Effect Of Ultrafiltration Volume On Hemoglobin And Hematocrit Profiles In Chronic Kidney Disease Patients Undergoing Hemodialysis

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ABSTRACT

Background: Chronic kidney disease is commonly associated with anemia caused by reduced erythropoietin production and impaired hematological function. Hemodialysis with ultrafiltration removes excess body fluid and may influence hemoglobin and hematocrit concentrations through changes in plasma volume. However, the relationship between ultrafiltration volume and hematological changes remains uncertain. **Objective:** This study aimed to determine the effect of ultrafiltration volume on hemoglobin and hematocrit profiles in chronic kidney disease patients undergoing hemodialysis. **Methods:** This study used an observational analytic design with a retrospective approach. Data were obtained from medical records of chronic kidney disease patients undergoing hemodialysis at RST Slamet Riyadi Surakarta. A total of 30 patients were selected based on inclusion and exclusion criteria. Hemoglobin, hematocrit, and ultrafiltration volume before and after hemodialysis were analyzed using paired sample testing and Spearman correlation analysis. **Results:** The majority of patients were male, aged 50–59 years, and had undergone hemodialysis for 1–5 years. The average ultrafiltration volume was 2562.29 milliliters. Hemoglobin levels showed a slight decrease after hemodialysis, while hematocrit levels showed a slight increase. Statistical analysis revealed no significant differences in hemoglobin and hematocrit levels before and after hemodialysis. Ultrafiltration volume also showed no significant correlation with changes in hemoglobin and hematocrit. **Conclusion:** Ultrafiltration volume during a single hemodialysis session does not significantly affect hemoglobin and hematocrit changes. Hematological profiles in chronic kidney disease patients are likely influenced by multiple factors related to chronic anemia and disease progression.

Keywords : Chronic Kidney Disease; Hematocrit; Hemodialysis; Hemoglobin; Ultrafiltration

INTRODUCTION

Chronic Kidney Disease (CKD) is a progressive and irreversible decline in kidney function lasting ≥3 months, characterized by reduced GFR or signs of kidney damage. The main causes include diabetes mellitus, hypertension, and other kidney diseases that damage nephrons. CKD has systemic impacts, not only on the kidneys but also on other organs, such as anemia due to decreased erythropoietin, cardiovascular disorders (hypertension, left ventricular hypertrophy), and bone abnormalities (renal osteodystrophy). In Indonesia, CKD remains a serious health problem, with 670,000 patients recorded by 2025, more than 130,000 undergoing hemodialysis, and mortality reaching 1.3 million. Central Java is among the provinces with high prevalence, although specific data for Surakarta City are limited.

Hematological complications, particularly anemia, almost always accompany CKD, caused by reduced erythropoietin production, chronic inflammation, and deficiencies in iron, vitamin B12, and folate. Clinically, anemia is marked by decreased hemoglobin (Hb) and hematocrit (Ht). Hemodialysis is the main therapy for advanced CKD, functioning to remove metabolic waste, maintain fluid and electrolyte balance, and eliminate excess fluid through ultrafiltration. Ultrafiltration reduces plasma volume without changing the number of erythrocytes, leading to hemoconcentration and relative increases in Hb and Ht. Therefore, interpretation of Hb and Ht values in HD patients must consider fluid status.

Previous studies have shown changes in Hb and Ht before and after HD, but results vary depending on ultrafiltration volume and other physiological factors. Kartikasari et al. (2020) and Pstras et al. (2019) reported increases in Hb and Ht after HD with ultrafiltration volumes >2 liters, while Cui et al. (2024) found lower Hb levels in patients with higher filtration. rates. The limited research integrating ultrafiltration volume with hematological parameters highlights a gap that needs further study. At RST Slamet Riyadi Surakarta, similar research is still rare, making this study important to provide empirical evidence and support evidence-based clinical practice.

METHODS

This study employs an **observational analytic design with a retrospective approach**, as the data used were obtained from secondary sources, namely patients' medical records that were already available. A retrospective approach means that the researcher traces past data to examine the relationship between the variables studied, namely hemoglobin (Hb), hematocrit (Ht), and changes in fluid volume (ultrafiltration) in chronic kidney disease patients undergoing hemodialysis. This design was chosen because the data were already available, making it more efficient in terms of time and cost, while not requiring direct intervention with patients. It is also suitable for assessing changes in clinical parameters (Hb and Ht) and their relationship with ultrafiltration in real-world healthcare practice.

Based on the research objectives, this design can also be categorized as a **comparative study (pre-post design)**, since the researcher will compare Hb and Ht levels before and after HD in the same subjects, or as an **analytic correlational study**, as the researcher will analyze the effect or relationship between changes in fluid volume (ultrafiltration) and changes in Hb and Ht levels.

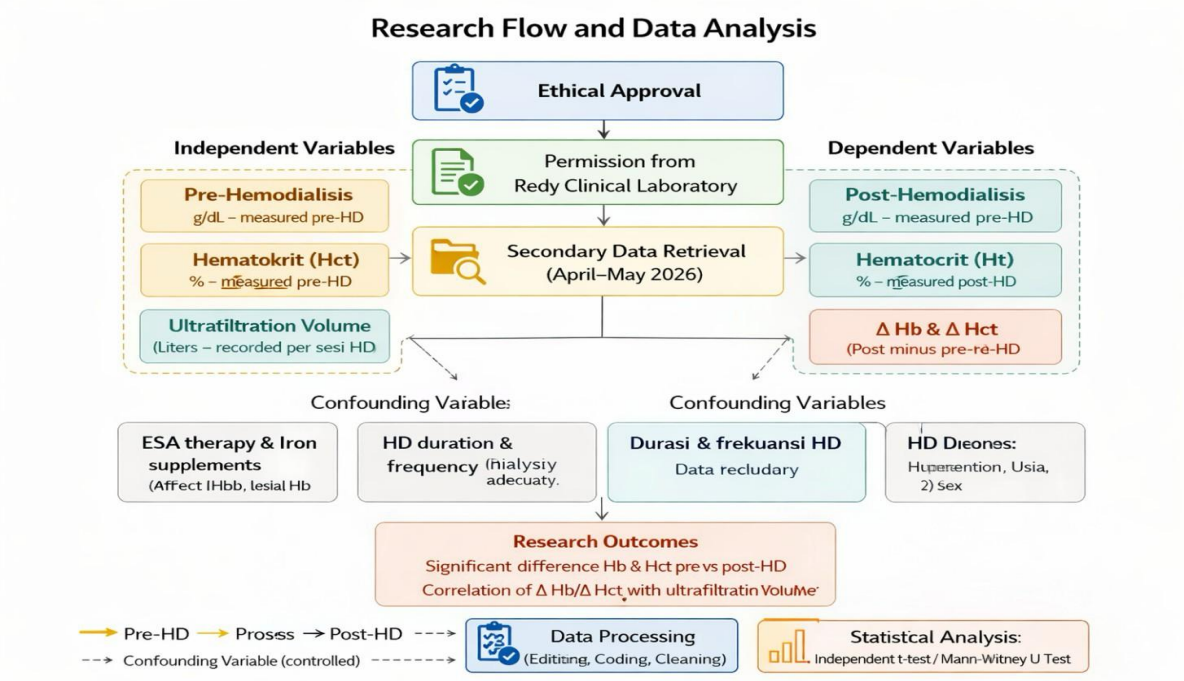

Figure 1. Research Stages Flowchart

The research process begins with Ethical Approval, ensuring that the study complies with medical research ethics. Following this, Permission from Redy Clinical Laboratory is obtained as institutional consent for data collection. The next stage is Secondary Data Retrieval (April–May 2026), where researchers collect existing medical records of patients

undergoing hemodialysis. These records are then filtered through Screening According to Inclusion and Exclusion Criteria to select eligible participants. From this screening, Consecutive Sampling (n = 50) is conducted, and participants are further organized through Classification of Participants.

The study variables are divided into Independent Variables and Dependent Variables. Independent variables include Pre-Hemodialysis measurements of hemoglobin (Hb), hematocrit (Ht), and ultrafiltration volume recorded per dialysis session. The central process is Hemodialysis, lasting 4–5 hours with ultrafiltration as the key mechanism. Dependent variables consist of Post-Hemodialysis measurements of Hb and Hct, along with ΔHb and ΔHct (the difference between post- and pre-HD values). Confounding Variables are controlled through inclusion/exclusion criteria and secondary data, such as ESA therapy and iron supplementation, dialysis duration and frequency, and comorbidities including diabetes mellitus, hypertension, age, and sex.

Finally, the data undergo Data Processing (editing, coding, cleaning), followed by Statistical Analysis using Shapiro–Wilk, Levene's Test, Independent t-test, or Mann–Whitney U Test depending on data distribution. The findings are synthesized in Interpretation of Results, leading to the Research Outcomes: significant differences in Hb and Hct before and after HD, and the correlation between ΔHb/ΔHct and ultrafiltration volume.

RESULTS

This study was conducted at the Hemodialysis Unit of RST. Slamet Riyadi Surakarta. The unit provides routine renal replacement therapy services for patients with Chronic Kidney Disease (CKD), generally performed 2–3 times per week. Excess fluid and metabolic waste removal were carried out using dialysis machines equipped with an ultrafiltration system.

Data were collected retrospectively from medical records during March–May 2026 and included patient characteristics, hemoglobin (Hb) levels before and after hemodialysis, hematocrit (Ht) levels before and after hemodialysis, and ultrafiltration volume.

Total of 50 patient records were screened; 20 patients were excluded, and 30 patients met the inclusion criteria.

1. Characteristics of Research Subjects

Table 1 Distribution of Patients Based on Characteristics (n = 30)

Characteristics	Category	Frequency (n)	Percentage (%)
Age Group (years)	< 40	3	10.0
	40–49	4	13.3
	50–59	12	40.0
	60–69	9	30.0
	≥70	2	6.7
	Total	**30**	**100**
Gender	Male	22	73.3
	Female	8	26.7

	Total	**30**	**100**
Duration of Hemodialysis	<1 year	2	6.7
	1–5 years	22	73.3
	>5 years	6	20.0
	Total	**30**	**100**
CKD Stage	Stage V	30	100
	Total	**30**	**100**

Source: Research Data (2026)

Most patients were aged 50–59 years (40.0%), male (73.3%), had undergone hemodialysis for 1–5 years (73.3%), and all patients were diagnosed with CKD Stage V.

2. Comparison of Hematological Parameters Before and After Hemodialysis Table 2 Comparison of Hemoglobin and Hematocrit Levels

Parameter	Minimum–Maximum	Mean	SD
Hb Before HD (g/dL)	7.2–11.4	9.02	±1.15
Hb After HD (g/dL)	7.0–11.5	8.98	±1.20
Ht Before HD (%)	24.5–36.2	30.20	±3.30
Ht After HD (%)	25.0–37.9	31.00	±3.50

Source: Research Data (2026)

The descriptive analysis showed a slight decrease in mean hemoglobin levels after hemodialysis, while hematocrit levels showed a slight increase.

3. Ultrafiltration Volume Profile

Table 3 Distribution of Ultrafiltration Volume

Ultrafiltration Category	Number of Patients	Percentage (%)
<2000 mL	5	16.7
2000–3000 mL	18	60.0
>3000 mL	7	23.3
Total	**30**	**100**

Source: Research Data (2026)

Most patients underwent ultrafiltration volumes ranging from 2000–3000 mL.

Table 4 Descriptive Statistics of Ultrafiltration Volume

Variable	Mean ± SD	Minimum	Maximum
Ultrafiltration Volume	2562.29 ± 550.74 mL	1500 mL	3500 mL

Source: Research Data (2026)

The average ultrafiltration volume was 2562.29 ± 550.74 mL.

4. Correlation Between Ultrafiltration and Hematological Changes

Table 5 Relationship Between Ultrafiltration Volume and Changes in Hb and Ht

Independent Variable	Dependent Variable	Mean ± SD	Spearman (r_s)	p-value	Interpretation
Ultrafiltration Volume	Δ Hb	–0.04 ± 0.60 g/dL	–0.21	0.27	Weak negative, not significant
Ultrafiltration Volume	Δ Ht	+0.80 ± 1.50%	–0.18	0.33	Weak negative, not significant

Source: Research Data (2026)

Spearman correlation analysis demonstrated that ultrafiltration volume was not significantly associated with changes in Hb or Ht values.

5. Statistical Analysis

Table 6 Normality Test Results

Variable	p-value	Interpretation
Δ Hb	>0.05	Normal Distribution
Δ Ht	>0.05	Normal Distribution

Source: Research Data (2026)

Because the data were normally distributed, Paired Sample t-Test was performed.

Table 7 Paired Sample Statistics

Variable	Mean	SD	n
Hb Before HD	9.05	1.25	30
Hb After HD	8.96	1.35	30
Ht Before HD	30.45	3.63	30
Ht After HD	31.06	3.90	30

Source: Research Data (2026)

Table 8 Paired Sample t-Test Results

Variable	Mean Before	Mean After	t-value	p-value	Interpretation
Hemoglobin (Hb)	9.05	8.96	0.74	0.466	Not Significant
Hematocrit (Ht)	30.45	31.06	–1.68	0.105	Not Significant

Source: Research Data (2026)

The statistical analysis indicated no significant differences in hemoglobin or hematocrit levels before and after hemodialysis ($p>0.05$).

DISCUSSION

1. Characteristics of Research Subjects

The majority of patients undergoing hemodialysis were aged 50–59 years, male, had undergone hemodialysis for 1–5 years, and all patients were classified as CKD Stage V. These findings indicate that chronic kidney disease progresses gradually over time and eventually requires renal replacement therapy. Aging contributes to declining nephron function and reduced glomerular filtration rate, accelerating kidney function deterioration. Male predominance may be associated with a higher prevalence of metabolic risk factors and lower hormonal protection compared with females.

2. Hemoglobin Profile Before and After Hemodialysis

The average hemoglobin level remained below the normal reference range both before and after hemodialysis, indicating persistent anemia among CKD Stage V patients. Statistical analysis demonstrated no significant difference in hemoglobin values before and after treatment ($p=0.466$).

This finding suggests that a single hemodialysis session does not substantially alter hemoglobin concentration. Chronic anemia in CKD is primarily influenced by reduced erythropoietin production, impaired iron metabolism, chronic inflammation, shortened erythrocyte lifespan, and blood loss during dialysis. Although ultrafiltration theoretically causes hemoconcentration and may increase hemoglobin levels, this effect was not clinically significant in this study.

3. Hematocrit Profile Before and After Hemodialysis

Hematocrit values before and after hemodialysis also remained below normal limits and showed no statistically significant difference ($p=0.105$). The low hematocrit levels reflect reduced red blood cell mass commonly observed in advanced CKD.

Because hemoglobin and hematocrit are closely related hematological parameters, minimal changes in hemoglobin were accompanied by similarly small changes in hematocrit. The expected increase caused by fluid removal during ultrafiltration was insufficient to produce significant hematological changes.

4. Relationship Between Ultrafiltration Volume and Changes in Hemoglobin and Hematocrit

Most patients underwent ultrafiltration volumes between 2000–3000 mL. Patients receiving larger ultrafiltration volumes tended to show greater changes in Hb and Ht values; however, the correlations were weak and not statistically significant.

Although ultrafiltration can reduce plasma volume and induce relative hemoconcentration, hematological responses are influenced by multiple factors including baseline hydration status, plasma refilling capacity, erythropoiesis-stimulating therapy, nutritional status, blood loss during dialysis, and severity of chronic anemia.

5. Overall Interpretation

The findings indicate that hemodialysis and ultrafiltration volume alone do not significantly affect hemoglobin and hematocrit levels in CKD Stage V patients. Hematological status in this population appears to be more strongly influenced by underlying chronic anemia and complex pathophysiological mechanisms associated with advanced kidney disease rather than acute fluid removal during a single hemodialysis session.

CONCLUSION

Based on the findings of this study on hemoglobin (Hb), hematocrit (Ht), and ultrafiltration volume among Chronic Kidney Disease (CKD) patients undergoing hemodialysis at RS Tk.III Slamet Riyadi Surakarta, several conclusions were obtained:

1. Most patients experienced anemia, with hemoglobin and hematocrit values remaining below normal ranges before and after hemodialysis.
2. Small changes in Hb and Ht levels occurred following hemodialysis; however, these changes were not clinically substantial.
3. Changes in hematocrit followed a similar pattern to hemoglobin and were associated with alterations in body fluid volume during treatment.
4. Higher ultrafiltration volumes tended to produce greater changes in Hb and Ht due to relative hemoconcentration, although the overall effect remained limited.
5. Most patients underwent ultrafiltration within the range of 2000–3000 mL, indicating considerable fluid retention among CKD patients.

Recommendations

1. **For Healthcare Professionals:** Routine monitoring of hemoglobin, hematocrit, and ultrafiltration volume is recommended to improve fluid and anemia management in hemodialysis patients.
2. **For Hospitals and Hemodialysis Units:** Regular evaluation of hemodialysis effectiveness and hematological monitoring should be strengthened to optimize patient care.
3. **For Educational Institutions:** This study may serve as a reference for learning in hematology and medical-surgical nursing.
4. **For Future Research:** Further studies should include larger sample sizes, prospective designs, and additional variables such as erythropoietin level, iron status, duration of hemodialysis, and treatment frequency.

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