Effects of Residual Renal Function on Clinical and Laboratory Features of Patients on Continuous Ambulatory Peritoneal Dialysis

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Background. The contribution of residual renal function (RRF) to dialysis adequacy in continuous ambulatory peritoneal dialysis (CAPD) patients is well known. The aim of our study was to evaluate the effects of RRF on various clinical and laboratory features including degree of anemia, phosphorus control, and nutritional parameters in patients on CAPD.

Methods. Patients on CAPD therapy who had undergone peritoneal and renal clearance study and had simultaneous biochemical analysis within the last 6 months were retrospectively investigated. Residual glomerular filtration rate (GFR) and biochemical measurements including hemoglobin concentration, serum albumin, cholesterol, triglycerides, calcium, phosphorus, parathormone and C-reactive protein (CRP) levels were obtained and recorded.

Results. Fifty-three patients (23 women, 30 men; mean age 48±15 years, range 21–77 years) receiving CAPD in our centre were analyzed. Patients were stratified into those with (n = 34) and without (n = 19) RRF. Patients with RRF had higher hemoglobin (11.2±1.9 vs. 9.9±1.7 g/dL; P = 0.022) and serum albumin levels (3.7±0.4 vs. 3.4±0.3 g/dL; P = 0.002). Among patients with RRF, residual GFR positively correlated with hemoglobin (P = 0.000) and normalized protein catabolic rate (P = 0.030), whereas negatively correlated with serum phosphorus (P = 0.020) and calcium and phosphorus product (P = 0.007).

Conclusions. Our study shows the contribution of RRF in maintaining serum hemoglobin levels, as well as its impact on phosphorus balance and beneficial effect on nutritional status in CAPD patients.

Key words: Albumin, anemia, continuous ambulatory peritoneal dialysis, end stage renal disease, hemoglobin, residual renal function.

Introduction

It has reported that initial low residual renal function (RRF) in peritoneal dialysis (PD) is associated with increased mortality in patients with end-stage renal disease (ESRD) (1). RRF continues to remain crucial throughout the dialysis therapy for patients on PD as well as those on hemodialysis (2). During the treatment course of PD, a decline in RRF contributes significantly to development of complications such as anemia, inflammation, and malnutrition in patients on dialysis (3). It was shown that patients with RRF have higher levels of hemoglobin (4, 5), presumably due to higher levels of endogenous erythropoietin (6). Normal serum phosphorus levels are easier to maintain in such patients (7). In patients on PD, it was also shown that the lower RRF was associated with increased inflammation (8). It is known that RRF is also important in maintaining the normal nutritional status of dialysis patients (3).

The aim of our study was to evaluate the effects of residual renal function on various clinical and laboratory criteria including degree of anemia, phosphorus control, and nutritional parameters in patients on continuous ambulatory peritoneal dialysis (CAPD).

Patients and Methods

After approval was obtained by the university medical center's Medical Records Review Committee, the records of patients on CAPD for 6 months or longer in the peritoneal dialysis clinic at the Department of Nephrology, Kocaeli University Hospital, were analyzed retrospectively. Patients who had undergone peritoneal and renal clearance studies and had simultaneous biochemical analysis within the last 6 months were included in the study. Patients on continuous cyclic PD (CCPD) were not included. All CAPD patients included in the study were on a standard CAPD program (four or five times daily with 2000 mL of fluid).

The peritoneal and renal clearance assessment included Kt/V (weekly clearance of urea normalized to total body water), creatinine clearance estimation from 24-hour effluent dialysate and urine collection and peritoneal equilibrium test. Demographic and clinical data were recorded for each patient as well as peritoneal transport expressed as creatinine dialysate to plasma ratio at 4 hours of peritoneal equilibrium test (D/P creatinine), peritoneal Kt/V, normalized protein catabolic rate (nPCR), and residual glomerular filtration rate (GFR). RRF was considered to be present if the patient had a daily diuresis over 200 mL.

Biochemical analysis at the time of peritoneal and renal clearance assessment including hemoglobin concentration, serum albumin, cholesterol, triglycerides, low density lipoprotein-cholesterol, high density lipoprotein-cholesterol, calcium, phosphorus, parathormone and C-reactive protein (CRP) levels were obtained from the patient files.

Statistical Analysis

Numeric values for continuous variables are expressed as mean ± standard deviation (SD). Student's *t*-test and Mann

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Whitney U test were used to compare the two groups for numeric data. Chi-square test was used to compare the categorical data between the two groups. The correlation between residual GFR with various biochemical and demographic parameters was tested by Pearson's correlation coefficient. The results were considered statistically significant if *P* value was lower than 0.05.

Results

Fifty-three patients (23 women, 30 men; mean age 48±15 years, range 21–77 years) were included into the study. The causes of ESRD were hypertensive nephropathy (n=16), diabetic nephropathy (n=7), polycystic kidney disease (n=3), reflux nephropathy (n=1), chronic glomerulonephritis (n=7) and unknown (n=19). The demographic, clearance, and peritoneal transport data are shown in Table 1.

Table 1. The demographic, clearance, and peritoneal transport data of study patients (n = 53)

	Mean	SD	(range)
Age	48	15	(25-77)
Duration of dialysis (months)	34	21	(6-113)
Weekly total Kt/V	2.2	0.8	(0.8-4.4)
Weekly peritoneal Kt/V	1.7	0.3	(0.9-2.7)
Weekly total CCr (L/wk/1.73 m2)	87	49	(30-205)
Weekly peritoneal CCr (L/wk/1.73 m2)	45	11	(30-76)
Residual GFR (mL/min)	6.9	4.9	(0.05-14.6)
D/P creatinine, (4 hours)	0.7	0.1	(0.4-1.03)
nPCR (g/kg/day)	1.10	0.46	(0.44-2.77)
Hemoglobin (g/dL)	10.8	1.9	(5.5-14.5)
Albumin (g/dL)	3.64	0.40	(2.88-4.49)

Abbreviations: Kt/V: Clearance of urea normalized to total body water; CCr: creatinine clearance; GFR: Glomerular filtration rate; D/P: Dialysate / Plasma; nPCR: Normalized protein catabolic rate

Patients were stratified into those with (n = 34) and without (n = 19) RRF. The clinical and demographical data and biochemical characteristics of patients according to the presence of RRF are shown in Table 2. Patients with RRF had a higher hemoglobin (11.2±1.9 vs. 9.9±1.7 g/dL; *P* = 0.022) and serum albumin levels (3.7±0.4 vs. 3.4±0.3 g/dL; *P* = 0.002). Patients with RRF had also lower serum CRP and parathormone levels although the difference was not statistically significant (for CRP; 0.91±1.08 vs. 1.57±2.97 mg/dL *P* =0.911 and for parathormone level; 164±156 vs. 304±267 pmol/L *P* = 0.06).

Table 2. Comparisons of clinical, demographic and biochemical characteristics of patients stratified according to presence of RRF (Values expressed as mean ± SD). Statistically significant values are underlined

	With RRF (n=34)	Without RRF (n=19)	*P* value
Age (years)	48±14	50±17	0.788
Male, n (%)	19 (56)	11 (58)	0.887
Duration of dialysis (months)	33±23	37±18	0.501
Systolic blood pressure (mmHg)	138±21	147±23	0.153
Diastolic blood pressure (mmHg)	84±14	90±15	0.151
Hemoglobin (g/dL)	11.2±1.9	9.9±1.7	0.022
Serum albumin (g/dL)	3.7±0.4	3.4±0.3	0.002
Serum calcium (mg/dL)	9.2±1.2	8.6±0.6	0.075
Serum phosphorus (mg/dL)	4.2±1.3	4.6±1.8	0.362
Calcium x phosphorus product (mg^2/dL^2)	38.7±11.4	40±15	0.742
Serum potassium (mEq/dL)	4.4±0.9	4.4±1.2	0.969
Cholesterol (mg/dL)	189±45	195±65	0.715
Triglycerides (mg/dL)	164±80	158±105	0.834
LDL-Cholesterol (mg/dL)	119±39	124±54	0.701
HDL-Cholesterol (mg/dL)	40±8	39±12	0.765
Parathyroid hormone (pmol/L)	164±156	304±267	0.060
Serum CRP (mg/dL)	0.91±1.08	1.57±2.97	0.911
Weekly total Kt/V	2.5±0.8	1.7±0.4	0.000
Weekly peritoneal Kt/V	1.6±0.3	1.7±0.4	0.640
Weekly total CCr (L/wk/1.73 m2)	108.1±49.1	49.3±9.8	0.000
Weekly peritoneal CCr (L/wk/1.73 m2)	42.9±11.1	49.3±9.8	0.040
Residual GFR (mL/min)	6.9±4.9	-	

Abbreviations: RRF: residual renal function (patients with RRF had a daily diuresis over 200 mL); LDL: Low density lipoprotein; HDL: High density lipoprotein; CRP: C-reactive protein; Kt/V: Clearance of urea normalized to total body water; CCr: creatinine clearance; GFR: Glomerular filtration rate

Among patients with RRF, residual GFR was positively correlated with hemoglobin (*P* = 0.001) and nPCR (*P* = 0.03), whereas negatively correlated with serum phosphorus (*P* = 0.02), calcium and phosphorus product (*P* = 0.007),

blood urea nitrogen concentration (P = 0.020), and serum creatinine (P = 0.000). Residual GFR did not correlate with serum albumin or serum parathormon levels.

Discussion

In this retrospective investigation of CAPD patients who underwent peritoneal and renal clearance studies, we observed that patients with RRF had higher serum hemoglobin and albumin. We also found that a higher level of residual GFR correlated with higher nPCR, a biochemical marker for improved nutritional status. Our findings suggest that RRF is important in maintaining targeted hemoglobin levels and nutritional status in patients on CAPD. The negative correlation between residual GFR and serum phosphorus and the product of calcium with phosphorus levels indicate the contribution of RRF to the phosphate balance.

With respect to the effect of RRF on clinical and laboratory parameters, we compared our findings to those of the previous studies (4,5). In 37 patients with ESRD treated by continuous ambulatory peritoneal dialysis it was found that RRF positively correlated with hemoglobin levels and nutrition parameters such as serum albumin and nPCR, as in our study (4). In 158 non-diabetic CAPD patients, Wang et al. showed that patients with greater residual GFR were less anemic and had lower degree of hypoalbuminemia (5). Higher hemoglobin levels shown in patients with RRF in previous studies as well as in our study suggest hematologically beneficial effects of RRF. Human erythropoietin levels were found to be higher in patients with RRF on maintenance hemodialysis and positively correlated with residual GFR (6). This suggests even smaller amounts of RRF may account for considerable improvements in the degree of anemia.

The impact of RRF on nutritional status in end stage renal disease was also studied in other studies (9-11). In patients on CAPD, it was shown that patients without RRF had lower nPCR and serum albumin levels than their counterparts with equal total weekly clearance (Kt/V) (9). In a cross- sectional and multicenteric study, it was shown that the loss of renal function is associated with anorexia and symptoms of severe malnutrition in CAPD patients (10). In patients on chronic hemodialysis, Suda et al. (11) showed the beneficial effects of RRF on nutritional parameters such as nPCR and serum albumin. Taken together, data from the previous studies as well as our study indicate that RRF has a significant positive effect on the nutritional status of ESRD patients on either CAPD or hemodialysis. There are several mechanisms for the contribution of RRF to an improved nutritional status including lower acidemia, better fluid control and lower dietary restriction (11). The nutritional parameters including albumin and nPCR correlate with the outcome on CAPD therapy and determine the prognosis in CAPD patients (12).

In this study, we also found that residual GFR was associated with better phosphorus control. Hyperphosphatemia is a common problem encountered in patients with ESRD and contributes to increased mortality in patients on renal replacement therapy (13). In 252 CAPD patients of whom 136 had RRF, a negative correlation was found between serum phosphorus and residual GFR (r = -0.393, P = <0.001), similar to our findings as shown in Table 3 (7).

Table 3. Correlation between glomerular filtration rate (mL/minute) and clinical and laboratory data in CAPD patients (n =34)

	r	P
Age (years)	0.308	0.077
Duration of dialysis (months)	-0.365	0.044
Systolic blood pressure (mmHg)	-0.118	0.512
Diastolic blood pressure (mmHg)	-0.186	0.301
Hemoglobin (g/dL)	0.668	0.000
Serum calcium (mg/dL)	0.171	0.333
Serum phosphorus (mg/dL)	-0.511	0.002
Calcium x phosphorus product (mg^2/dL^2)	-0.453	0.007
Blood Urea Nitrogen (mg/dL)	-0.398	0.020
Creatinine (mg/dL)	-0.679	0.000
Serum potassium (mEq/dL)	-0.350	0.054
Serum albumin (g/dL)	-0.152	0.389
nPCR	0.372	0.030
Parathyroid hormone (pmol/L)	-0.268	0.138
Serum CRP (mg/dL)	-0.012	0.952

Abbreviations: nPCR: Normalized protein catabolic rate; CRP: C-reactive protein

Our findings suggest that every effort should be made to preserve RRF in order to improve the health of patients with end stage renal disease. These may include regular measurements, attention to the maintenance of hydration if general anesthesia or major surgery is needed, appropriate diuretic usage to minimize the need for aggressive ultrafiltration, and avoidance from potentially nephrotoxic agents such as aminoglycosides, radiocontrast materials and nonsteroidal anti-inflammatory drugs (2).

Our study has several limitations. First, we did not take into account the total weekly clearance (Kt/V) of CAPD patients while grouping them according to the presence of RRF, although their ages and durations of dialysis were similar. Second, the creatinine clearance was used to estimate GFR. It is known that due to a substantial tubular secretion of creatinine at low glomerular filtration rates, the urea clearance provides a more accurate estimate of GFR than that of creatinine clearance (14). Third, the effects of medical treatments including recombinant human erythropoietin and phosphorus binding therapy were not assessed in this study. Such treatments might have affected the parameters we studied.

In conclusion, our study showed the importance of RRF in maintaining serum hemoglobin levels, its impact on phosphorus balance and the beneficial effects on nutritional status in CAPD patients.

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