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Original Article

Correlation Hemoglobin and Hematocrit Levels with Total Iron Binding Capacity (TIBC) Levels in Chronic Kidney Disease Patients

Galuh Ajeng Lidyaningrum[1], Andika Aliviameita[1*]

Department of Medical Laboratory Technology, Faculty of Health Sciences,
Universitas Muhammadiyah Sidoarjo, Indonesia

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Author's affiliation:
Department of Medical Laboratory Technology,
Faculty of Health Sciences,
Universitas Muhammadiyah Sidoarjo,
Indonesia

Author's correspondence:
Andika Aliviameita
Mojopahit 666B street, Sidoarjo,
East Java, 61215, Indonesia

E-mail:
aliviameita@umsida.ac.id

Abstract

Background : Chronic Kidney Failure (CKD) is a condition where the kidneys are structurally and functionally damaged characterized by a decrease in Glomerular Filtration Rate (GFR) reaching ≤ 60 ml/min/1.73m2 for more than three months. About 80 - 90% of patients with CKD experience anemia.
Aims : This research aims to determine the correlation of hemoglobin and hematocrit levels with Total Iron Binding Capacity (TIBC) levels in patients with chronic renal failure.
Methods : The research design used quantitative analysis with cross sectional method. The study used secondary data of as many as 55 respondents of chronic kidney disease patients undergoing hemodialysis. This study was conducted at the East Java Province Haji Hospital in March 2025.
Results : The normality test results showed that hemoglobin and hematocrit levels were not normally distributed ($p < 0.05$) while TIBC levels were normally distributed ($p > 0.05$). Kendall's tau b non-parametric correlation test there is no correlation between hemoglobin levels with TIBC ($r = 0.134$; $p = 0.154$), and hematocrit with TIBC levels ($r = 0.172$; $p = 0.066$).
Conclusion : The results of this study showed no correlation between hemoglobin and hematocrit levels with total iron binding capacity (TIBC) levels in chronic kidney disease patients undergoing hemodialysis at Haji Provincial General Hospital of East Java .

Keywords : Chronic Kidney Disease; Hemoglobin; Hematocrits; TIBC

INTRODUCTION

Structural and functional damage to the kidneys characterized by a decrease in glomerular filtration rate (GFR) to ≤ 60 ml/minute/1.73 m2 for more than three months is referred to as chronic kidney disease (CKD).[1] According to data from the World Health Organization (WHO), more than 843.6 million people suffered from kidney failure in 2021, and the death rate is projected to increase by 41.5% by 2040. This increase indicates that chronic kidney failure is the 12th leading cause of death worldwide.[2] The 2020 Basic Health Research (Riskesdas) results show that there are 18.613 patients with chronic kidney disease in Indonesia. East Java Province has a prevalence of 0.3% suffering from chronic kidney disease, suggesting that the prevalence of CKD patients in East Java remains relatively elevated.[3]

Disruption of kidney function can cause a decrease in the kidney's ability to filter creatinine, resulting in an increase in serum creatinine. An increase in blood creatinine levels determines whether patients with kidney dysfunction need to undergo hemodialysis or not.[4] Hemodialysis is a treatment method used to filter waste and fluids from the blood, similar to the function of normal kidneys. Hemodialysis contributes to controlling blood pressure and balancing essential mineral levels such as potassium, sodium, and calcium.[5]

Urea and creatinine can be used to diagnose kidney dysfunction, as these compounds can only be excreted by the kidneys. Urea is the final substance produced from protein metabolism taking place in the liver. Creatinine is the end product of creatine metabolism, which is a compound found in large quantities in muscles and contains nitrogen.[6]

One of the functions of the kidneys is to produce the hormone erythropoietin. Erythropoietin is a hormone used to stimulate the production of red blood cells. A reduction in erythropoietin production occurs in individuals suffering from CKD often leads to a decrease in the number of red blood cells, resulting in a decrease in hematocrit levels.[7] Approximately 80–90% of patients with chronic kidney disease experience anemia, especially in stage III. Patients with CKD are diagnosed with anemia if their hemoglobin levels are <12 g/dL for women and <13 g/dL for men.[8] In diagnosing anemia, laboratory tests such as hematology tests can be performed, including hemoglobin levels, hematocrit, red blood cell, red blood cell indices (MCV, MCH, MCHC), reticulocyte count, blood smear, and iron status tests, including Serum Iron (SI), Total Iron Binding Capacity (TIBC), Serum Ferritin, and Transferrin Saturation (ST).[9]

Previous research in 2017 showed that there was a correlation between creatinine levels and Hb (r=-0.424; *p*=0.000), RBC (r=-0.367; *p*=0.004), hematocrit (r=-0.421; *p*=0.001), Mean Corpuscular Hemoglobin (MCH) (r = -0.337; *p* = 0.009), Mean Corpuscular Hemoglobin Concentration (MCHC) (r = -0.272; *p* = 0.038), and SI (r=-0.299; *p*=0.034) in CKD patients undergoing hemodialysis at Sabratha Hospital in western Libya. The main reason for anemia in patients with CKD is the reduced production of erythropoietin (EPO) resulting from injury to the renal peritubular cells, with its occurrence rising as kidney function worsens.[10]

Previous research in 2020 showed that there was a weak correlation (r= 0.17; *p*= 0.02) between hemoglobin levels and TIBC in patients with chronic kidney failure non hemodialysis. The results of this study indicate that impaired kidney function is correlated with the severity of anemia due to various factors associated with the development of anemia in CKD patients. The average hemoglobin levels, red blood cell count, and hematocrit levels decreased significantly as kidney function deteriorated.[11]

A 2023 study indicate a weak correlation (r = 0.09; *p* = 0.684) between hemoglobin levels and Total Iron Binding Capacity (TIBC) levels in patients with stage V chronic kidney disease (CKD) undergoing hemodialysis at Toeloengredjo Hospital in Pare, Kediri. The study results indicate that low TIBC levels are not the sole cause of decreased hemoglobin levels. Hemoglobin levels decrease in CKD patients is caused by various factors, including reduced production of erythropoietin hormone, decreased longevity of red blood cells, inflammation and infection associated with hypothyroidism, advanced hyperparathyroidism, and aluminum poisoning, and most commonly due to iron and folate deficiency.[12]

METHODS

This study has obtained ethical approval from the Health Research Ethics Committee of the Haji Provincial General Hospital of East Java with certificate number: 445/56/KOM.ETIK/2025. The study design used was a quantitative analysis employing a cross-sectional approach, conducted at the Clinical Pathology Laboratory Unit of the Haji Provincial General Hospital of East Java in March 2025. The research sample was obtained using purposive sampling with criteria of patients with chronic kidney disease (CKD) undergoing hemodialysis with creatinine levels >7.0 mg/dL and aged >19 years. The study utilized secondary data from medical records and the Laboratory Information System (LIS) at the Haji Provincial General Hospital of East Java over the past five years (2021–2025), involving 55 respondents. Hemoglobin and hematocrit tests were performed using the Hematology Analyzer 5 diff (Sysmex Xn-550 and Sysmex Xn-350), and Total Iron Binding Capacity (TIBC) tests were conducted using the Cobas C-501. Data analysis was performed using SPSS version 23, followed by a normality test using the Kolmogorov-Smirnov test, and continued with a non-

parametric test using Kendall's tau-b correlation test.

RESULTS

In accordance with the results obtained from a study on the correlation between hemoglobin and hematocrit levels and total iron-binding capacity (TIBC) in 55 patients with chronic kidney disease. The study samples were obtained from secondary data taken from medical records and the laboratory information system (LIS) of patients with chronic kidney disease. Based on the study findings, there were 0 patients in 2021, 24 patients in 2022, 28 patients in 2023, 3 patients in 2024, and 0 patients in 2025 who underwent hemoglobin, hematocrit, and TIBC tests at the Clinical Pathology Laboratory of the Haji Jawa Timur Provincial General Hospital, as shown in Figure 1a.

DISCUSSION

According to the study results presented in the Figure 1 b, it was found showed a predominance of male patients (2:1) compared to female patients. This research corresponded with the findings of the study carried out by Wayan in 2023 at Sanjiwani Gianyar Hospital on patients with CKD, which showed that the number of male patients was 48 people (60%), while female patients were 32 people (40%). This condition can be caused by male tendency to work heavier, both physically and mentally, and can also be influenced by lifestyle factors such as smoking habits, alcohol consumption, a diet high in salt and fat, and low physical activity are known to be associated with an increased risk of metabolic diseases such as hypertension, obesity, and diabetes. These conditions are major risk factors contributing to the development of chronic kidney

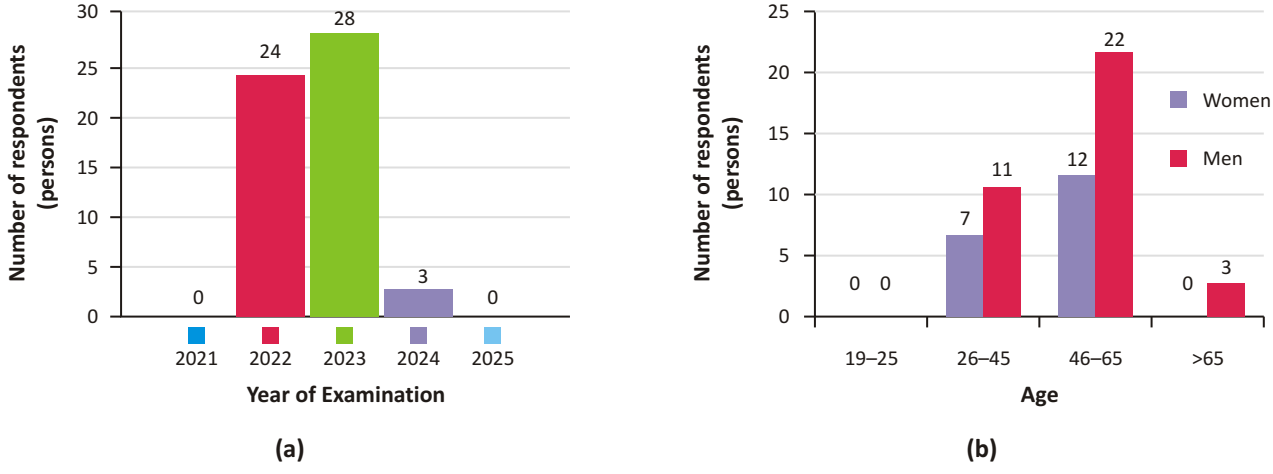

Figure 1. (a) Distribution of Respondents by Year of Examination, (b) Distribution of Respondents by Gender and Age

TABLE 1
Distribution of Respondents and Examination Results of Hemoglobin, Hematocrit, TIBC Levels

No	Characteristic Responden	N	%	Normal Value	Mean
1	Hemoglobin (g/dL)			11.2 – 17.5 g/dL	7.682 ± 1.31
	Normal	0	0		
	Mild Anemia	8	14.5		
	Moderate Anemia	33	60		
	Severe Anemia	14	25.5		
	Total	55	100		
2	Hematocrit (%)			34 – 51%	23.16 ± 3.91
	Normal	0	0		
	High	0	0		

TABLE 1. *Continued.*

No	Characteristic Responden	N	%	Normal Value	Mean
	Low	55	100		
	Total	55	100		
3	TIBC (µg/dL)			228 – 450 µg/dL	167.47 ± 48.178
	Normal	7	12.7		
	High	0	0		
	Low	48	87.3		
	Total	55	100		

TABLE 2
Kendall's tau b correlation

Variabel	(r)	(p)
Hemoglobin with TIBC	0.134	0.154
Hematokrit with TIBC	0.172	0.066

disease.[13,14]

Several epidemiological studies indicate a higher prevalence of CKD among men, partly due to occupational factors. Men tend to work in sectors involving heavy physical labor, such as construction, agriculture, mining, and manufacturing, which often involve exposure to excessive heat, chronic dehydration, and exposure to chemicals or heavy metals. This exposure triggers oxidative stress, impaired renal perfusion, and tubular damage, thereby accelerating progressive kidney function decline.[15,16]

In addition, the lower prevalence of CKD in women can be explained by the absence of testosterone or the presence of estrogen. Estrogen affects kidney function through various mechanisms, including improved metabolism, the selectivity of Angiotensin Type 2 (AT2) receptor signaling, diminished oxidative stress, and differential renin-angiotensin system (RAS). Endogenous estrogen plays a crucial role in non-communicable diseases such as CKD thanks to its ability to promote angiogenesis and vasodilation, while suppressing the production of reactive oxygen species and the development of fibrosis.[17]

Based on the age distribution in Figure 1 b, most patients with chronic kidney disease were between the ages of 46–65 (61.8%). This research corresponds with the findings of the study carried out by Lumbantobing in 2022 at Tarutung Hospital on patients with CKD who underwent hemodialysis showed that the most patients belonged in the 51–61 year age group as many as 32 patients (34.8%), this occurs because kidney function tends to decrease with age, especially if accompanied by a decline in life quality and the the presence of comorbid factors.[18]

As we age, the number of nephrons naturally decreases starting at age 40, by about 10% per decade. This decline increases the risk of CKD because the remaining nephrons must work harder (hyperfiltration) and enlarge (hypertrophy). As nephrons are lost without regeneration, the workload increases on the remaining units, leading to high intraglomerular pressure, glomerular sclerosis, tubular fibrosis, and progressive GFR decline. By the age of 70–75, the number of nephrons can decrease by up to 48% compared to younger ages, while cortical volume shrinks by only 16% due to temporary compensatory tubular hypertrophy, thereby accelerating damage in the presence of comorbid factors.[19]

Similar results were obtained from Fitri and Wahyu's research in 2022, which showed the highest prevalence of ureum and creatinine levels at the age of 40–45 years. The decline in kidney function begins to occur at the age of 40 years and above, with a decrease in function of up to 50% due to the reduced number of functioning nephrons and the absence of regeneration ability. This results in a reduced capacity of the kidney to regulate fluid output and increases the risk of protein loss through urinary excretion.[20]

In this study, 55 patients (100%) experienced anemia, with the classifications of: Mild Anemia (14.5%),

Moderate Anemia (60%), and Severe Anemia (25.5%), showing an average hemoglobin level of 7.682 g/dL. Followed by a decrease in hematocrit in all patients, with a mean hematocrit level of 23.16% as shown in Table 1. Based on hemoglobin levels, the degree of anemia can be classified into 3 categories: that mild anemia, that occurs when hemoglobin levels fall within the range of 9–10 g/dL, moderate anemia, that occurs when hemoglobin levels fall within the range of 7–8 g/dL, and severe anemia if hemoglobin levels are <7 g/dL.[21] Anemia commonly occurs in individuals with CKD and is linked to a reduced quality of life, as well as increased morbidity, mortality, and accelerated progression of CKD. The primary reason for anemia in CKD is the decreased generation of the hormone erythropoietin, which is responsible for the differentiation and development of red blood cell precursors.[22]

Based on the results of the distribution of TIBC levels in Table 1, it was found that the majority of patients had low TIBC levels (87.3%), with a mean TIBC level of 167.47 µg/dL, the TIBC level was below the normal limit. Decreased TIBC levels are found in conditions of hemochromatosis, hemosiderosis, thalassemia, hyperthyroidism, nephrotic syndrome, and anemia in chronic diseases.[23] TIBC is iron bound to the transferrin protein in plasma and plays a role in the transport of iron to the bone marrow for hemoglobin formation. The TIBC test is useful for determining the total amount of iron that can be absorbed by the transferrin protein.[24] Patients with CKD may experience chronic inflammation which can result in low TIBC levels.[12] Based on data from the Iron Disorders Institute, TIBC tends to increase when iron reserves decrease, and conversely, TIBC decreases when iron reserves increase.[25]

The majority of CKD patients in this study exhibited low TIBC levels, reflecting impaired iron metabolism due to chronic inflammation. This inflammation suppresses transferrin (an iron-carrying protein) synthesis in the liver via pro-inflammatory cytokines, thereby reducing TIBC. Furthermore, chronic inflammation also increases hepcidin levels, which inhibit iron release from macrophages and reduce iron absorption in the intestine, leading to impaired iron utilization or functional iron deficiency.[26]

The results of the Kolmogorov-Smirnov normality test in Table 2 for hemoglobin and hematocrit data, indicated that hemoglobin and hematocrit levels were not normally distributed because the *p*-value is <0.05, whereas TIBC levels showed normally distributed data because the *p*-value is >0.05. Therefore, the analysis continued with a nonparametric test, namely Kendall's tau-b.

The results of the Kendall's tau-b correlation test between Hemoglobin Levels and TIBC Levels obtained a value (r = 0.134; p = 0.154) (p> 0.05), while the correlation test between Hematocrit with TIBC Levels obtained a value (r = 0.172; p = 0.066) (p>0.05). The results of statistical test analysis showed that there were no correlation between hemoglobin and Hematocrit levels with TIBC levels in patients with CKD undergoing Hemodialysis at the Haji Hospital of East Java Province. There is no correlation between hemoglobin and hematocrit levels with TIBC levels because not all patients with chronic kidney disease experience iron deficiency anemia.[27]

This aligns with earlier studies carried out by L. V. Thang *et al* (2020) indicate a weak correlation (r = 0.17; p = 0.02) between hemoglobin and TIBC levels in non-hemodialysis chronic kidney disease patients. The results of this study indicate that decreased kidney function has a correlation with the severity of anemia due to various factors associated with the development of anemia in patients with CKD.[11]

The results of research conducted by Ekowati (2023) indicate a weak correlation (r = 0.09; p = 0.684) between Hemoglobin levels and TIBC levels in patients with grade V CKD who undergo Hemodialysis. This study's outcomes suggest that low TIBC levels are not the only cause of a decrease in hemoglobin levels. Hemoglobin levels decrease in patients with CKD is caused by many factors, including decreased production of the hormone erythropoietin, decreased longevity of red blood cells, inflammation and infection associated with hypothyroidism, advanced hyperparathyroidism, and aluminum poisoning, and most often due to iron and folate deficiency.[12]

In patients with chronic kidney disease, anemia is chiefly caused by reduced production of the hormone erythropoietin. The kidneys have a role in producing the hormone erythropoietin (EPO). This hormone is important in the process of RBC formation (erythropoiesis). Erythropoietin helps maintain the balance of the quantity of RBC within the body and ensures that tissues get enough oxygen. To maintain this balance, old red blood cells are replaced by new red blood cells.[28]

Anemia occurs when hemoglobin (Hb), hematocrit (HCT), and red blood cell counts are below normal values.[29] Hemoglobin as one of the signs to determine the decrease in the number of red blood cells (erythrocytes).[8] Hematocrit examination is one of the quality control examinations performed in the laboratory to determine the volume of erythrocytes contained in the blood. Hematocrit has a close relationship with hemoglobin levels. The higher the hemoglobin level, the hematocrit value will also increase, so that the viscosity or viscosity of the blood becomes more concentrated.[30]

The mechanism of anemia in patients with CKD is influenced by several factors. In addition to erythropoietin deficiency, anemia can also be caused by iron deficiency, which can occur due to blood loss or impaired iron absorption. In addition, the systemic

inflammation that occurs in CKD and its comorbidities causes iron storage to become ineffective. Other factors include reduced bone marrow response to erythropoietin due to uremic effects, shorter red blood cell lifespan, and vitamin B12 or folic acid deficiency.[28]

Iron plays a crucial role in oxygen binding in red blood cells and plays a vital role in various other cellular processes. Iron deficiency anemia can also be found in patients with CKD. Iron deficiency can be absolute, This condition is typically due to inadequate dietary consumption or hidden bleeding, or it may be functional, occurring when the iron demand in the erythroid bone marrow exceeds the iron supply available.[27] Patients with CKD who have anemia often maintain adequate iron levels in their bodies, but the iron is not optimally available in the bloodstream. This condition occurs due to a decrease in the amount of ferroportin (iron transport protein), so that the hemoglobin formation process is disrupted.[31]

Iron testing is important to diagnose iron deficiency or iron overload. The iron that is transferred from enterocytes to the transport protein assisted by hephaestin is called apotransferrin. When apotransferrin binds to iron, this protein turns into transferrin. TIBC is a direct measure of the amount of transferrin bound to iron in the blood. Transferrin itself is a glycoprotein that can bind two iron atoms per molecule. The amount of iron attached to transferrin indirectly reflects transferrin levels in the body. In iron deficiency conditions, the concentration of transferrin in the bloodstream is comparatively greater than that of iron, resulting in high TIBC values. Conversely, in iron overload conditions, the amount of transferrin in the blood decreases, resulting in a low TIBC value .[32,31]

CONCLUSION

According to the findings of the study regarding the correlation of hemoglobin and hematocrit levels with Total Iron Binding Capacity (TIBC) levels in patients with Chronic Renal Failure, it can be summarized that there is no correlation found between hemoglobin levels with TIBC (r = 0.134; p = 0.154), and hematocrit with TIBC levels (r = 0.172; p = 0.066) In patients with chronic kidney disease undergoing Hemodialysis at the Haji Provincial General Hospital of East Java .

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