

Determination of peritoneal phosphate transport as a tool for controlling serum phosphorus

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ABSTRACT

Background: Hyperphosphataemia (serum phosphorus ≥ 5.5 mg/dl) is an independent mortality factor for the dialysis population. We compared phosphorus, creatinine and urea peritoneal transport to demonstrate differences and indicate the relevance of these parameters in the control of serum phosphorus. **Material and method:** We included 60 patients on peritoneal dialysis and determined the dialysate/plasma phosphorus (D/P P) and creatinine (D/P Cr) ratios, weekly creatinine clearance (CrCl) and phosphorus clearance (PCI), weekly Kt/V of urea, and peritoneal phosphorus excretion (PEx). **Results:** D/P P was higher in patients with normal phosphataemia, compared with those who were hyperphosphataemic 0.61 ± 0.13 versus 0.54 ± 0.10 ($p = .035$). We observed an adequate correlation between D/P P and D/P Cr, $r = 0.90$, $p < .05$, but poor concordance between both, with a lower limit of -0.17 (-0.24 to -0.09 95% CI) and an upper limit of 0.47 (0.39 - 0.54 95% CI) for D/P Cr with respect to D/P P. PCI had an adequate correlation with D/P P in patients with a Kt/V ≥ 1.7 ($r = 0.384$, $p = .04$) and in anuric patients ($r = 0.392$, $p = .04$), but not with D/P Cr. There was poor concordance of the CrCl with respect to PCI with a lower limit of -13.54 l/week/ 1.73 m² BSA (-21.68 to -5.4 95% CI) and an upper limit of 58.98 l/week/ 1.73 m² BSA (50.84 - 67.12 95% CI). Total PEx was related to PCI ($r = 0.643$, $p < .05$), while it was not related to CrCl ($r = 0.222$, $p = .23$). Using the CHAID method, we created a classification tree for phosphorus transport based on its D/P, obtaining 5 nodes (≤ 0.5 , 0.51 - 0.55 , 0.56 - 0.66 , 0.67 - 0.76 , > 0.76), with statistically significant differences between nodes for serum phosphorus, total and peritoneal PCI and weekly Kt/V of urea. **Conclusions:** D/P P and PCI are not concordant with D/P Cr and CrCl respectively and therefore their determination is a clinical tool to control serum phosphorus levels.

Keywords: Hyperphosphataemia. Peritoneal dialysis. Creatinine clearance.

Determinación del transporte peritoneal de fósforo como herramienta para el control del fósforo sérico RESUMEN

Introducción: La hiperfosfatemia (fósforo sérico $\geq 5,5$ mg/dl) es un factor independiente de mortalidad en la población en diálisis. Comparamos el transporte peritoneal de fósforo, creatinina y urea para demostrar diferencias y señalar la relevancia de estos parámetros en el control del fósforo sérico. **Material y métodos:** Se incluyeron 60 pacientes en diálisis peritoneal y se determinó el índice dializante/plasma de fósforo (D/P P) y creatinina (D/P Cr), el aclaramiento semanal de fósforo (AcIP) y creatinina (AcICr), Kt/V de urea semanal y la excreción peritoneal de fósforo (ExP). **Resultados:** El D/P P fue superior en pacientes con normofosfatemia, comparados con los que presentaron hiperfosfatemia, $0,61 \pm 0,13$ frente a $0,54 \pm 0,10$ ($p = 0,035$). Se observó una adecuada correlación entre el D/P P y el D/P Cr, $r = 0,90$, $p < 0,05$, pero una pobre concordancia entre ambos, con un límite inferior de $-0,17$ ($-0,24$ a $-0,09$ IC 95 %) y límite superior de $0,47$ ($0,39$ - $0,54$ IC 95 %) para el D/P Cr respecto al D/P P. El AcIP tuvo una adecuada correlación con el D/P P en pacientes con Kt/V $\geq 1,7$ ($r = 0,384$, $p = 0,04$) y en anúricos ($r = 0,392$, $p = 0,04$), pero no con el D/P Cr. Hubo una pobre concordancia del AcICr respecto al AcIP con límite inferior de $-13,54$ l/sem/ $1,73$ m² SC ($-21,68$ a $-5,4$ IC 95 %) y límite superior de $58,98$ l/sem/ $1,73$ m² SC ($50,84$ - $67,12$ IC 95 %). La ExP total se relacionó con el AcIP ($r = 0,643$, $p < 0,05$), mientras que no lo hizo con el AcICr ($r = 0,222$, $p = 0,23$). Mediante el método CHAID se realizó un árbol de clasificación del transporte de fósforo con base en su D/P, obteniendo 5 nodos ($\leq 0,5$, $0,51$ - $0,55$, $0,56$ - $0,66$, $0,67$ - $0,76$, $> 0,76$), mostrando diferencias estadísticamente significativas entre nodos para niveles séricos de fósforo, AcIP total y peritoneal, así como Kt/V de urea semanal. **Conclusiones:** Las mediciones de D/P P y AcIP no concuerdan con las mediciones de D/P Cr y AcICr, respectivamente, por lo que su determinación es una herramienta clínica para el control del nivel de fósforo sérico.

Palabras clave: Hiperfosfatemia. Diálisis peritoneal. Aclaramiento de creatinina.

INTRODUCTION

Cardiovascular disease is the main cause of mortality in population with advanced renal disease, and hyperphosphatemia (serum phosphate > 5.5 mg/dl) is an

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independent risk factor that can range from 30 to 40% of the population subjected to renal replacement therapy, resulting amongst other complications, calcification of the tunica media of blood vessels, particularly in coronary arteries, which precipitates acute cardiovascular events, with fatal consequences¹⁻¹⁰. For these reasons, controlling serum phosphorus is imperative in the management of chronic kidney disease patients.

There is little information with respect to weekly phosphorus clearance (PCI) and dialysate/plasma phosphorus (D/P P). Sedlacek et al. found a high correlation between dialysate/plasma creatinine (D/P Cr) and D/P P, as well as their respective clearances, concluding that the clearance of both solutes is closely linked, and as such, the main determinant for weekly creatinine clearance (CrCl) and PCI is D/P Cr¹¹. In a study of paediatric patients on automated peritoneal dialysis, they found a good correlation between both D/P, but PCI was related better to D/P P than to D/P Cr, with the conclusion that the former is a better predictor¹². Bernardo et al. classified phosphorus transport by its D/P based on Twardowski's creatinine transport classification¹³ and they observed that the distribution of patients based on D/P P in the different categories was different to that presented for D/P Cr, suggesting that, despite there being a correlation between D/P P and D/P Cr, the latter measure is not adequate enough to classify patients in accordance with the transport of phosphorus¹⁴. This study evaluates concordance between D/P Cr and D/P P, and between CrCl and PCI, using the Bland and Altman method¹⁵, with the objective of finding out how much one test may differ from the other and thus determine whether D/P Cr and CrCl can continue to be reliable replacements of peritoneal phosphorus transport. Furthermore, we evaluated peritoneal phosphorus transport in a dialysis population with the aim of highlighting its role in phosphataemia control beyond dietary restriction and the use of phosphate binders.

MATERIALS AND METHODS

We carried out a cross-sectional, observational and comparative study in which we included 60 patients of the peritoneal dialysis outpatient clinic. Inclusion criteria: patients older than 16 years of age who were on renal replacement therapy for at least one month through continuous ambulatory peritoneal dialysis or nocturnal automated peritoneal dialysis (NAPD). Exclusion criteria: having presented with peritonitis at the time of the study, with this being considered to be the presence of 100 or more leukocytes per field in the cytological study of dialysate, who completed antibiotic treatment within the two previous months or patients who presented or had presented in the previous month with an incapacitating medical condition. For the peritoneal equilibration test (PET), we included as exclusion criteria ultrafiltration failure, defined as lower than 400ml after the application of a 4.25% 2000ml bag after 4

hours in the peritoneal cavity, catheter mechanical problems, defined as a fluid entry time greater than 10 minutes and an exit time greater than 30 minutes or having greater D/P P than the unit. The following were counted as exclusion criteria in solute clearance measurement: NAPD mode (reasons unrelated to the interests of this study), peritonitis, the 24-hour dialysate effluent volume being lower than the infused volume and a lack of adherence to the dialysis prescription, confirmed subjectively by the patient.

We performed a PET on all patients using a 4.25% solution to determine D/P P and D/P Cr. We carried out a cytology of the dialysate in order to rule out an active infectious condition. We calculated weekly the Kt/V of urea and weekly PCI and CrCl expressed in litres per week adjusted to body surface area (l/week/1.73m² BSA), all in their renal, peritoneal and total forms using standard methods¹⁶, as well as the normalized protein nitrogen appearance using the Randerson formula¹⁷. The urine samples were only collected for those with diuresis equal to or greater than 200ml/day; if this was not the case, they were considered anuric. The Department of Nutrition, through the food frequency questionnaire of the Nutritional Habits and Nutrient Consumption Evaluation System¹⁸ determined the average daily phosphorus intake.

STATISTICAL ANALYSIS

The results were expressed as means and standard deviations in the case of numeric variables or as proportions for categorical variables. The comparison of means between the two groups was carried out with Student's t-test for independent groups or with its non-parametric alternative (U-Mann-Whitney), in accordance with the distribution of each variable. The comparison of proportions was carried out using the χ^2 test. Variables were associated using Spearman's correlation coefficient.

We carried out a concordance analysis between two tests (D/P Cr and D/P P; CrCl and PCI) using the Bland and Altman method. We created a graph showing the difference between the two methods against their average. 95% of differences are found in this graph between two limits that define the confidence interval (CI). The concordance limits are displayed with their respective 95% CI.

To compare more than two means, we carried out a one-way ANOVA test with the Bonferroni test. In order to divide up the database in the best way possible with regard to the D/P P variable, we used a classification tree, taking the CHAID (*Chi Squared Automatic Interaction Detector*) method as the form of growth.

Values of $P < .05$ were considered to be statistically significant. The statistical package SPSS version 15 for Windows was used.

RESULTS

We included 60 patients, of which 4 PET were excluded due to having a greater D/P P than the unit and we eliminated 10 solute clearance measurements due to the following: one due to inadequate sample collection, one due to not requiring dialysis after recovery from acute renal damage, four due to a 24-hour ultrafiltration volume lower than the infused volume, two due to being in NAPD mode and two due to not having a stable dialysis dose because of poor adherence to their prescription.

The population characteristics and the biochemical and treatment parameters can be observed in Table 1.

Phosphorus

Mean serum phosphorus in our population was 5.3 ± 1.7 mg/dl (2.6-9.7 mg/dl), with 21 (31.3%) cases of hyperphosphataemia, with there being a low inverse correlation between phosphorus levels and D/P P, $r = -0.273$,

$p = .04$ and a statistically significant difference in D/P P in those with normal phosphataemia when we compared them with hyperphosphataemic patients, 0.61 ± 0.13 mg/dl versus 0.54 ± 0.10 mg/dl ($p = .035$). Daily estimated mean phosphorus intake was 1290 ± 472 mg/day (522-2794 mg/day). We found that those who consumed a quantity lower than or equal to 1000 mg/day ($n = 18$, 32%) had significantly lower serum phosphorus when we compared them with those who consumed more than 1000 mg/day (4.8 ± 1.6 mg/dl versus 5.6 ± 1.7 mg/dl, $p = .039$).

Dialysate/plasma phosphorus and creatinine ratios

The mean D/P Cr for our population was 0.70 ± 0.10 (0.51-0.92) and the mean D/P P was 0.58 ± 0.12 (0.28-0.85), and we observed an adequate correlation between the two, with $r = 0.90$, $p < .05$ (Figure 1). However, we observed a poor concordance between the two methods with upper and lower limits of D/P Cr with respect to D/P P of -0.17 (-0.21 to -0.13 95% CI) and 0.47 (0.35-0.59 95% CI), respectively (Figure 2).

Table 1. Population characteristics: medical and dialysis management

	n/%	Range
Population characteristics		
Sex (male/female)	30(50 %)/30 (50 %)	
Age (years)	45.8 ± 19.5	17-80
Diabetes mellitus 2	23 (38.3 %)	
Biochemical parameters		
Haemoglobin	9.8 ± 2.1 g/dl	5.6-15
Albumin	3.3 ± 0.53 g/dl	2.1-4.5
Cholesterol	181 ± 39 mg/dl	111-296
Urea nitrogen	54.28 ± 14.5 mg/dl	25-82
Calcium	9.5 ± 0.71 mg/dl	6.6-11
Phosphorus	5.3 ± 1.7 mg/dl	2.6-9.7
Calcium x phosphorus	50.13 ± 16.05	25.2-93.7
Intact parathyroid hormone	351.5 ± 241.1 pg/ml	55-1046
C-reactive protein	7.32 ± 9.8 mg/l	0.2-53
nPNA	1.1 ± 0.2	0.8-1.7
Treatment		
Phosphate binders	20 (33 %)	
Antihypertensive drugs	43 (72 %)	
Time on peritoneal dialysis	20.3 ± 22.6 meses	1-129
Patients with previous episodes of peritonitis	9 (15 %)	
Diurnal dialysis hours	12.7 ± 2.6	8-20
Litres of dialysis solution (diurnal)	7.8 ± 1.0	6-10
Patient with nocturnal dialysis	15 (25 %)	

nPNA: normalized protein nitrogen appearance

Phosphorus clearance, creatinine clearance and Kt/V of urea

We observed a low correlation between PCI and D/P P ($r=0.33$, $p=.02$), and between PCI and D/P Cr ($r=0.30$, $p=.03$). However, when we carried out a subanalysis that only included those with a Kt/V of urea ≥ 1.7 , we found a correlation between PCI and D/P P ($r=0.384$, $p=.04$), but not between PCI and D/P Cr ($r=0.348$, $p=.06$). We also explored this association in anuric patients, where we similarly observed that PCI was significantly related to D/P P ($r=0.392$, $p=.04$), but not to D/P Cr ($r=0.358$, $p=.52$).

We attempted to find an association between the Kt/V of urea, CrCl and PCI in their total, peritoneal and renal measurements and we found the following: Kt/V of urea had significant correlations with CrCl in its total, peritoneal and renal measurements ($r=0.68$, $p<.05$; $r=0.78$, $p<.05$; $r=0.47$, $p=.03$, respectively); PCI showed significant correlations with CrCl in its total, peritoneal and renal measurements ($r=0.45$, $p<.05$, $r=0.59$, $p<.05$ and $r=0.67$, $p<.05$, respectively). However, the concordance analysis showed that it is poor, with lower and upper concordance limits of $-13.54\text{l/week}/1.73\text{m}^2$ BSA (95% CI -21.68 to -5.4) and of $58.98\text{l/week}/1.73\text{m}^2$ BSA (95% CI 50.84 - 67.12), respectively, of total CrCl with respect to total PCI (Figure 3). Moreover, renal PCI showed an almost significant association with Kt/V of renal urea ($r=0.43$, $p=.05$), while total and peritoneal PCI did not display a significant association with Kt/V of total and peritoneal urea ($r=0.18$, $p=.31$ for both).

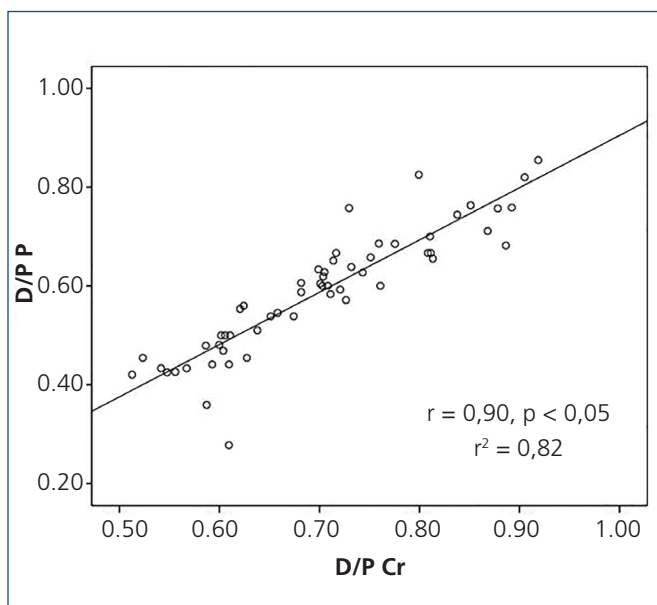


Figure 1. Correlation between the dialysate/plasma creatinine ratio and the dialysate/plasma phosphorus ratio. D/P Cr: dialysate/plasma creatinine ratio, D/P P: dialysate/plasma phosphorus ratio.

Phosphorus clearance, serum phosphorus levels and residual renal function

When we divided patients in accordance with diuresis and subdivided each group into normal phosphataemia and hyperphosphataemia (Table 2), we could observe that mean serum phosphorus for anuric patients with hyperphosphataemia was significantly higher than those with hyperphosphataemia who maintained diuresis ($7.4\pm 1.4\text{mg/dl}$ versus $6.3\pm 0.8\text{mg/dl}$, $p=.03$). D/P P was significantly lower in anuric patients with hyperphosphataemia, compared with those who had normal serum phosphorus levels (0.51 ± 0.8 versus 0.62 ± 0.14 , $p=.006$). Although total PCI was higher in patients with diuresis compared with the anuric patient subgroup ($40.2\pm 10.4\text{l/week}/1.73\text{m}^2$ BSA vs. $35.6\pm 9.6\text{l/week}/1.73\text{m}^2$ BSA, $p=.12$), it was not significantly different. However, peritoneal PCI in anuric patients was significantly higher when we compared it with patients who maintained diuresis ($35.5\pm 9.8\text{l/week}/1.73\text{m}^2$ BSA vs. $28.3\pm 10.25\text{l/week}/1.73\text{m}^2$ BSA, $p=.01$). Residual renal function was significantly lower in patients with hyperphosphataemia compared with those with normal phosphataemia ($3.2\pm 1.2\text{ml/min}$ vs. $4.8\pm 2.0\text{ml/min}$, $p=.048$).

Phosphorus excretion

We also evaluated the potential association between total and peritoneal phosphorus excretion with total and

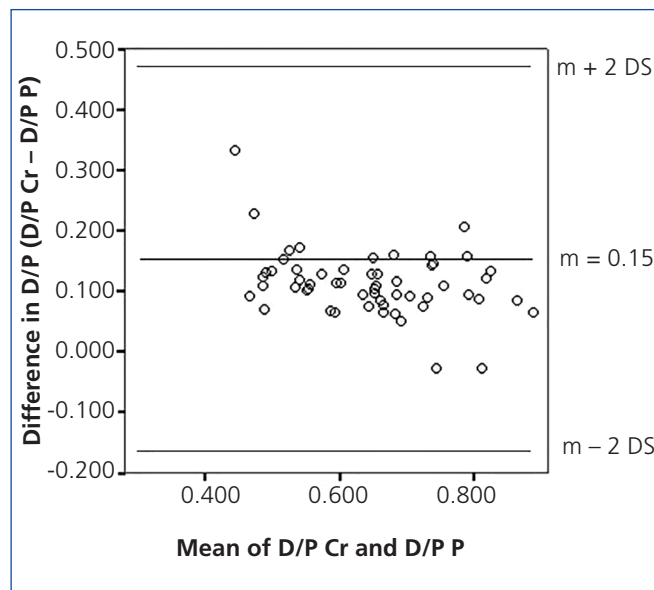


Figure 2. Concordance between the dialysate/plasma creatinine ratio and the dialysate/plasma phosphorus ratio. D/P Cr: dialysate/plasma creatinine ratio, D/P P: dialysate/plasma phosphorus ratio.

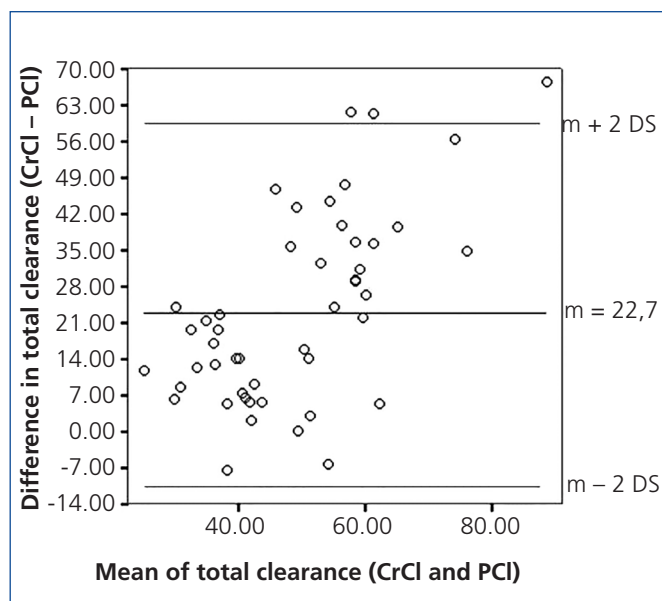


Figure 3. Concordance between creatinine clearance and phosphorus clearance.

CrCl: creatinine clearance, PCI: phosphorus clearance.

peritoneal CrCl and PCI, and we found the following: total phosphorus excretion showed a better correlation with total PCI ($r=0.62$, $p<.05$) than with total CrCl ($r=0.360$, $p<.05$). Peritoneal phosphorus excretion also had a better correlation with peritoneal PCI ($r=0.687$, $p<.05$) in comparison with peritoneal CrCl ($r=0.466$, $p<.05$). Lastly, in patients with a Kt/V of urea ≥ 1.7 the correlation between total PCI and total phosphorus excretion was significant ($r=0.643$, $p<.05$), but was not between total CrCl and total phosphorus excretion ($r=0.222$, $p=.23$).

Categorization of phosphorus transport

On the basis of D/P P distribution using the CHAID method, we created a classification tree and obtained the following nodes with their respective ranges: node 1: ≤ 0.5 , node 2: 0.51-0.55, node 3: 0.56-0.66, node 4: 0.67-0.76, node 5: >0.76 , and we found statistically significant differences between nodes in terms of serum phosphorus levels, total and peritoneal PCI, and Kt/V of urea (Table 3).

Table 2. Transport of solutes, dialysis dose and phosphataemia in accordance with residual uresis

	Population (n=50)				All patients (n = 50)
	Non-anuric ≥ 200 ml		Anuric		
	P ≤ 5.5 mg/dl (n = 10)	P > 5.5 mg/dl (n = 10)	P ≤ 5.5 mg/dl (n = 20)	P > 5.5 mg/dl (n = 10)	
Serum phosphorus	4.5 \pm 0.6	6.3 \pm 0.8	4.1 \pm 0.9	7.4 \pm 1.4**	5.3 \pm 1.7
Weekly Kt/V of total urea	2.19 \pm 0.31	1.9 \pm 0.45	1.75 \pm 0.32**	1.59 \pm 0.29	1.84 \pm 0.39
Weekly Kt/V of peritoneal urea	1.61 \pm 0.33	1.50 \pm 0.38	1.75 \pm 0.32	1.59 \pm 0.29	1.64 \pm 0.33
Weekly Kt/V of renal urea	0.57 \pm 0.28	0.41 \pm 0.19			0.50 \pm 0.25
Total weekly CrCl	86.1 \pm 16.4	72.32 \pm 11.7 ^a	49.2 \pm 11.1 ^b	43.6 \pm 5.8 ^b	58.9 \pm 21.3
Weekly peritoneal CrCl	41.9 \pm 11.23	41.15 \pm 10.3	49.2 \pm 11.1	43.6 \pm 5.8	45.0 \pm 10.4
Weekly renal CrCl	44.23 \pm 19.9	31.17 \pm 12.2			37.7 \pm 17.4
Total weekly PCI	39.02 \pm 9.5	41.4 \pm 11.8	36.0 \pm 10.88	34.45 \pm 7.6	37.4 \pm 10.1
Weekly peritoneal PCI	26.5 \pm 9.5	30.0 \pm 11.2	36.0 \pm 10.9 ^b	34.45 \pm 7.6	32.6 \pm 10.5
Weekly renal PCI	12.4 \pm 6.7	11.3 \pm 4.4			11.88 \pm 5.6
Residual renal function	4.8 \pm 2.0	3.2 \pm 1.2 ^a			1.34 \pm 2.18
D/P Cr	0.70 \pm 0.10	0.70 \pm 0.09	0.73 \pm 0.11	0.65 \pm 0.9*	0.70 \pm 0.10
D/P P	0.58 \pm 0.09	0.58 \pm 0.11	0.62 \pm 0.14	0.51 \pm 0.8*	0.58 \pm 0.12
nPNA	1.19 \pm 0.20	1.14 \pm 0.23	1.04 \pm 0.16	1.03 \pm 0.21	1.08 \pm 0.2

CrCl: creatinine clearance, PCI: phosphorus clearance, D/P Cr: dialysate/plasma creatinine ratio, D/P P: dialysate/plasma phosphorus ratio, nPNA: adjusted protein equivalent of total nitrogen appearance.

^a $P <.05$ on comparing hyperphosphataemic patients with patients with normal phosphataemia for the same uresis category.

^b $P <.05$ on comparing anuric patients with non-anuric patients for the same phosphataemia category.

DISCUSSION

Phosphorus clearance is the result of the complex interaction between diffusion, convection, osmotic and chemical factors, electrical gradients, and active transmembrane phosphorus transporters^{19,20}. It has been demonstrated that absorption by lymphatic convection has no impact and that solutions with a higher concentration remove a higher quantity of phosphorus and are attributed to the convection factor. However, it was not possible to establish for certain whether ultrafiltration influences clearance²¹. Messa et al. demonstrated in 35 patients that glucose concentration was one of the predictors of phosphorus clearance and this was independent of the ultrafiltration volume²², while Granja et al. calculated that 11% of the phosphorus eliminated was due to ultrafiltration²³.

In our population, we found that the frequency of hyperphosphataemia was 31.3%, which is similar to that reported in the literature⁷. In previous studies, an adequate correlation was found between D/P Cr and D/P P, and between CrCl and PCI, suggesting equivalence between them^{12,13}. In this study, we demonstrated that although, D/P Cr and D/P P displayed adequate correlation, the concordance was poor, since the concordance limits were very broad. With such great variability of D/P Cr or CrCl with respect to the phosphorus parameters, there would be a very significant impact on clearance, excretion and therefore serum phosphorus levels, and as such, these measurements could not be considered equivalents. For example, a patient with a D/P P of 0.4 may have a D/P Cr from 0.16 to 0.94, values that are very different from the value of D/P P. Likewise, a patient with PCI of 35l/week/1.73m² BSA could have CrCl from 13.32l/week/1.73m² BSA to 102.12l/week/1.73m² BSA. Given the poor concordance that exists between the values studied and that they cannot be taken as replacements, we proposed a phosphorus transport classification tree with five nodes based on its D/P P, amongst which we identified statistically significant differences between groups for total and peritoneal PCI.

Our results confirm the role of diuresis in maintaining phosphorus levels at low values compared to anuria. In anuric patients, in whom the peritoneum has an exclusive role in

phosphorus clearance, the determination of phosphorus transport indicators is particularly important for two factors: 1) D/P P is significantly lower in hyperphosphataemic patients; 2) Peritoneal PCI is significantly higher compared with those who maintain diuresis (Table 2).

The current recommendations for the prescription of peritoneal dialysis in accordance with the 2006 K/DOQI clinical guidelines²⁴, based on the results of three major studies²⁵⁻²⁷, set a Kt/V of urea target of ≥ 1.7 , which has not managed to reduce mortality in this population. As such, the search for new markers of targets is vitally important. The current recommendations are to maintain the phosphorus level within the normal limits²⁸, although this is an arduous challenge for patients and physicians, since beyond dietary restriction and the adequate use of binders, the doctor must know the role that dialysis exercises on PCI. This study demonstrates the independence of phosphorus transport with respect to urea and creatinine and it leads to a series of questions such as the PCI dose necessary for helping patients achieve the serum phosphorus targets, whether this value is different in patients with diuresis and anuric patients, whether the dialysis adjustment to achieve an established PCI target improves mortality compared with the current Kt/V of urea targets or whether a low D/P P is associated with greater mortality, amongst others. As such, studies must be carried out to determine the benefits of the adjustment of peritoneal dialysis based on D/P P with different PCI doses, establish the mid- and long-term morbidity and mortality, and thus compare them with the current recommendations on dialysis.

CONCLUSIONS

This study shows that D/P P and PCI measurements are not concordant with those of D/P Cr and CrCl, respectively, despite having an adequate correlation. As such, given the current lack of knowledge about phosphorus transport in peritoneal dialysis in clinical practice, in a group of patients in whom phosphataemia control is imperative, it is necessary to give continuity to the research of these indicators, since they are useful tools for physicians and may guide dialysis prescription in search for a better control of serum phosphorus.

Table 3. Phosphorus and clearance characteristics between transport nodes

	Node 1	Node 2	Node 3	Node 4	Node 5	P
Phosphorus (mg/dl)	5.8 ± 2.0	6.3 ± 2.6	5.2 ± 1.3	4.6 ± 1.2	4.6 ± 0.9	$p = 0.04$
Weekly peritoneal PCI	28.0 ± 8.0	34.7 ± 14.3	32.28 ± 11.75	37.4 ± 11.3	41.0 ± 2.8	$p = 0.03$
Total weekly PCI	32.5 ± 6.9	36.4 ± 11.0	39.3 ± 11.1	39.8 ± 12.7	41.0 ± 10.16	$p = 0.03$
Weekly peritoneal Kt/V of urea	1.35 ± 0.45	1.46 ± 0.15	1.51 ± 0.35	1.60 ± 0.29	1.77 ± 0.29	$p = 0.03$

PCI: phosphorus clearance.

Conflicts of interest

The authors declare that they have no conflicts of interest related to the contents of this article.

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