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Protein, phosphate intake and serum phosphate values in peritoneal dialysis patients

Maša Škrlep[1,2*] and Bojan Knap[3,4]

Abstract

Introduction: Evaluation of dietary intake of patients on peritoneal dialysis is necessary for understanding the elevated phosphate levels, as well as protein intake monitoring, which struggles to meet current dietary guidelines.

Methods: The single-center observational study. 20 patients on peritoneal dialysis were randomly selected. A food propensity questionnaire has been carried out with three unannounced 24-hour dietary recalls per participant through a web-based application. Body composition has been measured with bio impedance spectroscopy. Continuous variables between normal values and of study values were compared using paired t-tests and Wilcoxon signed ranks test. A two-tailed P value <0.05 was considered statisticallx significant.

Results: Average caloric intake of 20 patients was (25.6 ± 6.7) kcal/kg body mass (BM)/day, average protein intake was (0.9 ± 0.3) g/kg BM/day. They were inadequate according to the dietary recommendations for dialysis patients on peritoneal dialysis (PD). Average intake of micro-nutrients (K, P, Na) corresponds to the recommendations for dialysis patients which is surprisingly according to high levels of serum phosphorus ((1.6 ± 0.4) mmol/L) and intact parathyroid hormone ((450 ± 393) ng/L). Phosphorus intake was moderately correlated with the dietary energy intake (p = 0.0001). The correlation between dietary phosphorus intake and serum phosphorus was insignificant (p = 0.509). The correlation between dietary phosphorus to dietary protein ratio was 0,159. In dietary report showed 60 % of animal protein intake and 40 % of plant protein intake. Dietary phosphorus and protein intake ratio was (16 ± 3.6) mg/g. Inorganic phosphate from additives were not detected in all item because of lack of information in database.

Conclusion: Food databases are needed in order to provide optimal nutrition. Patients still lack proper nutritional knowledge, hence new educational technics and help will be needed in the future. Detecting inorganic phosphate is difficult due to lack of information in databases and specific bioavailability and absorption.

Keywords: Diet recall; Protein intake; Phosphate intake; Peritoneal dialysis; Hyperphosphatemia

Introduction

Nutritional management of patients should be an integral part of the treatment of dialysis patients. Successful nutritional counselling, which in addition to nutritional status assessment is essential for treatment determination,

Affiliation:

[1]Department of Food Science and Technology, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 10, 1000 Ljubljana, Slovenia

[2]Biotechnical centre Naklo, Strahinj 99, 4202 Naklo, Slovenia

[3]Department of Nephrology, Medical Faculty, University Medical Center, Ljubljana, Slovenia

[4]Faculty of Medicine, University of Ljubljana, Korytkova ulica 2, 1000 Ljubljana, Slovenia

***Corresponding author:**
Maša Škrlep, Department of Food Science and Technology, Biotechnical Faculty, University of Ljubljana, Jamnikarjeva 10, 1000 Ljubljana, Slovenia

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requires knowledge of the origin and problems of phosphate [1]. Elevated serum phosphate (P) concentrations and consequent hyperphosphataemia represent a major risk factor for poorer treatment outcomes and earlier mortality [2]. Serum phosphate concentrations depend on dietary phosphate intake, gastrointestinal absorption, glomerular filtration, renal tubular excretion and reabsorption, and the balance between excretion and resorption. Additional factors include vitamin D, parathyroid hormone and fibroblast growth factor (FGF-23) [3,4] estrogen and calcium intake. Normal concentrations should be between 3.0-4.5 mg/dl or 0.8-1.5 mmol/L [5] and vary according to the circadian rhythm (minimum values in the morning and maximum in the evening) [6]. In the course of chronical kidney disease (CKD), serum P levels remain within normal limits until advanced stages. Hyperphosphataemia should be considered as a very late indicator of P retention. Elevated intact parathyroid hormone (iPTH) is seen first, and elevated FGF-23 - which induces a phosphaturin response that contributes to the maintenance of a neutral P balance - is seen even earlier [5,6]. The ability to absorb is influenced by the total amount of dietary phosphate and the type of phosphate (organic and inorganic), the origin of the food (plant and animal), and the ratio of phosphate to the other components of the food [7,8,9]; how much is absorbed depends on the enzymatic degradation [6], with an efficiency of 55-90% [10]. Most dietary phosphate is absorbed in the intestine [10], especially inorganic phosphate from phosphate supplements (mainly free orthophosphate), which is 80-90% absorbed. Phytate is present in foods high in dietary fibre, which improves the integrity of the intestinal barrier, which plays a role in reducing toxin production, slowing CKD and inflammation, and anti-constipation [11-13], which occurs in PD patients due to phosphate binders, potassium restriction, and antibiotics [14,15]. Phosphate additives are still a major problem and are not present in food databases because only the name is recorded and not the concentrations, which can lead to a 30% deviation from the real phosphate value [16], and phosphates are not only present where they are actually listed, but also in modified starch [17], which is present in dairy and bakery products and in plant-based alternatives to dairy products [18,19].

Poor nutritional status is very common among dialysis patients, occurring in more than 20% of dialysis patients, who often experience protein-energy wasting (PEW), mainly due to dietary phosphate restriction [20,21]. Parameters related to nutritional status and survival are phase angle (a marker for predicting disease course) (22) and fat mass, which are obtained by bioimpedance analysis [23] In addition, parameters of nutritional analysis are important - energy intake, protein intake and micronutrient intake (Ca, P, Na), as well as parameters of biochemical analysis, in particular serum albumin, which is used as a marker of nutritional status mainly because it is influenced by protein intake and may also be affected by associated liver disease and gastrointestinal and renal losses. Low levels are associated with inflammatory processes, and a fall in albumin levels is significantly associated with the development of peritonitis [23]. Phosphate levels may be high, particularly in patients who have had CKD since childhood and have not had adequate dietary management, and therefore the consumption of dairy products is discouraged and a plant-based alternative is encouraged [18].

Methods

This study was an observational, cross-sectional study including patients treated with maintenance PD at the inpatient PD ward of the University Medical Centre Ljubljana. Patients were enrolled in the study from December 2017 to March 2018. Exclusion factors were active congestive heart failure, advanced liver disease, active malignancy, recent peritonitis. All subjects signed an informed consent before inclusion in the study. The study protocol was approved by the Medical Ethics Committee of the Republic of Slovenia (protocol code 0120-330/2017/6, 15 May 2018). Subjects participated in the study voluntarily and could withdraw from the study at any point. Twenty patients receiving dialysis treatment (PD and combined) were included in the study. Three patients were excluded from the study because they received a replacement therapy with a transplant before completion of the dietary interview. Mean age (54.7 ± 17.3) years, min 26 and max 91 years, 45% women and 55% men.

Nutritional status

A dietary interview was conducted three times over a period of three months to obtain the previous day's menu (24-hour recall) and analysed using the OPEN (Platform for Clinical Nutrition) online tool. Validated images were used in the interview to facilitate portion sizing. Pre-packaged foods were searched online and grams listed on the declarations were entered, missing values for the food (micronutrients) were found for the equivalent food during data processing, and missing values were added to the printout. Nutritional status was compared with body weight composition by bioimpedance spectroscopy (BIS) to calculate lean tissue index (LTI), fat tissue index (FTI), overhydration (OH) and Ph A as a prognostic index [15]. Ph A was calculated by bioimpedance spectroscopy using the following formula: Ph A (°) = arctangent (X c/R) * (180/π).

Biochemical tests

Data on biochemical tests were obtained from Hippocrates for the period during which the dietary interviews and bioimpedance analysis were performed. Blood samples were taken in the morning and plasma concentrations of calcium, phosphorus, albumin, magnesium and protein were measured.

Each value was expressed as a percentage or as mean ±

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SD. Continuous variables between baseline and study values were compared by paired t-tests and Wilcoxon signed rank tests. A two-sided P value < 0.05 was considered statistically significant. Statistical analysis of the data was performed using Excel and XLStat.

Results

The study included 20 patients undergoing dialysis treatment (PD and combined). Three patients were excluded from the study because they received a replacement therapy with a transplant before completion of the dietary intervention. Mean age (54.7 ± 17.3) years, min 26 and max 91 years, 45% women and 55% men. Baseline biochemical data (presented as mean values ± SD) are shown in table 1.

Energy, protein, fat, carbohydrate, potassium, sodium, phosphate intake (with 24-h recall), body mass composition with BIS (LTI, FTI, OH, PhA) compared with recommended or normal values for all parameters are shown in table 2.

The phase angle (4.9 ± 1.2)° was lower than recommended in 11 patients, 55% of patients had a damaged cell membrane. The body mass index (25.1 ± 3.2) kg/m^2 was not lower than 18.5 in any patient, indicating malnutrition, and the body mass index (12.7 ± 2.6) kg/m^2 was lower than recommended values in 45% of patients, indicating protein-energy malnutrition in patients, as confirmed by S-albumin (36.3 ± 4.2) g/l. Dietary intake was too low (25.6 ± 6.7) kcal/kg BM, minimum 12.45, maximum 39.4, as shown in table 3.

Body mass index (BMI) and reported energy intake were not positively correlated (r=-0.021, p=0.928). There is an association between energy intake and body weight (correlation coefficient 0.181, p=0.466), with a 20% increase in energy intake in patients with a BMI above 25 kg/m^2 reversing the association (Pearson test, correlation coefficient R=0.301, p=0.197), while a comparison between a 20% increase in energy intake and body weight showed a strong association r=0.443, p=0.05. It is possible that patients inadequately reported their energy intake, which may have influenced the inaccuracy of the overall results of the nutritional analysis. The mean protein intake of the analysed patients was (0.9 ± 0.3) g/kg BM/day. Only two patients reached the recommended values of 1.2 g/kg BM/day (Figure 1). If the recommended values according to the t-test

Table 1: Biochemical parameters obtained through blood analysis conducted on days of dietary interviews, including albumin (g/l), protein (g/l), phosphate (mmol/l), creatinine (µmol/l), urea (mmol/l), hemoglobin (g/l), potassium (mmol/l), calcium (mmol/l), iPTH (ng/l), sodium (mmol/l), and vitamin D (25-OH-D3) (nmol/l), all reported as mean ± SD, all accompanied by reference values.

Biochemical parameter	Mean ± SD	Reference value
Albumin (g/l)	36,3 ± 4,2	32-35
Protein (g/l)	64,2 ± 8,4	65-80
Phosphate (mmol/l)	1,6 ± 0,4	0,84-1,45
Creatinine (µmol/l)	745 ± 200	440-970
Urea (mmol/l)	21 ± 6,0	2,8-7,5
Hemoglobin (g/l)	114 ± 14	130-170
Potassium (mmol/l)	4,5 ± 0,5	3,8-5,50
Calcium (mmol/l)	2,3 ± 0,1	2,1-2,6
iPTH (ng/l)	450 ± 390	12-65
Natrium (mmol/l)	136,3 ± 4,3	135-145
Vit D (25-OH-D3) (nmol/l)	54 ± 20	75

Table 2: Anthropometric data acquired through bioimpedance analysis are displayed, featuring phase angle, BMI (body mass index), LTI (lean body mass index), and FTI (fat tissue index), all accompanied by reference values.

Body composition	Mean ± SD	Reference value
Phase angle (°)	4,9 ± 1,2	< 5 (man); <4,6 (woman)
BMI (kg/m^2)	25,1 ± 3,2	18 – 25
LTI (kg/m^2)	12,7 ± 2,6	< 14,6 (man); < 11,4 (woman)
FTI (kg/m^2)	11,8 ± 4,2	7

Table 3: Nutritional data acquired through dietary analysis of the previous day, conducted via dietary interviews using the online OPEN application. The data includes kcal/kg body mass (BM), protein (g/kg BM), fat (g), carbohydrates (g), sodium (mg), potassium (mg), phosphate (mg), and calcium (mg), all compared with recommended values in the rightmost column.

	Patients data	Recommended values
Kcal/ kg BM	25,6 ±6,7	35
Protein (g/kg BM)	0,9 ± 0,3	1.2
Fat (g)	55 ± 20	55
Carbohydrates (g)	181 ± 57	210
Na (mg)	2260 ± 1250	1800-2500
K (mg)	2390 ± 637	2000-2500
Phosphate (mg)	960 ± 220	800-1000
Calcium (mg)	753 ± 416	1000

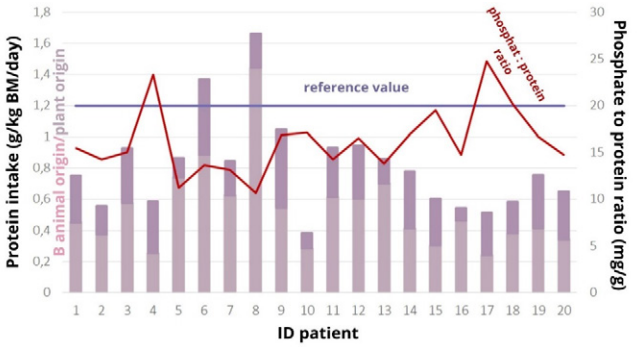

Figure 1: The protein intake in the studied dialysis patients, expressed in g/kg body mass (BM) per day and categorized by source. The purple line represents the recognized reference value for protein intake at 1.2 g/kg TB/day, while the red line represents the phosphate:protein ratio.

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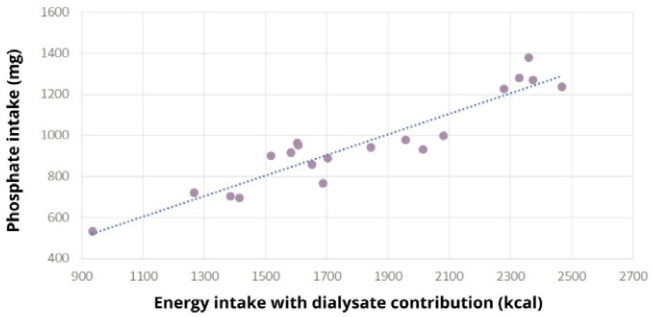

Figure 2: Scatterplot of the Pearson correlation test between normally distributed variables: phosphate intake (mg) and energy intake with contributions from dialysate energy (kcal) in the studied dialysis patients. A strong correlation is observed between energy intake and phosphate intake (r=0.937, p=0.0001), indicating that any under-reporting of energy intake results in under-reporting of phosphate intake.

were lowered to 1 g/kg (37) (BM/day, this would indicate that the patients consumed sufficient protein, as the p-value is greater than the statistical significance level of 0.05 (p= 0.057).

Student's t-test showed that the amount of phosphate consumed was not statistically different from the reference amount of 900 mg, p=0.265. The patients did not consume too much phosphate (958±22) mg. S-phosphate (1.6±0.4) mmol/L was elevated in 12 patients, severely elevated in two (2.21 and 2.72 mmol/L), at the reference limit in three patients, all with hyperphosphataemia. Dietary phosphate intake was not associated with serum phosphate levels, Spearman's test showed that there was no statistically significant association between the amount of phosphate intake and serum phosphate levels, p=0.509, r=0.156, indicating that phosphate intake is not associated with phosphate levels. There is a strong correlation between energy intake and phosphate intake (r=0.937, p=0.0001) (Figure 2), so any under-reporting of energy intake results in under-reporting of phosphate intake.

Discussion

Our observational, cross-sectional study revealed some limitations in estimating food intake, which contributed to the underestimation of reported food intake. The chosen method of using 24-h recall introduces the possibility of underreporting, which may be influenced by factors such as anxiety, discomfort, or cognitive biases associated with recalling food choices from the previous day, which may be as much as 20-86% higher than the real one [24,25]. This phenomenon is particularly prevalent among women, the elderly, and individuals with a body mass index >25 kg/m^2. Adherence to this limitation is crucial because underreported dietary intake can lead to misinterpretation of the true nutritional status of patients. In addition to underreporting, inadequate dietary intake also implies an underestimation of other nutrients, mainly protein, phosphate, calcium, potassium, and sodium, the data of which have an impact on patient pathogenesis. Our patient cohort had a wide age range, with a mean age of 54.7 years, comprising 45% women and 55% men. The baseline biochemical data presented in table 1 indicate variability in parameters such as energy, protein, fat, carbohydrate, potassium, sodium, and phosphate intake, which formed the basis for our subsequent analysis. The mean protein intake was low, which is in line with other studies, Silva et al. [26] so with 24h-recall estimated 0.90 (0.58-1.22) g/kg current BW/day, daily protein intake estimated by PNA was 0.81 (0.72-0.99) g/kg. An interesting finding was the higher proportion of animal protein consumed (60%), which deviated from the recommended ratio of at least 50% plant protein recommended by guidelines for dialysis patients [21,28]. These guidelines aim to reduce the risk of protein energy wasting (PEW), which is associated with adverse outcomes in patients with chronic kidney disease (CKD) like lowe pressure, slower regression of disease and prevention of metabolic diseases [29,30,41,42]. Addressing the composition of dietary protein sources is emerging as a potential strategy for optimizing dietary management and reducing the impact of hyperphosphatemia. Serum phosphate levels were elevated in most patients [12], and hyperphosphatemia was found in all patients, although they did not consume too much phosphate unless underreporting was a problem. Phosphate has a particular impact on malnourished patients with a low glomerular filtration rate (GFR) and concomitant high dietary phosphate intake [8], with meals of animal origin [31], making it reasonable to use the protein-phosphate ratio [32,33,7], especially when assessing protein foods. Wlodarek et al. [36] reported no difference between protein type and phosphorus intake ($r = 0.586$, $P < 0.01$, vs. $r = 0.674$, $P < 0.01$), but on the other side, Gebretsadik et al. [37] reported a higher correlation of animal protein and phosphours inake versus plant protein and phosphours intake ($r = 0.652$, $P < 0.01$, vs. $r = 0.202$, $P = 0.04$) but there was, for most participants energy, potassium and phosphorus intake below recommendations while protein intake was below -how is that? [25]. Azadbakht et al. [38] evaluate soy protein on renal markers and report that soy consumption reduces serum phosphate levels compared to animal protein. Doung et al. [39] discoverd that nutrition education about protein summplements was assicoated wiht increased protein intake and nutritional status but not serum phosphate in PD patients. Garcia-Torres et al. wanted to determine how protein source impacts phosphorus intake, but most patients consumed energy, protein, phosphorus and potassium below recommendations, but soduim and fats abouve recommendations. Those consuming more plant proteins had lower phosphorus and protein intakes. Low protein intake and, consequently, low s-albumin levels stimulate inflammatory processes, which are unfavorable for the outcome of treatment. Heat treatment of foods is also a possible method to reduce phosphate levels [34]. However,

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we do not know the amount of phosphate obtained from additives; therefore, guidelines need to be translated into real-world situations [35].

Conclusion

We rejected the hypothesis that patients overconsume phosphate and hypothesise that this is due to underreporting of total intake in the previous day's menu recall method ($p = 0.0001$) and the absence of data on phosphate additives in the database. Despite the small sample size (20), our findings highlight the problem of plasticity in setting dietary rules for patients, which may lead to collateral damage in other aspects - in our case, underestimation of energy and protein intake and consequent poorer quality of life of the patient. In the treatment of renal and other chronic diseases, a multidisciplinary approach is essential, both in terms of methods and personnel. It is important to monitor the nutritional status of patients and to analyse nutrient intakes. This will show the patient's willingness to contribute independently to the treatment and to work more successfully with the dietician and the doctor.

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