, are essential to reduce the burden of CKD and its complications. Despite its strengths, including the use of robust diagnostic criteria and a focus on a high-risk population, the study has certain limitations. The single-center design and relatively small sample size may limit the generalizability of the findings. Additionally, the retrospective nature of the study might have introduced selection bias. Future research should focus on larger, multicenter, prospective studies to validate these findings and explore additional factors influencing CKD progression, including genetic predisposition, socioeconomic status, and healthcare accessibility. This study also reaffirms the critical relationship between hypertension and CKD, providing valuable insights into its prevalence, risk factors, and disease progression. It highlights the urgent need for proactive measures to reduce the growing burden of CKD in hypertensive populations in Pakistan. Early detection and intervention, supported by routine screening and evidence-based management, have the potential to improve patient outcomes, mitigate healthcare costs, and alleviate the public health impact of this chronic disease**.**

LIMITATIONS AND FUTURE DIRECTIONS

While this study provides valuable insights, certain limitations warrant consideration. The retrospective design may introduce biases related to data availability and accuracy. Furthermore, the single-center focus and relatively small sample size limit the generalizability of findings. Future multicenter, prospective studies with larger cohorts are recommended to validate these results and explore additional variables, such as socioeconomic factors and genetic predisposition.

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