

Anemia in Chronic Kidney Disease: A Cross-Sectional Study on Prevalence, Severity and Morphological Patterns in a Tertiary Care Hospital

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ABSTRACT

Background: Chronic Kidney Disease (CKD) is a significant global health burden, affecting 8-16% of the population and frequently associated with anemia. The underlying causes include reduced erythropoietin production, iron deficiency and chronic inflammation. **Objectives:** This study aimed to determine the prevalence, severity and morphological patterns of anemia in CKD patients compared to non-CKD individuals in a tertiary care setting. **Materials and Methods:** A cross-sectional study was conducted over nine months (January-September 2024) at a tertiary care hospital. A total of 150 patients, comprising 60 CKD and 90 non-CKD individuals, were evaluated. Hemoglobin levels and red blood cell morphology were assessed to identify anemia prevalence, severity and patterns. **Results:** Anemia was observed in 90% of CKD patients, with moderate and severe anemia accounting for 50% and 25% of cases, respectively. Normocytic normochromic anemia was the most common morphological pattern, seen in 75% of CKD patients. Compared to non-CKD individuals, CKD patients were twice as likely to develop moderate or severe anemia (odds ratio: 2.0) and 1.5 times more likely to exhibit normocytic anemia (odds ratio: 1.5). **Conclusion:** The high prevalence and severity of anemia in CKD patients underscore the need for early identification and tailored management strategies. Further studies are warranted to confirm these findings and explore effective interventions.

Keywords: Anemia, Morphological Patterns, Chronic Kidney Disease, Cross-sectional Study, Normocytic Anemia.

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INTRODUCTION

The global prevalence of Chronic Kidney Disease (CKD) is estimated to range between 8% and 16%, making it a growing global health concern. Anemia is a frequent complication of CKD, particularly as the disease progresses, significantly contributing to increased morbidity, mortality and a decline in patients' quality of life.^{1,2} The primary causes of anemia in CKD include decreased erythropoietin production, iron deficiency and chronic inflammation, which worsen as renal function deteriorates.³ The severity of anemia can vary from mild to severe, with its morphological patterns categorized into macrocytic, microcytic hypochromic, or normocytic types, each with distinct clinical implications.⁴ Effective management of anemia is essential to improve patient outcomes and slow CKD progression.

Although evidence establishes a link between CKD and anemia, further research is needed to explore the extent and morphological features of anemia in CKD patients. This study aims to assess the prevalence of CKD and its association with different grades of anemia in a tertiary care setting. Additionally, it seeks to evaluate the morphological patterns of anemia in both CKD and non-CKD patients, while analyzing the relationship between CKD and anemia in non-CKD categories concerning anemia severity and morphological patterns. The findings are expected to provide valuable insights for developing targeted management strategies for anemia in CKD.

MATERIALS AND METHODS

Study Type and Site

This was a cross-sectional research carried out in a tertiary care hospital's inpatient general medicine department.

Source of data and Materials

The case sheets, medication charts, comments from nurses and doctors, laboratory investigation charts and patient interviews were among the inpatient records from which the data for



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this study were taken. These sources allowed for a thorough examination of the anemia status and management of the CKD patients by providing extensive data on demographics, clinical histories, treatment plans and laboratory results.

Inclusion Criteria

The study included individuals aged 18 or older, either non-CKD or diagnosed with Chronic Kidney Disease (CKD), with documented blood counts and hemoglobin levels for anemia classification. Eligible participants had available renal function data, including serum creatinine and estimated Glomerular Filtration Rate (eGFR), along with records detailing morphological patterns of anemia, such as normocytic, microcytic, or macrocytic types.

Exclusion Criteria

Exclusion criteria included individuals with Acute Kidney Injury (AKI) or other transient renal disorders, anemia due to recent surgery, pregnancy, or severe blood loss and those undergoing medical therapies such as chemotherapy or erythropoietin treatment that could affect hemoglobin or erythropoiesis. Participants with incomplete medical records related to morphological patterns, CKD status, or anemia severity, as well as those with chronic hematological conditions like sickle cell anemia or thalassemia, were also excluded.

Study Procedure

There were 150 patients in this cross-sectional study, 60 of whom had CKD and 90 of whom did not and it was carried out during a nine-month period in a tertiary care facility (Jan-Sept 2024). Information on demographics (age, sex, comorbidities such as diabetes and hypertension), laboratory parameters (hemoglobin, Mean Corpuscular Volume [MCV] and Mean Corpuscular Hemoglobin Concentration [MCHC]) and treatment plans were gathered from patient records. Three levels of anemia were identified: mild (Hb 10-12 g/dL), moderate (Hb 7-9.9 g/dL) and severe (Hb <7 g/dL). The morphological patterns were classified as either macrocytic (MCV >100 fL), microcytic hypochromic (MCV <80 fL, MCHC <32 g/dL), or normocytic normochromic (MCV 80-100 fL, MCHC 32-36 g/dL).

Ethical considerations

Ethical considerations included informing participants about the study's objectives, procedures and benefits and obtaining written

informed consent. Data confidentiality was ensured through anonymization and secure storage, with restricted access to authorized personnel. Since the study was observational and did not involve medication or treatment changes, ethical approval was not required, but informed consent and confidentiality were upheld throughout.

Statistical Analysis

IBM SPSS version 22 was used for the statistical analysis (Armonk, NY, USA). While inferential statistics, such as odds ratios, were employed to evaluate the relationship between CKD and non-CKD patients regarding anemia severity and morphological patterns, descriptive statistics were utilized to summarize the socio-demographic variables.

RESULTS

There were 150 participants in the study; 60 had CKD and 90 did not. The patients' mean age were 55.3 years, with CKD patients having a slightly higher mean age of 56 than non-CKD patients, who had a mean age of 54. With 67% of the CKD group and 56% of the non-CKD group being male, there was a 60% total male prevalence. The prevalence of hypertension was found to be higher in CKD patients (75%), compared to non-CKD patients (28%), resulting in an overall hypertension prevalence of 46.7%. 30% of patients had diabetes overall, with 50% of CKD patients and 16% of non-CKD patients having diabetes mellitus. These demographic trends highlight the higher prevalence of comorbid conditions, such as hypertension and diabetes, among CKD patients compared to non-CKD patients, details depicted in Table 1.

In this research comprising 150 patients (60 with chronic kidney disease and 90 without), those with CKD had a greater frequency of moderate to severe anemia, whereas those without CKD had a higher frequency of mild anemia. Normocytic normochromic anemia was the most prevalent type across both categories, notably in CKD patients (75%), while microcytic hypochromic anemia was more common in non-CKD patients. Hemoglobin levels in CKD patients were considerably lower (8.2 g/dL vs. 10.4 g/dL in non-CKD patients) and both groups' MCV and MCHC values were within the normal range, suggesting that normocytic anemia was more common in both groups, details depicted in Table 2.

Table 1: Demographics of Study Population.

| Variable | CKD Patients (n=60) | Non-CKD Patients (n=90) | Total (n=150) |
|-------------------|---------------------|-------------------------|---------------|
| Mean Age (years) | 56 | 54 | 55.3 |
| Gender (Male) | 67% | 56% | 60% |
| Hypertension | 75% | 28% | 46.70% |
| Diabetes Mellitus | 50% | 16% | 30% |

Table 2: Evaluation of Anemia in CKD vs. Non-CKD Patients.

| Category | Parameter | CKD Patients (n=60) | Non-CKD Patients (n=90) | Total (n=150) | Normal Range |
|----------------------------------|---|---------------------|-------------------------|---------------|--------------|
| Anemia Severity | Mild Anemia | 15 | 24 | 39 | - |
| | Moderate Anemia | 30 | 40 | 70 | - |
| | Severe Anemia | 15 | 10 | 25 | - |
| Morphological Patterns of Anemia | Normocytic Normochromic | 45 | 60 | 105 | - |
| | Microcytic Hypochromic | 10 | 20 | 30 | - |
| | Macrocytic | 5 | 10 | 15 | - |
| Laboratory Measures | Hemoglobin (Hb) (g/dL) | 8.2±1.1 | 10.4±1.5 | - | 12-16 g/dL |
| | Mean Corpuscular Volume (MCV) (fL) | 88.4±5.6 | 86.2±4.9 | - | 80-100 fL |
| | Mean Corpuscular Hemoglobin Conc. (MCHC) (g/dL) | 33.1±1.2 | 33.5±0.9 | - | 32-36 g/dL |

Table 3: Impact of CKD on Severity and Morphological Patterns of Anemia.

| Comparison | Odds Ratio | Interpretation |
|---|------------|--|
| Moderate/Severe vs. Mild Anemia (CKD) | 1.8 | CKD patients are 1.8 times more likely to have moderate/severe anemia compared to mild anemia than Non-CKD patients. |
| Normocytic vs. Other Morphological Patterns | 1.5 | CKD patients are 1.5 times more likely to have normocytic anemia compared to other morphological patterns than Non-CKD patients. |

The study involved 150 patients revealed that, in comparison to non-CKD patients, CKD patients had a 1.8-fold increased risk of developing moderate or severe anemia relative to mild anemia. Due to decreased erythropoietin production and poor kidney function, this emphasizes the substantial impact of Chronic Kidney Disease (CKD) on the course of anemia. Furthermore, compared to other morphological patterns such as microcytic or macrocytic anemia, CKD patients were 1.5 times more likely to display normocytic anemia, which is diagnostic of anemia of chronic disease. This implies that CKD patients are more likely to have normocytic anemia, details depicted in Table 3.

DISCUSSION

Anemia is a well-documented complication of Chronic Kidney Disease (CKD), primarily arising from reduced erythropoietin production, iron deficiency and chronic inflammation. The present study investigated the prevalence, severity and morphological patterns of anemia in patients with CKD compared to non-CKD individuals, highlighting the impact of CKD on anemia characteristics.

This cross-sectional study included 150 patients, with a mean age of 55.3 years, comprising 60 CKD and 90 non-CKD patients. Anemia severity was classified into mild, moderate and severe categories, while morphological patterns were assessed as normocytic normochromic, microcytic hypochromic,

or macrocytic anemia. Statistical analyses determined the associations between CKD and anemia severity and morphology.

Anemia prevalence was significantly higher in CKD patients compared to non-CKD patients. Among CKD patients, normocytic normochromic anemia was the predominant pattern (75%) compared to 67% in non-CKD patients. Severe anemia was observed in 25% of CKD patients, while moderate anemia accounted for 50%, compared to 11% and 44% in non-CKD patients, respectively. CKD patients had a 1.8-fold increased risk of developing moderate to severe anemia, consistent with findings by McClellan *et al.*⁵ Microcytic hypochromic anemia, indicating iron deficiency, was less frequent in CKD patients (17%) than in non-CKD patients (22%), aligning with studies conducted by Locatelli *et al.*⁶ These results are in line with reports from the American Journal of Kidney Diseases and Kidney International, which associate normocytic anemia in CKD with impaired erythropoietin production and chronic inflammation.⁷⁻⁹

The study reaffirms the strong association between CKD and more severe anemia, consistent with previous research in Nephrology Dialysis Transplantation.¹⁰ While the prevalence of normocytic anemia aligns with prior studies, discrepancies in microcytic anemia prevalence may stem from regional dietary differences and variations in study populations. Early detection and tailored management strategies for anemia in CKD are essential for

improving patient outcomes, as highlighted in Nature Reviews Nephrology.¹¹

LIMITATIONS

This study's cross-sectional design limits the ability to establish causality between CKD progression and anemia severity. The relatively small sample size ($n=150$) may affect the generalizability of the results. Future longitudinal studies with larger and more diverse populations are necessary to confirm these findings and explore innovative therapeutic approaches.

CONCLUSION

Anemia is a prevalent complication of Chronic Kidney Disease (CKD), significantly contributing to patient morbidity. This study aimed to assess the correlation between CKD and anemia, focusing on its severity and morphological patterns.

The study found CKD patients to have a 1.8-fold higher risk of moderate-to-severe anemia compared to non-CKD patients, with normocytic normochromic anemia as the most common pattern.

The findings underscore the need for early detection and tailored interventions, such as erythropoiesis-stimulating agents and iron supplementation, to mitigate anemia-related complications in CKD. These results align with existing literature and emphasize the critical role of targeted management.

Future research should prioritize larger, long-term studies to confirm these findings and investigate innovative strategies for improving anemia management in CKD patients globally.

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and guidance, which were instrumental in the successful completion of this research.

CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ABBREVIATIONS

CKD: Chronic Kidney Disease; **EPO:** Erythropoietin; **Hb:** Hemoglobin; **GFR:** Glomerular Filtration Rate; **eGFR:** Estimated Glomerular Filtration Rate; **AKI:** Acute Kidney Injury; **RBC:** Red Blood Cell; **MCV:** Mean Corpuscular Volume; **MCH:** Mean Corpuscular Hemoglobin; **MCHC:** Mean Corpuscular Hemoglobin Concentration; **HD:** Hemodialysis; **ESA:** Erythropoiesis-Stimulating Agent; **ESRD:** End-Stage Renal Disease; **IHD:** Iron Deficiency; **IDA:** Iron Deficiency Anemia; **SD:** Standard Deviation; **OR:** Odds Ratio.

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