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Research Article

Severity and Determinants of Anemia Among Patients with Chronic Kidney Disease in a Tertiary Care Hospital

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Abstract

Background: Anemia is a common and clinically significant complication of chronic kidney disease (CKD), contributing to morbidity, reduced quality of life, and adverse cardiovascular outcomes. Its prevalence and severity increase with declining renal function and are influenced by multiple clinical and biochemical factors.

Objective: To assess the severity and determinants of anemia among patients with CKD attending a tertiary care hospital.

Methods: A cross-sectional observational study was conducted among 150 CKD patients attending the nephrology and medicine departments of a tertiary care teaching hospital. CKD staging was based on estimated glomerular filtration rate (eGFR) according to KDIGO guidelines. Hemoglobin levels were categorized per WHO criteria. Clinical, demographic, and laboratory parameters including iron profile, serum creatinine, eGFR, and comorbidities were analyzed. Associations between anemia severity and CKD stage were evaluated using chi-square and logistic regression analysis.

Results: The overall prevalence of anemia was 74%. Anemia prevalence increased progressively with CKD stage: 22% in stage 1–2, 58% in stage 3, 82% in stage 4, and 96% in stage 5. Moderate-to-severe anemia was significantly associated with advanced CKD stage ($p<0.001$), low serum ferritin ($p=0.01$), and presence of diabetes ($p=0.03$). Multivariate analysis identified CKD stage 4–5 (OR 5.8, 95% CI 2.6–12.9) and iron deficiency (OR 3.1, 95% CI 1.4–6.9) as independent determinants.

Conclusion: Anemia is highly prevalent among CKD patients and strongly correlates with disease progression and iron deficiency. Early screening and stage-based

anemia management strategies are essential to improve outcomes in CKD populations.

Keywords: Chronic kidney disease, anemia, hemoglobin, iron deficiency, CKD stage

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Introduction

Chronic kidney disease (CKD) is a major global public health problem characterized by progressive and irreversible decline in renal function, leading to multiple systemic complications. Among these, anemia is one of the most common and clinically significant manifestations, contributing substantially to morbidity and reduced quality of life in affected patients. Anemia in CKD impairs exercise tolerance, cognitive function, and physical capacity, and is strongly associated with adverse cardiovascular outcomes and increased mortality. The pathophysiology of anemia in CKD is complex and multifactorial. The primary mechanism is inadequate erythropoietin production by the diseased kidneys, compounded by iron deficiency, chronic inflammation, reduced red blood cell lifespan, and nutritional deficiencies. As renal function deteriorates, these mechanisms intensify, resulting in a progressive increase in both the prevalence and severity of anemia, particularly in advanced CKD and dialysis-dependent stages.

The clinical consequences of untreated anemia in CKD are substantial. Persistent anemia contributes to left ventricular hypertrophy, heart failure, fatigue, reduced work capacity, frequent hospitalization, and poor overall survival. Evidence suggests that early detection and appropriate management of anemia—through iron supplementation and erythropoiesis-stimulating therapies—can improve functional status, cardiovascular outcomes, and patient well-being. Despite this, anemia in CKD remains underdiagnosed and undertreated in many settings, especially in developing and resource-limited healthcare systems where patients often present in advanced disease stages and access to specialized care is limited.

Understanding the distribution and determinants of anemia across CKD stages is therefore essential for timely intervention and risk stratification. Clinical factors such as disease stage and comorbidities, along with biochemical parameters including iron status, play important roles in anemia severity. Identifying these determinants can help guide stage-based screening and individualized management strategies. In this context, the present study was undertaken to evaluate the prevalence and

severity of anemia among CKD patients attending a tertiary care hospital and to analyze its association with CKD stage and iron status, with the aim of informing improved anemia management in this population.

Materials and Methods

This cross-sectional observational study was conducted in the Departments of Medicine and Nephrology of a tertiary care teaching hospital over a period of 12 months. The study aimed to assess the prevalence, severity, and determinants of anemia among patients with chronic kidney disease (CKD). Institutional ethical approval was obtained prior to study initiation, and all participants provided informed consent before enrollment.

Study Population

A total of 150 adult patients aged 18 years and above with a confirmed diagnosis of CKD were included. CKD was defined and staged according to kidney disease: Improving Global Outcomes (KDIGO) guidelines based on estimated glomerular filtration rate (eGFR) values. Patients were recruited consecutively from outpatient and inpatient services to minimize selection bias. Individuals with conditions that could independently influence hemoglobin levels were excluded, including acute kidney injury, known hematological disorders, active malignancy, recent blood transfusion (within the previous three months), and pregnancy.

Data Collection

After enrollment, detailed demographic and clinical information was recorded using a structured proforma. Variables included age, sex, CKD etiology, duration of kidney disease, comorbidities such as diabetes mellitus and hypertension, and medication history. Anthropometric parameters and blood pressure were also documented.

Venous blood samples were collected under aseptic conditions for laboratory analysis. Hemoglobin concentration was measured using an automated hematology analyzer calibrated according to standard laboratory quality control procedures. Iron status was evaluated by measuring serum ferritin and transferrin saturation using standardized biochemical assays. Serum creatinine was estimated by an enzymatic method, and eGFR was calculated using the CKD-EPI equation. CKD staging was categorized into stages 1–5 based on KDIGO eGFR thresholds.

Definitions

Anemia was defined according to World Health Organization criteria as hemoglobin <13 g/dL in men and <12 g/dL in women. The severity of anemia was classified as mild (10–12 g/dL), moderate (8–9.9 g/dL),

and severe (<8 g/dL). Iron deficiency was considered when serum ferritin and/or transferrin saturation were below standard reference ranges. CKD stages were defined according to KDIGO eGFR categories.

- Anemia: Hb <13 g/dL (men) and <12 g/dL (women)
- Severity: Mild (10–12 g/dL), Moderate (8–9.9 g/dL), Severe (<8 g/dL)
- CKD staging: KDIGO eGFR categories

Statistical analysis: Data analyzed using SPSS v25. Chi-square test assessed association between anemia severity and CKD stage. Logistic regression identified determinants. $p<0.05$ considered significant.

Results:

Results shows the distribution of anemia among patients with different stages of chronic kidney disease (CKD). A total of 150 CKD patients were evaluated, of whom 111 (74%) were anemic overall. The prevalence of anemia increased progressively with advancing CKD stage, demonstrating a clear stage-dependent relationship. In early CKD (stage 1–2), only 4 out of 18 patients (22%) had anemia, indicating relatively preserved erythropoietin production and less metabolic disturbance. In stage 3, anemia prevalence increased markedly to 58% (26/45), reflecting declining renal function and emerging erythropoietin deficiency. The burden of anemia became more pronounced in stage 4, where 82% (41/50) of patients were affected. The highest prevalence was observed in stage 5 (end-stage renal disease), with 96% (35/37) of patients being anemic, showing that anemia is almost universal in advanced CKD.

Overall, the table demonstrates a strong positive association between CKD severity and anemia prevalence. As kidney function declines, impaired erythropoietin synthesis, iron dysregulation, chronic inflammation, and reduced red cell survival contribute to increasing anemia frequency. These findings highlight the importance of early anemia screening beginning in stage 3 CKD and aggressive management in stages 4–5 to prevent complications such as cardiovascular morbidity and reduced quality of life (table 1).

Table 1: Prevalence of Anemia by CKD Stage

CKD Stage	Total Patients	Anemia n (%)
Stage 1–2	18	4 (22%)
Stage 3	45	26 (58%)
Stage 4	50	41 (82%)
Stage 5	37	35 (96%)
Total	150	111 (74%)

Anemia prevalence increased significantly with CKD stage ($p<0.001$).

Among the 111 anemic CKD patients, mild anemia was the most common, affecting 46 patients (41%). Moderate anemia was observed in 42 patients (38%), while severe anemia occurred in 23 patients (21%). This distribution indicates that although a substantial proportion had early-stage anemia, nearly 59% of patients had moderate to severe anemia, reflecting significant hematological impairment in CKD. The presence of moderate and severe anemia highlights the need for timely evaluation and treatment to prevent disease-related complications (table 2).

Table 2: Severity Distribution

Severity	n (%)
Mild	46 (41%)
Moderate	42 (38%)
Severe	23 (21%)

Moderate and severe anemia predominated in stages 4–5.

Table 3 presents the factors independently associated with moderate to severe anemia in CKD patients using logistic regression analysis. Patients in advanced CKD (stages 4–5) had 5.8 times higher odds of having moderate–severe anemia compared with those in earlier stages (95% CI 2.6–12.9; $p<0.001$), indicating a strong and statistically significant association. Low serum ferritin, reflecting iron deficiency, was associated with a 3.1-fold increased risk of moderate–severe anemia (95% CI 1.4–6.9; $p=0.01$), highlighting iron deficiency as a key contributor. Diabetes

mellitus also showed a significant association, with diabetic CKD patients having 2.2 times higher odds of more severe anemia (95% CI 1.1–4.8; p=0.03). Since all p-values are <0.05 and confidence intervals do not cross 1, these variables are significant independent determinants of anemia severity in CKD.

Table 3: Determinants of Moderate–Severe Anemia

Variable	OR	95% CI	p
CKD stage 4–5	5.8	2.6–12.9	<0.001
Low ferritin	3.1	1.4–6.9	0.01
Diabetes mellitus	2.2	1.1–4.8	0.03

Discussion

This study demonstrates a high prevalence (74%) of anemia among CKD patients, with a strong stage-dependent increase reaching 96% in stage 5 disease. These findings align with global epidemiological data showing progressive anemia with declining renal function due to reduced erythropoietin production and increasing inflammation. The predominance of moderate-to-severe anemia in advanced CKD stages highlights the clinical burden and need for early intervention.

Iron deficiency emerged as a major determinant, consistent with evidence that impaired iron utilization and chronic inflammation contribute to functional iron deficiency in CKD. Diabetes was also associated with more severe anemia, possibly reflecting microvascular damage and inflammatory burden. These results support routine screening of hemoglobin and iron indices across CKD stages.

The observed prevalence is comparable to reports from tertiary care settings in developing countries, where late presentation and limited anemia management resources contribute to higher severity. Early iron supplementation and erythropoiesis-stimulating therapy in stages 3–4 may prevent progression to severe anemia.

Conclusion

Anemia is highly prevalent among CKD patients and increases markedly with disease progression. Advanced CKD stage and iron deficiency are the principal

determinants of moderate-to-severe anemia. Stage-based screening and individualized anemia management strategies should be integrated into CKD care to reduce morbidity and improve patient outcomes.

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DATA AVAILABILITY: All datasets generated or analyzed during this study are included in the manuscript.

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