Characteristics of peripheral blood cells in patients with chronic renal failure at Thai Nguyen Central General Hospital

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Summary

Objective: To describe the characteristics of peripheral blood cells and analyze factors associated with changes in peripheral blood cell parameters among patients with chronic kidney disease (CKD) treated at Thai Nguyen Central General Hospital. *Subject and method:* A cross-sectional descriptive study was conducted on 116 patients with CKD. Hematological indices (RBC, HGB, HCT, MCV, MCH, MCHC, WBC, PLT), biochemical parameters (total protein, albumin, creatinine, urea, serum iron, and ferritin), and CKD stages were collected and analyzed to determine their relationships. Results: The mean age was 65.7 ± 13.9 years, with 72.4% aged ≥ 60 years. Anemia was present in 65.5% of patients, including 46.6% with moderate and 6.9% with severe anemia. Mean values of HGB (111.6 ± 24.3g/L), HCT (33.2 ± 7.4%), and RBC (3.88 ± 0.87T/L) were below normal reference ranges. Red cell indices - MCV (86.9 ± 8.6fL), MCH (29.0 ± 3.6pg), and MCHC (331.2 ± 32.1g/L) - were mostly within normal limits, indicating normocytic-normochromic anemia. HGB, HCT, and RBC levels were significantly lower in CKD stages IV - V compared with stages I–III ($p<0.001$), while MCV, MCH, MCHC, WBC, and PLT showed no significant differences. The severity of anemia correlated negatively with serum creatinine ($r = -0.495$) and positively with serum albumin ($r = 0.379$), suggesting that both progressive renal impairment and protein-energy wasting contribute to the pathogenesis of anemia. *Conclusion:* Anemia is a common and progressive complication of CKD, predominantly normocytic-normochromic, reflecting reduced erythropoietin production. Both declining renal function and malnutrition are associated with disease progression. Regular monitoring of HGB, albumin, and creatinine is essential for early detection and management of anemia in CKD patients.

Keywords: Chronic kidney disease, anemia, Peripheral Blood Cells.

I. BACKGROUND

Chronic kidney disease (CKD) is a major global health problem, with an increasing prevalence due to the growing burden of chronic conditions such as hypertension, diabetes mellitus, and metabolic disorders [1,2]. As renal function declines, patients experience multiple disturbances in homeostasis, among which hematological abnormalities are common and clinically significant complications [3].

Peripheral blood cell disorders in CKD patients include anemia, alterations in red blood cells, leukocytes, and platelets, as well as changes in related hematologic parameters [4]. Among these, anemia is the most frequent complication, typically observed in advanced stages of CKD due to decreased erythropoietin production, functional iron deficiency, chronic inflammation, and protein–energy malnutrition [4,5]. If not detected and managed in time, anemia and other hematologic

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abnormalities can exacerbate heart failure, reduce quality of life, and increase mortality risk [6].

The evaluation of peripheral blood cell indices using modern hematology analyzers is a simple, cost-effective, and valuable method for monitoring disease progression and assessing treatment outcomes [7]. However, in Vietnam, studies on hematologic characteristics in CKD patients remain limited, particularly regarding detailed descriptions of changes in peripheral blood cells according to CKD stage [8].

Therefore, investigating the hematological profiles of CKD patients has practical significance for diagnosis, assessing disease severity, and guiding supportive management. We conducted this study entitled **"**Peripheral blood cell characteristics in patients with chronic kidney disease at Thai Nguyen Central General Hospital" with the following objectives: *To describe the changes in peripheral blood cells among patients with chronic kidney disease at Thai Nguyen Central General Hospital.To analyze several factors associated with alterations in peripheral blood cells in patients with chronic kidney disease.*

II. SUBJECTS AND METHODS

2.1. Study subjects

All patients with chronic kidney disease (CKD) treated at Thai Nguyen Central General Hospital from January 2025 to July 2025.

Inclusion criteria:

Patients diagnosed with chronic kidney disease (CKD) who were hospitalized and treated in the Department of Nephrology, Thai Nguyen Central General Hospital, from January 2025 to July 2025.

Exclusion criteria:

Patients were excluded from the study if they met any of the following conditions: unclear or incomplete medical records; pregnancy; presence of fever or bleeding; liver diseases (such as liver cancer, hepatitis, or cirrhosis); infections; hematologic disorders (such as leukemia, thalassemia, or other blood or bone marrow diseases); or a history of blood transfusion within the previous three months.

2.2. Research Methods

Study site: Department of Nephrology, Thai Nguyen Central General Hospital.

Study design: Cross-sectional descriptive study.

Sample size: All patients with chronic kidney disease treated at Thai Nguyen Central General Hospital from January 2025 to July 2025.

Data collection methods:

Data were collected using a structured medical record form.

Estimation of glomerular filtration rate (GFR): The estimated GFR (eGFR) was calculated using the CKD-EPI 2021 equation. The stages of chronic kidney disease were classified according to GFR levels following the KDIGO 2012 guidelines.

Classification of anemia severity:

Mild anemia: Male: Hb 11.0-12.9g/dL; Female: Hb 11.0-11.9g/dL.

Moderate anemia: Hb 8.0-10.9g/dL.

Severe anemia: Hb < 8.0g/dL.

Study contents and parameters:

Demographic characteristics: age and sex.

Peripheral blood cell counts and biochemical parameters including plasma urea, plasma creatinine, total protein, and serum albumin.

Relationship between peripheral blood cell indices and renal function status.

Correlation between hematologic parameters and biochemical markers: total protein, serum albumin, plasma urea, and plasma creatinine.

Relationship between hematologic parameters and iron metabolism markers: serum iron and ferritin.

Statistical analysis: Data were processed using medical statistical methods with appropriate statistical tests. An independent T-test was applied to compare two means, and Pearson's correlation coefficient was used to evaluate relationships between continuous variables. A p-value < 0.05 was considered statistically significant.

2.3. Research Ethics

The study was approved by the Ethics Committee of Thai Nguyen University of Medicine and Pharmacy, Thai Nguyen University.

III. RESULTS

3.1. Characteristics of the study population

Table 1. Characteristics of the study group

Characteristics		n	%
Age (years)	≤ 39 years	9	7,8
	40-59 years	23	19,8
	≥ 60 years	84	72,4
	Mean age (± SD)	65,7±13,9	
Gender	Male	56	48,2
	Female	60	49,8
Ethnicity	Kinh	73	62,9
	Minority groups	43	37,1
Place of residence	Urban	44	37,9
	Rural	72	62,1

Comment: Table 1 shows that the study group consisted of 116 patients with chronic kidney disease, most of whom were aged ≥ 60 years (72.4%), with a mean age of 65.7 ± 13.9 years. The proportion of females (57.8%) was higher than that of males (42.2%). The majority of patients were of Kinh ethnicity (62.9%) and lived in rural areas (62.1%).

3.2. Changes in peripheral blood cells in patients with chronic kidney disease at Thai Nguyen Central General Hospital

Table 2. Characteristics of peripheral blood cells in patients with chronic kidney disease

Hematologic Index		n (%)	$\bar{X}$ ± SD	Hematologic Index		n (%)	$\bar{X}$ ± SD
RBC (T/L)	< 4	69 (59,5%)	3,88 ± 0,87	MCH (pg)	< 27	23 (19,8%)	28,99 ± 3,63
	≥ 4	47 (40,5%)			27-32	77 (66,4%)	
HGB (g/L)	<80	8 (6,9%)	111,59 ± 24,27		> 32	16 (13,8%)	
	80-109	54 (46,6%)		MCHC (g/L)	< 320	17 (14,7%)	331,24 ± 32,11
	110-119 female 110 -129 male	22 (19,0%)			320-360	99 (85,3%)	
	≥ 120 female ≥ 130 male	32 (27,6%)			> 360	0 (0,0%)	
HCT (%)	< 34	63 (54,3%)	33,18 ± 7,39	WBC (G/L)	< 4	3 (2,6%)	7,95 ± 2,72
	≥ 34	53 (45,7%)			4-10	95 (81,9%)	
MCV (fL)	< 80	19 (16,4%)	86,89 ± 8,63		> 10	18 (15,5%)	
	80-100	94 (81,0%)		PLT (G/L)	< 150	6 (5,2%)	248,09 ± 76,92
	> 100	3 (2,5%)			150-450	109 (94,0%)	
					> 450	1 (0,8%)	

Comment: The results showed that 72.4% of CKD patients were anemic, with 46.6% moderate and 6.9% severe anemia. Mean values of HGB (111.6 ± 24.3g/L), HCT (33.2 ± 7.4%), and RBC (3.88 ± 0.87T/L) were below the normal range. Red cell indices MCV (86.9 ± 8.6fL), MCH (29.0 ± 3.6pg), and MCHC (331.2 ± 32.1 g/L) were mostly within normal limits, indicating normocytic–normochromic anemia characteristic of erythropoietin deficiency. WBC (7.95 ± 2.72G/L) and platelet counts (248.1 ± 76.9G/L) remained normal in most patients, suggesting no generalized bone marrow suppression.

3. Relationship between peripheral blood cells and stages of Chronic Kidney Disease

Table 3. Relationship between peripheral blood cells indices and stages of chronic kidney Disease

Hematologic Index	CKD Stage I-III (n = 49)	CKD Stage IV, V (n = 67)	p
RBC (T/L)	4.35 ± 0.88	3.64 ± 0.77	<0.0001
HGB (g/L)	127.48 ± 24.16	103.24 ± 19.86	<0.0001
HCT (%)	38.08 ± 6.76	30.60 ± 6.36	<0.0001
MCV (fL)	88.27 ± 6.11	86.16 ± 9.65	>0.05
MCH (pg)	29.75 ± 2.70	28.60 ± 3.99	>0.05
MCHC (g/L)	335.98 ± 13.44	328.75 ± 38.32	>0.05
WBC (G/L)	8.21 ± 2.67	7.82 ± 2.78	>0.05
PLT (G/L)	241.50 ± 86.74	251.09 ± 71.59	>0.05

"Kiểm định T-test độc lập; p<0,05 có ý nghĩa thống kê."

Comment: Comparison between the two groups showed that red blood cell (RBC) count, hemoglobin (HGB), and hematocrit (HCT) levels were significantly lower in patients with stage IV-V chronic kidney disease (CKD) compared with those in stages I-III (p<0.0001). The mean HGB level in early-stage CKD (I–III) was 127.5 ± 24.2g/L, whereas it decreased to 103.2 ± 19.9g/L in advanced stages (IV-V), demonstrating a clear progression of anemia with worsening renal function. In contrast, there were no statistically significant differences in mean corpuscular indices (MCV, MCH, MCHC), white blood cells (WBC, neutrophils), or platelets (PLT) between the two groups (p>0.05). These findings indicate that anemia in CKD mainly results from reduced erythropoiesis rather than morphological abnormalities of peripheral blood cells.

Table 4. Correlation between peripheral blood cell indices and selected biochemical parameters

Hematologic Index		Total Protein (n = 116)	Serum Albumin (n = 116)	Creatinin (n = 116)	Ure (n = 116)
RBC (T/L)	r	0.237	0.312	-0.114	-0.362
	p	<0.05	0.003	0.225	0.000
HGB (G/L)	r	0.180	0.379	-0.176	-0.495
	p	0.091	0.000	0.058	0.000
HCT (L/L)	r	0.252	0.435	-0.146	-0.461
	p	0.017	0.000	0.118	0.000
MCV (fl)	r	0.014	0.092	-0.117	-0.240
	p	0.897	0.393	0.209	0.010
MCH (pg)	r	-0.031	0.056	-0.122	-0.220
	p	0.773	0.606	0.192	0.017
MCHC (g/L)	r	-0.182	-0.032	-0.120	-0.363
	p	0.087	0.765	0.198	0.000

Comment: Pearson correlation analysis revealed significant positive correlations between RBC, HGB, HCT and both total protein and serum albumin (r = 0.237–0.435; p<0.05), and significant negative correlations with serum creatinine (r = –0.362 to –0.495; p<0.001). No significant associations were observed with blood urea levels (p>0.05). Morphological red cell indices (MCV, MCH, MCHC) showed only weak or nonsignificant correlations with biochemical parameters. These findings suggest that the decrease in hemoglobin and hematocrit is associated with higher creatinine and lower albumin levels, reflecting the combined effects of renal dysfunction and protein–energy malnutrition on anemia in CKD patients.

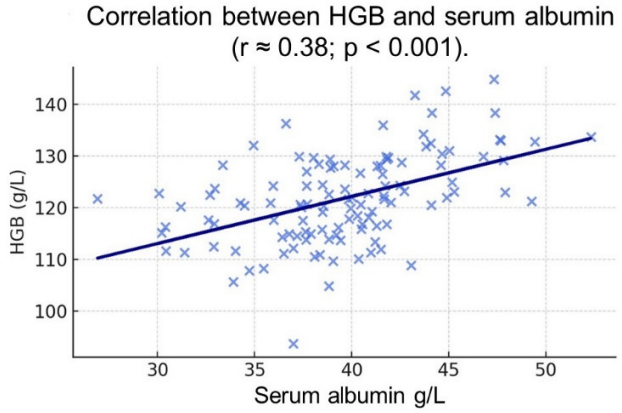

Figure 1. Positive correlation between HGB and plasma albumin (r = 0.379; p<0.001).

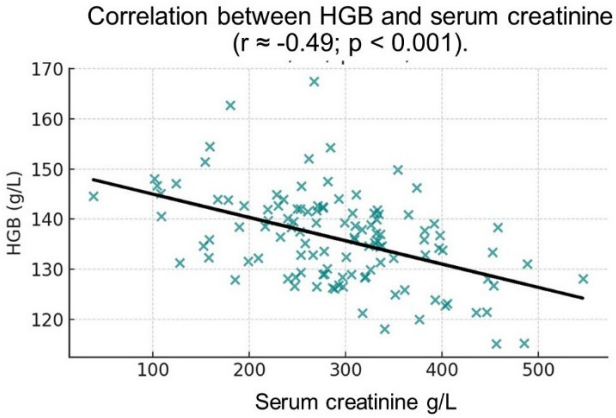

Figure 2. Inverse correlation between HGB and plasma creatinine (r = –0.495; p<0.001).

Table 5. Relationship Between Anemia Severity and Chronic Kidney Disease (n = 116)

CKD Stage	Mild Anemia (100 ≤ HGB < 120 g/L)	Moderate Anemia (80 ≤ HGB < 100 g/L)	Severe Anemia (HGB < 80 g/L)
CKD Stage I–III	7 (50.0%)	6 (42.9%)	1 (7.1%)
CKD Stage IV–V	31 (50.0%)	24 (38.7%)	7 (11.3%)
p	>0.05		

Comment: In patients with CKD stages IV–V, the proportions of moderate and severe anemia were 38.7% and 11.3%, respectively-higher than those observed in stages I-III. However, the difference was not statistically significant (p>0.05).

IV. DISCUSSION

In our study, the mean age of patients with chronic kidney disease (CKD) was 65.7 ± 13.9 years, with the ≥60-year-old group accounting for the highest proportion (72.4%). This finding aligns with epidemiological characteristics of CKD, which predominantly affects older adults due to the age-related decline in glomerular filtration rate (GFR) and the increasing prevalence of chronic comorbidities such as diabetes mellitus, hypertension, and metabolic disorders [1-3]. The male-to-female ratio was nearly equal, suggesting that CKD affects both sexes similarly, consistent with KDIGO observations in Asian CKD populations [4]. The fact that 62.1% of patients resided in rural areas may indicate limited access to healthcare and delayed diagnosis, a pattern also reported in other developing countries [5].

4.1. Characteristics of peripheral blood cells in patients with chronic kidney disease at Thai Nguyen Central General Hospital

The results (Table 2) showed that 72.4% of patients with chronic kidney disease (CKD) had anemia, predominantly of moderate to severe degree, with mean values of HGB = 111.6 ± 24.3 g/L,

HCT = 33.2 ± 7.4%, and RBC = 3.88 ± 0.87T/L, all lower than the normal reference range. This prevalence is comparable to the findings of Sofue et al. (2020) in Japan (61.2%) [6] and Locatelli et al. (2023) in Europe (63.8%) [7]. In Vietnam, Pham Quoc Hung (2023) reported a similar rate of 64.5% among outpatients with CKD [8]. These results confirm that anemia is a common and progressive complication of CKD, reflecting decreased erythropoietin (EPO) production secondary to renal interstitial fibrosis.

Regarding hematologic morphology, the mean values of MCV (86.9 ± 8.6fL), MCH (29.0 ± 3.6pg), and MCHC (331.2 ± 32.1g/L) were mostly within normal limits, indicating normocytic-normochromic anemia. This finding is consistent with the KDIGO 2023 guidelines [4] and WHO 2021 [9], which define CKD-associated anemia as "normocytic–normochromic anemia due to insufficient erythropoietin production." Similarly, studies by Taderegew et al (2023) [10] and Kovesdy et al. (2020) [11] reported that more than 85-90% of CKD patients had normal MCV, while only 5-10% exhibited mild microcytosis due to coexisting functional iron deficiency.

Leukocyte and platelet indices: In this study, the mean WBC (7.95 ± 2.72 G/L) and PLT (248.1 ± 76.9 G/L) values were predominantly within normal limits (81.9% and 94.0%, respectively), suggesting that CKD did not cause generalized bone marrow suppression but rather selectively affected the erythroid lineage. Approximately 15.5% of patients had mild leukocytosis, possibly associated with chronic inflammation or concomitant urinary tract infections.

These findings are consistent with those of Pham Quoc Hung (2023), who observed that platelet abnormalities were more common in end-stage CKD patients or those undergoing maintenance hemodialysis [8]. Kovesdy et al (2020) also noted that leukocyte and platelet dysfunction typically occur only in cases of prolonged uremia, metabolic acidosis, and chronic inflammation [11]. Although thrombocytopenia (< 150G/L) was found in only 5.2% of cases, several studies have reported that platelet aggregation function may be impaired by uremic toxins even when platelet counts remain within normal ranges [8].

4.2. Relationship Between Changes in Peripheral Blood Cells and Stages of Chronic Kidney Disease

The analysis (Table 3) showed that RBC, HGB, and HCT values were significantly lower in patients with CKD stages IV-V compared with those in stages I-III ($p<0.0001$), while MCV, MCH, MCHC, WBC, and PLT showed no statistically significant differences ($p>0.05$). These findings indicate that anemia in CKD is primarily caused by decreased erythropoietin (EPO) production and bone marrow suppression secondary to chronic inflammation, rather than absolute iron deficiency [4,7]. Locatelli et al. (2023) [7] reported an average 24g/L reduction in hemoglobin between CKD stages 3 and 5, which is consistent with our results (from 127.5 ± 24.2g/L to 103.2 ± 19.9 g/L). Similarly, Sofue et al (2020) [6] observed that the prevalence of anemia increased from 23.4% in stage 3 CKD to 68.9% in stage 5 CKD. The major contributing mechanisms include: (1) Reduced erythropoietin synthesis due to injury of peritubular renal cells; (2) Chronic inflammation and protein-energy wasting (PEW), which impair bone marrow responsiveness to EPO; and (3) Uremic toxins and oxidative stress, which shorten red blood cell lifespan and increase hemolysis [11].

Correlation Analysis Between Hematologic and Biochemical Parameters: Correlation analysis (Table 4) showed that HGB and HCT had a strong negative correlation with serum creatinine ($r = –0.495$ and -0.461; $p<0.001$) and a significant positive correlation with serum albumin ($r = 0.379$ and 0.435; $p<0.001$). This finding confirms that as renal function declines, the severity of anemia increases correspondingly, while low albumin levels reflect protein–energy wasting (PEW) and chronic inflammation, which together reduce erythropoietin responsiveness. These results are consistent with the study by Kovesdy et al (2020) [11]. Figures 1 and 2 illustrate a clear linear trend: Patients with serum creatinine > 500µmol/L almost invariably had HGB < 100g/L, whereas those with albumin > 40g/L typically had HGB > 110g/L. Similarly, Pham Quoc Hung (2023) [8] reported that albumin < 35g/L was an independent factor associated with anemia (OR = 2.8; $p<0.01$).

Serum Iron and Ferritin Levels: No significant differences in serum iron and ferritin concentrations were observed across CKD stages ($p>0.05$), indicating that anemia in CKD is not due to absolute iron deficiency, but rather to functional iron deficiency resulting from increased hepcidin levels and chronic inflammatory responses. This finding is consistent with the observations of Yamamoto T. (2025) [12], who reported that serum ferritin levels are often falsely elevated due to chronic inflammation, whereas serum iron may remain normal or slightly reduced but still lead to impaired erythropoiesis.

Therefore, HGB, serum albumin, and serum creatinine are simple, accessible, and cost-effective biological markers for assessing anemia in CKD. Regular monitoring of these indices enables early detection of anemia, determination of the optimal timing for erythropoiesis-stimulating agent (ESA) therapy or nutritional intervention, and ultimately contributes to improving the clinical prognosis of patients with chronic kidney disease.

V. CONCLUSION

Through the study of 116 patients with chronic kidney disease (CKD) treated at the Department of Nephrology, Thai Nguyen Central General Hospital, the following conclusions were drawn:

Anemia was present in 72.4% of CKD patients, of whom 46.6% had moderate and 6.9% had severe anemia. The mean values of HGB = 111.6 ± 24.3g/L, HCT = 33.2 ± 7.4%, and RBC = 3.88 ± 0.87T/L were all below normal reference ranges. Red blood cell indices, including MCV (86.9 ± 8.6fL), MCH (29.0 ± 3.6pg), and MCHC (331.2 ± 32.1g/L), were mostly within normal limits, indicating normocytic–normochromic anemia.

The hematologic parameters HGB, HCT, and RBC were significantly lower in CKD stages IV–V compared with stages I-III ($p<0.001$), whereas MCV, MCH, MCHC, WBC, and PLT showed no significant differences ($p>0.05$).

The severity of anemia showed a strong negative correlation with serum creatinine ($r = -0.495$) and a positive correlation with serum albumin ($r = 0.379$), suggesting a combined role of progressive renal dysfunction and protein–energy wasting (PEW) in the pathogenesis of anemia among CKD patients.

Recommendations

Routine screening for anemia should be performed in all CKD patients from stage III onward, in conjunction with simultaneous assessment of renal function and nutritional status.

Early intervention with erythropoiesis-stimulating agents (ESA), iron supplementation, and appropriate nutritional management is strongly recommended at the primary healthcare level to improve quality of life and reduce complications. Future studies with larger sample sizes and additional measurements of inflammatory biomarkers (such as CRP and IL-6) and plasma erythropoietin levels are warranted to further elucidate the pathophysiological mechanisms of anemia in CKD within the Vietnamese population.

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