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Original Article

The Relationship between Knowledge about Phosphorus, Dietary Phosphorus Intake and Serum Phosphorus Level in Maintenance Hemodialysis Patients

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Abstract

Background: Renal diet knowledge -especially phosphorus knowledge- is generally poor in Maintenance Hemodialysis (MHD) patients due to the complexity of information about dietary phosphorus thus causing poor compliance to dietary phosphorus guidelines and hyperphosphatemia.
Objective(s): This study aimed to investigate the relationship between knowledge about phosphorus, dietary phosphorus intake and serum phosphorus level in MHD patients.
Methods: A cross-sectional study was conducted on 110 MHD patients in the hemodialysis center in Alexandria Main University Hospital. A questionnaire was used to collect demographic and clinical data and 24-hour dietary recall. A 25-item nutrition knowledge questionnaire was asked to patients. Patients' medical records were reviewed to collect data about the underlying cause of End Stage Renal Disease (ESRD), duration of dialysis and serum biochemical parameters. Dry Body Weight (DBW) and height were measured using a stadiometer following a standard protocol and Body Mass Index (BMI) was calculated.
Results: Hyperphosphatemia was common (44.5%) in the present sample. Energy intake and protein intake were inadequate in 76.4% and 74.5% of patients. Mean phosphorus intake of hyperphosphatemia patients was higher than controlled patients (1053.99±420.18 mg/d vs 854.18±353.99 mg/d). Almost half of the patients (51.2 %) who consumed phosphorus intake >1000 mg/d had hyperphosphatemia and 61.0 % of patients with poor total renal diet knowledge and two thirds of patients (66.7%) with poor phosphorus knowledge had hyperphosphatemia. Phosphorus knowledge was a strong determinant for controlled serum phosphorus (OR =0.545 p=0.005), dietary phosphorus intake was a risk factor for hyperphosphatemia (OR=1.001, p=0.024). The main determinant of dietary phosphorus adherence was protein intake (OR =1.084, p<0.001).
Conclusion: MHD patients have both poor renal diet and phosphorus knowledge. Phosphorus knowledge protects against development of hyperphosphatemia. Patients with higher protein intake had a high phosphorus intake. MHD patients need to be educated how to consume adequate protein while choosing lower phosphorus protein choices.

Keywords: Maintenance Hemodialysis, Hyperphosphatemia, Renal diet, Dietary phosphorus knowledge

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INTRODUCTION

Hyperphosphatemia is a common metabolic derangement encountered in End Stage Renal disease (ESRD) patients and if left untreated hyperphosphatemia is a risk factor for bone mineral disease (BMD), cardiovascular diseases (CVD) due to vascular calcification and all-cause mortality [(1)]. Management of hyperphosphatemia is multimodal including a phosphate binder therapy, a low-phosphorus diet, and maintenance hemodialysis (MHD)[(2)]. Removal of phosphorus during a hemodialysis session accounts for almost 600-1200 mg phosphorus and phosphate binders can bind to approximately 200-300 mg of phosphorus daily, thus MHD patients need in addition to restrict their dietary phosphorus intake to keep their serum phosphorus level of less than 5.5 mg/dl [(3)]. MHD patients are prone to malnutrition if their protein intake became inadequate when applying dietary phosphorus restriction [(4)].

Dietary phosphorus has diverse sources (plant

versus animal origin) and different types of phosphorus (inorganic versus organic). Phosphorus from plant origin has a lower bioavailability (10-30%) than that of animal origin (40-60%). Not only patients need to avoid high sources of dietary phosphorus but also need to avoid inorganic phosphorous salts which is hidden in processed foods and not usually listed on the nutrition labels and has a high bioavailability (100%) that causes the highest impact on serum phosphorus[5]. Dietary patterns with high intake of sugar sweetened beverages (SSB) like cola beverages and drinks with added condensed and evaporated milk is significantly associated with higher serum phosphorus levels in MHD patients compared to a dietary pattern with high intake of fresh fruits and vegetables, animal proteins and legumes[6]. MHD patient should aim to restrict dietary phosphorus intake to 800-1000 mg/d through choosing foods with low protein to phosphorus ratio while maintaining a high protein intake [7].

Compliance to dietary phosphate guidelines rates is suboptimal and are influenced by both patient factors and health care providers -especially nurses- nutrition knowledge. Patient's factors like poor nutrition knowledge, lack of social support, unpalatability of the low phosphorus diet regimen and food aversions in these patients make dietary adherence a problem [4]. It is recognized that knowledge alone is insufficient to change dietary behavior [8]. Additionally, nurses in dialysis units have been found to have low level of renal diet knowledge scores and the scores for phosphorus knowledge was lower compared to knowledge of the other nutrients like potassium, sodium and fluid, emphasizing the need for training the new dialysis staff [9, 10].

The relation between phosphorus related knowledge, dietary phosphorus restriction and control of serum phosphorus in MHD patients shows contradictory results. So, this research was conducted to find out the level of renal diet knowledge among a sample of MHD patients and the adequacy of dietary phosphorus restriction and their relation to serum phosphorus control.

METHODS

A cross-sectional study was conducted in the hemodialysis center in Alexandria Main University Hospital.

Sampling design

Based on the prevalence of hyperphosphatemia among MHD patients in Menoufia Governorate which was 74 %[11], the minimum required sample was 106 patients calculated using Epi-Info 7® software at margin of error 7 % and 90 % confidence level. Accordingly, 110 ESRD patients undergoing regular hemodialysis (3 times per week) were included in the study.

Data collection methods and tools

Sociodemographic data as age, sex, education, and employment status were collected from all patients using face-to-face interviewing. Educational level was categorized into low (illiterate, read and write, primary), middle (preparatory) and high which was secondary school and university education. Medical Records were reviewed to collect information about underlying causes of ESRD, duration of dialysis, laboratory investigations as serum phosphorus, serum calcium, serum potassium and serum parathormone levels. Serum phosphorus was categorized as hyperphosphatemia based on the cut off level of 5.5 mg/dl. For each participant Dry Body Weight (DBW) was measured using a digital balance and height was measured using a stadiometer following a standard protocol [12]. Body Mass Index (BMI) was calculated as weight (kg) divided by the height squared (m^2).

Dietary recall

A 24-hour dietary recall for two days were collected as one dialysis day and one non-dialysis day. Patients were asked about the types and quantities of food and beverages that they consumed, and all recall sheets were analysed using Elizabeth Stewart Hands and Associates (ESHA) Food Processor ® software adapted to the Egyptian Foods [13]. The nutrient values of different food items were acquired from "Food Composition Tables for Egypt" issued by National Nutrition Institute [14]. Dietary adherence to energy and protein requirements, sodium, potassium, and phosphorus recommendations were based on Kidney Disease Outcomes Quality Initiative (KDOQI) guidelines for nutrition in Chronic Kidney Disease (CKD) [15]. An Adjusted Dry Body Weight (AjDBW) was used for overweight and obese individuals for calculation of nutrient requirements when their actual body weight was ≥ 120 % of ideal body weight (IBW) [16]. Energy requirements calculated as 25 Kcal/kg; Protein requirements calculated as 1.2 g/kg. Energy and protein intake adequacy was calculated as actual intake/ calculated requirement × 100. Intake of energy and protein were considered adequate if they were ≥ 100 % of the calculated requirements and inadequate if they were < 100 % of the calculated requirements. A recommended phosphorus intake was set at 1000 mg/d, for potassium at 2400 mg/d and for sodium at 3 mg/d. [15]

Renal diet and phosphorus knowledge questionnaire

A questionnaire which consisted of 20 multiple choice questions was designed to evaluate renal diet knowledge of patients regarding five nutrients that are relevant to hemodialysis patients: protein (3

questions), potassium (3 questions), sodium (2 questions), fluid intake (2 questions) and phosphorus (10 questions). The questions included inquiry about the recommended intakes of protein, fluids and sodium, and consequences of low protein intake and high intake of phosphorus, potassium and sodium and high food sources of potassium. Phosphorus knowledge questions included asking about high phosphorus foods, bioavailability of different animal sources, plant sources of phosphorus, and dietary sources of inorganic phosphorus salts used as additives. The reliability of the questionnaire was measured using a Cronbach's alpha which was calculated to be 0.877. Correct answer for each question was given a score of 1, and incorrect was given a score of zero, so the total score of knowledge questions ranged from zero-20 and each section of knowledge was given an individual score. Total and individual scores were converted to percentages and were categorized as follows: poor knowledge <50 %, fair knowledge from 50-<75% and good knowledge >75 %.

Laboratory investigations

Serum phosphorus, serum calcium, serum potassium and serum parathormone levels were collected from patients' medical records. The following were the cut off levels used for high or uncontrolled serum levels: Serum phosphorus >5.5 mg/dl, serum potassium > 5.3 mg/dl, and serum Parathormone (PTH) > 300 pg/ml.

Statistical analysis of the data

The collected data was subjected to statistical analysis using suitable techniques to achieve the objectives of the study. Data were entered into SPSS software package version 20.0. (Armonk, NY: IBM Corp) where categorical data were illustrated as number and percentage while numerical data were illustrated as mean and standard deviation. Significance of the attained results was judged at the 5% confidence level. For categorical data Chi-square test was used to compare between different groups. For normally distributed numerical variables student t -test was used and for not normally distributed numerical variables Mann Whitney test was used. Logistic regression analysis was used to find out the risk factors for both high serum phosphorus and high phosphorus intake.

Ethical considerations

The ethical committee of the High Institute of Public Health approved the research, and the research followed the international guidelines for research ethics. All patients were informed about the purpose of the study and oral consent was taken after explaining the purpose of the study. Confidentiality of the collected data was considered. No obligation of any kind was used to let the patients participate in the study, and any participant was free to withdraw from completing the study.

RESULTS

Figure 1 illustrates the distribution of studied maintenance hemodialysis patients according to serum phosphorus. It showed that 49 patients (44.5% of the sample) had a serum phosphorus level > 5.5 mg/dl.

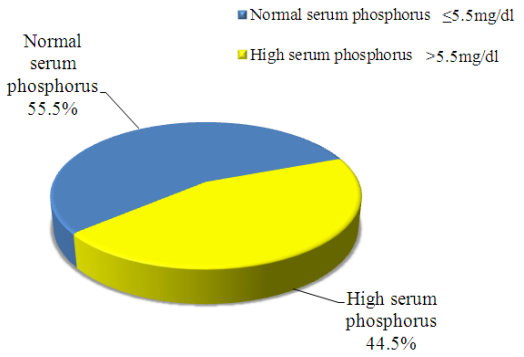

Figure (1): Distribution of the studied maintenance hemodialysis patients based on serum phosphorus

According to table 1, those with controlled serum phosphorus were older than the hyperphosphatemia group (59.28±14.11 vs 54.49±13.69), however this difference was statistically insignificant. In the studied sample males were more prevalent than females (72 males and 38 females) and there was no significant difference between controlled and hyperphosphatemia patients regarding sex. The mean BMI of the sample was 28.7 ± 5.7 kg/m^2, and overweight and obesity were prevalent among patients (44 patients were overweight and 35 patients were obese). Most of the sample (81 patients) had a high level of education and most of patients (84 patients) had no work (either unemployed or retired) and there was no significant difference between both groups regarding BMI, education and employment status.

Table 1 also shows that the most common underlying cause of ESRD was type 2 diabetes (42 patients) followed by hypertension (32 patients) and Glomerulonephritis (30 patients), and no difference was noted between the controlled and hyperphosphatemia patients. The mean duration of dialysis was 3.8 ± 4.1 years (range = 0.1 – 18 years). Serum calcium level of almost half (57 patients) of the sample was in the normal range (8.4-9.5 mg/dl) and no significant difference between hyperphosphatemia and controlled patients. Almost two thirds of patients with high serum Parathormone (65.1 %) had hyperphosphatemia and 61.4 % of patients with normal parathormone level had controlled serum phosphorus level and this difference between groups was statistically significant (p=0.002) The mean PTH

level in hyperphosphatemia patients was significantly higher than controlled patients (477.02± 476.4 pg/ml, 258.20±215.3 pg/ml, p=0.017). Almost two thirds (62.2 %) of patients with hyperkalemia had hyperphosphatemia (p=0.008) and the mean serum potassium of hyperphosphatemia group was 5.43±0.75 compared to 4.94±0.56 mg/dl in controlled patients (p<0.001).

Table (1): Distribution of hyperphosphatemia and controlled maintenance hemodialysis patients according to demographic and clinical data

	Total (n = 110) No.	Serum Phosphorus ≤5.5 controlled (n = 61) No. (%)	Serum Phosphorus > 5.5 hyper (n = 49) No. (%)	Test of sig.	p
Sex					
Male	72	41 (56.9%)	31 (43.1%)	$\chi^2 = 0.187$	0.665
Female	38	20 (52.6%)	18 (47.4%)		
Age (years)					
Mean ± SD	57.1 ± 14.1	59.28 ± 14.11	54.49 ± 13.69	t = 1.799	0.075
BMI kg/m^2					
Under weight (<18.5)	1	0 (0.0%)	1 (100%)		
Normal (18.5 – 24.9)	30	16 (53.3%)	14 (46.7%)	$\chi^2 = 4.516$	$^{MC}p = 0.181$
Overweight (25 – 29.9)	44	29 (65.9%)	15 (34.1%)		
Obese (30 – 34.9)	35	16 (45.7%)	19 (54.3%)		
Mean ± SD	28.7 ± 5.7	28.53± 5.54	28.86± 5.85	t = 0.306	0.760
Educational level					
Low	17	8 (47.1%)	9 (52.9%)		
Medium	12	8 (66.7%)	4 (33.3%)	$\chi^2 = 1.096$	0.578
High	81	45 (55.6%)	36 (44.4%)		
Employment status					
No work	84	47 (56.0%)	37 (44.0%)	$\chi^2 = 0.036$	0.850
Working	26	14 (53.8%)	12 (46.2%)		
Medical cause for ESRD					
Diabetes	42	23 (54.8%)	19 (45.2%)		
Hypertension	32	20 (62.5%)	12 (37.5%)		
Polycystic kidney	1	1 (100%)	0 (0.0)	$\chi^2 = 2.319$	$^{MC}p = 0.749$
Glomerulonephritis	30	15 (50.0%)	15 (50.0%)		
Obstructive uropathy	5	2 (40.0%)	3 (60.0%)		
Duration of dialysis (years)					
Mean ± SD	3.8 ± 4.1	3.33±3.62	4.47±4.58	U = 1182.0	0.059
Laboratory investigations					
Serum calcium (mg/dl)					
Low <8.4	37	19 (51.4%)	18 (48.6%)		
Normal 8.4 - 9.5	57	35 (61.4%)	22 (38.6%)	$\chi^2 = 1.956$	0.376
High <9.5	16	7 (43.8%)	9 (56.3%)		
Mean ± SD.	8.6 ± 1.1	8.67±0.90	8.62± 1.33	t = 0.236	0.814
Serum parathormone (pg/ml)					
Low <150	35	23 (65.7%)	12 (34.3%)		
Normal 150 - 300	32	23 (71.8%)	9 (28.1%)	$\chi^2 = 12.350^*$	0.002^*
High >300	43	15 (34.9%)	28 (65.1%)		
Mean ± SD.	355.7± 370.7	258.20± 215.3	477.02± 476.4	U = 1098.5	0.017^*
Serum potassium (mg/dl)					
≤5.3	73	47 (64.4%)	26 (35.6%)	$\chi^2 = 7.005^*$	0.008^*
>5.3	37	14 (37.8%)	23 (62.2%)		
Mean ± SD.	5.15±0.69	4.94±0.56	5.43±.75	$t = 3.931^*$	$<0.001^*$

p: p value for comparing between controlled and hyperphosphatemia, χ^2: Chi square test , MC: Monte Carlo, t: Student t-test, U: Mann Whitney test, *: Statistically significant at p ≤ 0.05, BMI: Body Mass Index, ESRD: End Stage Renal Disease.

Table 2 shows that the mean reported energy intake was 1502.6 ± 436.6 kcal/d, most of the sample (84 patients) did not consume adequate calories daily, and no difference was noted between controlled and hyperphosphatemia patients. The mean protein intake in controlled patients was 70.26±21.80 g/d and in hyperphosphatemia was 68.16 ± 25.77 g/d. Most of the patients (82 patients) did not consume adequate protein intake daily and the difference in protein intake between controlled and hyperphosphatemia patients was not significant. Almost half of the patients (51.2 %) who consumed high phosphorus intake > 1000 mg/d and 40.3 % of patients who consumed recommended phosphorus intake had hyperphosphatemia and this difference between groups was not significant. About one-third (41 patients) and one quarter (30 patients) of studied MHD patients had high sodium and potassium intake respectively, with no significant difference between the two groups.

Table (2): Serum phosphorus in maintenance hemodialysis patients in relation to dietary intake and dietary adequacy

Dietary intake	Total (n = 110)	Serum Phosphorus ≤5.5 controlled (n = 61)	Serum Phosphorus >5.5 hyper (n = 49)	Test of sig.	p
	No.	No. (%)	No. (%)		
Energy intake (kcal/d)					
Mean ± SD	1502.6 ± 436.6	1491.56±406.19	1516.43±475.72	U =1491.0	0.983
Adequate No.(%)	26	16 (61.5%)	10 (38.5%)	χ^2 = 0.510	0.475
Inadequate No.(%)	84	45 (53.6%)	39 (46.4%)		
Protein intake (g/d)					
Mean ± SD	69.3 ± 23.6	70.26±21.80	68.16±25.77	U = 1379.0	0.487
Adequate No.(%)	28	18 (64.3%)	10 (35.7%)	χ^2 = 1.186	0.276
Inadequate No.(%)	82	43 (42.4%)	39 (47.6%)		
Fat intake (g/d)					
Mean ± SD	50.2 ± 16.8	49.78±16.38	50.67±17.38	t = 0.276	0.783
Carbohydrate intake (g/d)					
Mean ± SD	189.1 ± 66	186.69±62.63	192.0±70.51	U = 1444.0	0.761
Phosphorus intake (mg/d)					
Mean ± SD	943.2 ± 395.8	854.18±353.99	1053.99±420.18	t =2.657*	0.009*
Recommended No.(%)	67	40 (59.7%)	27 (40.3%)	χ^2 = 1.251	0.263
High No.(%)	43	21 (48.8%)	22 (51.2%)		
Sodium intake (mg/d)					
Mean ± SD	2805.2 ± 1525.5	2914.36±1584.6	2669.23±1453.3	U = 1392.0	0.538
Recommended No.(%)	69	35 (50.7%)	34 (49.3%)	χ^2 = 1.677	0.195
High No.(%)	41	26 (63.4%)	15 (36.6%)		
Potassium intake (mg/d)					
Mean ± SD	2046.7 ± 807.6	1925.31±690.6	2197.79±918.1	U = 1320.0	0.294
Recommended No.(%)	80	48 (60.0%)	32 (40.0%)	χ^2 = 2.453	0.117
High No.(%)	30	13 (43.3%)	17 (56.7%)		

p: p value for comparing between controlled and hyperphosphatemia, χ^2: Chi square test, t: Student t-test, U: Mann Whitney test, *: Statistically significant at $p \leq 0.05$

Table 3 shows that most of the sample (59 patients) had poor total renal diet knowledge and that 61.0 % of patients with poor total knowledge level had hyperphosphatemia and 72.7% of patients with good total knowledge had controlled serum phosphorus level and this difference between groups was significant (p=0.001). Poor phosphorus knowledge was reported in most of the sample (60 patients). Two thirds of patients (66.7%) with poor phosphorus knowledge had hyperphosphatemia while 84.6 % of patients with good phosphorus knowledge had controlled serum phosphorus and this difference was statistically significant (p<0.001). Individual protein, phosphorus, and potassium knowledge levels were worse than sodium and fluid knowledge. Poor protein knowledge level was reported in 69 patients, poor potassium knowledge level was reported in 67 of patients On the other hand, poor fluid knowledge was reported in only 21 patient and poor sodium knowledge was reported in 36 patients and no statistically significant difference regarding protein, potassium, sodium and fluid knowledge level among hyperphosphatemia and controlled patients.

Multivariate logistic regression analysis was carried out to uncover the predicators of hyperphosphatemia and dietary phosphorus non-adherence, adjusting for all variables that were statistically significant at univariate analysis (Table 4). Factors like age, sex, duration of dialysis, education, employment status, dietary intake and dietary knowledge were examined by the model. It is apparent that higher dietary phosphorus consumption is a significant risk factor for hyperphosphatemia (OR=1.001, 95% CI=1.000-1.003, p=0.024) and that higher phosphorus related knowledge level is a significant protective factor against hyperphosphatemia in MHD patients (OR=0.545, 95% CI=0.357-0.830, p=0.005). The constructed model explained 29.9 % of the variance. Examining the risk factors for dietary phosphorus non-adherence, it is evident from table 4, that being male and having a fixed job are significant risk factors for high dietary phosphorus intake in univariate analysis but not in multivariate analysis (p=0.018, OR=2.883, CI=1.197-6.947 and p= 0.029, OR=2.727, CI= 1.180-6.712 respectively). High dietary protein intake is also a significant risk factor for high dietary phosphorus intake in multivariate analysis (p<0.001, OR=1.084, C.I =1.051-1.118, R^2=55.5%).

Table (3): Renal diet knowledge levels among controlled and hyperphosphatemia maintenance hemodialysis patients

Knowledge levels	Total (n = 110) No.	Serum Phosphorus ≤5.5 controlled (n = 61) No. (%)	Serum Phosphorus >5.5 hyper (n = 49) No. (%)	Test of sig.	p
Protein					
Poor	69	35 (50.7%)	34 (49.3%)		
Fair	31	21 (67.7%)	10 (32.3%)	$\chi^2 = 2.640$	0.267
Good	10	5 (50.0%)	5 (50.0%)		
Potassium					
Poor	67	39 (58.2%)	28 (41.8%)		
Fair	30	12 (40.0%)	18 (60.0%)	$\chi^2 = 5.532$	0.063
Good	13	10 (76.9%)	3 (23.1%)		
Sodium					
Poor	36	21 (58.3%)	15 (41.%)		
Fair	43	24 (55.8%)	19 (44.2%)	$\chi^2 = 0.308$	0.857
Good	31	16 (51.6%)	15 (48.4%)		
Fluid					
Poor	21	12 (57.1%)	9 (42.9%)		
Fair	57	26 (45.6%)	31 (54.4%)	$\chi^2 = 5.752$	0.056
Good	32	23 (71.9%)	9 (28.1%)		
Phosphorus					
Poor	60	20 (33.3%)	40 (66.7%)		
Fair	37	30 (81.1%)	7 (18.9%)	$\chi^2 = 26.197^*$	<0.001*
Good	13	11 (84.6%)	2 (15.4%)		
Total Knowledge score					
Poor	59	23 (39.0%)	36 (61.0%)		
Fair	40	30 (75.0%)	10 (25.0%)	$\chi^2 = 13.995^*$	0.001*
Good	11	8 (72.7%)	3 (27.3%)		

p: p value for comparing between controlled and hyperphosphatemia patients, χ^2: Chi square test , t: Student t-test, U: Mann Whitney test, *: Statistically significant at $p \leq 0.05$

Table (4): Univariate and multivariate logistic regression analysis for hyperphosphatemia and high dietary phosphorus intake

Serum Phosphorus (R^2= 29.9%)	Univariate p	Univariate OR (95%C.I)	#Multivariate p	#Multivariate OR (95%C.I)
Age	**0.079**	0.975 (0.949 – 1.003)		
Sex (Male = 0/ Female=1)	**0.665**	1.190 (0.541 – 2.621)		
Years in dialysis	**0.154**	1.072 (0.974 – 1.179)		
Educational level (high = 0)				
Low	**0.524**	1.406(0.493-4.012)		
Medium	**0.471**	0.625(0.174-2.243)		
Employment status (unemployed = 0, employed = 1)	**0.850**	1.089(0.450-2.633)		
BMI	**0.758**	1.011 (0.945 – 1.080)		
Phosphorus intake	**0.010***	1.001 (1.000 – 1.002)	0.024*	1.001 (1.000 – 1.003)
Protein intake	**0.641**	0.996 (0.980 – 1.012)		
Knowledge score				
Protein	**0.164**	0.726 (0.463 – 1.140)		
Potassium	**0.714**	0.928 (0.623 – 1.383)		
Sodium	**0.584**	1.145 (0.706 – 1.856)		
Fluid	**0.174**	0.680 (0.390 – 1.186)		
Phosphorus	**<0.001***	0.627 (0.504 – 0.780)	0.005*	0.545 (0.357 – 0.830)
Total score	**0.001***	0.820 (0.729 – 0.922)	0.417	1.102 (0.871 – 1.394)
Phosphorus intake (mg/d) (R^2= 55.5%)				
Age	**0.296**	0.985(0.959-1.013)		
Sex (Female=0, Male = 1)	**0.018***	2.883(1.197-6.947)	0.879	1.100 (0.324-3.730)
Years in dialysis	**0.227**	1.059(0.965-1.163)		
Educational level (high = 0)				
Low	**0.340**	0.576(0.186-1.788)		
Medium	**0.571**	0.691(0.192-2.483)		
Employment status (unemployed = 0, employed = 1)	**0.029***	2.727(1.180-6.712)	0.064	3.206 (0.937-10.976)
BMI	**0.070**	0.932(0.863-1.006)		
Protein intake	**<0.001***	1.080(1.049-1.112)	<0.001*	1.084 (1.051-1.118)
Knowledge score				
Protein	**0.568**	0.996(0.983-1.010)		
Potassium	**0.662**	0.997(0.985-1.010)		
Sodium	**0.046***	0.990(0.980-0.999)	0.009*	0.980 (0.966-0.995)
Fluid	**0.712**	0.998(0.987-1.009)		
Phosphorus	**0.174**	0.987(0.969-1.006)		
Total score	**0.151**	0.984(0.963-1.006)		

B: Unstandardized Coefficients, C.I: Confidence interval . #: All variables with p<0.05 was included in the multivariate , *: Statistically significant at $p \leq 0.05$

DISCUSSION

Hyperphosphatemia is a common complication of End Stage Renal Disease (ESRD) and is present in most patients on dialysis [1]. This is evident in the present study where 44.5 % had serum phosphorus levels > 5.5 mg/dl. This percentage was in accordance with the Spanish study by Lorenzo et al [17] where the prevalence of hyperphosphatemia was noted in 46 % of MHD, and with the study by Khor et al [6] conducted on 435 MHD Malaysian patients where the prevalence was 47.8%, and with the Dialysis Outcomes and Practice Patterns Study (DOPPS) study from 7 countries (France, Germany, Italy, Japan, Spain, United Kingdom, and United States) that showed that 46.7% of patients had high serum phosphorus levels [18]. However, this percentage was less than the multicenter study conducted by Afifi et al [19] in Egypt in 2005 and on 1005 patients in 38 HD centers and showed that hyperphosphatemia was present in 69.1% of cases.

Determinants for poor phosphorus control in the dialysis patients are multifactorial and includes sociodemographic characteristics, such as age and disease related factors. In the present study it was noted that hyperphosphatemia patients are younger and with a longer duration of dialysis compared to the controlled group although this difference was not significant (p=0.075, p=0.059 respectively). Same was reported by Joson et al [20] who studied 133 patients in a single HD center and found that patients with hyperphosphatemia (>5.5 mg/dl) were significantly younger than controlled group. Likewise, a 7 years cohort study including 258,510 American patients on MHD [21] revealed that patients' age and race were the strongest determinants of serum phosphorus level. The authors found that older patients had a lower serum phosphorus than younger patients. A possible explanation is that younger patients might have a preference to fast foods and processed foods that are high in inorganic phosphorus additives, and that older individuals have a more structured lifestyle that enables them to implement the dietary recommendations and have healthier food choices. In another study [22] a contrasting finding reported that patient's age and length of time on dialysis were associated with poorer serum phosphorus control. perhaps this might be attributed to non-adherence to and forgetting phosphorus binder medications, additionally ESRD patients experience high rates of depressive symptoms and change of appetite [23]. This highlights the importance of addressing the ongoing barriers and challenges facing ESRD patients with low phosphorus diet adherence with continuous reinforcement of the dietary message.

Higher dietary phosphorus intake is associated with increased serum phosphorus in dialysis patients due to inadequate removal. ESRD patients need to increase their protein intake to prevent malnutrition and improve survival, that's why it is important to choose protein sources with low phosphorus -to-protein ratio[7].In the present study mean phosphorus intake is significantly higher in hyperphosphatemia patients. High phosphorus intake is significant risk factor for hyperphosphatemia in multiple regression analysis. The only determinant for dietary phosphorus non-adherence after examining all factors in multivariate analysis was high protein intake. Inadequate energy and protein intake and high dietary phosphorus intake among MHD patients has been similarly reported among 156 MHD Moroccan patients [24] and 91 Spanish patients [25]. Mohd Isa et al. reported high percentage of MHD patients had high dietary phosphorus intake in dialysis and non-dialysis days (25 % and 40 % respectively). Also the authors found a significant but weak correlation between serum phosphate levels and dietary phosphorus intake on dialysis day ($r = 0.200$, $p = 0.047$) and non-dialysis day ($r = 0.228$, $p = 0.032$)[26].

Poor renal diet knowledge has been linked to non-adherence to low phosphorus diet in dialysis patients. Specifically dietary phosphorus knowledge is lower than other nutrients because phosphorus does not have physical properties that the patients can relate to like sodium which tastes salty [10]. Almost half of the sample had poor renal diet knowledge level. Comparing individual nutrients' knowledge scores showed that protein, phosphorus, and potassium knowledge level were worse than sodium and fluid knowledge level. In studies examining MHD patients' nutritional knowledge, it has been found that patients' knowledge of phosphorus is the lowest compared to knowledge of other nutrients like sodium, potassium and fluid [10, 27, 28]. In the present study higher phosphorus related knowledge level is a significant determinant of better serum phosphorus level control in the multivariable regression model and this is not in line with many studies that reported better knowledge is not associated with higher adherence to dietary advice and controlled serum phosphate levels [10, 20, 28]. Similarly, a cross-sectional study of 188 dialysis patients who were recruited from 14 dialysis centers in Malaysia revealed that only quarter of the sample were adherent to dietary recommendations. Patients were considered as dietary compliant when both serum potassium and phosphorus were within the recommended levels. Knowledge scores on potassium and phosphorus were negatively correlated with dietary compliance ($r = -0.345$, $p<0.01$) [29]. Dietary knowledge alone may be insufficient for nutrition behavior changes. Healthcare professionals need to adopt new techniques like motivational interviewing to improve dietary compliance. The present study reveals the complexity of nutrition data about dietary

phosphorus and difficulty to restrict foods rich in phosphorus like milk, cheese, beans, soft drinks, and processed food.

Extensive dietary counselling is an important pillar in hyperphosphatemia management. In a study of 36 Chinese patients who were exposed to routine dietary education about phosphorus their mean phosphorus intake was 931.1 ±290.4 mg/d, and 69% of patients were within the recommended target phosphorus intake. Most of patients (91%) in high phosphorus intake group (>1000 mg/d) demonstrated hyperphosphatemia. [30]. The long hours spent in dialysis session cause an increased sense of tiredness and lack of time and energy to prepare healthy home cooked meals. Patients thus resort to fast food meals containing protein choices with high phosphorus-to-protein ratio like processed meat, processed cheese, and offal (liver, brain…etc.). Also, patients resort to non-protein snacks with high inorganic phosphorus used as additives like carbonated beverages, commercial cakes and biscuits and instant coffee.

The limitations of the present study were the small sample size and that all patients were selected from a single hemodialysis center. Data about compliance to phosphorus binder therapy was not collected and this is a confounding variable affecting serum phosphorus level besides diet. Also, the use of 24-hour dietary recall is known to be subjected to recall bias and underestimation of nutrient intake. Another limitation is the absence of complete database about phosphorus content especially inorganic phosphorus that is used as additive in processed food.

CONCLUSION AND RECOMMENDATIONS

Hyperphosphatemia is common among MHD patients. Poor dietary phosphorus knowledge is related to hyperphosphatemia. Patients with higher protein intake are more prone to have a high phosphorus intake especially if their protein choices are of high phosphorus-to protein ratio.

Nutritional education and counselling for patients with ESRD plays a major role in the preservation of renal functions and prevention of morbidity. Dietary phosphorus information is complex, and messages delivered by the health care professionals should be simple and practical. These messages need to be reinforced with more frequent counselling to improve dietary phosphorus compliance. Innovative and varied approaches to deliver the messages should be used like one-to-one counselling, group counselling, cooking classes, recipes with food samples, posters, and videos.

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CONFLICT OF INTEREST

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