Al-Azhar International Medical Journal

Volume 4 | Issue 8 Article 9

2023

Section: Internal Medicine

Hemoglobin changes as a Marker of Blood Volume changes in Hemodialysis Patients

Safwat Farrag Ahmed
Department of Internal Medicine and Nephrology, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt.

Hani Ismail Hamed
Department of Internal Medicine and Nephrology, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt.

Mohamed Elsayed Abu Ghabsha
Department of Clinical Pathology, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt.

Mostafa Abd El Hady Ibrahim Gabr
Department of Clinical Pathology, Faculty of Medicine for boys, Al-Azhar University, Cairo, Egypt., gabrm452@gmail.com

Follow this and additional works at: https://aimj.researchcommons.org/journal

Part of the Medical Sciences Commons, Obstetrics and Gynecology Commons, and the Surgery Commons

How to Cite This Article

Ahmed, Safwat Farrag; Hamed, Hani Ismail; Ghabsha, Mohamed Elsayed Abu; and Gabr, Mostafa Abd El Hady Ibrahim (2023) "Hemoglobin changes as a Marker of Blood Volume changes in Hemodialysis Patients," *Al-Azhar International Medical Journal*: Vol. 4: Iss. 8, Article 9.
DOI: https://doi.org/10.58675/2682-339X.1950

This Original Article is brought to you for free and open access by Al-Azhar International Medical Journal. It has been accepted for inclusion in Al-Azhar International Medical Journal by an authorized editor of Al-Azhar International Medical Journal. For more information, please contact dryasserhelmy@gmail.com.

ORIGINAL ARTICLE

Hemoglobin Changes as a Marker of Blood Volume Changes in Hemodialysis Patients

Safwat Farrag Ahmed [a], Hani Ismail Hamed [a], Mohamed Elsayed Abu Ghabsha [b], Mostafa Abd El Hady Ibrahim Gabr [a,*]

[a] Department of Internal Medicine and Nephrology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt
[b] Department of Clinical Pathology, Faculty of Medicine for Boys, Al-Azhar University, Cairo, Egypt

Abstract

Background: **Hemodialysis patients routinely employ relative blood volume (RBV) monitoring to direct fluid management and enhance cardiovascular stability.**

Aim: **In order to determine how estimates of relative blood volume changes may vary based on the monitoring method, the current study sought to examine changes in hematocrit, haemoglobin, or total blood protein concentration in patients receiving normal maintenance hemodialysis.**

Subject and methods: **This was a prospective cross-sectional study carried out at the Nephrology Departments of Al Hussien University Hospitals and Ahmed Maher Teaching Hospital. The study was conducted over a one-year period, from September 2021 to September 2022.**

Results: **Globulin level showed an increase after hemodialysis as it increased from 2.93 g/dl before hemodialysis up to 3.3 g/dl after it. Nonetheless, that rise was considered statistically insignificant (($P = 0.181$).**

Conclusion: **With a considerable decrease in serum urea, hemodialysis is linked to a significant rise in haemoglobin, total plasma protein, and total blood protein. After the hemodialysis setting, the prior parameters could be utilised to track changes in blood volume.**

Keywords: Blood, Hematocrit, Hemodialysis, Hemoglobin, Relative blood volume

1. Introduction

Hemodialysis patients routinely employ relative blood volume (RBV) monitoring to direct fluid management and enhance cardiovascular stability. Online assessments of particular haemoconcentration markers, such as hematocrit (HCT), haemoglobin (HGB), or total blood protein concentration are frequently used to detect RBV changes (TBP). The start of hemodialysis involves injecting the patient's blood into the extracorporeal circuit while discarding or injecting priming saline. As a result, the beginning of hemodialysis may be accompanied by relatively dynamic changes in the circulation, and as a result, the observed RBV changes may be dependent on the exact moment the measurements were started.[1]

The model-based simulations show that, especially with large priming volumes, a minute or two's variation in the timing of initiating RBV tracking through measurements of HCT, HGB, or TBP may have a significant impact on the RBV changes observed during the dialysis session. When measurements begin immediately after the priming saline infusion has completed, there is a greater chance of overestimating the real RBV changes.[1]

Even with a fully functioning vascular refilling mechanism, the total blood volume frequently drops during a typical HD session as a few litres (2−4 L) of fluid are withdrawn from circulation over the course of a few hours (3−5 h). Continuous (or quasi-continuous) non-invasive measurements of the blood's optical, electrical, acoustic, or viscous

Accepted 18 January 2023.
Available online 7 November 2023

* Corresponding author at: Department of Internal Medicine and Nephrology, Faculty of Medicine for Boys, Al-Azhar University, Resident of Internal Medicine, Cairo, Egypt. Fax: 01121209929.
E-mail address: gabrm452@gmail.com (M.A. El Hady Ibrahim Gabr).

https://doi.org/10.58675/2682-339X.1950
2682-339X/© 2023 The author. Published by Al-Azhar University, Faculty of Medicine. This is an open access article under the CC BY-SA 4.0 license (https://creativecommons.org/licenses/by-sa/4.0/).

properties travelling through the dialyzer lines are widely employed to determine relative blood volume changes during hemodialysis. Measurements of either hematocrit, total blood protein concentration, or whole blood haemoglobin concentration are the basis for the three most popular methods for determining RBV changes during HD.[2]

The assumptions regarding the pooling or release of blood with varying levels of HCT at different regions of circulation or the sequestering of erythrocytes in the spleen are critical for predicting RBV changes from changes in HGB or TBP. This is due to the fact that the quantity of erythrocytes in the system influences the level of HGB in blood.[1]

In order to determine how estimates of relative blood volume changes may vary based on the monitoring method, the current study sought to examine changes in hematocrit, haemoglobin, or total blood protein concentration in patients receiving normal maintenance hemodialysis.

2. Patients and methods

This was a prospective cross-sectional study curried out at Nephrology Departments of Al Hussien University Hospitals and Ahmed Maher Teaching Hospital. The study was conducted over a one-year period, from September 2021 till September 2022.A total of 21 patients who presented to the hemodialysis units of the previous two hospitals were included in the current study.

2.1. Inclusion criteria

Patient's age >18 and < 65 years old and patients undergoing regular hemodialysis thrice-weekly HD with duration of approximately 4 h.

2.2. Exclusion criteria

Patient's age <18 and >65 years old, patients on conservative treatment and chronic illness patients especially chronic liver disease and congestive heart failure.

2.3. Ethical consideration

The Al-Azhar University faculty of medicine's local scientific and ethical committee gave the study their blessing. Every patient felt free to leave the research at any moment, based on their request. Patient confidentiality was preserved, and the collected data were used only for scientific purposes.

2.4. Patient consent

An informed written consent was obtained from all patients after explaining the benefits and possible drawbacks of each intervention.

2.5. Patient evaluation

2.5.1. History taking

Personal history including name, age, gender, occupation, residence, and special habits, duration and etiology of CKD, duration since starting hemodialysis therapy, frequency of hemodialysis, current medical comorbidities with its duration and commenced treatment and previous surgical history.

2.5.2. Clinical examination

General examination, encompassing evaluation of the patient's appearance, complexion, weight, physique, heart and lungs condition, and vital signs (pulse, blood pressure, temperature, and respiratory rate). Inspection, palpation, and auscultation of the abdomen locally.

2.5.3. Laboratory investigations

Blood samples were collected from the arterial hemodialysis line just before hemodialysis, and they included: Hemoglobin level, serum albumin, serum globulin, total plasma proteins, total blood proteins were calculated as the sum of hemoglobin and total plasma proteins corrected for hematocrit, serum urea and creatinine, serum calcium and phosphorus and serum alkaline phosphatase.

2.6. The hemodialysis procedure

The dialyzer won't be changed while the session is taking place. The priming saline that was in the extracorporeal circuit before to each dialysis was always delivered into the patient once the circuit was filled with the patient's blood. The dialyzer blood flow rate, dialyzer make-up, and rate of ultrafiltration were identical for each session (all of which varied between the patients and the studied sessions). The temperature was always kept at 36 C, and the dialysate flow rate was always set at 500 mL/min. The majority of the dialysis treatments were delivered by low-flux dialyzers. Throughout each dialysis treatment, the patients were remained supine.

2.7. Post-dialysis assessment

Hemoglobin, albumin, globulin, total plasma and blood proteins, serum urea, and patient weight were repeated again after hemodialysis.

2.8. Primary outcome

Evaluating hemoglobin changes after hemodialysis.

2.9. Secondary outcomes

Evaluating body weight, albumin, globulin, urea, plasma and total blood protein changes after hemodialysis.

2.10. Statistical analysis

The tabulation and analysis of the data were done using the SPSS programme. Quantitative data was expressed as mean and standard deviation, or median and range, whereas categorical data was expressed as numbers and percentages. The latter data type was compared between the two time points using the paired t-test. A p value less than 0.05 was considered significant.

3. Results

Fig. 1.

The description of age in the studied patients. The mean age of all patients was 52.33 ± 9.26 years with minimum age of 32 years and maximum age of 64 years Fig. 2, Table 1.

There was a statistically significant (**p value < 0.05**) comparison between pre and post according to Alb Table 2.

There was a statistically nonsignificant (**p value > 0.05**) comparison between pre and post according to Glb Table 3.

There was a statistically significant (**P value < 0.05**) comparison between pre and post according to TP Table 4.

There was a statistically significant (**P value < 0.05**) comparison between pre and post according to TBP Fig. 3.

There was a statistically significant (**p value < 0.05**) comparison between pre and post according to urea Table 5.

This table shows description of S. Creat in the studied patients. The mean S. Creat of all patients was 8.49 ± 1.81 with minimum of S. Creat 5.5 and maximum of S. Creat 12 Table 6.

Description of CA in the studied patients; the mean CA of all patients was 8.16 ± 0.47 with minimum of CA 7.5 and maximum of CA 9.1. Description of PO4 in the studied patients; the mean PO4 of all patients was 4.69 ± 1.38 with minimum of PO4 2.4 and maximum of PO4 8.2. Description of IPTH in the studied patients; The mean IPTH of all patients was 315.38 ± 225.38 with minimum of IPTH 45 and maximum of IPTH 900. Description of Alk. phosphatase in the studied patients. The mean Alk. phosphatase of all patients was 85.57 ± 50.36 with minimum of Alk. Phosphatase 50 and maximum of Alk. phosphatase 274.

4. Discussion

The removal of the extra fluid that builds up in the patient's body as a result of renal failure is one of the fundamental objectives of dialysis therapy. During haemodialysis (HD), a procedure known as ultrafiltration removes extra fluid (water and tiny solutes) from the blood moving through the dialyzer.[1]

The current study was conducted at Al Hussien University Hospitals and Ahmed Maher Teaching Hospital aiming to analyze changes of hematocrit, hemoglobin or total blood protein concentration in patients undergoing routine maintenance

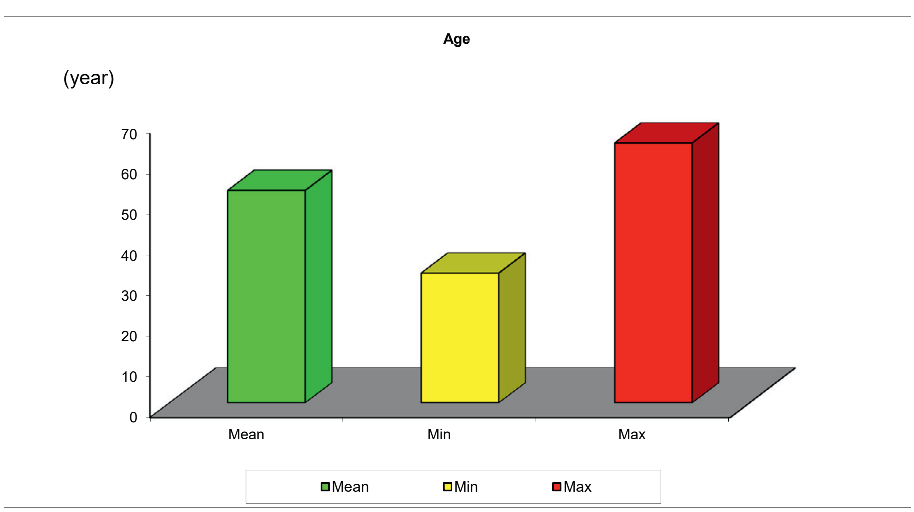

Fig. 1. Distribution of age in all the studied patients.

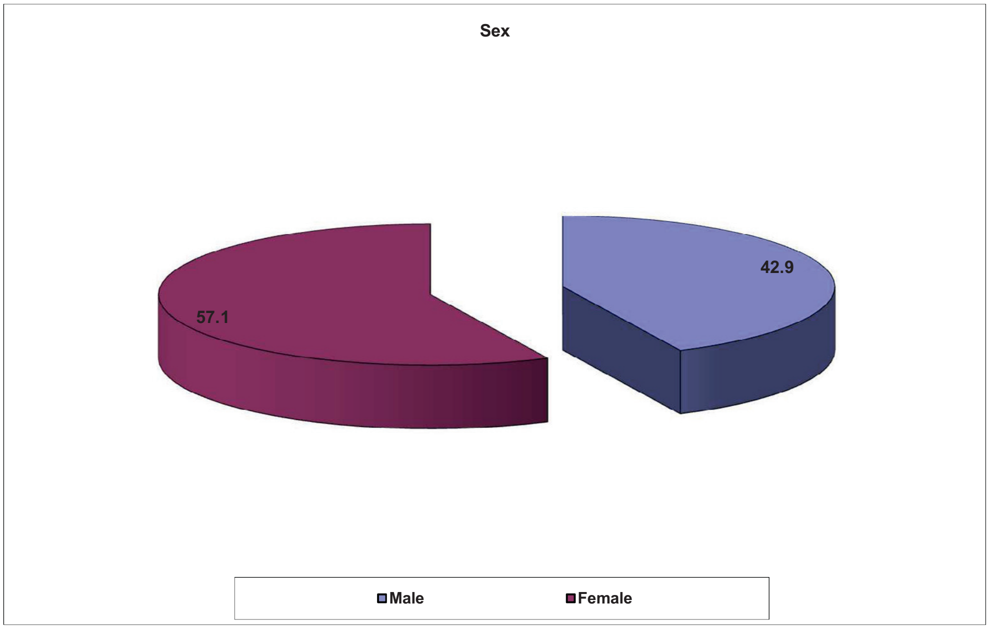

Fig. 2. Distribution of sex in the studied patients there were 9 males (42.9%) and 12 females (57.1%).

Table 1. Comparison between pre and post according to albumin.

	Pre	Post	*t*. test	*P* value
Alb (g/dl)				
Range	2.7—4	3.2—4.2	3.149	0.003*
Mean ± S. D	3.27 ± 0.31	3.54 ± 0.24		

Table 2. Comparison between pre and post according to Glb

	Pre	Post	*t*. test	*P* value
Glb (g/dl)				
Range	2.2—5.1	2.5—6.7	1.360	0.181
Mean ± S. D	2.93 ± 0.69	3.30 ± 1.06		

hemodialysis. A total of 21 patients on maintenance hemodialysis were included in the current study. Their age ranged between 32 and 64 years (mean = 52.33 years).Another previous Egyptian study conducted in Tanta university reported that the mean age of the included hemodialysis patients was 53.04 ± 14.7 years,[3] which is near to our findings. **Mourad** et al.,[4] also reported a mean age of 50.23 years for their hemodialysis population sample, which also in line with our findings.In the current study, women represented 57.1% of the study population, whereas the remaining portion was occupied by men (42.9%).

Kamal et al.,[5] confirmed our findings regarding gender, as there were 81 males (47.6%) and 89 females (52.4%) among the studied sample.On the other hand, another study reported higher prevalence of male gender in the selected hemodialysis population, as the study patients (641) consisted of 61.6% male and 38.4% female patients.[6]

Table 3. Comparison between pre and post according to TP.

	Pre	Post	*t* test	*P* value
TP				
Range	5.2—8.6	5.9—9.9	2.057	0.046*
Mean ± S. D	6.20 ± 0.84	6.82 ± 1.11		

Our findings showed that the prevalence of diabetes was 38.1%, as it was detected in eight out of the included 21 patients.It is known that diabetes mellitus is the most prevalent cause of ESRD.[7] Nearly 40% of dialysis patients suffer from diabetic nephropathy,[8] which coincides with our study findings.Another recent report published by Al-Ghamdi and his coworkers reported that diabetes was present in 45%—74% in hemodialysis patients **Al-Ghamdi** et al.,[9] which is higher than our reported ratio. In our study, hypertension was present in 17 cases out of the included 21 cases, with a prevalence rate of 81%.According to Bucharles et al., only a minority of regular hemodialysis patients have acceptable blood pressure control, and hypertension (blood pressure >140/90 mmHg) affects 70—80% of

Table 4. Comparison between pre and post according to TBP.

	Pre	Post	*t* test	*P* value
TBP (g/dl)				
Range	12.9—17.7	14.3—20.0	4.00	0.001*
Mean ± S. D	15.49 ± 1.20	17.22 ± 1.59		

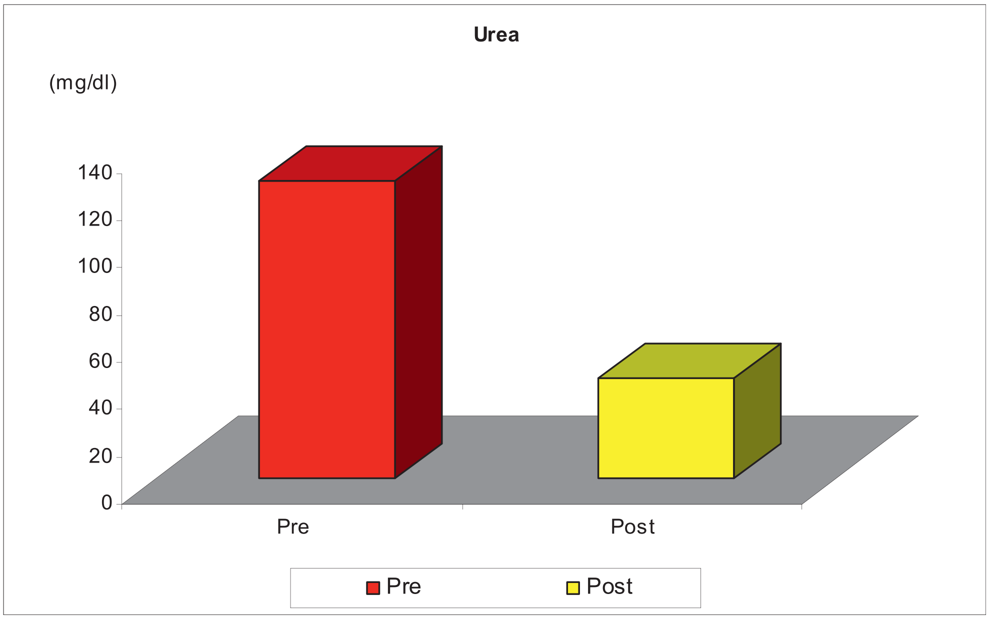

Fig. 3. Comparison between pre and post according to urea.

Table 5. Criteria of S. Creat in all the studied patients.

	Range	Mean ± S. D
S. Creat (mg/dl)	5.5–12	8.49 ± 1.81

patients on regular hemodialysis, which is consistent with our findings.[10]

Furthermore, epidemiological research in hemodialysis patients in the USA found that 72–88% of all patients had increased blood pressure. These studies used various techniques to define hypertension.[11,12]

Although sodium retention and volume overload appear to be the primary pathogenic mechanisms of hypertension in this population, other factors like increased arterial stiffness, renin-angiotensin-aldosterone system activation, sleep apnea, sympathetic nervous system activation, and use of recombinant erythropoietin may also be involved.[13]

When it comes to albumin levels in our study, it showed a significant increase after hemodialysis session ($P = 0.003$), as it increased from 3.27 g/dl before dialysis up to 3.54 g/dl after it. Our observation that serum albumin levels tended to increase over time on dialysis is consistent with results from previous studies **Parker Iii** et al.[14]; **Goldwasser** et al.[15]; **Mehrotra *et al.***[16] These results imply that an increased extracellular fluid volume contributes to the predialysis decrease in serum albumin levels. On the other hand, the Italian Cooperative Dialysis Study found that serum albumin levels gradually decreased over time in a study of patients who often had hemodialysis.[17]

In our study, globulin level showed an increase after hemodialysis as it increased from 2.93 g/dl before hemodialysis up to 3.3 g/dl after it. Nonetheless, that rise was considered statistically insignificant (($P = 0.181$).To the best of our knowledge, no previous studies have evaluated the effect of hemodialysis on serum globulin level, but we think that a slight nonsignificant increase in our study could be explained by the removal of excess body fluid leading to an increase in its concentration. Our findings showed a significant increase in total plasma protein levels after hemodialysis ($P = 0.046$), as it increased from 6.2 g/dl before dialysis to 6.82 g/dl after it. This is in accordance with Pstras et al. who reported similar changes in the same parameter, which increased from 6.5 g/dl before dialysis (range, 4.8–7.5) up to 7.5 g/dl after it (range, 6–8.9) (p value < 0.001).[1]

In the current study, there was a significant rise of hemoglobin levels after hemodialysis ($P = 0.044$). it increased from 9.19 g/dl before hemodialysis to 10.25 g/dl after it. These modifications are brought on by the gradual reequilibration process that

Table 6. Criteria of Ca, PO4, IPTH and Alk. Phophatase in all the studied patients.

	Range	Mean ± S. D
CA (mg/dl)	7.5–9.1	8.16 ± 0.47
PO4 (mg/dl)	2.4–8.2	4.69 ± 1.38
IPTH (pg/ml)	45–900	315.38 ± 225.38
Alk. Phosphatase (Iu/l)	50–274	85.57 ± 50.36

occurs after a hemodialysis session and may cause hemoconcentration in hemodialysis patients.[18]

Another study conducted in 2019 agreed with the previous findings, as hemoglobin levels ranged between 9.6 and 14.5 g/dl before dialysis (mean = 11.4), and it significantly increased to 12.6 g/dl (range, 10.8–16) after the session ($P < 0.001$).[1]

In our study, TBP showed a significant increase after hemodialysis ($P = 0.001$), as it increased from 15.49 g/dl before hemodialysis to 17.22 g/dl after it. In line with the previous findings, Pstras and his associates reported that predialysis TBP ranged between 13.3 and 18.6 g/dl (mean = 15.6), and it ranged between 15 and 20.3 g/dl after it (mean = 17.2), with a significant difference between the two time points ($P < 0.001$).[1]

One should take into account the possibility that the amount of plasma proteins in the circulatory system may vary as a result of protein replenishing from the interstitium during HD, which may further bias the TBP-based technique of calculating RBV alterations (through the lymphatic system and transcapillary fluid absorption).[19]

Although patients weight decreased from 73.67 kg prior to dialysis down to 72.02 kg after it, that decline was statistically insignificant ($P = 0.4$). As hemodialysis filters the blood to remove excess fluid from the blood, it is expected to witness some decline in body weight. In our study, serum urea showed a significant drop after hemodialysis ($P = 0.001$), as it decreased from 125.48 mg/dl before it down to 42.29 mg/dl after it. In agreement with our findings, Zenuz et al. reported a significant decline of the same parameter from 113 mg/dl before dialysis down to 32 mg/dl after it, with a significant difference on statistical analysis ($P < 0.001$).[20]

Ajam also confirmed the previous findings, as the same parameter had mean values of 27.47 and 20.72 mmol/l before and after hemodialysis respectively ($P < 0.001$).[21]

According to our research, the mean level of serum creatinine was 8.49 mg/dl. A waste product of muscular activity found in the blood is creatinine. The kidneys ordinarily filter it out of the blood, but when kidney function declines, the creatinine level increases.[22]

This explains our observations. In the current study, serum calcium and phosphorus had mean values of 8.16 and 4.69 mg/dl respectively. One could notice the tendency of such cases to have lower calcium levels and higher phosphorus levels compared to the normal population. Another study reported mean values of 8.52 and 4.63 mg/dl for the same parameters respectively.[6]

The mean level of serum PTH in the current study was 315.38 pg/ml. The mean result in another study was 266.25 pg/ml.[6] Chronic kidney disease (CKD) impairs vitamin D activation in the kidneys, causing hypocalcemia and hyperphosphatemia. As a result, the parathyroid gland's cellularity and parathyroid hormone synthesis rise, leading to secondary hyperparathyroidism.[23]

In our investigation, the median serum alkaline phosphatase concentration was 85.57 iu/l. ALP may also be a marker of rapid bone turnover without the side effects of serum parathyroid hormone (PTH), and it has been suggested that individuals with chronic kidney illness may be more likely to have ALP levels in their blood (CKD).[24] RBV monitor accuracy may also be impacted by the properties of the blood (such as oxygen saturation) and the dialysis settings (such as blood flow rate or dialyzer inflow pressure).[25]

Additionally, keep in mind that all RBV monitor readings refer to BV changes relative to the measurement start, which means that the patient's body may not be in a steady-state condition for fluid and blood distribution at that time.[26]

Our study has some limitations, manifested mainly by the small sample size. Also, we should have correlated the difference of changes in the tested parameters to elucidate what is the best parameter to reflect blood volume changes. That should encourage us to conduct more studies including more cases from different dialysis centers in the near future.

4.1. Conclusion

With a considerable decrease in serum urea, hemodialysis is linked to a significant rise in haemoglobin, total plasma protein, and total blood protein. After the hemodialysis setting, the prior parameters could be utilised to track changes in blood volume.

Disclosure

The authors have no financial interest to declare in relation to the content of this article.

Authorship

All authors have a substantial contribution to the article.

Sources of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of interest

The authors declare no conflict of interest.

References

1. Pstras L, Debowska M, Wojcik-Zaluska A, Zaluska W, Waniewski J. Hemodialysis-induced changes in hematocrit, hemoglobin and total protein: implications for relative blood volume monitoring. *PLoS One*. 2019;14:e0220764.
2. Dasselaar JJ, van der Sande FM, Franssen CFM. Critical evaluation of blood volume measurements during hemodialysis. *Blood Purif*. 2012;33:177–182.
3. El-Sheikh M, El-Ghazaly G. Assessment of hemodialysis adequacy in patients with chronic kidney disease in the hemodialysis unit at Tanta University Hospital in Egypt. *Indian J Nephrol*. 2016;26:398.
4. Mourad B, Hegab D, Okasha K, Rizk S. Prospective study on prevalence of dermatological changes in patients under hemodialysis in hemodialysis units in Tanta University hospitals, Egypt. *Clin Cosmet Invest Dermatol*. 2014;7:313.
5. Kamal NN, Kamel EG, Eldessouki KH, Ahmed MG. Health-related quality of life among hemodialysis patients at El-Minia University Hospital, Egypt. *J Public Health*. 2013;21:193–200.
6. El-Zorkany KMA. Maintenance hemodialysis in Menoufia governorate, Egypt: is there any progress? *J Egypt Soc Nephrol Transpl*. 2017;17:58.
7. Kuo H-W, Tsai S-S, Tiao M-M, Yang C-Y. Epidemiological features of CKD in taiwan. *Am J Kidney Dis*. 2007;49:46–55.
8. Yarragudi R, Gessl A, Vychytil A. New-onset diabetes mellitus in peritoneal dialysis and hemodialysis patients: frequency, risk factors, and prognosis—a review. *Ther Apher Dial*. 2019;23:497–506.
9. Al-Ghamdi SMG, Bieber B, AlRukhaimi M, et al. Diabetes prevalence, treatment, control, and outcomes among hemodialysis patients in the gulf cooperation council countries. *Kidney Int Rep*. 2022;7:1093–1102.
10. Bucharles SGE, Wallbach KKS, Moraes TPD, Pecoits-Filho R. Hypertension in patients on dialysis: diagnosis, mechanisms, and management. *Braz J Nephrol*. 2018;41:400–411.
11. Salem MM. Hypertension in the hemodialysis population: a survey of 649 patients. *Am J Kidney Dis*. 1995;26:461–468.
12. Agarwal R, Nissenson AR, Batlle D, Coyne DW, Trout JR, Warnock DG. Prevalence, treatment, and control of hypertension in chronic hemodialysis patients in the United States. *Am J Med*. 2003;115:291–297.
13. Sarafidis PA, Persu A, Agarwal R, et al. Hypertension in dialysis patients: a consensus document by the European renal and cardiovascular medicine (EURECA-m) working group of the European renal association–European dialysis and transplant association (ERA-EDTA) and the hypertension and the kidney working group of the European society of hypertension (ESH). *Nephrol Dial Transplant*. 2017;32:620–640.
14. Parker Iii TF, Wingard RL, Husni L, Ikizler TA, Parker RA, Hakim RM. Effect of the membrane biocompatibility on nutritional parameters in chronic hemodialysis patients. *Kidney Int*. 1996;49:551–556.
15. Goldwasser P, Kaldas AI, Barth RH. Rise in serum albumin and creatinine in the first half year on hemodialysis. *Kidney Int*. 1999;56:2260–2268.
16. Mehrotra R, Berman N, Alistwani A, Kopple JD. Improvement of nutritional status after initiation of maintenance hemodialysis. *Am J Kidney Dis*. 2002;40:133–142.
17. Locatelli F, Mastrangelo F, Redaelli B, et al. Effects of different membranes and dialysis technologies on patient treatment tolerance and nutritional parameters. *Kidney Int*. 1996;50:1293–1302.
18. Castillo N, García-García P, Rivero A, et al. Should we adjust erythropoiesis-stimulating agent dosage to postdialysis hemoglobin levels? A pilot study. *BMC Nephrol*. 2012;13:1–6.
19. Pietribiasi M, Katzarski K, Galach M, et al. Kinetics of plasma refilling during hemodialysis sessions with different initial fluid status. *ASAIO J*. 2015;61:350–356.
20. Taghavi Zenuz A, Pakdel F, Mortazavi F, Katebi K. Comparison of changes in urea and electrolyte levels in saliva and serum of patients before and after hemodialysis. *Int J Pharm Phytopharmacol Res*. 2020;10:142–146.
21. Ajam WH. Evaluating of serum electrolyte changes in chronic renal failure pre and post dialysis. *Prof.(Dr) RK Sharma*. 2020;20:41010.
22. Wong Vega M, Swartz SJ, Devaraj S, Poyyapakkam S. Elevated serum creatinine: but is it renal failure? *Pediatrics*. 2020;146:1.
23. Habas Sr E, Eledrisi M, Khan F, Elzouki A-NY. Secondary hyperparathyroidism in chronic kidney disease: pathophysiology and management. *Cureus*. 2021;13:7.
24. Kovesdy CP, Ureche V, Lu JL, Kalantar-Zadeh K. Outcome predictability of serum alkaline phosphatase in men with predialysis CKD. *Nephrol Dial Transplant*. 2010;25:3003–3011.
25. Rauch A, Wiklund J, Lumpkin GT, Frese M. Entrepreneurial orientation and business performance: an assessment of past research and suggestions for the future. *Entrep Theory Pract*. 2009;33:761–787.
26. Dasselaar JJ, Huisman RM, de Jong PE, Franssen CFM. Measurement of relative blood volume changes during haemodialysis: merits and limitations. *Nephrol Dial Transplant*. 2005;20:2043–2049.