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ORIGINAL ARTICLE

Assessment of Serum Phosphate, Calcium, and Parathyroid Hormone Levels in Relation to Metabolic Disturbances in Maintenance Hemodialysis Patients

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ABSTRACT

Background: *Maintenance hemodialysis (MHD) is the primary treatment for end-stage renal disease (ESRD), but it is associated with significant metabolic disturbances. Serum phosphate, calcium, and parathyroid hormone (PTH) imbalances contribute to chronic kidney disease-mineral and bone disorder (CKD-MBD), which increases morbidity and cardiovascular risks. Understanding the relationship between these biochemical parameters and metabolic disturbances is crucial for improving patient management.*

Aim: *To assess the relationship between serum phosphate, calcium, and PTH levels with metabolic disturbances in MHD patients in Bangladesh.* ***Methods & Materials:*** *A cross-sectional study was conducted at Dhaka Medical College Hospital with 80 MHD patients. Clinical and biochemical data, including serum phosphate, calcium, iPTH, and lipid profiles, were analyzed using SPSS (version 26). Correlation analysis was performed to examine associations between metabolic disturbances and biochemical markers.* ***Results:*** *Mean serum phosphate, calcium, and iPTH levels were 5.56±1.36 mg/dl, 8.74±1.30 mg/dl, and 274.59±150.34 pg/ml, respectively. Significant correlations were found between metabolic disturbances and serum phosphate (r=0.652, p<0.001), iPTH (r=0.725, p<0.001), and LDL-C (r=0.382, p=0.008), while serum calcium showed a negative correlation (r=-0.320, p=0.012).* ***Conclusion:*** *Hyperphosphatemia, secondary hyperparathyroidism, and dyslipidemia contribute to metabolic disturbances in MHD patients. Effective biochemical management is crucial for improving patient outcomes. Further studies with larger cohorts are recommended to validate these findings.*

Keywords: *Maintenance hemodialysis, Chronic kidney disease, Metabolic disturbances, Serum phosphate, Calcium, Parathyroid hormone*

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INTRODUCTION

Chronic kidney disease (CKD) and its progression to end-stage renal disease (ESRD) necessitating maintenance hemodialysis (MHD) are associated with significant metabolic disturbances, particularly involving serum phosphate, calcium, and parathyroid hormone (PTH) levels. [1] Chronic kidney disease-mineral and bone disorder (CKD-MBD) is a systemic condition frequently observed in patients with CKD. It is characterized by abnormalities in serum calcium (Ca), phosphate (P), and intact parathyroid hormone (iPTH) levels, which are associated with increased risks of extraosseous and vascular calcification. These abnormalities in Ca, P, and iPTH levels are linked to a higher incidence of cardiovascular disease (CVD) and mortality. [2,3] CKD-MBD is especially prevalent among patients undergoing maintenance hemodialysis (MHD), who represent a vulnerable group experiencing multiple metabolic and systemic complications. [2] CKD is a significant public health problem worldwide, with progressive renal function loss being its most severe outcome. Treatment options for CKD include dialysis (hemodialysis or peritoneal dialysis) or kidney transplantation. [4,5] Haemodialysis (HD) is the commonest form of kidney replacement therapy in the world,

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accounting for approximately 69% of all kidney replacement therapy and 89% of all dialysis.[6] Abnormalities in serum Ca, P, and iPTH levels are highly prevalent in chronic dialysis patients and are associated with increased morbidity and mortality.[7] Elevated serum phosphate (Pi), calcium-phosphate product (Ca-Pi), or iPTH levels, as well as low iPTH levels, have been linked to vascular calcification, cardiovascular complications, and mortality in dialysis patients.[8] Ongoing research has established biologically plausible mechanisms by which these abnormalities contribute to adverse outcomes, including vascular calcification and its systemic effects.[9] However, conflicting clinical results have created uncertainty regarding optimal therapeutic targets and strategies for managing these metabolic disturbances.[10] International guidelines, such as the Kidney Disease Outcomes Quality Initiative (KDOQI) and Kidney Disease: Improving Global Outcomes (KDIGO), provide recommendations for the management of CKD-MBD parameters, including serum Ca, P, and iPTH levels. These guidelines aim to optimize patient outcomes and reduce mortality risks associated with CKD-MBD. [11,12] The complexity of mineral metabolism physiology in CKD patients is further compounded by interactions among individual parameters and their evolution over the course of the disease.[10] Older patients undergoing MHD generally show better control of serum phosphate (P) and intact parathyroid hormone (iPTH) levels. Despite this, they face higher mortality rates, reflecting the complex relationship between age, metabolic disturbances, and clinical outcomes.[13] The interaction between CKD-MBD parameters and systemic complications, including inflammation, malnutrition, and cardiovascular risks, emphasizes the importance of developing comprehensive management strategies that are adapted to local contexts.[14] Furthermore, the lack of interdisciplinary care in addressing related complications, such as periodontal disease and inflammation, may exacerbate the burden of CKD-MBD in these patients.[15] The aim of this study was to evaluate serum phosphate, calcium, and parathyroid hormone levels in relation to metabolic disturbances in MHD patients in Bangladesh.

METHODS & MATERIALS

This rigorously structured cross-sectional study was meticulously executed at the Department of Nephrology, Dhaka Medical College and Hospital (DMCH), located in Dhaka, Bangladesh. Spanning a comprehensive one-year period, from May 2021 to April 2022, this investigation aimed to thoroughly examine patients undergoing maintenance hemodialysis. A purposive sampling method was employed to carefully select a total of 80 patients, establishing a well-defined and representative cohort that provided the necessary clinical insights. Stringent eligibility criteria were applied to ensure that the study participants met the required standards, thereby enhancing the scientific validity and clinical relevance of the findings.

Inclusion Criteria:

The study exclusively included individuals aged between 18 and 64 years who were currently undergoing maintenance hemodialysis treatment.

Exclusion Criteria:

Patients with acute kidney injury superimposed on chronic kidney disease (CKD), individuals with a prior history of carotid artery surgery, alcohol consumers, smokers, and pregnant women were systematically excluded.

Data Collection

Data collection was executed with precision using a well-structured and pre-validated questionnaire. This tool captured key demographic and clinical information, including age, gender, blood pressure, body mass index (BMI), and the duration of dialysis. Additionally, relevant laboratory variables such as serum phosphate, serum calcium, serum intact parathyroid hormone (iPTH), and fasting lipid profiles were measured to assess the biochemical status of the participants. The collection process was conducted in full compliance with ethical standards, with informed consent obtained from all participants prior to enrollment. The study was approved by the institutional ethics committee, ensuring adherence to ethical research practices and safeguarding participants' rights.

Statistical Analysis

The collected data were systematically analyzed using the SPSS software (version 26). Continuous variables were presented as mean ± standard deviation (SD), while categorical variables were summarized as frequencies and percentages to provide a comprehensive overview. Statistical comparisons of quantitative variables were conducted using the unpaired t-test, and the chi-square test was applied for categorical data to evaluate relationships between variables. Pearson's correlation coefficient was employed to explore the degree of association between selected variables. A p-value of less than 0.05 was considered statistically significant, thus ensuring that the results are both reliable and robust, contributing valuable insights into the clinical context of maintenance hemodialysis.

RESULT

The study included maintenance hemodialysis patients with a mean age of 43.17±11.38 years. The majority (61.25%) were between 31-50 years old, where 58.75% were male. BMI classification showed that 67.50% had a normal weight and 2.50% were obese. The mean systolic and diastolic blood pressures were 153.21±22.43 mmHg and 89.64±10.45 mmHg, respectively. The average duration of dialysis was 3.56±2.27 years (Table I). Table II shows that the mean serum phosphate was 5.56±1.36 mg/dl, calcium was 8.74±1.30 mg/dl, and iPTH was 274.59±150.34 pg/ml. Lipid profile assessment showed an average total cholesterol of 189.13±42.50 mg/dl, triglycerides at 188.28±70.01 mg/dl, LDL-C at 121.86±26.67 mg/dl, and HDL-C at 37.93±8.50 mg/dl (Table III). Regarding metabolic disturbances, 35% had mild, 45% moderate, and 20% severe disturbances (Table IV). Correlation analysis

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revealed significant associations of metabolic disturbances with serum phosphate (r=0.652, p<0.001), iPTH (r=0.725, p<0.001), and LDL-C (r=0.382, p=0.008), while serum calcium showed a negative correlation (r=-0.320, p=0.012). Other lipid parameters showed no significant correlations (Table V).

Table – I: Demographic and clinical characteristics of the study participants (*n*=80)

Variables	Frequency (n)	Percentage (%)
		Mean±SD
Age (years)		
18-30	10	12.50
31-50	49	61.25
>50	21	26.25
Mean±SD		43.17±11.38
Gender		
Male	47	58.75
Female	33	41.25
BMI (kg/m²)		
Underweight (<18.5)	13	16.25
Normal (18.5-24.9)	54	67.50
Over weight (25.0-29.9)	11	13.75
Obese (>30.0)	2	2.50
Blood pressure (mmHg)		
Systolic		153.21±22.43
Diastolic		89.64±10.45
Duration of dialysis (years)		
Mean±SD		3.56± 2.27

Table – II: Serum phosphate, calcium, and intact parathyroid hormone (iPTH) levels among study participants (*n*=80)

Variables	Mean±SD	Min-max
Serum phosphate (mg/dl)	5.56±1.36	1.89–9.10
Serum calcium (mg/dl)	8.74±1.30	4.22–11.10
iPTH (pg/ml)	274.59±150.34	5.96–727.50

Table – III: Lipid profile characteristics of the study population (*n*=80)

Variables	Mean±SD	Min-max
Total cholesterol (mg/dl)	189.13±42.50	136-287
Triglyceride (mg/dl)	188.28±70.01	88-34
LDL-C (mg/dl)	121.86±26.67	84-176
HDL-C (mg/dl)	37.93±8.50	25-55

LDL-C: Low-Density Lipoprotein Cholesterol; HDL-C: High-Density Lipoprotein Cholesterol.

Table – IV: Distribution of patients by severity of metabolic disturbances (*n*=80)

Severity	Frequency (n)	Percentage (%)
Mild	28	35.00
Moderate	36	45.00
Severe	16	20.00

Table – IV: Correlation between laboratory parameters and metabolic disturbances (*n*=80)

Variables	Metabolic Disturbances (r-value)	P value
Serum phosphate (mg/dl)	0.652	<0.001
Serum calcium (mg/dl)	-0.320	0.012
Intact Parathyroid Hormone (iPTH) (pg/ml)	0.725	<0.001
Total cholesterol (mg/dl)	0.215	0.074
Triglyceride (mg/dl)	0.198	0.092
LDL-C (mg/dl)	0.382	0.008
HDL-C (mg/dl)	-0.145	0.192

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DISCUSSION

Metabolic disturbances are common in maintenance hemodialysis patient's due to impaired kidney function, leading to abnormalities in mineral metabolism and lipid profiles. Dysregulation of serum phosphate, calcium, and iPTH plays a crucial role in the progression of chronic kidney disease-mineral and bone disorder (CKD-MBD) and increases the risk of cardiovascular complications. Elevated phosphate and iPTH levels, along with calcium imbalances, contribute to bone disorders, vascular calcification, and overall metabolic instability. This study aims to assess the relationship between these biochemical parameters and metabolic disturbances in hemodialysis patients, providing insights into disease management and potential therapeutic interventions. In our study, the participants had a mean age of 43.17±11.38 years with the majority (61.25%) were between 31 and 50 years old. Kuswardhani et al. conducted a study on 68 hemodialysis patients and reported a mean age of 56.28±11.79 years. [16] Males were more prevalent in this study, accounting for 58.75%. Our result is consistent with the study of Ayub et al. who showed that male was higher (56.4%) than female (43.2%) in similar study. [17] In this study, over two-thirds (67.5%) of the patients had a normal BMI, followed by 16.3% who were underweight, 13.8% who were overweight, and 2.5% who were classified as obese. Our study is comparable with the study of Al Saran et al. [18] Obesity is considered a contributing factor to metabolic disturbances. [19] The mean duration of dialysis was 3.56±2.27 years, consistent with patients who have long-term dependence on renal replacement therapy. Barzegar et al found that the mean duration of hemodialysis patients was 34.03 months. [20] In this study, serum phosphate levels were elevated with a mean value of 5.56±1.36 mg/dl, which exceeds the normal reference range. Hyperphosphatemia is a well-recognized complication in chronic kidney disease (CKD) patients on hemodialysis, often resulting from impaired phosphate excretion. Similar findings were reported by Block et al., who observed that elevated phosphate levels in dialysis patients were significantly associated with increased mortality risk. [21] Hyperphosphatemia is usually mild and rarely severe enough to cause metabolic acidosis on its own. [22] Conversely, serum calcium levels were within the lower normal range (8.74±1.30 mg/dl), with some patients exhibiting hypocalcemia. A study by Ketteler et al. also reported a high prevalence of hypocalcemia in dialysis patients. [23] Hypocalcemia in metabolic diseases can result from vitamin D deficiency, chronic kidney disease, or hypoparathyroidism. [24] Parathyroid hormone (iPTH) levels varied widely, with a mean of 274.59±150.34 pg/ml, and ranged from 5.96 to 727.50 pg/ml. This variability suggests that secondary hyperparathyroidism is prevalent in the study population, driven by chronic hypocalcemia and hyperphosphatemia. Similar observations were made by Levin et al., who highlighted the necessity of individualized PTH control strategies to minimize metabolic disease like cardiovascular complications. [25] The lipid profile analysis revealed dyslipidemia, characterized by elevated total cholesterol (189.13±42.50 mg/dl) and triglycerides (188.28±70.01 mg/dl). LDL-C was notably high (121.86±26.67 mg/dl), whereas HDL-C was relatively low (37.93±8.50 mg/dl). These findings are in line with previous research by Vaziri (2006), who reported that hemodialysis patients frequently exhibit an atherogenic lipid profile, contributing to increased cardiovascular morbidity. [26] The study classified metabolic disturbances into mild (35%), moderate (45%), and severe (20%). Correlation analysis revealed a significant positive association between serum phosphate levels and metabolic disturbances ($r=0.652$, $p<0.001$), highlighting hyperphosphatemia as a key contributor to metabolic complications in hemodialysis patients. Similarly, iPTH levels exhibited a strong positive correlation ($r=0.725$, $p<0.001$), further emphasizing the role of secondary hyperparathyroidism in metabolic derangements. A meta-analysis by Tentori et al. supports this correlation, demonstrating a clear link between high phosphate and PTH levels with poor patient prognosis in hemodialysis. [27] Conversely, serum calcium levels showed a significant inverse correlation with metabolic disturbances ($r=-0.320$, $p=0.012$), suggesting that lower calcium levels may exacerbate these complications. Among lipid parameters, LDL-C was significantly associated with metabolic disturbances ($r=0.382$, $p=0.008$), reinforcing the link between dyslipidemia and systemic metabolic imbalances. However, total cholesterol, triglycerides, and HDL-C did not demonstrate significant correlations.

LIMITATIONS OF THE STUDY

- No control groups.
- In this study, all patients were from a single dialysis center, who got twice-weekly hemodialysis using the same dialysis solution. But adequacy of dialysis of individual patients was not measured.
- The study did not consider dietary intake, medication adherence, or genetic factors that could influence serum phosphate, calcium, and PTH levels, which may contribute to metabolic disturbances.

CONCLUSION

In conclusion, this study highlights the significant prevalence of metabolic disturbances among maintenance hemodialysis patients, with serum phosphate and intact parathyroid hormone levels playing key roles in disease severity. Elevated serum phosphate and iPTH levels were positively correlated with metabolic disturbances, whereas serum calcium showed an inverse correlation. Dyslipidemia, particularly high LDL-C levels, also exhibited a significant association with metabolic imbalances. These findings underscore the necessity of close monitoring and comprehensive management strategies to mitigate metabolic complications in hemodialysis patients. Further research with larger, multi-center cohorts and longitudinal designs is warranted to develop targeted interventions that optimize patient outcomes and improve overall quality of life.

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REFERENCES

1. *Chartsrisak K, Vipattawat K, Assanatham M, Nongnuch A, Ingsathit A, Domrongkitchaiporn S, Sumethkul V, Distha-Banchong S. Mineral metabolism and outcomes in chronic kidney disease stage 2–4 patients. BMC nephrology. 2013 Dec;14:1-7.*
2. *Moe SM, Dru T. Improving global outcomes in mineral and bone disorders. Clinical journal of the American Society of Nephrology. 2008 Nov 1;3(Supplement_3):S127-30.*
3. *Cozzolino M, Ciceri P, Galassi A, Mangano M, Carugo S, Capelli I, Cianciolo G. The key role of phosphate on vascular calcification. Toxins. 2019 Apr 9;11(4):213.*
4. *Levey AS, Coresh J. Chronic kidney disease. The lancet. 2012 Jan 14;379(9811):165-80.*
5. *Eckardt KU, Berns JS, Rocco MV, Kasiske BL. Definition and classification of CKD: the debate should be about patient prognosis—a position statement from KDOQI and KDIGO. American journal of kidney diseases. 2009 Jun 1;53(6):915-20.*
6. *Bello AK, Okpechi IG, Osman MA, Cho Y, Htay H, Jha V, Wainstein M, Johnson DW. Epidemiology of haemodialysis outcomes. Nature Reviews Nephrology. 2022 Jun;18(6):378-95.*
7. *Slinin Y, Foley RN, Collins AJ. Calcium, phosphorus, parathyroid hormone, and cardiovascular disease in hemodialysis patients: the USRDS waves 1, 3, and 4 study. Journal of the American Society of Nephrology. 2005 Jun 1;16(6):1788-93.*
8. *Stack AG, Bloembergen WE. A cross-sectional study of the prevalence and clinical correlates of congestive heart failure among incident US dialysis patients. American journal of kidney diseases. 2001 Nov 1;38(5):992-1000.*
9. *Ketteler M, Bongartz P, Westenfeld R, Wildberger JE, Mahnken AH, Böhm R, Metzger T, Wanner C, Jahnen-Dechent W, Floege J. Association of low fetuin-A (AHSG) concentrations in serum with cardiovascular mortality in patients on dialysis: a cross-sectional study. The Lancet. 2003 Mar 8;361(9360):827-33.*
10. *Sutton RA, Cameron EC. Renal osteodystrophy: pathophysiology. InSeminars in nephrology 1992 Mar (Vol. 12, No. 2, pp. 91-100).*
11. *National Kidney Foundation. K/DOQI clinical practice guidelines for bone metabolism and disease in chronic kidney disease. Am J Kidney Dis. 2000;42:S1–S201.*
12. *Kidney Disease: Improving Global Outcomes (KDIGO) CKD-MBD Work Group. KDIGO clinical practice guideline for the diagnosis, evaluation, prevention, and treatment of chronic kidney disease-mineral and bone disorder (CKD-MBD). Kidney international. Supplement. 2009 Aug 1;76(113):S1-130.*
13. *Fuller DS, Dluzniewski PJ, Cooper K, Bradbury BD, Robinson BM, Tentori F. Combinations of mineral and bone disorder markers and risk of death and hospitalizations in the international Dialysis Outcomes and Practice Patterns Study. Clinical kidney journal. 2020 Dec;13(6):1056-62.*
14. *Vadakedath S, Kandi V. Dialysis: a review of the mechanisms underlying complications in the management of chronic renal failure. Cureus. 2017 Aug;9(8).*
15. *Ismail G, Dumitriu HT, Dumitriu AS, Ismail FB. Periodontal disease: a covert source of inflammation in chronic kidney disease patients. International journal of nephrology. 2013;2013(1):515796.*
16. *Kuswardhani RT, Wiradharma KG, Kandarini Y, Widiana GR, Martadiani ED. Factors associated with carotid intima-media thickness in patients on maintenance hemodialysis. International journal of general medicine. 2018 Dec 18:1-6.*
17. *Ayub H, Ghulam MF, Hashmi MF. Correlation Between Calcium Phosphorus Product and Carotid Intimal-Medial Thickness in Patients of Chronic Kidney Disease Presenting to a Tertiary Care Hospital. InMedical Forum Monthly 2020 (Vol. 31, No. 3).*
18. *Al Saran K, Elsayed S, Sabry A, Hamada M. Obesity and metabolic syndrome in hemodialysis patients: single center experience. Saudi Journal of Kidney Diseases and Transplantation. 2011 Nov 1;22(6):1193-8.*
19. *Yang M, Liu S, Zhang C. The related metabolic diseases and treatments of obesity. InHealthcare 2022 Aug 25 (Vol. 10, No. 9, p. 1616). MDPI.*
20. *Barzegar H, Jafari H, Charati JY, Esmaeili R. Relationship between duration of dialysis and quality of life in hemodialysis patients. Iranian Journal of Psychiatry and Behavioral Sciences. 2017 Dec 31;11(4).*
21. *Block GA, Hulbert-Shearon TE, Levin NW, Port FK. Association of serum phosphorus and calcium x phosphate product with mortality risk in chronic hemodialysis patients: a national study. American Journal of Kidney Diseases. 1998 Apr 1;31(4):607-17.*
22. *Sadjadi SA, Pi A. Hyperphosphatemia, a cause of high anion gap metabolic acidosis: Report of a case and review of the literature. The American Journal of Case Reports. 2017;18:463.*
23. *Ketteler M, Block GA, Evenepoel P, Fukagawa M, Herzog CA, McCann L, Moe SM, Shroff R, Tonelli MA, Toussaint ND, Vervloet MG. Executive summary of the 2017 KDIGO Chronic Kidney Disease–Mineral and Bone Disorder (CKD-MBD) Guideline Update: what's changed and why it matters. Kidney international. 2017 Jul 1;92(1):26-36.*
24. *Schafer AL, Shoback DM. Hypocalcemia: diagnosis and treatment.*
25. *Levin A, Bakris GL, Molitch M, et al. Prevalence of abnormal serum vitamin D, PTH, calcium, and phosphorus in patients with chronic kidney disease: results of the study to evaluate early kidney disease. Kidney Int. 2007;71(1):31-38.*
26. *Vaziri ND. Dyslipidemia of chronic renal failure: the nature, mechanisms, and potential consequences. American Journal of Physiology-Renal Physiology. 2006 Feb 1.*
27. *Tentori F, Blayney MJ, Albert JM, Gillespie BW, Kerr PG, Bommer J, Young EW, Akizawa T, Akiba T, Pisoni RL, Robinson BM. Mortality risk for dialysis patients with different levels of serum calcium, phosphorus, and PTH: the Dialysis Outcomes and Practice Patterns Study (DOPPS). American Journal of Kidney Diseases. 2008 Sep 1;52(3):519-30.*