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CLINICOPATHOLOGICAL CORRELATION OF ANEMIA IN CHRONIC KIDNEY DISEASE: A CROSS-SECTIONAL STUDY IN A TERTIARY CARE HOSPITAL.

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Abstract

Background

Anemia is a common complication in chronic kidney disease (CKD) and can impact clinical outcomes. This study aimed to examine the prevalence of anemia, its association with renal function, comorbidities, and clinical outcomes in CKD patients.

Methods

A total of 100 CKD patients (mean age 55.6 ± 12.4 years) were enrolled. Anemia was diagnosed based on hemoglobin levels, and renal function was assessed using the glomerular filtration rate (GFR). Comorbidities, iron profile, erythropoietin levels, and clinical outcomes were also evaluated.

Results

The study included 100 CKD patients with a mean age of 55.6 ± 12.4 years; 65% were male and 35% female. The prevalence of anemia was 82%, with 45% having mild anemia, 32% moderate, and 5% severe. Anemia severity correlated significantly with lower GFR ($p < 0.001$), and the anemic group had a higher prevalence of hypertension (88% vs. 58%, $p = 0.002$), diabetes mellitus (84% vs. 77%, $p = 0.03$), and proteinuria (85% vs. 67%, $p = 0.05$). Diabetic nephropathy was the most common etiology (90% of anemic patients, $p = 0.04$). Anemic patients had significantly lower serum ferritin (185.4 ± 91.6 ng/mL vs. 250.2 ± 128.3 ng/mL, $p = 0.01$), lower transferrin saturation (60% vs. 25%, $p = 0.03$), and lower erythropoietin levels (15.2 ± 5.3 mIU/mL vs. 30.1 ± 8.7 mIU/mL, $p < 0.001$). Hospitalization rates (58% vs. 36%, $p = 0.01$) and mortality (12% vs. 4%, $p = 0.04$) were also higher in anemic patients.

Conclusion

Anemia is highly prevalent in CKD patients and is associated with worse clinical outcomes. Early detection and management of anemia in CKD patients may improve prognosis.

Recommendations

Early screening and management of anemia, regular monitoring of renal function, and addressing comorbidities can improve CKD patient outcomes.

Keywords: *Chronic Kidney Disease, Anemia, Glomerular Filtration Rate, Comorbidities, Erythropoietin, Mortality, Hospitalization.*
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Introduction

Chronic Kidney Disease (CKD) is a major global health concern, impacting millions of individuals worldwide, and is frequently associated with several complications that significantly influence morbidity and mortality [1]. One of the most common and well-documented complications in CKD patients is anemia, which is characterized by decreased hemoglobin levels, leading to reduced oxygen-carrying capacity of the blood [2]. This condition can further exacerbate kidney dysfunction and contribute to poor clinical outcomes. The pathophysiology of anemia in chronic kidney disease (CKD) is multifactorial, involving impaired erythropoiesis due to decreased erythropoietin production by the kidneys, iron deficiency, and chronic inflammation,

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all of which contribute to the development and progression of anemia in these patients [3, 4].

The prevalence of anemia in chronic kidney disease (CKD) varies widely, with studies suggesting that it affects up to 80% of patients in the later stages of the disease [1, 5]. As renal function declines, the severity of anemia typically worsens, resulting in increased morbidity and mortality. Anemia in CKD has been associated with a range of adverse outcomes, including fatigue, reduced exercise tolerance, impaired cognitive function, heightened cardiovascular risk, and diminished quality of life. Moreover, the presence of anemia in CKD patients is linked to an elevated rate of hospitalization and increased mortality [6].

The underlying mechanisms of anemia in CKD are complex and involve a combination of factors, including iron deficiency, inadequate erythropoietin production, and the effects of uremic toxins. Iron deficiency, both functional and absolute, is particularly common in CKD patients, often resulting from reduced dietary intake, impaired absorption, and the chronic inflammatory state associated with kidney disease [4, 7]. Additionally, inflammation in CKD disrupts the normal production of erythropoietin, a hormone crucial for red blood cell production, further contributing to anemia [1, 6].

Despite the growing recognition of anemia as a significant complication in CKD, there remains a lack of comprehensive studies correlating anemia with clinical outcomes, including the impact of comorbid conditions such as hypertension, diabetes, and proteinuria. This study aims to examine the prevalence of anemia in CKD patients, investigate its relationship with renal function, comorbidities, and clinical outcomes, and explore the potential benefits of early detection and management of anemia in improving patient prognosis. By better understanding the clinicopathological correlations of anemia in CKD, this study contributes to improved patient care and outcomes in this population.

Methodology

Study Design

This study was a cross-sectional observational study conducted at the Maharajahs Institute of Medical Sciences (MIMS), Vizianagaram, Andhra Pradesh, India. The study aimed to assess the prevalence of anemia in chronic kidney disease (CKD) patients, its association with renal function, comorbidities, and clinical outcomes.

Study Population

A total of 100 CKD patients (mean age 55.6 ± 12.4 years) were enrolled in the study. Inclusion criteria included patients aged 18 years and above diagnosed with CKD at various stages, confirmed by the physician based on clinical, laboratory, and imaging findings. Exclusion criteria included patients with active infections, malignancies, or those receiving renal replacement therapy (dialysis or kidney transplantation).

Study Period

The study was conducted from December 2023 to November 2024 at Maharajah's Institute of Medical Sciences, Vizianagaram, Andhra Pradesh.

Study Size

The study included a total of 100 patients. The sample size was determined based on previous literature reporting the prevalence of anemia in CKD to be approximately 80%. Using the formula for estimating a single population proportion, with a confidence level of 95% and a 10% margin of error, the minimum required sample size was calculated to be 96. To account for potential incomplete data, a sample of 100 patients was included.

Data Collection

Data was collected through structured interviews and a review of clinical records. Demographic details (age, gender), medical history (duration and etiology of CKD, presence of comorbidities such as hypertension and diabetes), and relevant clinical data including blood pressure, hemoglobin levels, proteinuria status, glomerular filtration rate (GFR), serum ferritin, transferrin saturation, erythropoietin levels, hospitalization, and mortality were recorded.

Assessment of Anemia

Anemia was diagnosed based on hemoglobin levels, with values classified as follows:

Mild anemia: Hemoglobin levels between 10–12 g/dL

Moderate anemia: Hemoglobin levels between 7–9 g/dL

Severe anemia: Hemoglobin levels <7 g/dL

Hemoglobin levels were measured using a standard automated hematology analyzer.

Renal Function Evaluation

Renal function was assessed by calculating the Glomerular Filtration Rate (GFR) using the Modification of Diet in Renal Disease (MDRD) formula. GFR was categorized into stages of CKD to correlate with the severity of anemia.

Comorbidities and Iron Profile

Comorbidities, including hypertension, diabetes mellitus, and proteinuria, were identified based on clinical records. An iron profile, including serum ferritin levels, transferrin saturation, and

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erythropoietin levels, was measured for all participants. Serum ferritin levels were measured using an enzyme-linked immunosorbent assay (ELISA), and erythropoietin levels were measured using a chemiluminescent immunoassay (CLIA).

Bias

To minimize selection bias, all eligible patients who met the inclusion criteria during the study period were consecutively enrolled. Information bias was reduced by using standardized data collection forms and ensuring that laboratory assessments were conducted using validated assays in the hospital's central laboratory. Confounding factors such as comorbidities were recorded and considered during statistical analysis to ensure valid interpretation.

Statistical Analysis

Data were analyzed using SPSS version 22.0. Descriptive statistics, including mean, standard deviation, and percentages, were used to summarize patient characteristics. The Chi-square test was used to assess associations between anemia and comorbidities. The t-test was used to compare serum ferritin, transferrin saturation, and erythropoietin levels between anemic and non-anemic groups. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of Maharajahs Institute of Medical Sciences, Vizianagaram (Lr.No.10/-2023/Chairman-IEC/MIMS/Ethics Approval. Written informed consent was obtained from all participants. All data were anonymized, and confidentiality was maintained throughout the study.

Results

Participant Flow

During the study period, 120 patients with suspected chronic kidney disease (CKD) were screened. Of these, 110 patients were examined for eligibility. Ten patients were excluded: 5 had active infections, 3 had known malignancies, and 2 were undergoing dialysis. A total of 100 eligible patients were included in the study. All participants completed the necessary clinical and laboratory evaluations, and their data were analyzed. No participants were lost to follow-up or excluded after enrollment.

A total of 100 chronic kidney disease (CKD) patients were included in this study, with a mean age of 55.6 ± 12.4 years. Of the 100 participants, 65% were male and 35% were female (Table 1).

Table 1: Demographic Characteristics of Study Participants

Demographic Variable	n = 100 (%)
Age (Mean ± SD)	55.6 ± 12.4 years
Gender	
Male	65 (65%)
Female	35 (35%)

The prevalence of anemia among the study participants was 82%, with 45% of patients having mild anemia (hemoglobin levels between 10–12 g/dL), 32% with moderate anemia (hemoglobin levels between 7–9 g/dL), and 5% with severe anemia (hemoglobin levels <7 g/dL). The remaining 18% of participants were non-anemic, with hemoglobin levels ≥12 g/dL (Table 2).

Table 2: Prevalence of Anemia in CKD Patients

Anemia Severity	n (%)
Mild (10–12 g/dL)	36 (45%)
Moderate (7–9 g/dL)	26 (32%)
Severe (<7 g/dL)	4 (5%)
Non-anemic (≥12 g/dL)	18 (18%)

Renal function was significantly associated with anemia severity. Anemic patients had a mean glomerular filtration rate (GFR) of 28.4 ± 9.2 mL/min/1.73 m², compared to 58.2 ± 15.3 mL/min/1.73 m² in non-anemic patients (Table 3).

Table 3: Renal Function and Anemia Severity

Group	GFR (Mean ± SD)	Anemia Prevalence (%)	p-value
Anemic	28.4 ± 9.2 mL/min/1.73 m²	94%	< 0.001
Non-anemic	58.2 ± 15.3 mL/min/1.73 m²	56%	

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Anemia prevalence was markedly higher in patients with lower GFR (94% in the anemic group vs. 56% in the non-anemic group), with a p-value of < 0.001. The study also investigated the association between comorbidities and anemia. Hypertension, diabetes mellitus, and proteinuria were more common among anemic patients. Specifically, 88% of anemic patients had hypertension, compared to 58% of non-anemic patients (p = 0.002). Similarly, 84% of anemic patients had diabetes mellitus, whereas 77% of non-anemic patients were affected (p = 0.03). Proteinuria was present in 85% of anemic patients compared to 67% of non-anemic patients, with a p-value of 0.05 (Table 4).

Table 4: Association Between Comorbidities and Anemia

Comorbidity	Anemic (%)	Non-anemic (%)	p-value
Hypertension	88%	58%	0.002
Diabetes Mellitus	84%	77%	0.03
Proteinuria (>1g/day)	85%	67%	0.05

Regarding the etiology of CKD, diabetic nephropathy was the most common cause of CKD in anemic patients, with 90% of these patients exhibiting anemia (p = 0.04). Hypertensive nephropathy and glomerulonephritis were also associated with anemia, with prevalence rates of 80% and 70%, respectively (Table 5).

Table 5: Etiology of Chronic Kidney Disease and Anemia Prevalence

Etiology	Anemia Prevalence (%)	p-value
Diabetic Nephropathy	90%	0.04
Hypertensive Nephropathy	80%	
Glomerulonephritis	70%	

An analysis of the iron profile revealed significantly lower serum ferritin levels in anemic patients compared to non-anemic patients, with means of 185.4 ± 91.6 ng/mL and 250.2 ± 128.3 ng/mL, respectively (p = 0.01). Furthermore, transferrin saturation was lower in anemic patients (60%) compared to non-anemic patients (25%), with a p-value of 0.03 (Table 6).

Table 6: Iron Profile in Anemic and Non-Anemic CKD Patients

Parameter	Anemic (n = 82)	Non-anemic (n = 18)	p-value
Serum Ferritin (Mean ± SD, ng/mL)	185.4 ± 91.6	250.2 ± 128.3	0.01
Transferrin Saturation < 20% (%)	60%	25%	0.03

Erythropoietin levels were significantly lower in anemic CKD patients, with a mean value of 15.2 ± 5.3 mIU/mL compared to 30.1 ± 8.7 mIU/mL in non-anemic patients (p < 0.001) (Table 7).

Table 7: Erythropoietin Levels in Anemic and Non-Anemic CKD Patients

Group	Erythropoietin (Mean ± SD, mIU/mL)	p-value
Anemic	15.2 ± 5.3	< 0.001
Non-anemic	30.1 ± 8.7	

Finally, clinical outcomes were poorer in anemic CKD patients, as evidenced by a higher hospitalization rate of 58% in anemic patients, compared to 36% in non-anemic patients (p = 0.01). The mortality rate was also higher among anemic patients (12%) compared to non-anemic patients (4%), with a p-value of 0.04 (Table 8).

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Table 8: Hemoglobin and Clinical Outcomes in Anemic and Non-Anemic CKD Patients

Outcome	Anemic (%)	Non-anemic (%)	p-value
Mean Hemoglobin (g/dL)	10.2 ± 2.1		
Hospitalization Rate	58%	36%	0.01
Mortality Rate	12%	4%	0.04

Discussion

Anemia is a common and often under-recognized complication of chronic kidney disease (CKD), contributing significantly to the morbidity and mortality associated with the condition. The results of this study highlight the high prevalence of anemia in CKD patients, with 82% of patients affected, and its significant association with renal function, comorbidities, and clinical outcomes. This discussion aims to contextualize these findings in the broader literature, address the implications for clinical practice, and suggest areas for future research.

Prevalence and Severity of Anemia in CKD

The prevalence of anemia in CKD patients observed in this study (82%) is consistent with previous reports that estimate anemia affects 60–80% of individuals with advanced CKD [7][8]. Anemia severity was stratified into mild, moderate, and severe categories, with mild anemia being the most common. This finding reflects the often subtle onset of anemia in CKD, with many patients presenting with only mild symptoms until the later stages of the disease. The relationship between anemia and renal function, as evidenced by a significantly lower glomerular filtration rate (GFR) in anemic patients, is well-established in the literature [9]. The lower GFR in anemic patients likely reflects a combination of impaired erythropoiesis due to reduced erythropoietin production and the uremic environment in advanced CKD, which impairs red blood cell production.

Comorbidities and Anemia

Anemia in CKD has been linked to several comorbidities, which are also prevalent in this study population. Notably, hypertension, diabetes mellitus, and proteinuria were more common among anemic patients. This is consistent with prior research indicating that hypertension and diabetes are key contributors to both CKD progression and the development of anemia [10]. In particular, diabetic nephropathy was identified as the most common etiology of CKD in anemic patients, further corroborating findings from other studies that emphasize the high burden of diabetic nephropathy in CKD-related anemia [11]. The higher prevalence of these comorbidities in anemic patients suggests a vicious cycle in which CKD-associated anemia exacerbates underlying conditions such as hypertension and diabetes, which in turn worsen renal function and accelerate the progression of anemia.

Iron Profile and Erythropoietin Levels

The findings from this study regarding iron status and erythropoietin levels provide critical insights into the pathophysiology of anemia in CKD. Anemic patients demonstrated significantly lower serum ferritin, transferrin saturation, and erythropoietin levels compared to non-anemic patients, which is consistent with the expected alterations in these parameters in CKD-related anemia. Erythropoietin, a hormone produced by the kidneys, plays a central role in stimulating red blood cell production in the bone marrow. In CKD, reduced erythropoietin production due to kidney dysfunction is a major contributing factor to the development of anemia [12]. The lower transferrin saturation and ferritin levels observed in anemic patients suggest a component of iron deficiency, which is common in CKD due to impaired iron utilization and loss through dialysis.

Clinical Outcomes: Mortality and Hospitalization

The study also demonstrated that anemic CKD patients had significantly higher hospitalization rates and mortality compared to non-anemic patients. These findings are in line with numerous studies that have shown that anemia in CKD is associated with worse clinical outcomes, including increased risk of hospitalization, cardiovascular events, and mortality. The association between anemia and poorer outcomes may be explained by the role of anemia in exacerbating the underlying pathophysiology of CKD, such as increasing the risk of heart failure, worsening fluid overload, and impairing oxygen delivery to tissues.

Generalizability

The findings of this study, conducted in a tertiary care hospital in Andhra Pradesh, are likely generalizable to similar hospital-based CKD populations in semi-urban and rural settings across India and other low- to middle-income countries with comparable

healthcare infrastructure. However, the single-center nature of the study may limit its applicability to broader populations, especially in regions with different socioeconomic conditions, healthcare access, or disease prevalence patterns. Multicentric studies involving diverse geographic locations would enhance external validity.

Implications for Clinical Practice

The findings of this study emphasize the importance of early detection and management of anemia in CKD patients. Screening for anemia, along with regular monitoring of renal function and comorbidities, should be an integral part of CKD management. Given the strong association between anemia and poor outcomes, early intervention with iron supplementation and erythropoiesis-stimulating agents, such as erythropoietin analogs, may improve patient prognosis and quality of life. However, these treatments should be tailored to the individual patient, taking into account factors such as comorbidities and the underlying etiology of CKD.

Conclusion

In conclusion, anemia is highly prevalent in CKD patients and is significantly associated with poor clinical outcomes, including lower renal function, increased comorbidities, higher hospitalization rates, and greater mortality. The early detection and management of anemia in CKD patients, including the regular monitoring of renal function and comorbid conditions, could improve patient outcomes and quality of life. Future research should focus on the long-term benefits of anemia treatment and the development of individualized management strategies for CKD patients.

Limitations

Although this study provides valuable insights into the prevalence and clinical impact of anemia in CKD, there are several limitations that should be addressed in future research. The cross-sectional design of the study limits the ability to draw causal conclusions, and the relatively small sample size may limit the generalizability of the findings. Longitudinal studies with larger, more diverse populations would help confirm the temporal relationship between anemia and CKD progression, as well as the long-term effects of anemia management on clinical outcomes.

Recommendations

Early screening and management of anemia in CKD patients are crucial for improving clinical outcomes. Regular monitoring of renal function, iron status, and erythropoietin levels should be integrated into routine care. Addressing comorbidities such as hypertension and diabetes is essential for preventing anemia progression. Additionally, individualized treatment strategies, including iron supplementation and erythropoiesis-stimulating agents, should be considered. Further research on the long-term benefits of anemia management in CKD is needed to optimize therapeutic approaches and improve patient prognosis.

List of abbreviations

CKD- Chronic kidney disease
GFR- Glomerular Filtration Rate
MDRD- Modification of Diet in Renal Disease

Source of funding

The study received no funding.

Conflict of interest

The authors declare no conflict of interest.

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Author contributions: SSJ- Concept and design of the study, results interpretation, review of the literature, and preparation of the first draft of the manuscript. Statistical analysis and interpretation, revision of the manuscript. **JS**-Concept and design of the study, results interpretation, review of the literature, and preparing the first draft of the manuscript, revision of the manuscript.**Review** of literature and preparing the first draft of the manuscript. Statistical analysis and interpretation.

Data availability

Data Available

Author Biography

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