Original Article

Study of Serum Magnesium, Calcium, Phosphorous and Alkaline Phosphatase in Chronic Kidney Disease

Nirmala Devi.K[1], Arshiya Begum.A[2], Sathiya.K[3], Deepa Lakshmi.P[4]

[1]Professor & HOD, [2]Professor, [3]Reserve Tutor, [4]Post Graduate, Department of Biochemistry,
K.A.P.V. Govt. Medical College, Trichy.

ABSTRACT

Introduction: Chronic Kidney Disease (CKD) nowadays becomes an emerging condition with increasing morbidity and mortality. It is associated with complex disturbances in calcium, phosphorous, alkaline phosphatase and magnesium levels especially in stage 4 and 5 of CKD.

Aim And Objective: The main aim of this study is to compare the levels of serum, calcium, phosphorous, alkaline phosphatase and magnesium levels in stages 4 and 5of chronic kidney disease patients with healthy individuals.

Materials and Method: About 30 CKD patients in stage 4 and 5, attending Nephrology out- patient department and 30 healthy individuals between the age group 25 to 78 were included in this study, conducted from April to June 2016 at Mahatma Gandhi Memorial Government Hospital, Trichy. Serum levels of Calcium, Phosphorous, Alkaline Phosphatase (ALP) and Magnesium were measured; eGFR was calculated by CKD -EPI Formula. All measured variables were correlated with e GFR and compared between cases and controls.

Statistical Analysis: Statistical analysis is done by SPSS Software.

Results and Conclusion: The results are presented as a mean ± SD and 'p' value of less than 0.05 is considered as significant. In our study, serum Calcium is decreased, serum Magnesium, Phosphorous, Alkaline Phosphatase levels are increased in stage 4 and 5 of CKD (p-value<0.01.Hypocalcemia and hyper phosphatemia due to failing kidney results in secondary hyper parathyroidism in advanced Chronic Kidney Disease, responsible for abnormal mineral metabolism observed in our study.

Key Words: Chronic Kidney Disease, eGFR, Calcium, Magnesium, Phosphorous, Alkaline Phosphatase.

INTRODUCTION:

Chronic Kidney Disease (CKD) is defined as the presence of kidney damage or GFR < 60 ml/min/1.73 m^2 for atleast 3 months, with pathological abnormalities or damage, including abnormalities in blood or urine tests or imaging studies[1] . In advanced CKD (stage 4 and 5) circulating levels of parathyroid hormone (PTH) are progressively increased as kidney function declines, as a result of phosphate retention[2], hypocalcemia, decreased production of 1,25-dihydroxycholecalciferol results in endogenous changes within the parathyroid gland and skeletal resistance to the actions of PTH[3]. Secondary Hyperparathyroidism is associated with abnormal mineral metabolism[3] in the form of increased

Address for correspondence:
Dr. A.Arshiya Begum, Professor, Department of Biochemistry, K.A.P.V. Govt. Medical College, Trichy.
Phone no: 8903609719, Email ID: arshiyavasi@gmail.com

Alkaline phosphatase due to increased bone turn over[4&5]. Stage 4 and 5 of CKD is associated with increased magnesium due to decreased excretion of magnesium[6]. In this study, we measured the levels of serum calcium, phosphorous, alkaline phosphatase and magnesium in stage 4 & 5 of chronic kidney disease, correlated with e GFR and compared with controls.

MATERIALS AND METHODS:

This study was conducted from April to June 2016 at Mahatma Gandhi Memorial Government Hospital, Trichy in 30 patients of Advanced Chronic Kidney Disease (stage 4 and 5) between the age group of 25 to 78 years and age matched 30 healthy individuals as controls. Informed consent was obtained from patients and blood samples were collected within 24 hours of admission in hospital. Serum levels of Magnesium measured by Calmagite method, Serum Calcium by Arsenazo method, Serum Phosphorous levels by Ammonium Molybdate method, Serum Alkaline Phosphatase levels by PNPP/PMP method. eGFR is calculated by CKD-EPI formula for staging Chronic Kidney Disease.

Statistical analysis was done using SPSS software. Student't' test was used to compare the difference between the two means.

Inclusion criteria:

Patients in stages 4 & 5of CKD -eGFR were 15 to 29 mL/min/ 1.73 m2&< 15 mL/min/ 1.73 m2 of both sexes, age group 25 to 78 years.

Exclusion criteria:

Chronic Kidney Disease patients those who are on peritoneal dialysis or Hemodialysis.

RESULTS:

In Chronic Kidney Disease patients and controls, Mean and Standard Deviations were calculated for all quantitative variables. Table 1 shows the Mean & SD of e GFR, Urea and Creatinine of control and cases with the statistical significance (p=<0.01). Table 2 shows the Comparison of Mean & SD of calcium, phosphorous, ALP and Magnesium between control and cases with the statistical significance (p=<0.01).Table 3 shows the Mean, Standard Deviation of GFR, serum Urea, creatinine, calcium, phosphorous, ALP and Magnesium between male and female cases. As shown in the Table -3, there is no statistical significance of the difference observed in variables with 'p' values of e GFR (p=0.938), Urea(p=0.161), Creatinine(p=0.152), Calcium(p=0.207), Phosphorous(0.06), ALP(0.295) and Magnesium(0.694).

Table 1. Mean & SD of e GFR, Urea and Creatinine of control and cases

Variables	Patients (Mean±SD)	Controls (Mean±SD)	P value
Urea mg/dl	111.9±60.2	31.5±4.71	< 0.01
Creatinine mg/dl	6.04± 4.32	1.33±0.37	
eGFR ml/mt /1.73 m2	15.9±9.5	91.9±24.0	

Table 2. Comparison of Mean &SD of calcium, phosphorous, ALP, Magnesium between control and cases

Variables	Patients (Mean±SD)	Control (Mean±SD)	P value
Calcium mg/dl	6.5±.9	9.09± 0.45	<0.01
Phosphorous mg/dl	6.2±2.6	3.41± 0.61	
Alkaline phosphatase U/L	169.57±76.82	101.3±20.3	
Magnesium mg/dl	4.3±1.2	1.49±0.41	
eGFR ml/mt/1.73 m^2	15.9±9.5	91.9±24.0	

Table 3. Comparison of Mean and SD of all variables between male and female cases

Variables	Male	SD	Female	SD	P -value
	Mean		Mean		
GFR (ml/min/1.73m2)	16.03	10.22	15.75	6.77	0.93
Urea (mg/dl)	118.47	52.55	163.5	113.68	0.16
Creatinine (mg/dl)	6.54	4.65	4.6	2.13	0.15
Calcium (mg/dl)	6.44	2.94	6.98	0.82	0.20
Phosphorous(mg/dl)	6.42	2.94	5.13	0.58	0.06
ALP-U/L	169	70.73	141	50.75	0.29
Magnesium(mg/dl)	4.12	0.85	3.98	0.74	0.69

DISCUSSION :

Chronic Kidney Disease (CKD) encompasses a spectrum of different pathophysiological process associated with abnormal kidney function and progressive decline in Glomerular Filtration Rate[2]. CKD is classified into 0 - 5 stages based on the GFR Stage 1& 2 are not usually associated with any symptoms arising from the decrease in GFR. If GFR declines further to level of stage 3, 4 & 5 complications are more common , almost all the systems are affected especially anaemia, malnutrition, Bone Mineral Disease and the abnormalities of sodium, potassium, water and acid homeostasis. Advanced stage of CKD is associated with diminished 1,25,dihydroxy cholecalciferol synthesis which results in Renal osteodystrophy[7]. The present study shows as in Table 1, there is statistically significant increase in blood Urea and creatinine in stage 4 and 5 of CKD with p value of <0.01.

Renal osteodystrophy is the spectrum of histological changes, which occur in bone architecture of patients with CKD. In advanced stages of CKD, plasma phosphate concentration rises, resulting in reduced ionised calcium[8].

In our study as shown in the Table- 2 serum Calcium is decreased in stage 4 and 5of CKD when compared with that of the controls which is statistically significant (p value < 0.01), this correlates with the study of Lim et al article[9] , this is also in concordance with the study of Patel et al article[10].

As depicted in table 2, statistically significant elevated phosphorous levels in stage 4 and 5 of CKD patients compared to the controls observed in our study, this is in concordance with the study of Patel et al article[10].

Calcium exerts negative feedback on PTH secretion through the calcium-sensing receptors in the parathyroid[11]. Decrease in serum calcium during the course of CKD caused by phosphate retention and decreased 1,25 dihydroxycholecalciferol leads to increased PTH[12]. Elevated PTH stimulates bone demineralization and lead to high turnover, a condition characterised by accelerated rates of bone absorption and resorption with concurrent production of alkaline phosphatase from osteoblast cells contributing to its high levels in plasma as the renal function or GFR declines[4,5]. Freethi[13] etal showed increased levels of Alkaline phosphatase in CKD patients (stage 4 and 5) which correlates with our study which shows elevated levels of Alkaline phosphatase in stage 4 and 5 of CKD patients with p value < 0.01 which is statistically significant as depicted in Table - 2.

In advanced stages of CKD, the quantitative excretion of magnesium tends to decrease and cannot be compensated any longer by an increased fractional excretion of magnesium. Thus, hypermagnesaemia develops frequently in patients with creatinine clearance <10 mL/min[14]. Koycheva

et al studies[14] showed increased levels of magnesium instage 4 and 5 of CKD, which is in concordance with our study which shows elevated levels of magnesium in CKD (stage 4 and 5)as in Table 2 with statistically significant p value < 0.01. Present study shows, as depicted in table 3 there is a difference in measured variables between male and female patients namely Urea, Creatinine, Calcium, Phosphorous, ALP and Magnesium but there is no statistical significance.

CONCLUSION:

Based on the results of our study, abnormalities in Calcium, Phosphorous and Magnesium metabolisms in the form of Hypocalcaemia, hyperphospataemia, hypermagnesaemia and increased levels of Alkaline phosphatase are observed in stages 4 and 5 of CKD.

Limitations of the study:

1. For better understanding of pathophysiology of CKD - BMD (Bone Mineral Disease estimation of PTH (Parathyroid Hormone) is useful.
2. Since Magnesium is primarily an intracellular cation Magnesium Tolerance test is a better method to assess the body magnesium content.

REFERENCES:

1. Burtis CA, Ashwood ER, Bruns DE. Tietz textbook of clinical chemistry and molecular diagnostics. 4th Edition; Elsevier Health Sciences;2012:1693.
2. Braunwald E, Fauci AS, Kasper DL, Hauser SL, Longo DL, Jameson JL. Chronic Renal Failure. Harrison's Principles of internal medicine1. 18thEdition;2001:1316-23.
3. Levin A, Bakris G, Molitch M, Smulders M, Tian J, Williams L, 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 international. 2007;71(1):31-8.
4. O'Neill WC. Pyrophosphate, alkaline phosphatase, and vascular calcification. Circulation research. 2006;99(2):e2-e.
5. Torres PU. Bone alkaline phosphatase isoforms in chronic renal failure. Kidney international. 2002;61(3):1178-9.
6. Kanbay M, Goldsmith D, Uyar ME, Turgut F, Covic A. Magnesium in chronic kidney disease: challenges and opportunities. Blood purification. 2010;29(3):280-92.
7. Mani MK. Prevention of chronic renal failure at the community level. Kidney international. 2003;63:S86-S9.
8. Lopez-Hilker S, Galceran T, Chan Y-L, Rapp N, Martin K, Slatopolsky E. Hypocalcemia may not be essential for the development of secondary hyperparathyroidism in chronic renal failure. Journal of Clinical Investigation. 1986;78(4):1097.
9. Thomas R, Kanso A, Sedor JR. Chronic kidney disease and its complications. Primary care: Clinics in office practice. 2008; 35(2): 329-44.
10. Patel L, Bernard LM, Elder GJ. Sevelamer versus calcium-based binders for treatment of hyperphosphatemia in CKD: A meta-analysis of randomized controlled trials. Clinical Journal of the American Society of Nephrology. 2016;11(2):232-44.

11. Kalantar-Zadeh K, Kuwae N, Regidor D, Kovesdy C, Kilpatrick R, Shinaberger C, et al. Survival predictability of time-varying indicators of bone disease in maintenance hemodialysis patients. Kidney international. 2006;70(4):771-80.

12. Massy ZA, Drüeke TB. Magnesium and outcomes in patients with chronic kidney disease: focus on vascular calcification, atherosclerosis and survival. Clinical kidney journal. 2012;5(Suppl 1):i52-i61.

13. Freethi R, Raj AV, Ponniraivan K, Khan MR, Sundhararajan A, Venkatesan. Study of serum levels of calcium, phosphorus and alkaline phosphatase in chronic kidney disease. Health Sciences. 2016;5(3):49-56.

14. Cunningham J, Rodríguez M, Messa P. Magnesium in chronic kidney disease Stages 3 and 4 and in dialysis patients. Clinical kidney journal. 2012;5(Suppl 1):i39-i51.

15. Koycheva R, Cholakov V, Iliev R, Tsoneva V. Influence of serum magnesium on markers of calcium-phosphorus metabolism in patients on regular haemodialysis. Trakia Journal of Sciences. 2014;12(3):233.

Received on 22/02/2017 **Revised** on 21/04/2017 **Accepted** on 04/09/2017