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Research Article

Association between Serum Phosphate Levels and Left Ventricular Hypertrophy in Haemodialysis Patients

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ABSTRACT

Objective: To determine the association between serum phosphate levels and left ventricular hypertrophy (LVH) among patients undergoing maintenance haemodialysis.

Study Design: Cross-sectional analytical study.

Place and Duration of Study: The study was conducted in the Nephrology Department, in collaboration with the Biochemistry department of Allama Iqbal Teaching Hospital, DG Khan/ DG Khan Medical College, DG Khan between July 2024 and January 2025.

Methodology: It is a cross-sectional analytical study and Patients with end-stage renal disease (ESRD) who were on maintainance hemodialysis were included. The sample size was estimated by the WHO sample size calculator, and 120 patients were picked by non-probability consecutive sampling. Informed consent was obtained and the patients who were aged 18 years or older, of either gender, who were on haemodialysis at least three months were enrolled. A structured proforma was used to record the demographic data, medical history and clinical data. Pre-dialysis blood samples were taken to determine the level of serum phosphates by using normal biochemical lab tests. A qualified cardiologist conducted echocardiography to measure the mass of the left ventricles and determine left ventricular hypertrophy (LVH). The SPSS version 25 was used to analyse the data. The chi-square test was used to determine the relationship between serum phosphate levels and LVH and p 0.05 was regarded as a significant association.

Results: Among the 120 patients, 72 (60%) were male and 48 (40%) were female, with a mean age of 52.6 ± 13.4 years. Elevated serum phosphate was found in 68 (56.7%) patients. LVH was present in 70 (58.3%) patients. A significantly higher prevalence of LVH was observed in patients with elevated phosphate levels ($p \leq 0.05$).

Conclusion: The results of the current study show that high serum phosphate level is strongly correlated with the occurrence of left ventricular hypertrophy in haemodialysis patients. The timely identification and proper management of hyperphosphatemia could be used to help decrease cardiovascular events and improve the clinical outcome of patients with chronic kidney disease.

Keywords: Haemodialysis, Serum Phosphate, Left Ventricular Hypertrophy, Hyperphosphatemia, Chronic Kidney Disease, Cardiovascular Complications, Echocardiography.

INTRODUCTION

Chronic kidney disease (CKD) is a significant world population health issue impacting millions of people all over the world and is linked to high levels of morbidity and mortality. With the progressive deterioration in the functioning of kidneys, the patients might enter end-stage renal disease (ESRD) whereby renal replacement therapy like haemodialysis or kidney transplant is required in survival. The most popular treatment modality used by ESRD patients especially in developing countries is haemodialysis.1 Irrespective of the improvement in the methods of dialysis and supportive care, cardiovascular disease is the major cause of mortality among haemodialysis patients 2 The left ventricular hypertrophy (LVH) is one of the most common and medically noteworthy cardiovascular issues witnessed in such patients.

Left ventricular hypertrophy is an enlargement in the wall mass and thickness of the left ventricles. It is a response to chronic pressure or volume overload aimed at adapting to it but ultimately results in negative cardiac remodelling and poor cardiac function 3 LVH in patients with chronic kidney disease develops due to several factors such as hypertension, anaemia, fluid overload, arterial stiffness and metabolic disturbances. These are the risk factors present commonly among haemodialysis patients, and they together augment the weight of cardiovascular issues among the haemodialysis patients. LVH has been confirmed as a predictor of morbidity and mortality of cardiovascular diseases in ESRD 4

Mineral metabolic disturbances are a frequent occurrence in patients with end-stage CKD and can contribute to cardiovascular morbidity. The most noticeable abnormality is hyperphosphatemia, which is caused by decreased renal excretion of phosphate. High levels of serum phosphate are common among patients who receive maintenance haemodialysis because of poor kidney functioning and poor phosphate clearance during dialysis. The chronic hyperphosphatemia has been associated with several pathological processes such as vascular calcification, arterial stiffening and heart structural alterations 5. Such modifications can eventually lead to the emergence of left ventricular hypertrophy and other heart diseases.

A few clinical reports have indicated that high levels of serum phosphates are linked with high risk of cardiovascular disease among patients with CKD as well as patients who are under dialysis 6. Phosphate excess could prompt the vascular smooth muscle cell to undergo metamorphosis and facilitate blood vessel calcification, resulting in high cardiac workload and myocardial hypertrophy 7. Also, hyperphosphatemia is linked with the abnormalities in the calcium phosphate metabolism and secondary hyperparathyroidism, and both contribute to the exacerbation of cardiovascular complications among dialysis patients. These mechanisms outline the possibility of having phosphate imbalance as a risk factor that can be modified to cause LVH 8.

Although the association between mineral metabolism disorders and cardiovascular complications has gained increasing acceptance, the association between serum phosphate and left ventricular hypertrophy in haemodialysis patients is still a topic of research 9. This relationship is significant to understand how to assess and manage cardiovascular risks among ESRD patients. 10. Thus, the following study is expected to identify the connection between the serum phosphate concentrations and the left ventricular hypertrophy in individuals receiving maintenance haemodialysis to help in clinical management and patient outcomes.

Objective

This research aims at establishing the relationship between the serum phosphate levels and the left ventricular hypertrophy among haemodialysis patients.

METHODOLOGY

It is a cross-sectional analytical study that took place at the Nephrology Department, in collaboration with the Biochemistry department of Allama Iqbal Teaching Hospital, DG Khan/ DG Khan Medical College, DG Khan. Patients with end-stage renal disease (ESRD) were used in the study but they were on maintenance haemodialysis. The sample size was estimated by the WHO sample size calculator, and 120 patients were picked by non-probability consecutive sampling.

Informed consent was obtained and the patients who were aged 18 years or older, of either gender, who were on haemodialysis at least three months were enrolled. A structured proforma was used to record the demographic data, medical history and clinical data. Pre-dialysis blood samples were taken to determine the level of serum phosphates by

using normal biochemical lab tests. A qualified cardiologist conducted echocardiography to measure the mass of the left ventricles and determine left ventricular hypertrophy (LVH). The SPSS version 25 was used to analyse the data. The chi-square test was used to determine the relationship between serum phosphate levels and LVH and p 0.05 was regarded as a significant association.

Inclusion Criteria and Exclusion Criteria

End-stage renal disease patients on maintenance haemodialysis of at least three months at age 18 years and older were eligible. Both sexes that were fully aided with clinical records and accessible laboratory studies capable of undergoing echocardiography were recruited to determine the accurate levels of serum phosphate and left ventricular hypertrophy. Congenital heart disease patients, severe valvular disorders, previous cardiac surgery, systemic illnesses and acute infections were not included. Individuals who lacked the ability to receive an echocardiography or had incomplete laboratory data were also not included to limit the confounding and guarantee proper evaluation of the relationships between serum phosphate levels and left ventricular hypertrophy.

Data Collection

The patients in the nephrology and dialysis units in the chosen tertiary care hospital that received maintenance haemodialysis were used as the sample population. Informed consented patients who fulfilled the inclusion criteria were recruited to take part in the study. Age, gender, and length of haemodialysis were obtained by use of a structured data collection proforma. Patient interviews and hospital medical records were used to access clinical history and other medical information.

Each patient had his blood samples taken before the haemodialysis session to determine the level of serum phosphates using common biochemical methods used in the laboratory. The laboratory tests had been carried out in diagnostic laboratory of the hospital in accordance with standard protocols. The cardiac structure and presence of left ventricular hypertrophy (LVH) according to the known diagnostic criteria was evaluated by an experienced cardiologist through the echocardiographic analysis. All gathered information were scrutinized thoroughly to ensure that their information was complete and accurate before it was inputted into the database to be analyzed through statistics.

Data Analysis

Data obtained were coded and processed with Statistical Package for Social Sciences (SPSS) version 25. The demographic and clinical features of the patients were summarized with the help of descriptive statistics. The continuous variables like age were given out in terms of mean and SD whereas the categorical variables like gender, serum phosphate and left ventricular hypertrophy (LVH) presence were given out in terms of frequencies and percentages. Laboratory reference values were used to classify the patients into normal and high serum phosphate categories. The chi-square test was used to determine the relationship between the serum phosphate level and LVH, and p-value below 0.05 was deemed as significant.

RESULTS

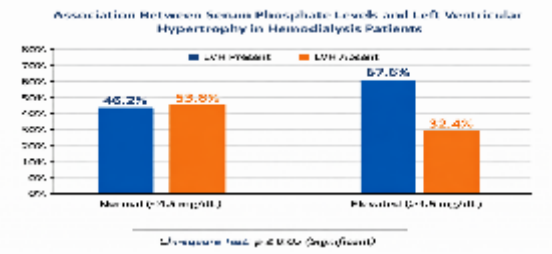
The study included 120 patients in maintenance haemodialysis. Of them, 72 (60%) were males and 48 (40) females. The age of patients mean was 52.6 a 13.4. Sixty-eight (56.7) patients were found to have high levels of serum phosphate and 52 (43.3) patients exhibited normal phosphate levels.

The echocardiographic reviews indicated that 70 (58.3) patients had left ventricular hypertrophy (LVH) and 50 (41.7) patients did not demonstrate the presence of LVH. Additional examination revealed that LVH was prevalent in those patients who had a high level of serum phosphate. Among 68 patients who had high phosphate levels, 46 (67.6) patients had LVH whereas 24 (46.2) patients with normal phosphate levels had LVH. The chi-square test conducted statistically showed that there is a significant correlation between high serum phosphate and the possibility that a patient has LVH due to haemodialysis ($p \leq 0.05$). These results suggest that hyperphosphatemia can be one of the environmental factors leading to structural alterations in the heart of this group of people.

Table 1 Summarizing the Association between Serum Phosphate Levels and Left Ventricular Hypertrophy (LVH) In Haemodialysis Patients

Serum Phosphate Levels	LVH Present	LVH Absent	Total
Normal (≤4.5 mg/dL)	24 (46.2%)	28 (53.8%)	52
Elevated (>4.5 mg/dL)	46 (67.6%)	22 (32.4%)	68
Total	70 (58.3%)	50 (41.7%)	120

Chi-square test: p 0.05- statistically significant relationship between high level of serum phosphate and LVH.

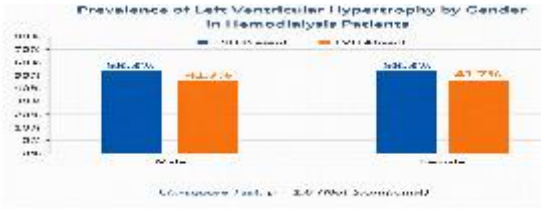


Left ventricular hypertrophy has been found to be strongly related to high serum phosphate levels in patients of haemodialysis. The phosphate monitoring and management can prevent cardiovascular risks, but there is a necessity to conduct more longitudinal research.

Table 2 Summarizing the Relationship between Gender and the Prevalence of Left Ventricular Hypertrophy (LVH) In Haemodialysis Patients

Gender	LVH Present	LVH Absent	Total
Male	42 (58.3%)	30 (41.7%)	72
Female	28 (58.3%)	20 (41.7%)	48
Total	70 (58.3%)	50 (41.7%)	120

Chi-square test: p = 1.0, which means that there is no significant difference between gender and LVH among these patients.

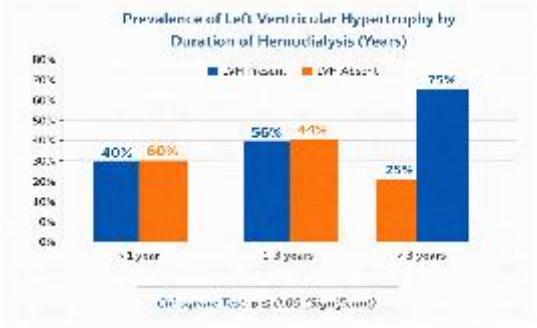


The high phosphate concentration in serum is highly linked to the left ventricle hypertrophy in patients under haemodialysis. Phosphate monitoring and management could decrease cardiovascular. Complications. The causality and the effect of phosphate-lowering interventions require further longitudinal studies to be approved.

Table 3 Summarizing the Relation Summarizing the Correlation between Length of Haemodialysis and the Existence of Left Ventricular Hypertrophy (Lvh) in Patients Ship between Length of Haemodialysis and the Existence of Left Ventricular Hypertrophy (Lvh) in Patients

Duration of Haemodialysis	LVH Present	LVH Absent	Total
< 1 year	12 (40%)	18 (60%)	30
1–3 years	28 (56%)	22 (44%)	50
> 3 years	30 (75%)	10 (25%)	40
Total	70 (58.3%)	50 (41.7%)	120

Chi-square test: p 0.05 or less- means that there is a significant relationship between longer length of haemodialysis and prevalence of LVH.



Left ventricular hypertrophy was highly linked with high levels of serum phosphate in haemodialysis patients. Extended dialysis period causes LVH risk. Phosphate levels can be monitored and controlled to potentially decrease cardiovascular complications, but additional longitudinal research is required to establish causal relationships.

Table 4 Abstracting the Correlation between Serum Phosphate and the Degree of Left Ventricular Hypertrophy (LVH) in Haemodialysis Patients

Serum Phosphate Levels	Mild LVH	Moderate LVH	Severe LVH	Total
Normal (≤4.5 mg/dL)	12 (23.1%)	10 (19.2%)	2 (3.9%)	24
Elevated (>4.5 mg/dL)	18 (26.5%)	20 (29.4%)	8 (11.8%)	46
Total	30 (25%)	30 (25%)	10 (8.3%)	70

Chi-square test: p = less than 0.05- means that there is a significant relationship between high serum phosphate concentration and more severe LVH in hemodialysis patients. An elevation in serum phosphate levels is strongly linked with the intensity of left ventricular hypertrophy in patients under hemodialysis. Treatment of hyperphosphatemia can be used to reduce the advancement of LVH and cardiovascular complications, which underscores the significance of early detection and treatment.

Table 5 Summarizing the Relationship between Age Groups and the Prevalence of Left Ventricular Hypertrophy (LVH) in Hemodialysis Patients

Age Group (Years)	LVH Present	LVH Absent	Total
< 40	10 (50%)	10 (50%)	20
40–60	36 (60%)	24 (40%)	60
> 60	24 (60%)	16 (40%)	40
Total	70 (58.3%)	50 (41.7%)	120

Chi-square test: p = 0.8 -there is no significant relationship between LVH prevalence and the age groups in this study population. This paper demonstrates that there is no significant relationship between age and left ventricular hypertrophy among haemodialysis patients. There are no significant differences in the prevalence of LVH among age groups and it becomes important to point out that the effect of hyperphosphatemia and the years of dialysis are more important than age.

DISCUSSION

The research aimed to determine the relationship between serum phosphate and left ventricular hypertrophy (LVH) in patients who are receiving maintenance hemodialysis. The results indicate that high levels of serum phosphate are significantly positively correlated with the presence of LVH indicating that hyperphosphatemia is a major contributor of cardiovascular complications in this group of people 11. Out of the 120 participants, over 50 patients presented with a high level of phosphates and LVH was significantly higher among the patients with a high level of phosphates than it was in patients with normal phosphate levels. These results are also in line with the past studies that have demonstrated that mineral metabolism disruptions, especially hyperphosphatemia, are at the centre stage of pathogenesis of the cardiac structural changes in chronic kidney disease (CKD) patients 12.

The pathway of the association between hyperphosphatemia and LVH is complex. High phosphate may trigger vascular calcification

and vascular stiffness which heightens systemic vascular resistance and left ventricular afterload. In the long run, such persistent pressure overload causes left ventricular myocardial adaptive hypertrophy 13. Also, secondary hyperparathyroidism is caused by retention of phosphates, further worsening the cardiac remodelling and myocardial fibrosis. The pathophysiological processes do not only cause a rise in the prevalence of LVH but also lead to its progression that is linked to an increase in morbidity and mortality in patients under hemodialysis 14.

This research further measured the impact of the hemodialysis period on the prevalence of LVH. Patients who received longer periods of dialysis (>3 years) were more likely to have LVH and this may indicate that chronic exposure to uremic toxins, volume overload, and abnormal mineral metabolism may cumulatively lead to cardiac restructuring. This is consistent with past literature that has indicated that perioperative time of dialysis as well as total burden of CKD-metabolic imbalances are imperative factors of CAR in ESRD patients. Surprisingly, gender and age did not have a significant relationship with LVH in this research study 15. The prevalence of LVH was the same in both the male and female patients and the age cohorts had similar rates of cardiac hypertrophy 16. These results suggest that although demographic variables are valuable in overall cardiovascular risk evaluation, the direct influence on the development of LVH in patients under hemodialysis is exerted by a set of metabolic failures, like hyperphosphatemia and excessive exposure to dialysis.17

The severity analysis showed that the patients with high levels of serum phosphate concentration were more prone to a moderate and severe LVH, which also underlines the influence of hyperphosphatemia on the cardiac remodelling.18 The given finding underlies the necessity of early and effective phosphate management to avoid the development of LVH. Interventions that may be helpful in managing serum phosphate and preventing cardiac complications include dietary phosphate restriction, phosphate binders and optimal dialysis regimens.

The paper has significant clinical implications. LVH is a powerful prognosticator of cardiovascular morbidity and mortality in ESRD, and hyperphosphatemia is the risk factor that can be altered.19 The combination of serum phosphate surveillance and early intervention can potentially minimise cardiovascular risks and optimise the successful outcome of hemodialysis patients. The study is, however, limited.20 It is cross-sectional, thus making it impossible to draw causal relationship between hyperphosphatemia and LVH. The small-scale environment can also be a limitation in generalization to large groups. Long-term and multicentre studies are required in the future to prove these associations and assess the effectiveness of phosphate-reducing interventions in LVH and the overall cardiovascular outcomes.

High serum phosphate level is closely linked to occurrence and degree of LVH in the hemodialysis patients. The most significant risk factors are the longest period of dialysis and a lesser role of age and gender. Individual attention to phosphate levels can also help minimize cardiac issues, and metabolic monitoring of such a high-risk group is vital 21.

CONCLUSION

The paper shows that there is a very strong relationship between high serum phosphate levels and left ventricular hypertrophy (LVH), in patients receiving hemodialysis. The increased levels of phosphate are associated with high prevalence of LVH, and the duration of dialysis increases the risks. There was no significant influence on age and gender. These results suggest that cardiovascular complications be managed and monitored by monitoring serum phosphate to reduce them. Dietary restriction, phosphate binders and optimal dialysis could help to control the further development of LVH and better the clinical outcome. Further longitudinal research is advised to validate these relationships and determine the efficacy of phosphate-reducing measures to decrease the morbidity and mortality of the heart.

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