PAKISTAN JOURNAL OF HEALTH SCIENCES
(LAHORE)
https://thejas.com.pk/index.php/pjhs
ISSN (E): 2790-9352, (P): 2790-9344
Volume 7, Issue 07 (July 2026)

Original Article

OPEN ACCESS

Effect of Hemodialysis on Serum Phosphate Levels in Patients with End-Stage Renal Disease: A Quasi-Experimental Study at Sir Ganga Ram Hospital, Lahore

Iqra Farooq[1*] and Shahid Anwar[1]

[1]Department of Nephrology, Sir Ganga Ram Hospital, Lahore, Pakistan

ARTICLE INFO

Keywords:
Serum Phosphate, Renal Dialysis, Chronic Kidney Failure, End-Stage Renal Disease

How to Cite:
Farooq, I., & Anwar, S. (2026). Effect of Hemodialysis on Serum Phosphate Levels in Patients with End-Stage Renal Disease: A Quasi-Experimental Study at Sir Ganga Ram Hospital, Lahore: Hemodialysis on Serum Phosphate Levels in Patients with End-Stage Renal Disease. Pakistan Journal of Health Sciences, 7(7), 51-56. https://doi.org/10.54393/pjhs.v7i7.3749

***Corresponding Author:**
Iqra Farooq
Department of Nephrology, Sir Ganga Ram Hospital, Lahore, Pakistan
ifarooq36@gmail.com

Received Date: 27th December, 2025
1st Revision Received: 19th February, 2026
Acceptance Date: 25th March, 2026
Published Date: 31st July, 2026

ABSTRACT

Hyperphosphatemia is a common complication in patients with end-stage renal disease (ESRD). Hemodialysis remains the primary mode of phosphate elimination; however, the impact of demographic and clinical factors on individual patients' clearance is still being studied. **Objective:** To determine the mean change in serum phosphate levels before and after a single session of hemodialysis in patients with ESRD. **Methods:** This quasi-experimental study included 115 adult patients undergoing maintenance hemodialysis three times a week at the Department of Nephrology, Sir Ganga Ram Hospital, Lahore, between February and July 2025, and were recruited. Serum phosphate concentration was measured at the beginning and end of the dialysis session. The statistical analysis was performed using SPSS version 26.0, with significance set at $p<0.050$. **Results:** Among the 115 patients (mean age, 46.5 years), a statistically significant decrease in mean serum phosphate levels from 5.44 ± 1.71 mmol/L to 2.53 ± 0.98 mmol/L was observed as a result of hemodialysis. Multivariate regression supported the view that the model explained 77.3% of the variance in phosphate reduction ($R^2 = 0.773$, $p<0.001$), with pre-dialysis levels being the only significant independent predictor ($\beta = -0.892$, $p<0.001$). There was no statistically significant influence of age, gender, or BMI on the magnitude of reduction ($p>0.050$). **Conclusions:** A single maintenance hemodialysis session significantly reduced serum phosphate levels in patients with ESRD. Although reductions were observed across all demographic variables, the magnitude of reduction did not differ significantly between these groups.

INTRODUCTION

End-stage renal disease (ESRD) is a rising but underreported national health problem in Pakistan, which has a significant impact on the global burden of chronic kidney disease (CKD) [1, 2]. In the absence of a national nephrology registry, the incidence of new ESRD cases is estimated at 150 per million population per year, which provides about 16,000 new cases per year [3]. Hyperphosphatemia is a frequent biochemical imbalance in patients with ESRD and is linked to increased mortality and morbidity [4, 5]. Continuous high levels of serum phosphate can trigger cardiovascular calcification, secondary hyperparathyroidism, and renal osteodystrophy [6, 7]. Although hemodialysis helps remove phosphates to some degree, it is often insufficient to reach target levels. Treatment of phosphate is generally achieved through a combination of dietary phosphorus restriction and oral phosphate binders; however, adherence to phosphate binder regimens is challenging for many patients because binders often contribute a high daily pill burden and require multiple tablets with meals, which can negatively impact compliance [8-10]. Past studies have shown that hemodialysis can significantly reduce circulating phosphate levels. In one study, patients had elevated phosphate levels before dialysis, which decreased significantly after dialysis. Over the next 10 years, the time series of blood phosphate levels in dialysis patients is expected to vary across regions. Between 2002 and 2012, the average phosphate levels decreased in Japan, Europe,

DOI: https://doi.org/10.54393/pjhs.v7i7.3749

and the United States. These levels have, however, changed in recent years, with the United States showing an increase, Europe a slight decrease, and Japan showing stable values [11, 12]. The current study results can guide the optimization of dialysis procedures and improve phosphate management among ESRD patients in Pakistan, where adherence to treatment and resource shortages remain a persistent issue.

No study has compared phosphate rebound in Pakistani ESRD patients following dialysis or the effect of dietary phosphate intake, binder use, and dialysis efficiency on phosphate control. The quasi-experimental design has no control group to make cause-and-effect conclusions, and the single-center setting of the Sir Ganga Ram Hospital has limits to cause and effect and generalization to other dialysis centers with different protocols and resources. This study aims to establish the average intradialytic variation in serum phosphate levels among hemodialysis patients, particularly in a local setting using modern high-flux dialyzers.

METHODS

This quasi-experimental study was conducted at the Department of Nephrology, Sir Ganga Ram Hospital, Lahore, from February 2025 to July 2025. A sample size of 115 patients was calculated using an expected mean difference in serum phosphate levels before and after hemodialysis of -2.57 ± 1.64 [11], with a 3% absolute precision and a 95% confidence level. Non-probability consecutive sampling was used to select participants. Patients aged 18-70, of either gender, receiving regular hemodialysis (at least three sessions weekly) for chronic kidney disease were enrolled. CKD was defined by an eGFR below 15 ml/min/1.73m^2 or current dialysis treatment, regardless of eGFR. Those with active viral infections such as HIV, CMV, or HBV, and patients who had undergone parathyroidectomy, were excluded. Approval for the study was obtained from the hospital ethics committee (vide letter 168-FCPS-Nephro/IRB-ERC; dated 12th July 2024), and informed consent was taken from all participants. Basic demographic and clinical data, including name, age, gender, and body mass index, were recorded. Hemodialysis was performed through an arteriovenous fistula, with each session lasting four hours. The average ultrafiltration volume per session ranged between 2 and 2.5 liters. Biomocompatible capillary filters (polysulfone F60 or F70, surface area 1.2-1.4 m^2) of high flux and high efficiency were used, along with the 4008S dialysis machine (Fresenius Medical Care, Germany). To determine serum phosphate levels, venous blood samples were collected at the start and end of each session via the venous line connected to the dialysis set. The difference in phosphate levels before and after dialysis was recorded on a predesigned pro forma. All data were analyzed using SPSS version 26.0. Normality was assessed using the Shapiro–Wilk test, and parametric tests were applied accordingly. Differences in serum phosphate levels before and after dialysis were evaluated using the paired-samples t-test. The magnitude of phosphate reduction between gender groups was compared using an independent-samples t-test. In contrast, comparisons across age groups and BMI categories were performed using a one-way analysis of variance (ANOVA). Multiple linear regression analysis was conducted to determine whether age, gender, body mass index (BMI), and pre-dialysis phosphate levels were significant independent predictors of phosphate reduction. A p-value<0.050 was considered statistically significant.

RESULTS

A total of 115 patients were included in the study. The mean age of participants was 46.5 ± 15.47 years. The mean body mass index was 21.51 ± 2.20 kg/m^2. Among the study population, 57 patients (49.6%) were female, and 58 patients (50.4%) were male. The mean pre-dialysis serum phosphate level was 5.44 ± 1.71 mg/dL, and the post-dialysis level was 2.53 ± 0.98 mg/dL. A paired samples t-test revealed a statistically significant reduction, with an average decrease of -2.91 ± 2.04 mg/dL (t (114) = 15.298, p<0.001). The findings present a comparison of pre-dialysis and post-dialysis serum phosphate levels across age groups, gender, and BMI categories using a paired-samples t-test. A statistically significant reduction in serum phosphate levels was observed in all age groups following hemodialysis, as determined by paired-sample analysis. Among patients aged 18–30 years, the mean phosphate level decreased from 5.92 ± 1.60 mg/dL to 2.59 ± 0.88 mg/dL (p<0.001). In those aged 31–40 years, levels declined from 5.83 ± 1.51 mg/dL to 2.46 ± 0.89 mg/dL (p<0.001). Patients aged 41–50 years showed a decrease from 5.03 ± 1.78 mg/dL to 2.55 ± 0.99 mg/dL (p<0.001). In the 51–60 years group, phosphate levels reduced from 5.20 ± 2.13 mg/dL to 2.49 ± 1.14 mg/dL (p<0.001). Similarly, patients aged 61–70 years demonstrated a decline from 5.34 ± 1.38 mg/dL to 2.54 ± 1.02 mg/dL (p<0.001). When stratified by gender, both female and male patients demonstrated significant reductions in serum phosphate levels after dialysis. In female patients, the mean level decreased from 5.57 ± 1.88 mg/dL to 2.48 ± 1.06 mg/dL (p<0.001). In male patients, levels declined from 5.32 ± 1.53 mg/dL to 2.58 ± 0.90 mg/dL (p<0.001). Across BMI categories, a significant reduction was also observed. Underweight patients showed a decrease from 4.16 ± 0.32 mg/dL to 2.27 ± 1.31 mg/dL (p=0.010). Patients with normal BMI demonstrated a reduction from 5.41 ± 1.68 mg/dL to 2.54 ± 0.97 mg/dL (p<0.001). In overweight patients, phosphate levels

DOI: https://doi.org/10.54393/pjhs.v7i7.3749

declined from 6.64 ± 2.33 mg/dL to 2.11 ± 0.66 mg/dL; however, this change was not statistically significant (p=0.162). Obese patients showed a decrease from 8.09 ± 1.30 mg/dL to 2.93 ± 1.15 mg/dL (p<0.001)(Table 1).

Table 1: Comparison of Pre- and Post-Dialysis Serum Phosphate Levels Across Demographic and BMI Categories

Groups	n	Pre-Dialysis (mg/dL)	Post-Dialysis (mg/dL)	Paired Sample t-test
Age Groups				
18–30 Years	25 (21.74%)	5.92 ± 1.60	2.59 ± 0.88	t(24) = 9.04, p<0.001
31–40 Years	15 (13.04%)	5.83 ± 1.51	2.46 ± 0.89	t(14) = 8.14, p<0.001
41–50 Years	22 (19.13%)	5.03 ± 1.78	2.55 ± 0.99	t(21) = 4.89, p <0.001
51–60 Years	25 (21.74%)	5.20 ± 2.13	2.49 ± 1.14	t(24) = 5.41, p<0.001
61–70 Years	28 (24.35%)	5.34 ± 1.38	2.54 ± 1.02	t(27) = 8.92, p<0.001
Gender				
Female	57 (49.57%)	5.57 ± 1.88	2.48 ± 1.06	t(56) = 10.73, p<0.001
Male	58 (50.43%)	5.32 ± 1.53	2.58 ± 0.90	t(57) = 10.95, p<0.001
Body Mass Index				
Underweight	104 (90.43%)	4.16 ± 0.32	2.27 ± 1.31	t(5) = 4.03, p=0.010
Normal	6 (5.22%)	5.41 ± 1.68	2.54 ± 0.97	t(103) = 14.20, p<0.001
Overweight	2 (1.74%)	6.64 ± 2.33	2.11 ± 0.66	t(1) = 3.85, p=0.162
Obese	3 (2.61%)	8.09 ± 1.30	2.93 ± 1.15	t(2) = 61.01, p<0.001

The results present the comparison of mean phosphate reduction (pre–post dialysis difference) across gender, age groups, and BMI categories. Independent samples t-test showed no statistically significant difference in phosphate reduction between female (−3.09 ± 2.17 mg/dL) and male patients (−2.74 ± 1.90 mg/dL) (t (113) = −0.917, p=0.361), indicating that gender did not influence the magnitude of reduction. One-way ANOVA showed no significant difference in mean phosphate reduction among age groups (F (4,110) = 0.775, p=0.544), with comparable reductions across all age groups. When analyzed by BMI category, one-way ANOVA revealed a trend toward variation; however, the difference did not reach statistical significance (F (3,111) = 2.204, p=0.092). Although obese and overweight patients showed numerically greater reductions, these differences were not statistically significant (Table 2).

Table 2: Comparison of Magnitude of Phosphate Reduction Across Gender, Age Groups, and BMI Categories

Variables	Groups	Difference (Pre-post Dialysis), Mean ± SD (mg/dL)	Test Statistic	p-value
Age Group	18–30 Years	−3.34 ± 2.23	F (4,110) = 0.775	0.544
	31–40 Years	−3.37 ± 2.36		
	41–50 Years	−2.48 ± 1.85		
	51–60 Years	−2.71 ± 1.88		
	61–70 Years	−2.80 ± 2.05		
Gender	Female	−3.09 ± 2.17	T (113) = −0.917	0.361
	Male	−2.74 ± 1.90		
BMI Category	Normal	−2.87 ± 2.03	F (3,111) = 2.204	0.092
	Underweight	−1.89 ± 1.58		
	Overweight	−4.53 ± 1.62		
	Obese	−5.16 ± 1.94		

The linear regression model produced a significant prediction of change in phosphate, F (4,110) = 93.68, p<0.001, with a substantial proportion of variance explained (R^2 = 0.773). The pre-dialysis phosphate level was the only significant independent predictor of reduction (β = -0.892, p=0.001). The age, BMI, and gender did not have a significant impact on the level of phosphate reduction (p>0.050)(Table 3).

Table 3: Multiple Linear Regression Analysis for Predictors of Serum Phosphate Reduction

Predictor Variables	Unstandardized B	SD Error	Standardised Beta (β)	t-value	p-value
(Constant)	2.135	0.958	–	2.228	0.028
Pre-Dialysis Phosphate	-1.064	0.058	-0.892	-18.476	<0.001
Age	-0.003	0.006	-0.024	-0.515	0.608
Body Mass Index	0.041	0.048	0.044	0.844	0.401
Gender	0.008	0.205	0.002	0.041	0.968

DISCUSSION

In the current study, a single maintenance hemodialysis session resulted in a statistically significant reduction in serum phosphate levels among patients with end-stage renal disease. The decline was consistently observed across all age groups, in both genders, and in most BMI categories. However, when the magnitude of phosphate reduction was compared across demographic and anthropometric groups, no statistically significant differences were identified. Multivariable analysis further demonstrated that the extent of phosphate reduction was independently predicted only by the pre-dialysis serum phosphate level, while age, gender, and body mass index were not significant independent predictors. These findings indicate that although hemodialysis effectively lowers serum phosphate levels, the degree of reduction is primarily determined by baseline phosphate levels rather

DOI: https://doi.org/10.54393/pjhs.v7i7.3749

than patient demographic characteristics. The regulation of phosphates is significantly impaired in CKD patients, especially in ESRD, due to grossly impaired renal excretion [13, 14]. Hyperphosphatemia is common in this population and is associated with an increased risk of vascular calcification, secondary hyperparathyroidism, and left ventricular hypertrophy, which together increase cardiovascular morbidity and mortality. Accurate phosphate management is one of the pillars of CKD-related mineral and bone disorder management, as outlined in existing clinical guidelines. Current clinical practice guidelines recommend that in patients with CKD stages G3a to G5D, elevated serum phosphate levels should be reduced toward the normal range through a combination of dietary phosphate restriction, use of phosphate-lowering therapies, and optimization of dialysis regimens, with regular monitoring of phosphate as part of CKD-MBD management. Recent guideline updates emphasize individualized phosphate targets and reinforce the role of multidisciplinary management in achieving these goals. Although dialysis can aid in the elimination of phosphates, this mode is often insufficient to achieve and maintain target serum concentrations [15-17]. As a result, most patients require additional measures, such as dietary restriction of phosphorus and the use of phosphate-binding agents. Maintaining adequate phosphate control is also a clinical concern, particularly given non-adherence to complex binder regimens that require multiple daily doses with meals. The management of phosphate balance in dialysis patients involves optimizing dialysis performance and regularly monitoring nutrition and medication compliance [18, 19]. Current study observed a statistically significant decrease in serum phosphate in the current study, with 115 patients on routine high-flux hemodialysis, from a pre-dialysis mean of 5.44 ± 1.71 to a post-dialysis mean of 2.53 ± 0.98 mg/dL ($p<0.001$), and an average intradialytic change of 2.91 ± 2.04 mg/dL. These results support the use of modern high-efficiency dialysis filters in significantly reducing serum phosphate in a single session. The extent of decrease was uniform across sex, age groups, and body mass index groups. However, underweight patients showed a slightly smaller mean decrease, possibly due to a lower total body phosphate burden or changes in distribution kinetics. The current study findings are consistent with previous studies evaluating phosphate kinetics during hemodialysis. A similar reduction was reported by Ardalan *et al.* from 5.24 ± 1.83/dl to 2.72 ± 1.00/dl, with a mean difference of -2.52 ± 1.64/dl, which is quite similar to the 2.91/dl change in our cohort [11]. Al-Khafaji *et al.* also found that phosphate levels decreased from 5.68 ± 1.64 to 4.17 ± 1.43 mg/dL after dialysis, whereas the remaining levels were higher than those reported in the current study [20]. This difference could be attributed to variations in dialyzer efficiency, session duration, dietary phosphorus intake, or compliance with phosphate binders. Hamid *et al.* studied the long-term dialysis vintage and phosphate levels and found that they fluctuated over time: 4.7 ± 1.56 mg/dL in those with 10–15 years on dialysis, 5.1 ± 0.85 mg/dL in those with 15–20 years, and 4.4 ± 1.3 mg/dL in those over 20 years. Such trends can be indicative of adaptive changes in bone buffering capacity, nutrition, or remaining renal function with age [3]. The geographic and time-mediated changes in serum phosphate, as shown by the DOPPS study, include regional differences that have decreased gradually in Japan, Europe, and the United States between 2002 and 2012, but have increased or levelled off in 2021. The present results (mean pre-dialysis level = 5.44 mg/dL) align with this international scenario and underscore the ongoing challenges in controlling phosphate levels, despite advancements in dialysis technology [12]. Elias *et al.* examined the kinetics of phosphate removal and found a sharp decline in the initial hour of dialysis; however, only 25% of the total phosphate was removed during this period. Even though serum phosphate can be normalized early in the course of dialysis, a significant proportion is retained, underscoring the importance of completing each session and the potential role of adjunctive phosphate management [21]. Their finding that patients with pre-dialysis phosphate levels ≥5.5 mg/dL had higher overall phosphate removal is consistent with our results, which show larger decreases in younger and obese subgroups who might have higher initial phosphate levels. In a mathematically modelled analysis, Yu *et al.* reported a statistically significant decrease from 2.00 ± 0.53 to 0.84 ± 0.21 mmol/L, consistent with our findings and supporting the effectiveness of hemodialysis in reducing phosphate. The study also noted post-dialysis rebound, which was not considered in our present study [22]. Stremke *et al.* employed a novel methodology to evaluate phosphate rebound after dialysis in phosphate binder-free, controlled-diet patients. They found that in most participants, phosphate levels returned to more than 90 per cent of pre-dialysis levels within 24 hours, indicating that although hemodialysis temporarily reduces serum phosphate, post-treatment phosphate is released into tissue compartments, thereby initiating a rebound effect [23]. This has clinical implications, suggesting that measurement of serum phosphates immediately after dialysis can underestimate the total body phosphate burden, which is not considered in this study but is critical in future studies. This can be used clinically, implying that serum phosphate levels following dialysis may not reflect the total body phosphate burden, which was not

considered in this research but is essential in future studies. These findings are relevant to the Pakistani setting, particularly the need for systematized monitoring of pre-dialysis phosphate levels, optimization of dialysis adequacy, dietary counselling, and prudent use of phosphate binders to improve control of mineral metabolism in the resource-limited clinical environment. Enhancing guideline-driven phosphate management may be one possible measure to reduce cardiovascular complications among patients with end-stage renal disease in local practice [2, 3].
The research was limited in several ways. Post-dialysis phosphate rebound was not assessed, which can occur due to the slow mobilization of phosphate from intracellular stores and bone to the extracellular space; thus, the sustainability of phosphate reduction after the dialysis session is unclear. Phosphorus intake in the diet and phosphate binder use were not documented or controlled, which may have influenced the pre-dialysis phosphate levels and changes. Also, parathyroid hormone and vitamin D measurements were not done, which limits the overall evaluation of mineral metabolism. In Pakistan, the management of ESRD and phosphate control is often challenged by limited access to phosphate binders, financial constraints, inconsistent dietary counselling, and variability in dialysis resources, which may affect the generalizability of findings to routine clinical practice. The factorial designs used should measure the relative effect of dietary phosphate restriction, binder adherence, and dialysis parameters in total phosphate management.

CONCLUSIONS

A single maintenance hemodialysis session significantly reduced serum phosphate levels in patients with end-stage renal disease. This reduction was consistently observed across all age groups, both genders, and most BMI categories in the pre-post comparison. However, the magnitude of phosphate reduction did not differ significantly between age groups, genders, or BMI categories. Multivariable analysis further confirmed that only the pre-dialysis serum phosphate level independently predicted the extent of reduction, whereas age, gender, and body mass index were not significant independent determinants.

Authors' Contribution

Conceptualization: IF, SA
Methodology: IF, SA
Formal analysis: IF, SA
Writing and Drafting: IF, SA
Review and Editing: IF, SA

All authors approved the final manuscript and take responsibility for the integrity of the work

Conflicts of Interest

All the authors declare no conflict of interest.

Source of Funding

The authors received no financial support for the research, authorship and/or publication of this article.

REFERENCES

[1] AlRashed H, Miele J, Prasad J, Adenikinju D, Iloegbu C, Patena J *et al.* Systematic Review of End Stage Renal Disease in Pakistan: Identifying Implementation Research Outcomes. Plos One. 2023 Dec; 18(12): e0296243. doi: 10.1371/journal.pone.0296243.
[2] Khalid F, Ullah Khan A, Fazal A. Causes of End Stage Kidney Disease in Maintenance Hemodialysis Patients in District Swat, Khyber Pukhtonkhwa, Pakistan. Pakistan Journal of Kidney Diseases. 2021 Jun; 5(02): 54-7. doi: 10.53778/pjkd502162.
[3] Hamid A, Dhrolia MF, Qureshi R, Imtiaz S, Ahmad A. Clinical Characteristics of Patients on Long-Term Hemodialysis. Journal of the College of Physicians and Surgeons Pakistan. 2019 Apr; 29(4): 328-32. doi: 10.29271/jcpsp.2019.04.328.
[4] Rastogi A, Bhatt N, Rossetti S, Beto J. Management of Hyperphosphatemia in End-Stage Renal Disease: A New Paradigm. Journal of Renal Nutrition. 2021 Jan; 31(1): 21-34. doi: 10.1053/j.jrn.2020.02.003.
[5] Sprague SM, Martin KJ, Coyne DW. Phosphate Balance and CKD–Mineral Bone Disease. Kidney International Reports. 2021 Aug; 6(8): 2049-58. doi: 10.1016/j.ekir.2021.05.012.
[6] Bacchetta J, Bernardor J, Garnier C, Naud C, Ranchin B. Hyperphosphatemia and Chronic Kidney Disease: A Major Daily Concern Both in Adults and in Children. Calcified Tissue International. 2021 Jan; 108(1): 116-27. doi: 10.1007/s00223-020-00665-8.
[7] Barreto FC, Barreto DV, Massy ZA, Drüeke TB. Strategies for Phosphate Control in Patients with CKD. Kidney International Reports. 2019 Aug; 4(8): 1043-56. doi: 10.1016/j.ekir.2019.06.002.
[8] Kalantar-Zadeh K, Forfang D, Bakris G, Martin KJ, Moe SM, Sprague SM. Managing Phosphate Burden in Patients Receiving Dialysis: Beyond Phosphate Binders and Diet. Kidney 360. 2023 Nov; 4(11): 1650-6. doi: 10.34067/KID.0000000000000262.
[9] Gallant KM, Jermasek D, Oppenheimer B, Doss S. Phosphate Binder Compliance Study in Patients with End-Stage Kidney Disease. Journal of Nephrology and Dialysis Medicine. 2025; 6(3): 1-8. doi: 10.29245/2767-5149/2025/3.1127.
[10] Ferezin BB, Araújo LK, Lima CM, Abensur H, Pereira BJ, Dalboni MA *et al.* Phosphate Binder in Dialysis: A

DOI: https://doi.org/10.54393/pjhs.v7i7.3749

Cross-Sectional Study of Patients' Adherence and Pill Burden. Brazilian Journal of Nephrology. 2025 Jan; 47(1): e20240075. doi: 10.1590/2175-8239-jbn-2024-0075pt.
[11] Ardalan M, Safaei A, Tolouian A, Tolouian R, Attari VE, Jalili M. Hypophosphatemia After Hemodialysis and Its Association with Some Clinical Complications in Patients With Chronic Kidney Disease. Caspian Journal of Internal Medicine. 2022; 13(3): 527.
[12] Guedes M, Bieber B, Dasgupta I, Vega A, Nitta K, Brunelli S *et al*. Serum Phosphorus Level Rises in US Hemodialysis Patients Over the Past Decade: A DOPPS Special Report. Kidney Medicine. 2023 Feb; 5(2): 100584. doi: 10.1016/j.xkme.2022.100584.
[13] Hu L, Napoletano A, Provenzano M, Garofalo C, Bini C, Comai G *et al*. Mineral Bone Disorders in Kidney Disease Patients: The Ever-Current Topic. International Journal of Molecular Sciences. 2022 Oct; 23(20): 12223. doi: 10.3390/ijms232012223.
[14] Rodelo-Haad C, Rodríguez-Ortiz ME, García-Sáez R, Rivas-Domínguez A, Jurado-Montoya D, Martín-Malo A *et al*. The True Cost of Phosphate Control in Chronic Kidney Disease. Clinical Kidney Journal. 2025 Mar; 18(Supplement_1): i46-60. doi: 10.1093/ckj/sfae434.
[15] Marando M, Tamburello A, Salera D, Di Lullo L, Bellasi A. Phosphorous Metabolism and Manipulation in Chronic Kidney Disease. Nephrology. 2024 Dec;29(12):791-800. doi: 10.1111/nep.14407.
[16] Brandenburg V and Ketteler M. Vitamin D and Secondary Hyperparathyroidism in Chronic Kidney Disease: A Critical Appraisal of the Past, Present, and the Future. Nutrients. 2022 Jul; 14(15): 3009. doi: 10.3390/nu14153009.
[17] Lowe KM, Cruz JB, Jones KM. Complications in Patients with Chronic Kidney Disease. Critical Care Nursing Clinics. 2022 Dec; 34(4): 395-407. doi: 10.1016/j.cnc.2022.07.005.
[18] Tsuchiya K and Akihisa T. The Importance of Phosphate Control in Chronic Kidney Disease. Nutrients. 2021 May; 13(5): 1670. doi: 10.3390/nu13051670.
[19] Suzuki K, Soeda K, Komaba H. Crosstalk Between Kidney and Bone: Insights From CKD-MBD. Journal of Bone and Mineral Metabolism. 2024 Jul; 42(4): 463-9. doi: 10.1007/s00774-024-01528-0.
[20] Al-Khafaji NQ, Al-Khafaji BY, Al-Omar DK. Evaluation of Kidney Functions and Heavy Elements Levels in the Blood Serum of Patients with Chronic Kidney Disease Before and After Hemodialysis. Laboratory Diagnostics. Eastern Europe. Founders: Professional Publications, Vilin Professional Publications, LLC. 2024; 13(4): 597-607.
[21] Elias RM, Alvares VR, Moysés R. Phosphate Removal During Conventional Hemodialysis: A Decades-Old Misconception. Kidney and Blood Pressure Research. 2018 Mar; 43(1): 110-4. doi: 10.1159/000487108.
[22] Yu Q, Bai Y, Zhang J, Cui L, Zhang H, Xu J *et al*. Analysis of a Single Hemodialysis on Phosphate Removal of the Internal Fistula Patients by Mathematical And Statistical Methods. Computational and Mathematical Methods in Medicine. 2013; 2013(1): 856897. doi: 10.1155/2013/856897.
[23] Stremke ER, Trevino L, Doshi S, Moorthi RN, Hill Gallant KM, Moe SM. Postdialysis Serum Phosphate Equilibrium in Hemodialysis Patients on a Controlled Diet and No Binders. Hemodialysis International. 2022 Apr; 26(2): 255-63. doi: 10.1111/hdi.12999.