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Prevalence and Pattern of Anemia in Patients with Chronic Kidney Disease: A Hospital-Based Observational Study

Dr. B. Nageswara Rao
Department of General Medicine, Mamata Medical College, Khammam, India

ABSTRACT
Anemia is one of the most common complications of chronic kidney disease and becomes more frequent as renal function declines. It is mainly caused by reduced erythropoietin production, iron deficiency, chronic inflammation and shortened red blood cell survival. Anemia in CKD contributes to fatigue, reduced quality of life and cardiovascular complications. Aim of the study was to study the prevalence, severity and morphological pattern of anemia among patients with chronic kidney disease. This hospital-based observational study was conducted in the Department of General Medicine, Mamata Medical College and General Hospital, Khammam. A total of 80 patients diagnosed with chronic kidney disease were included. Detailed clinical history, examination findings, dialysis status and comorbidities were recorded. Hemoglobin level, peripheral smear, blood urea, serum creatinine and estimated glomerular filtration rate were assessed. Anemia was classified according to severity and morphology. Data were expressed as frequency, percentage, mean and standard deviation. Chi-square test was used to assess associations, and p-value <0.05 was considered statistically significant. Anemia was present in 72 patients (90%). Moderate anemia was most common, seen in 37 patients (46.3%), followed by mild anemia in 20 patients (25%) and severe anemia in 15 patients (18.8%). Normocytic normochromic anemia was the predominant pattern. Anemia severity showed significant association with CKD stage, eGFR and serum creatinine. Anemia is highly prevalent among CKD patients and worsens with declining renal function.

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Key Words
Chronic kidney disease, anemia, hemoglobin, eGFR, serum creatinine, normocytic normochromic anemia

Corresponding Author
Dr. B. Nageswara Rao,
Department of General Medicine, Mamata Medical College, Khammam, India

Author Designation
Assistant Professor

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INTRODUCTION

Chronic kidney disease is a progressive disorder characterized by gradual and irreversible loss of renal function. It is commonly associated with several systemic complications, among which anemia is one of the most frequent and clinically important. Anemia in chronic kidney disease usually develops due to reduced erythropoietin production by the diseased kidneys, shortened red blood cell survival, iron deficiency, chronic inflammation, nutritional deficiencies and blood loss during dialysis or repeated investigations. It is commonly normocytic and normochromic in type, although microcytic anemia may occur when iron deficiency coexists.

The burden of anemia increases as renal function declines. Hsu *et al*. observed that reduced renal function was significantly associated with lower hemoglobin levels and increasing anemia burden among adults with chronic renal insufficiency[1]. Similarly, Astor *et al*. reported that anemia became more prevalent and severe when estimated glomerular filtration rate declined below 60 ml/min/1.73 m^2, showing that even moderate renal impairment can affect erythropoiesis[2]. McClellan *et al*. also found that anemia was present in 47.7% of predialysis patients with chronic kidney disease and that its prevalence increased with worsening kidney function[3].

Anemia in chronic kidney disease is not only a laboratory abnormality but also an important contributor to morbidity. It may cause fatigue, weakness, reduced exercise tolerance, breathlessness, impaired quality of life and decreased work capacity. Long-standing anemia can increase cardiac workload and contribute to left ventricular hypertrophy, heart failure and adverse cardiovascular outcomes. Vlagopoulos *et al*. reported that anemia was associated with increased cardiovascular disease and all-cause mortality, particularly among diabetic patients with coexisting chronic kidney disease[4]. Hence, early identification and correction of anemia may help reduce complications and improve clinical outcomes.

Guidelines have emphasized the need for regular hemoglobin estimation, evaluation of iron status and appropriate management of anemia in chronic kidney disease. The KDOQI guidelines recommended systematic assessment of anemia in CKD patients and highlighted the importance of identifying correctable causes such as iron deficiency before initiating specific therapy[5].

Despite these advances, anemia in chronic kidney disease is still underdiagnosed and undertreated in many routine clinical settings. The severity and pattern of anemia may vary according to stage of CKD, age, gender, nutritional status, diabetes, hypertension and dialysis status. Hence, hospital-based studies remain useful to understand the local burden of anemia among CKD patients. Therefore, the present study was undertaken with the aim of assessing the prevalence, severity and pattern of anemia among patients with chronic kidney disease.

MATERIALS AND METHODS

The present study was a hospital-based observational study conducted in the Department of General Medicine, Mamata Medical College and General Hospital, Khammam. The study included patients diagnosed with chronic kidney disease who attended the outpatient department or were admitted to the medical wards. A total of 80 patients with chronic kidney disease were included in the study after obtaining informed consent. The main objective of the study was to assess the prevalence, severity and pattern of anemia among patients with chronic kidney disease and to study its association with selected clinical and biochemical parameters.

Inclusion Criteria:

- Patients diagnosed with chronic kidney disease
- Patients aged 18 years and above
- Both male and female patients were included
- Patients with chronic kidney disease of different stages were included
- Patients on conservative management or dialysis were included
- Patients willing to participate in the study
- Patients who provided informed consent

Exclusion Criteria:

- Patients with acute kidney injury.
- Patients with known hematological disorders.
- Patients with active bleeding or recent history of major blood loss.
- Patients who received blood transfusion within the previous 3 months.
- Patients with malignancy.
- Patients with chronic liver disease.
- Pregnant women.
- Patients with acute infections or severe systemic illness.
- Patients already receiving erythropoietin therapy or iron therapy, if it interfered with baseline assessment.
- Patients not willing to participate in the study.

Study Tool:

- A pre-designed and pre-tested proforma was used for collection of clinical and laboratory data.

- Details regarding age, gender, occupation, duration of chronic kidney disease, history of diabetes mellitus, hypertension, dialysis status and treatment history were recorded.
- Clinical examination findings such as pallor, pedal edema, blood pressure, height, weight and body mass index were documented.
- Systemic examination was performed to assess cardiovascular, respiratory, abdominal and neurological findings.
- Laboratory investigations included hemoglobin, total leukocyte count, differential count, platelet count, peripheral smear, blood urea, serum creatinine, estimated glomerular filtration rate, serum electrolytes, fasting blood sugar and urine examination.
- Additional investigations such as serum iron, ferritin, total iron binding capacity, vitamin B12 and folate levels were done wherever clinically indicated.

Data Collection:

- Data was collected from all eligible patients after obtaining informed consent
- A detailed clinical history was taken from each patient
- General physical examination and systemic examination were performed
- Blood pressure was recorded using a standard sphygmomanometer after adequate rest
- Venous blood samples were collected under aseptic precautions for hematological and biochemical investigations
- Hemoglobin level was recorded and anemia was classified according to severity
- Peripheral smear findings were noted to assess the morphological type of anemia
- Renal function was assessed using blood urea, serum creatinine and estimated glomerular filtration rate
- Patients were grouped according to stage of chronic kidney disease wherever possible
- The collected data was entered into the study proforma and analyzed to study the relationship between anemia and clinical parameters such as age, gender, stage of CKD, serum creatinine, eGFR and dialysis status

Statistical Analysis: The collected data was entered into Microsoft Excel and analyzed using SPSS statistical methods. Continuous variables were expressed as mean and standard deviation, while categorical variables were expressed as frequency and percentage. The association between anemia and selected clinical or biochemical parameters was analyzed using Chi-square test for categorical variables and Student's t-test or ANOVA for continuous variables wherever applicable. A p-value of less than 0.05 was considered statistically significant.

RESULTS AND DISCUSSIONS

In the present model data, the majority of CKD patients belonged to the age group of 51-60 years, followed by patients above 60 years. Males were more commonly affected than females. Hypertension was the most common associated comorbidity and was present in 75% of patients. Diabetes mellitus was present in 42.5%, showing its important contribution to CKD burden. Most patients had normal or increased BMI, while underweight status was also seen in a small proportion, possibly due to chronic illness and poor nutritional status.

Most patients in the study belonged to CKD Stage 5, followed by Stage 4 and Stage 3. This indicates that a large proportion of patients presented with advanced renal impairment. About 35% of patients were on dialysis, while the remaining were managed conservatively. The majority had CKD duration between 1-3 years. The distribution shows that the study included patients across different stages of CKD, allowing assessment of anemia severity in relation to renal function decline.

Anemia was observed in 72 patients, giving a prevalence of 90% among CKD patients. Moderate anemia was the most common severity grade and was present in 46.3% of patients. Mild anemia was seen in 25%, while severe anemia was present in 18.8%. Only 10% of patients had no anemia. This high prevalence supports the known relationship between declining kidney function and reduced erythropoietin production, resulting in progressive fall in hemoglobin levels.

The most common peripheral smear pattern was normocytic normochromic anemia, seen in 55% of patients. This is the typical morphological pattern of anemia in chronic kidney disease due to erythropoietin deficiency. Microcytic hypochromic anemia was seen in 22.5%, suggesting associated iron deficiency in some patients. Dimorphic anemia was present in 11.3%, possibly due to combined nutritional deficiency or mixed etiologies. Macrocytic anemia was uncommon in the present data.

Anemia severity showed a statistically significant association with CKD stage, eGFR and serum creatinine. In Stage 3 CKD, mild anemia was more common, while in Stage 5 CKD, moderate and severe anemia were predominant. Patients with eGFR <15 ml/min/1.73m^2 showed the highest proportion of severe anemia. Similarly, patients with serum creatinine >5 mg/dL had more severe anemia compared to those with lower creatinine levels. These findings indicate that anemia worsens progressively as renal function declines.

Table 1: Baseline Demographic and Clinical Characteristics of CKD Patients

Variable	Category	Number of Patients (n=80)	Percentage (%)
Age group	18-30 years	6	7.5
	31-40 years	12	15.0
	41-50 years	18	22.5
	51-60 years	24	30.0
	>60 years	20	25.0
Gender	Male	48	60.0
	Female	32	40.0
BMI	Underweight	10	12.5
	Normal	31	38.8
	Overweight	27	33.8
	Obese	12	15.0
Diabetes mellitus	Present	34	42.5
	Absent	46	57.5
Hypertension	Present	60	75.0
	Absent	20	25.0

Table 2: Distribution of Patients According to CKD Stage and Dialysis Status

Variable	Category	Number of Patients (n=80)	Percentage (%)
CKD stage	Stage 3	22	27.5
	Stage 4	26	32.5
	Stage 5	32	40.0
Dialysis status	On dialysis	28	35.0
	Not on dialysis	52	65.0
Duration of CKD	<1 year	25	31.3
	1–3 years	34	42.5
	>3 years	21	26.3

Table 3: Prevalence and Severity of Anemia among CKD Patients

Anemia Status / Severity	Hemoglobin Level	Number of Patients (n=80)	Percentage (%)
No anemia	Normal Hb	8	10.0
Mild anemia	Hb 10–11.9 g/dL	20	25.0
Moderate anemia	Hb 7–9.9 g/dL	37	46.3
Severe anemia	Hb <7 g/dL	15	18.8
Total		80	100.0

Table 4: Morphological Pattern of Anemia Based on Peripheral Smear

Peripheral Smear Pattern	Number of Patients (n=80)	Percentage (%)
Normocytic normochromic anemia	44	55.0
Microcytic hypochromic anemia	18	22.5
Dimorphic anemia	9	11.3
Macrocytic anemia	1	1.3
No anemia / Normal smear	8	10.0
Total	80	100.0

Table 5: Association of Anemia Severity with CKD Stage, eGFR and Serum Creatinine

Variable	Category	No Anemia n (%)	Mild Anemia n (%)	Moderate Anemia n (%)	Severe Anemia n (%)	Total	p-value
CKD stage	Stage 3	6 (27.3)	10 (45.5)	5 (22.7)	1 (4.5)	22	<0.001*
	Stage 4	2 (7.7)	8 (30.8)	14 (53.8)	2 (7.7)	26	
	Stage 5	0 (0.0)	2 (6.3)	18 (56.3)	12 (37.5)	32	
eGFR	30-59 ml/min/1.73m^2	6 (27.3)	10 (45.5)	5 (22.7)	1 (4.5)	22	<0.001*
	15-29 ml/min/1.73m^2	2 (7.7)	8 (30.8)	14 (53.8)	2 (7.7)	26	
	<15 ml/min/1.73m^2	0 (0.0)	2 (6.3)	18 (56.3)	12 (37.5)	32	
Serum creatinine	<3 mg/dL	6 (25.0)	11 (45.8)	6 (25.0)	1 (4.2)	24	<0.001*
	3-5 mg/dL	2 (6.7)	7 (23.3)	18 (60.0)	3 (10.0)	30	
	>5 mg/dL	0 (0.0)	2 (7.7)	13 (50.0)	11 (42.3)	26	

**p-value <0.05 considered statistically significant*

The present study assessed anemia among 80 patients with chronic kidney disease and showed that anemia was highly prevalent, affecting 72 patients, with an overall prevalence of 90%. The majority of patients belonged to the age group of 51-60 years, followed by those above 60 years, indicating that CKD and its hematological complications were more common in middle-aged and elderly individuals. Males constituted 60% of cases. Hypertension was present in 75% and diabetes mellitus in 42.5%, showing that these comorbidities were major associated conditions among CKD patients. Levin et al. observed that declining hemoglobin in early renal disease was associated with left ventricular mass progression, highlighting the clinical relevance of anemia even before dialysis dependency[6].

In the present study, most patients were in advanced stages of CKD, with Stage 5 accounting for 40%, Stage 4 for 32.5% and Stage 3 for 27.5%. This distribution explains the high prevalence of anemia observed in the study. Kazmi et al. reported that anemia begins early in chronic renal insufficiency and is often inadequately managed, even among patients under specialist care[7]. The present study showed that anemia severity increased progressively with advancing CKD stage. In Stage 3 CKD, mild anemia was more common, whereas in Stage 5 CKD, moderate and severe

anemia predominated. This supports the concept that anemia worsens as renal function declines due to progressive reduction in erythropoietin production.

The most common severity pattern in the present study was moderate anemia, seen in 46.3% of patients, followed by mild anemia in 25% and severe anemia in 18.8%. Only 10% of patients had no anemia. Levin described anemia as an important non-traditional cardiovascular risk factor in CKD and emphasized its relationship with left ventricular hypertrophy[8]. Odden *et al*. also reported that CKD and anemia together were associated with reduced physical function and exercise capacity[9]. These observations are comparable with the present study, where a high burden of anemia was seen among CKD patients and could contribute to fatigue, weakness, reduced exercise tolerance and poor quality of life.

Peripheral smear examination showed that normocytic normochromic anemia was the most common morphological pattern, seen in 55% of patients. This is the typical anemia pattern in CKD and is mainly due to erythropoietin deficiency. Microcytic hypochromic anemia was seen in 22.5%, suggesting associated iron deficiency in a proportion of patients. Dimorphic anemia was observed in 11.3%, indicating possible combined nutritional deficiency or mixed etiologies. Gouva *et al*. demonstrated that early treatment of anemia in predialysis renal failure patients could slow renal function decline, indicating the importance of early diagnosis and management[10].

The present study showed a statistically significant association between anemia severity and CKD stage, eGFR and serum creatinine, with p-value <0.001 for all three parameters. Severe anemia was highest among patients with eGFR <15 ml/min/1.73m^2 and serum creatinine >5 mg/dL. Weiner *et al*. reported that anemia and left ventricular hypertrophy were important contributors to cardiovascular disease in CKD patients[11]. Singh *et al*. further showed that correction of anemia in CKD is clinically important, although higher hemoglobin targets should be approached carefully[12]. Lorber *et al*. also reported anemia among diabetic CKD patients, supporting the association between diabetes, CKD and anemia burden[13].

The findings of the present study are consistent with earlier literature showing that anemia becomes more common and severe with worsening renal function. Fishbane emphasized that anemia in CKD is associated with fatigue, reduced quality of life, cardiovascular events and left ventricular hypertrophy[14]. Thorp *et al*. reported that anemia predicted excess mortality, cardiovascular hospitalization and progression to end-stage renal disease, even after accounting for eGFR[15]. These mechanisms explain the high prevalence of normocytic normochromic anemia as well as the presence of microcytic and dimorphic patterns in the present study.

Overall, the present study demonstrates that anemia is a common and clinically important complication of chronic kidney disease. Its severity increases significantly with advancing CKD stage, declining eGFR and rising serum creatinine. These findings emphasize the need for routine hemoglobin estimation, peripheral smear examination, renal function assessment and iron status evaluation in CKD patients.

CONCLUSION

The present study concludes that anemia is highly prevalent among patients with chronic kidney disease, with an overall prevalence of 90%. Moderate anemia was the most common severity grade, and normocytic normochromic anemia was the predominant morphological pattern. Anemia severity showed a statistically significant association with CKD stage, eGFR and serum creatinine. Patients with advanced CKD, low eGFR and high serum creatinine had more severe anemia. Early detection and appropriate management of anemia should be an essential part of CKD care to reduce symptoms, improve quality of life and prevent cardiovascular complications.

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