Section: Miscellaneous

Original Research Article

# EXPLORING THE PREVALENCE OF PULMONARY ARTERY HYPERTENSION IN CHRONIC KIDNEY DISEASE PATIENTS AT A RURAL TERTIARY CARE HOSPITAL IN NORTH GUJARAT

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**ABSTRACT**

**Background:** Pulmonary hypertension (PH) is a serious complication of chronic kidney disease (CKD) associated with increased morbidity and mortality. This study aimed to investigate the prevalence and associated factors of PH in a cohort of CKD patients within a rural setting in North Gujarat, India.

**Materials and Methods:** This cross-sectional study included 110 CKD patients. Data were collected on demographics, medical history, CKD stage (based on estimated glomerular filtration rate), laboratory parameters (including hemoglobin, serum creatinine, and electrolytes), and comorbidities (such as hypertension and diabetes). Pulmonary artery pressure was estimated using transthoracic echocardiography.

**Results:** The prevalence of PH in the study population was 18.18% (n=20). Multivariate analysis revealed that advanced CKD stages (p=0.001), lower hemoglobin levels (p=0.02), and higher serum creatinine levels (p=0.004) were independent predictors of PH. Comorbidities such as hypertension (85%) and diabetes (60%) were significantly associated with PH.

**Conclusion:** This study demonstrates a significant prevalence of PH in CKD patients within a rural Indian setting. The identification of key risk factors emphasizes the importance of routine screening for PH in this vulnerable population. Early diagnosis and appropriate management are crucial for improving patient outcomes and reducing the morbidity and mortality associated with this potentially life-threatening complication.

**Keywords:** Chronic Kidney Disease, Pulmonary Hypertension, Echocardiography, Prevalence, Risk Factors, Rural India.

## INTRODUCTION

Chronic Kidney Disease (CKD) is a significant global health concern, characterized by a progressive decline in kidney function over time, affecting millions worldwide. Among the various complications associated with CKD, Pulmonary Artery Hypertension (PAH) has emerged as a notable contributor to morbidity and mortality in affected patients. PAH is defined by an elevated mean pulmonary arterial pressure (PAP) greater than 25 mmHg at rest, as measured by right heart catheterization. The prevalence of PAH in CKD patients is considerably higher than in the general population, particularly in those with end-stage renal disease (ESRD) and individuals undergoing dialysis.[1,2]

The pathophysiology of PAH in CKD is complex and multifactorial. Factors such as volume overload, anemia, inflammation, and vascular changes in the pulmonary circulation play significant roles in the development of PAH among CKD patients.

Additionally, alterations in renal hemodynamics, including activation of the renin-angiotensin-aldosterone system (RAAS), and reduced clearance of vasoconstrictors have been proposed as contributing factors.[3,4] Studies have shown that the coexistence of PAH and CKD is associated with a higher risk of cardiovascular events, poorer prognosis, and increased mortality rates.[5]

PAH in CKD is commonly underdiagnosed, as its symptoms can be subtle or masked by the primary kidney disease. Right heart catheterization remains the gold standard for diagnosing PAH, though other non-invasive methods, such as echocardiography, are frequently used.[6] Furthermore, PAH is associated with worsened kidney function, increased hospitalization rates, and diminished quality of life, highlighting its clinical significance in CKD management.[7,8]

In rural regions such as North Gujarat, healthcare access is often limited, and awareness of complications like PAH is frequently inadequate. These challenges may result in a higher prevalence of undiagnosed or inadequately managed PAH among CKD patients. This study aims to explore the prevalence of PAH in CKD patients at a rural tertiary care hospital in North Gujarat, providing crucial insights into the local burden of this disease and its impact on patient care.

## MATERIALS AND METHODS

This hospital-based cross-sectional study was conducted over 12 months, from February 2024 to January 2025, at a rural tertiary care hospital in North Gujarat. The study aimed to evaluate the prevalence of pulmonary hypertension (PHT) in patients with chronic kidney disease (CKD) and its association with clinical parameters. The prevalence of PHT in CKD has been well-documented in previous studies, where it was observed that approximately 30–60% of CKD patients may develop pulmonary hypertension, underscoring the importance of timely diagnosis and management.[9,10]

The sample size was calculated using the formula $n = Z^2 \times p \times (1 - p) / d^2$, where Z represents the standard normal variate (1.96 for a 95% confidence interval), p is the expected prevalence of pulmonary hypertension (PHT) among CKD patients (50%), and d is the margin of error (10%). Using these parameters, the minimum required sample size was 96. To account for a potential 10% non-response rate, the sample size was adjusted to 110 participants, who were then randomly selected for the study. Sample size calculations for similar studies in CKD populations have generally followed this approach to ensure sufficient power to detect significant associations

Patients aged 18 years and older with a confirmed diagnosis of CKD were eligible for the study. CKD stages were determined by GFR values: Stage 1 (GFR >90 ml/min/1.73 m²), Stage 2 (GFR 60–89 ml/min/1.73 m²), Stage 3a (GFR 45–59 ml/min/1.73 m²), Stage 3b (GFR 30–44 ml/min/1.73 m²), Stage 4 (GFR 15–29 ml/min/1.73 m²), and Stage 5 (GFR <15 ml/min/1.73 m²). Albuminuria levels were also assessed and classified as A1 (<30 mg/g), A2 (30–300 mg/g), and A3 (>300 mg/g). The classification of CKD and albuminuria follows the KDIGO 2012 guidelines (KDIGO, 2012).[11] Patients with valvular or congenital heart diseases, chronic obstructive or restrictive lung diseases, HIV infection, chronic liver disease, connective tissue disorders, or thyroid dysfunctions were excluded from the study to reduce confounding factors.

Data collection encompassed the recording of participant demographics, clinical history, CKD stage, and comorbid conditions such as diabetes and hypertension. Laboratory tests included hemoglobin, serum creatinine, blood urea nitrogen, serum calcium, phosphorus, bicarbonate, and parathyroid hormone levels. Pulmonary artery pressure (PAP) was assessed using transthoracic Doppler echocardiography, performed either after dialysis or during routine clinical evaluations. The use of Doppler echocardiography for assessing PAP is a well-established non-invasive method in the management of CKD patients with suspected pulmonary hypertension.[12,13]

Statistical analysis: Data were analyzed using SPSS version 22.0. Frequencies, means, and percentages were calculated for descriptive statistics. The Chi-square test was used for categorical data, and Student's t-test was used for continuous variables. The correlation between pulmonary hypertension and clinical parameters was assessed using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant.

## RESULTS

A total of 110 patients were included in this study, with a mean age of 56.3 ± 12.5 years. The majority of participants were male (60%), while 40% were female. The distribution of CKD stages among the participants is presented in Table 1. The highest percentage of patients were in Stage 5 (42.73%), followed by Stage 4 (31.82%) and Stage 3 (25.45%). The prevalence of pulmonary hypertension (PHT) among the participants was 18.18% (n=20), as shown in Table 2. The remaining 81.82% of the patients did not exhibit PHT. The severity of pulmonary hypertension among the 20 patients with PHT is outlined in Table 3. The majority of these patients had mild PHT (50%), followed by moderate PHT (35%) and severe PHT (15%).

**Table 1: CKD Stage Distribution Among Study Participants**

| CKD Stage | Number of Subjects | Percentage (%) |
|---|---|---|
| **Stage 3** | 28 | 25.45 |

| | | |
|---|---|---|
| **Stage 4** | 35 | 31.82 |
| **Stage 5** | 47 | 42.73 |
| **Total** | 110 | 100 |

**Table 2: Prevalence of Pulmonary Hypertension in CKD Patients**

| Pulmonary Hypertension | Number of Subjects | Percentage (%) |
|---|---|---|
| **Present** | 20 | 18.18 |
| **Absent** | 90 | 81.82 |
| **Total** | 110 | 100.00 |

**Table 3: Classification of Pulmonary Hypertension Severity in CKD Patients**

| **Grading** | **Number of Subjects** | **Percentage (%)** |
|---|---|---|
| Mild | 10 | 50.00 |
| Moderate | 7 | 35.00 |
| Severe | 3 | 15.00 |
| Total | 20 | 100.00 |

Table 4 highlights key factors significantly linked to pulmonary hypertension in CKD patients. These include age, smoking, CKD stage, hemoglobin, serum creatinine, serum albumin, dialysis status, and serum phosphorus levels. Patients with pulmonary hypertension were generally older, had lower hemoglobin, elevated serum creatinine, reduced serum albumin, and higher serum phosphorus levels compared to those without the condition. Additionally, a greater proportion of individuals with pulmonary hypertension were in advanced CKD stages (4/5) and undergoing dialysis. However, no significant associations were found between pulmonary hypertension and gender, BMI, or serum sodium levels in this study.

**Table 4: Bivariate Analysis of Factors Associated with Pulmonary Hypertension in CKD Patients**

| **Variable** | **PH Present (n=20)** | **PH Absent (n=90)** | **p-value** | **Significance** |
|---|---|---|---|---|
| **Age (mean ± SD, years)** | 60.8 ± 10.5 | 54.5 ± 12.2 | 0.03 | Significant |
| **Male Gender (n, %)** | 12 (60%) | 54 (60%) | 0.98 | Not Significant |
| **BMI (mean ± SD, kg/m²)** | 23.4 ± 3.1 | 24.8 ± 2.8 | 0.15 | Not Significant |
| **Smoking Status (n, %)** | 8 (40%) | 18 (20%) | 0.05 | Significant |
| **CKD Stage 4/5 (n, %)** | 18 (90%) | 30 (33.3%) | <0.001 | Highly Significant |
| **Hemoglobin (mean ± SD, g/dL)** | 7.8 ± 1.5 | 9.3 ± 1.2 | 0.02 | Significant |
| **Serum Creatinine (mean ± SD, mg/dL)** | 6.2 ± 1.3 | 4.8 ± 1.4 | 0.004 | Highly Significant |
| **Serum Albumin (mean ± SD, g/dL)** | 3.2 ± 0.5 | 3.8 ± 0.4 | 0.01 | Significant |
| **On Dialysis (n, %)** | 14 (70%) | 35 (38.9%) | 0.03 | Significant |
| **Serum Phosphorus (mean ± SD, mg/dL)** | 5.9 ± 1.1 | 4.8 ± 0.9 | 0.001 | Highly Significant |
| **Serum Sodium (mean ± SD, mmol/L)** | 137 ± 4 | 138 ± 3 | 0.28 | Not Significant |
| **Serum Potassium (mean ± SD, mmol/L)** | 4.5 ± 0.8 | 4.4 ± 0.6 | 0.45 | Not Significant |
| **Urine Output <500 mL/day (n, %)** | 15 (75%) | 58 (64.4%) | 0.42 | Not Significant |
| **Peripheral Edema (n, %)** | 10 (50%) | 38 (42.2%) | 0.54 | Not Significant |

As shown in Table 5, The multivariate analysis revealed several important determinants of pulmonary hypertension. A significant positive association was found between age and pulmonary artery pressure, with a coefficient of 0.42 ($p = 0.03$), indicating that as patients age, their risk for pulmonary hypertension increases. Chronic Kidney Disease (CKD) stage was also a highly significant predictor, with a coefficient of 1.10 ($p = 0.001$), suggesting that worsening kidney function plays a key role in the progression of pulmonary hypertension. Haemoglobin levels showed a significant negative correlation with pulmonary artery pressure, with a coefficient of -0.50 ($p = 0.02$), suggesting that lower hemoglobin levels are associated with increased pulmonary artery pressure, which may reflect the exacerbating effects of anemia on pulmonary vascular resistance. Serum creatinine, a marker of renal function, was found to have a highly significant positive correlation with pulmonary artery pressure (coefficient = 0.95, $p = 0.004$), reinforcing the relationship between declining kidney function and the development of pulmonary hypertension.

**Table 5: Multivariate Linear Regression Analysis of Pulmonary Hypertension Determinants**

| **Variable** | **Coefficient** | **p-value** | **Significance** |
|---|---|---|---|
| Age | 0.42 | 0.03 | Significant |
| CKD Stage | 1.1 | 0.001 | Highly Significant |
| Hemoglobin | -0.5 | 0.02 | Significant |
| Serum Creatinine | 0.95 | 0.004 | Highly Significant |
| Serum Phosphorus | 0.32 | 0.06 | Not Significant |
| Serum Albumin | -0.4 | 0.04 | Significant |
| Parathyroid Hormone | 0.08 | 0.08 | Not Significant |
| Diabetes Mellitus | 0.28 | 0.1 | Not Significant |

The presence of comorbidities, such as hypertension and diabetes, was notably high among patients with pulmonary hypertension. Of the 20 patients with PHT, 85% had hypertension and 60% had diabetes. The study found that pulmonary hypertension was present in 18.18% of the CKD patients (n=20), with the majority of cases observed in patients with advanced CKD stages (Stages 4 and 5). Figure 1 highlights the association between CKD stage and the prevalence of pulmonary hypertension, underscoring the increasing burden of this complication with CKD progression.

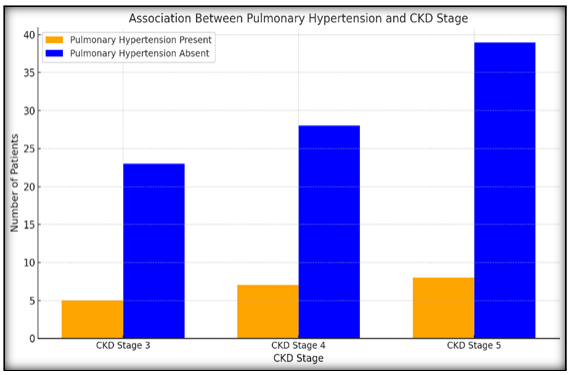


**Figure 1: Association between Pulmonary Hypertension and CKD Stage**

## DISCUSSIONS

This study contributes to the growing understanding of pulmonary hypertension (PH) in patients with chronic kidney disease (CKD). The prevalence of PH in this cohort was 18.18%, which is lower than the 30–60% range reported in earlier studies. For example, Yigla et al,[14] found a PH prevalence of 39% in dialysis patients, while Eid M et al,[15] observed a prevalence of 26.7% in an Egyptian CKD population. These discrepancies may be due to differences in population characteristics, diagnostic methods, and access to healthcare facilities across regions.

Our results confirm a strong link between advanced CKD stages and the occurrence of PH, with most cases seen in Stages 4 and 5. This trend aligns with studies Agarwal et al,[2] which noted an increase in pulmonary artery pressure in hemodialysis patients. Pulmonary hypertension (PHT) was observed in 18.18% of participants, with a mean systolic pulmonary artery pressure (SPAP) of 46.7 mmHg, similar to findings by Bozbas et al.[16] The longer duration of dialysis therapy in patients with PHT suggests its role in vascular remodeling, while the higher prevalence of PHT in hemodialysis (HD) patients compared to peritoneal dialysis (PD) supports the impact of HD-related volume overload and hemodynamic changes. These results highlight the need for routine screening in end-stage renal disease (ESRD) patients, especially those undergoing long-term HD.

Key factors associated with PH in this study included age, hemoglobin levels, CKD stage, and serum creatinine. The observed inverse relationship between hemoglobin and pulmonary artery pressure supports findings from study by Gomez-Aviles P. et al,[17] who identified anemia as a critical factor due to its effects on cardiac output and pulmonary vasoconstriction. Additionally, the positive correlation between serum creatinine and pulmonary artery pressure corroborates findings by Navaneethan et al,[18] emphasizing the role of uremic toxins and vascular stiffness in PH development.

The high prevalence of hypertension and diabetes among PH patients in this study is consistent with other research. Georgiopoulou VV et al,[19] underscored hypertension's contribution to left ventricular dysfunction and pulmonary venous congestion, exacerbating PH. Similarly, diabetes has been widely linked to vascular remodelling and endothelial dysfunction, further worsening pulmonary vascular disease.

Compared to studies conducted in urban or well-equipped tertiary care centres, the prevalence of PH observed in this rural setting appears to be lower. This difference may stem from limited access to advanced diagnostic tools such as right heart catheterisation, the gold standard for PH diagnosis, which could result in the underdiagnosis of mild cases. In contrast, Doppler echocardiography, used in this study, offers a practical yet less sensitive alternative, particularly in resource-limited environments like North Gujarat.

## CONCLUSION

This study aimed to assess the prevalence and associated factors of pulmonary hypertension (PH) in patients with chronic kidney disease (CKD) within a rural setting in North Gujarat, India. The findings revealed a significant prevalence of PH (18.18%) among the study population. Advanced CKD stages, lower hemoglobin levels, and higher serum creatinine levels were identified as crucial predictors of PH development. These findings underscore the critical need for routine screening for PH in CKD patients, particularly those with advanced disease. Early diagnosis and prompt management are essential for improving patient outcomes and mitigating the adverse effects of this potentially life-threatening complication.

**Limitations**

Several limitations should be considered when interpreting the study findings. Firstly, the cross-sectional study design precludes the establishment of a definitive cause-and-effect relationship between the identified factors and PH development. Secondly, the use of echocardiography for PH assessment, while a valuable non-invasive tool, may have limitations in accurately diagnosing mild cases compared to the gold standard, right heart

catheterization. Thirdly, the relatively small sample size may limit the generalizability of the findings to larger populations. Finally, the study was conducted in a rural setting, and the findings may not be entirely representative of urban populations or regions with better access to healthcare resources.

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