Al-Farouk journal of sciences
Volume (2), Issue (5) (Nov, 2026)
ISSN: 3135-2359

مجلة الفاروق للعلوم
المجلد (2) العدد 5 نوفمبر 2026
عدد خاص بالمؤتمر العلمي الرابع للعلوم والتقنية
28–29 نوفمبر 2026 مصراتة – ليبيا
إدارة المعاهد العليا – وزارة التعليم التقني

Evaluation of Changes in Hemoglobin Levels Before and After Hemodialysis and Their Relationship with Erythropoietin Dosage

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Received: 29/7/2026 Revised: 20/8/2026 Accepted: 28/8/2026 Publication: 28/11/2026

Abstract

Background: Anemia is a common complication of chronic kidney disease (CKD) in patients receiving maintenance hemodialysis. Hemoglobin (Hb) concentration may change during dialysis because of fluid removal and associated plasma-volume shifts.

Objective: To evaluate changes in Hb concentration before and immediately after hemodialysis and examine whether the acute change in Hb is associated with weekly erythropoietin (EPO) dose.

Methods: An analytical cross-sectional study was conducted at Ali Omar Asker Dialysis Center (Asbeea) and Tarhuna Dialysis Center, Libya, from November 2025 to February 2026. Fifty adult patients receiving maintenance hemodialysis and EPO therapy were included. Hb was measured immediately before and after the same dialysis session. Clinical and treatment data were obtained from medical records. Pre- and post-dialysis Hb levels were compared using a paired-samples t-test, and the association between the change in Hb (Δ Hb) and weekly EPO dose was assessed using Spearman's rank-order correlation.

Results: Mean age was 52.6 ± 13.4 years, and 70.0% of participants were male. Mean Hb increased significantly from 9.54 ± 1.28 g/dL before dialysis to 9.78 ± 1.35 g/dL after dialysis (mean difference, 0.24 g/dL; $t = -4.045$; $df = 49$; $p < 0.001$). No significant correlation was observed between Δ Hb and weekly EPO dose ($r_s = 0.135$; $p = 0.351$).

Conclusion: The immediate post-dialysis increase in Hb is most consistent with hemoconcentration associated with fluid removal rather than acute erythropoiesis. The acute change in Hb was not associated with weekly EPO dose. Standardized pre-dialysis Hb measurements and longitudinal clinical assessment may provide a more appropriate basis for monitoring anemia and EPO therapy.

Keywords: chronic kidney disease; hemodialysis; hemoglobin; erythropoietin; anemia; hemoconcentration.

1. Introduction

Chronic kidney disease (CKD) is a major global health problem characterized by progressive loss of kidney function and impaired regulation of metabolic, fluid, and electrolyte homeostasis (Kovesdy, 2022; Francis *et al.*, 2024). Its burden continues to increase, with diabetes and hypertension among the major contributing conditions (Romagnani *et al.*, 2025). In advanced CKD, maintenance hemodialysis is required to replace essential renal functions and maintain physiological homeostasis.

Anemia is one of the most common complications of advanced CKD, particularly among patients receiving maintenance hemodialysis. Its pathogenesis is multifactorial and includes reduced renal erythropoietin production, iron disturbances, inflammation, blood loss, nutritional factors, and reduced

red blood cell survival (Badura *et al.,* 2024). Erythropoiesis-stimulating agents (ESAs), including recombinant erythropoietin, are an important component of anemia management, making accurate and consistent hemoglobin (Hb) monitoring essential (Ku *et al*., 2023).

Hemoglobin concentration can vary during a dialysis session because of intravascular fluid removal and changes in plasma volume. Therefore, an increase in post-dialysis Hb may reflect hemoconcentration rather than a true increase in red blood cell mass. A study from Al-Zawiya Teaching Hospital in Libya also reported higher mean Hb after dialysis (Albeshti *et al.,* 2024).

Despite these observations, limited evidence is available regarding the immediate change in Hb before and after hemodialysis and its relationship with EPO dosage among Libyan patients. This study therefore aimed to evaluate pre- and post-dialysis Hb concentrations, determine the acute change associated with a dialysis session, and examine its relationship with weekly EPO dosage.

2. Materials and Methods

2.1 Study Design, Setting, and Participants

An analytical cross-sectional study was conducted at Ali Omar Asker Dialysis Center (Asbeea) and Tarhuna Dialysis Center, Libya, from November 2025 to February 2026. The study included 50 adult patients with end-stage renal disease secondary to CKD who were receiving regular maintenance hemodialysis and EPO therapy. Eligible participants were aged ≥18 years, had undergone maintenance hemodialysis for at least three months, and received two to three dialysis sessions per week.

Patients with active bleeding, recent blood transfusion, hematological disorders unrelated to renal disease, severe acute infection, acute kidney injury, or incomplete clinical or laboratory data were excluded. Participants were included after providing consent to participate.

2.2 Hemodialysis and Data Collection

Hemodialysis sessions were performed using standard dialysis machines available at the participating centers. Each session lasted approximately four hours and was conducted two to three times weekly according to the patient's clinical condition and treating physician's recommendations. Data collected from clinical records included age, sex, duration of hemodialysis, number of weekly dialysis sessions, pre- and post-dialysis Hb concentrations, and weekly EPO dose (IU/week).

2.3 Blood Sampling and Laboratory Analysis

Venous blood samples were collected immediately before and after the same hemodialysis session. Samples were collected into EDTA tubes and analyzed using an automated hematology analyzer. Hb concentration was expressed in g/dL. The change in Hb concentration (Δ Hb) was calculated as post-dialysis Hb minus pre-dialysis Hb.

2.4 Erythropoietin Therapy

Weekly EPO doses were obtained from patients' treatment records. All participants received recombinant human erythropoietin according to the treating nephrologist's prescription and established treatment protocols.

2.5 Statistical Analysis

Data were analyzed using IBM SPSS Statistics, version 26. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. The Shapiro–Wilk test was used to assess normality. Pre- and post-dialysis Hb concentrations were compared using a paired-samples t-test. Pearson's correlation was used to assess the relationship between pre- and post-dialysis Hb concentrations, while Spearman's rank-order correlation was used to evaluate the association between Δ Hb and weekly EPO dose because EPO dose was not normally distributed. The Mann–Whitney U test was used to compare weekly EPO doses between male and female patients, and the Kruskal–Wallis test was used to compare EPO doses across age groups. A two-sided p-value < 0.05 was considered statistically significant.

2.6 Ethical Considerations

Approval was obtained from the participating dialysis centers before the study commenced. Patient confidentiality was maintained throughout the study, and all collected data were used exclusively for scientific research purposes.

3. Results

3.1 Demographic Characteristics

A total of 50 patients receiving maintenance hemodialysis were included. The mean age was 52.6 ± 13.4 years. Thirty-five participants (70.0%) were male and 15 (30.0%) were female. Regarding age distribution, 15 participants (30.0%) were younger than 40 years, 27 (54.0%) were aged 40–60 years, and 8 (16.0%) were older than 60 years (Table 1).

Table 1. Demographic characteristics of the study population (n = 50).

Variable	Category	n (%)
Age, years	Mean ± SD	52.6 ± 13.4
Sex	Male	35 (70.0)
	Female	15 (30.0)
Age group	<40 years	15 (30.0)
	40–60 years	27 (54.0)
	>60 years	8 (16.0)
Total	—	50 (100.0)

3.2 Comparison of Hemoglobin Concentrations Before and After Hemodialysis

A statistically significant difference was observed between pre- and post-dialysis Hb concentrations. Mean Hb increased from 9.54 ± 1.28 g/dL before dialysis to 9.78 ± 1.35 g/dL immediately after dialysis, corresponding to a mean increase of 0.24 g/dL. The paired-samples t-test demonstrated a significant difference between the two measurements ($t = -4.045$, $df = 49$, $p < 0.001$) (Table 2).

Table 2. Comparison of hemoglobin concentrations before and after hemodialysis.

Measurement	n	Mean Hb (g/dL)	SD	Mean difference (g/dL)	t	df	p-value
Pre-dialysis	50	9.54	1.28	0.24	−4.045	49	<0.001
Post-dialysis	50	9.78	1.35	—	—	—	—

3.3 Relationship Between ΔHb and Weekly Erythropoietin Dose

The change in Hb concentration (ΔHb) was calculated as post-dialysis Hb minus pre-dialysis Hb. Because the weekly EPO dose was not normally distributed according to the Shapiro–Wilk test ($p = 0.001$), Spearman's rank-order correlation was used. No statistically significant correlation was identified between ΔHb and weekly EPO dose ($r_s = 0.135$, $n = 50$, $p = 0.351$). The correlation coefficient indicated a very weak positive association that was not statistically significant (Table 3).

Table 3. Spearman's correlation between ΔHb and weekly EPO dose.

Variables	n	Spearman's rs	p-value
ΔHb and weekly EPO dose	50	0.135	0.351

Overall, Hb concentration increased significantly immediately after hemodialysis, whereas the magnitude of this acute change was not significantly associated with the prescribed weekly EPO dose.

4. Discussion

Anemia is a common complication of advanced CKD, particularly among patients receiving maintenance hemodialysis. Its development is multifactorial and involves reduced erythropoietin production, iron disturbances, inflammation, blood loss, nutritional factors, and reduced red blood cell survival (Badura *et al.,* 2024). Accurate and standardized Hb assessment is therefore important for monitoring anemia and evaluating ESA therapy.

In the present study, males represented 70.0% of participants and most patients were aged 40–60 years. A similar predominance of male and middle-aged patients was reported in a Libyan

hemodialysis population at Zawia Hospital (Albeshti *et al.*, 2024). Comparable age patterns have also been reported in other maintenance hemodialysis populations (Qian *et al.,* 2022; Young *et al.,* 2023).

The principal finding was a significant increase in mean Hb following hemodialysis, from 9.54 g/dL before dialysis to 9.78 g/dL after dialysis, with a mean difference of 0.24 g/dL ($p < 0.001$). This finding is consistent with previous reports of higher post-dialysis Hb concentrations. Sagheb et al. (2016) attributed such increases primarily to plasma-volume contraction resulting from ultrafiltration rather than an increase in red blood cell mass. Albeshti *et al*. (2024) similarly reported an increase in Hb after hemodialysis and related it to fluid removal and hemoconcentration. Qian *et al.* (2022) also demonstrated that changes in plasma volume during hemodialysis can influence measured Hb concentrations.

The increase observed in the present study is therefore most plausibly explained by hemoconcentration associated with intravascular fluid removal. A reduction in plasma volume increases the concentration of circulating blood components, including Hb, without necessarily indicating increased erythropoiesis. Thus, post-dialysis Hb values should be interpreted in relation to the timing of blood sampling and the physiological effects of dialysis.

The second major finding was the absence of a significant association between ΔHb and weekly EPO dose ($rs = 0.135$, $p = 0.351$). This result is consistent with the multifactorial determinants of ESA requirements. Pan *et al.* (2022) reported that ESA dose and responsiveness are influenced by several clinical factors rather than Hb concentration alone. El-Shishtawy *et al.* (2024) identified inflammation, nutritional status, and body mass index as factors associated with ESA responsiveness, while Atzinger *et al.* (2025) reported that patients with ESA hyporesponsiveness may require higher doses despite comparable Hb concentrations.

The lack of a significant association may also be explained by the different time scales represented by the two variables. The immediate change in Hb during a dialysis session primarily reflects acute changes in plasma volume, whereas EPO requirements reflect longer-term erythropoietic needs and are influenced by multiple clinical and biological factors. Therefore, a single post-dialysis Hb measurement should not be considered a direct indicator of the factors determining EPO requirements.

Overall, the findings indicate that Hb concentration increases significantly immediately after maintenance hemodialysis, most likely because of hemoconcentration associated with fluid removal. However, this acute change was not significantly associated with weekly EPO dose. These findings support standardized Hb assessment at a consistent pre-dialysis time together with longitudinal clinical assessment and consideration of other determinants of anemia when evaluating EPO therapy.

5. Study Limitations

This study has several limitations. The sample size was relatively small, and participants were recruited from only two dialysis centers, which may limit the generalizability of the findings. In addition, the cross-sectional design and assessment of Hb during a single dialysis session do not allow evaluation of long-term changes in Hb or EPO requirements. Other potentially relevant factors, including iron status, inflammatory markers, nutritional status, dialysis adequacy, and ultrafiltration volume, were not included in the analysis.

6. Conclusion

Hemoglobin concentration increased significantly immediately after maintenance hemodialysis, rising from 9.54 to 9.78 g/dL. This increase was most likely related to hemoconcentration associated with fluid removal rather than acute improvement in erythropoiesis. No significant association was observed between the acute change in Hb concentration and weekly EPO dose ($rs = 0.135$, $p = 0.351$). These findings highlight the importance of considering dialysis timing when interpreting Hb measurements and support standardized pre-dialysis Hb assessment together with longitudinal clinical evaluation when monitoring anemia and EPO therapy.

7. Recommendations

- Pre-dialysis Hb measurements should be obtained at a standardized time when monitoring anemia and comparing serial measurements.
- EPO therapy should be individualized based on longitudinal Hb levels and relevant clinical and laboratory parameters rather than an isolated post-dialysis Hb value.
- Iron status and other determinants of ESA responsiveness should be considered alongside Hb concentration during anemia management.

- Larger multicenter studies with longer follow-up are recommended to further evaluate changes in Hb and their relationship with EPO requirements.

Acknowledgments

The authors gratefully acknowledge the Departments of Pharmacy and Medical Laboratories at the Higher Institute of Science and Technology, Souk Al-Khamis Amsihel, as well as the Institute Administration, for their support and cooperation. The authors also thank the Fourth Scientific Conference for Science and Technology for providing the opportunity to present and share this research.

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