



# THE IMPORTANCE OF USING PERITONEAL EQUILIBRATION TEST FOR THE PERITONEAL TRANSPORT TYPE CHARACTERIZATION IN CONTINUOUS AMBULATORY PERITONEAL DIALYSIS PATIENTS

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## ABSTRACT

The aim of this study was to analyze the importance of the peritoneal equilibration test (PET) in evaluation of the peritoneal membrane transport status in patients treated with continuous ambulatory peritoneal dialysis (CAPD). The study included 30 adult continuous ambulatory peritoneal dialysis (CAPD) patients, 16 male and 14 female, mean age  $61 \pm 16,5$  years with a prescription of four exchanges of 2 litres (L) per day, who underwent peritoneal equilibration test (PET). Eleven of patients were diabetics. A modified PET was performed during a 4 hours dwell using 4,25% glucose dialysis solution. The dialysate/ plasma ratio of creatinine (D/P) at the end of the procedure, and the dialysate 240 min/ initial dialysate ratio of glucose (D/Do) were calculated and used as parameter of solute transport. With the test, categorisation of patients was possible into high (H), high-average (HA), low average (LA), and low (L) transporters. In multivariate analysis age, gender, time on dialysis, comorbid diseases, diabetes mellitus (DM), serum albumin, were considered as independent factors influencing the PET. Among 30 patients 5 (16,7%) were classified as H transporters, 6 (20%) as HA, and 19 (63,3%) as LA. There were no patients in low category. Creatinine D/P at 4 hours was not different DM and non-DM patients. There were significant differences in gender, comorbid disease, serum albumin, D<sub>4</sub>/D<sub>0</sub> glucose and volume drained in 4 hours. The high transporter group had higher proportion of man ( $p < 0,05$ ), higher proportion of patients with comorbid diseases, lower serum albumin concentration ( $p < 0,001$ ), lower D<sub>4</sub>/D<sub>0</sub> glucose ( $p < 0,001$ ), and lower drained volume ( $p < 0,001$ ). The PET was an easy, inexpensive, reliable test to assess peritoneal transport type and it also provided information about peritoneal clearance of solutes and ultrafiltration. Peritoneal transport type classification was recognized not only as aid for prescription, but also as a prognostic index.

KEY WORDS: peritoneal membrane function, peritoneal equilibration test, ultrafiltration failure

## INTRODUCTION

Peritoneal membrane function in patients on peritoneal dialysis influenced dialysis prescription, clinical outcome and may be changed with time on treatment. For the adequate prescription of peritoneal dialysis, peritoneal transport characteristics should be known. The most widely used test for classifying a patient's peritoneal type has been the peritoneal equilibration test (PET). The originally test, developed and described by Twardovski, was performed using a 2,27% glucose solution and focused on transport of small solutes (1). Most nephrologists use the PET which is performed during a 4 h dwell with a 4,25% glucose dialysis solution instead of the 2,27% glucose solution because it was more sensitive to detect clinically significant ultrafiltration failure (2). It allowed assessment a number of aspects of membrane function including solute transport rates, ultrafiltration capacity, effective reabsorption, transcellular water transport, and permeability to macromolecules. Intra-individual changes can than be detected and adjustments can be made. Also, the results of interventions can be examined and complications can be detected at an early stage. The aim of this study was to analyze the importance of the PET in evaluation of the peritoneal membrane transport status in patients treated with continuous ambulatory peritoneal dialysis (CAPD) and factors influencing the peritoneal transport rate.

## MATERIALS AND METHODS

A prospective single center study was used with long-term follow up. The study included 30 adult continuous ambulatory peritoneal dialysis (CAPD) patients, 16 male and 14 female, mean ages  $61 \pm 16,5$  years with a prescription of four exchanges of 2 L per day, who underwent peritoneal equilibration test (PET). Eleven of patients were diabetics included both type I and type II. Other causes of their chronic uremia included chronic glomerulonephritis (8 cases), chronic pyelonephritis (6 cases), hypertensive nephropathy (3 cases), endemic nephropathy (1 case) and reflux nephropathy (1 case). Cardiovascular disease (CVD; defined as previous history of congestive heart failure, myocardial infarction, angina, peripheral vascular disease, or cerebrovascular disease) was presented in 9 patients. Of 12 diabetics patients 7 had CVD. Respiratory disease (chronic lung disease) had one patient. No restriction criteria were applied for age, gender, comorbid diseases, serum albumin. Patients on immunosuppressive therapy and those with hepatitis, and those having a peritonitis

episode within the previous 30 days, or three or more episodes during the previous 12 months, were excluded. Each patient underwent the PET. The PET was done in the standard way, using 2 L of 4,25% glucose concentration dialysate. Samples were drawn at 0, 2 and 4 hours, and the blood sample was drawn at hour 2. The dialysate/plasma ratio of creatinine (D/P Cr) at the end of the procedure, and the dialysate 240 min/initial dialysate ratio of glucose (Dt/Do) are calculated and are used as parameter of solute transport. With the test, categorization of patients was possible into high (H), high-average (HA), low-average (LA) and low (L) transporters. The mean D/P creatinine ratio at 4 hours was 0,65. Patients with D/P creatinine values lower than 0,5 showed low transport characteristics and high 4-hour dialysate glucose level, which was greater than 52,5 mmol/L. In patients with high solute transport D/P creatinine ratio has been 0,81-1,03 and the 4-hour dialysate glucose level was less than 28,0 mmol/L. The ultrafiltration capacity can be defined as the net fluid removed during a standardized exchange, after 4 hours using 4,25% glucose solution. The diagnosis membrane failure can be made when the net ultrafiltered volume is  $< 400\text{ml}$  after a standardized 4h dwell using a 4,25% glucose solution (ISPD Guidelines) (2). Glucose, urea, and creatinine were measured in each sample, using conventional techniques in a centralized reference laboratory.

### Statistics

Results are expressed as mean  $\pm$  standard deviation (SD). The ANOVA test was used to compare the difference in clinical characteristics between different transporter groups. Comparison of the differences in the subgroups was made using the t test and Kruskal Wallis test. A difference was considered significant when the p value was less than 0.05.

## RESULTS

Of 30 patients, 5 (16,7%) were classified as H transporters, 6 (20%) as HA, and 19 (63,3%) as LA transporters. There were no patients in low category. The distribution of creatinine D/P ratio from the PET is shown in Table 1. In the study group, the mean D/P creatinine ratio at 4 hours in patients with high solute transport was  $0,84 \pm 0,03$  and the dialysate 240 min/ initial dialysate ratio of glucose (Dt/Do) was  $0,23 \pm 0,07$ ; in patients with low-average solute transport D/P creatinine ratio was  $0,57 \pm 0,05$  and the glucose ratio (Dt/Do) level was greater  $0,42 \pm 0,14$ . The ultrafiltration capacity results on the PET has been linked with the results

of glucose absorption and D/P creatinine ratios were as follows : 0,6 ± 0,2 L (H), 0,8 ± 0,3 L (HA) and 1,02 ± 0,35 L (LA). We also examined a drop in dialysate sodium during the first hour of a 4,25% exchange. It was greater than 5 mmol/L in all transport groups and ultrafiltration failure via water channels were ruled out.

	LA n=19 63,3 %	HA n=6 20,0 %	H n=5 16,7%
D2/P2 Cr	0,46±0,03	0,61±0,06	0,69±0,05
D4/P4 Cr	0,57±0,048	0,74±0,06	0,84±0,03
D4/Do glucose	0,42±0,14	0,26±0,04	0,23±0,07
D/P Na (1/2h)	0,942±0,026	0,95±0,01	0,96±0,01
Na(D) (1/2h)	134,17±2,33	133,83±0,98	136,67±3,51
D/P Na (1h)	0,88±0,04	0,92±0,01	0,95±0,03
Na(D) mmol/L	125,67±4,79	127,67±2,50	131,33±5,77
D/P Na (2h)	0,86±0,049	0,91±0,01	0,96±0,03
Na (D) mmol/L	122,5±6,26	126,67±2,73	132,33±5,77
PET UF ml	1016,67±355,1	800 ± 268,33	600 ± 173,21

Legend: H = high transporter; HA = high-average transporter ; LA = low -average transporter; L = low transporter; CVD = cardiovascular disease; D2/P2 Cr = dialysate-to-plasma creatinine concentration ratio at 2 hours of dwell; D4/P4 Cr = dialysate-to-plasma creatinine concentration ratio at 4 hours of dwell; D4/Do glucose = concentration ratio of dialysate glucose at 4 hours and at 0 dwell time; D/P Na = dialysate-to-plasma; Values are express as mean as ± standard deviation

TABLE 1. Creatinine D/P ratios throughout 4-hour peritoneal equilibration test (PET)

The clinical characteristics of four transport groups of CAPD patients are shown in Table 2.

	H (n=5)	HA (n=6)	LA (n=19)	L(n=0)	p value
Age (years)	65 ± 12,5	58 ± 13,8	60±13,4		NS
Male gender (n) %	5 (100,0%)	2 (33,3%)	9 (47,4%)		< 0,05
Diabetes (n)	2 (40,0%)	3 (50,0%)	7 (36,8%)		NS
CVD	3 (60,0%)	2 (33,3%)	4 (21,1%)		<0,05
Respiratory disease			1 (5,3%)		NS
Serum albumin (gr/L)	29 ± 6,0	32 ± 3,0	37 ± 5,2		<0,001
D4/P4 Cr	0,84 ± 0,03	0,74 ± 0,06	0,57 ± 0,05		<0,001
D4/Do glucose	0,23 ± 0,07	0,26 ± 0,04	0,42 ± 0,14		<0,001
Drained volume (ml) at 4 hours	600 ± 173	800 ± 268	1016 ± 355		<0,001
D4/Do glucose	0,23 ± 0,07	0,26 ± 0,04	0,42 ± 0,14		<0,001
Drained volume (ml) at 4 hours	600 ± 173	800 ± 268	1016 ± 355		<0,001

Legend: H = high transporter; HA = high-average transporter ; LA = low -average transporter ; L = low transporter; CVD = cardiovascular disease;D4/P4 Cr = dialysate-to-plasma creatinine concentration ratio at 4 hours of dwell; D4/Do glucose = concentration ratio of dialysate glucose at 4 hours and at 0 dwell time; Values are express as mean as ± standard deviation except for gender, diabetes mellitus, CVD and respiratory wich are absolute frequencies and percentages

TABLE 2. Clinical characteristics of four transport groups of CAPD patients

There were significant differences in gender, comorbid diseases, initial serum albumin, D4/Do glucose, and the volume drained in 4 hours. The H transporters had high proportion of man, more comorbide diseases, lower initial serum albumin, lower D4/Do glucose and lower drained volume. The H transporters had a significantly higher proportion of CVD, but not diabetes or respiratory disease. The distribution of comorbid disease according to gender is shown Table 3. Male patients had significantly more comorbid disease, overall and more diabetes compared to female.

	Male (n=16)	Female (n=14)	P value
Comorbid disease (%)	(93,1 %)	(57,0 %)	< 0,05
Diabetes (%)	(50,0 %)	(28,5 %)	< 0,05
Cardiovascular disease (%)	(31,2 %)	(28,6 %)	NS
Respiratory disease (%)		(7,1 %)	NS

TABLE 3. Distribution of comorbid disease according to gender

Values are expressed as mean as percentages and absolute frequencies.

## DISCUSSION

The present study shows that CAPD patients, who were high transporters at the start of CAPD, had more comorbid diseases, a higher proportion of males, lower serum albumin and lower drained volumes. We found that high peritoneal transport rate was related to comorbid diseases. It is generally accepted that peritoneal transport rate depends on both effective peritoneal surface area and permeability and that peritoneal permeability is affected by peritoneal blood circulation (3,4) . Many of the mediators produced in the inflammatory process can affect microvascular permeability and vascular tone (6). Thus, our finding of a significant relation between peritoneal transport rate and comorbid diseases suggests that comorbid diseases may affect microcirculation, and may also affect peritoneal transport characteristics at the start of CAPD (5). The CANUSA study showed that a grater proportion of patients had diabetes mellitus with higher peritoneal membrane transport rate, according to PET at 1 month after initiation of dialysis (8). Reyes et al. reported that initial D/P Cr was significantly higher in patients with CVD (7). In the present study, high transporters had more CVD compared to the other groups. The significantly higher proportion of men in the high transporter group is also consistent with previous studies (10,11). In a study of 60 CAPD patients, Devuyst et al. reported that D/P Cr was strongly correlated with male

gender (9). The CANUSA study showed a significantly increased proportion of man with increased transport rate (8). The cause of this effect is not clear. However, our finding of significantly more comorbid diseases in male patients leads us to speculate that the effect of comorbid diseases on the peritoneal transport rate may explain the relation between men and high transport rate. The CANUSA study showed that increased transport rate was associated with low serum albumin but not with other initial nutritional parameters such as subjective global assessment, percent lean body mass, or normalized protein catabolic rate (8). In addition to comorbid diseases, our study reveals that initial serum albumin concentration is significantly lower in initial H peritoneal transport rate, a finding consistent with previous reports. Coester et al. found that initial D/P Cr was negatively correlated with

initial serum albumin and positively correlated with low hyaluronan (4). Acute and chronic infections and inflammation are present in a large proportion of predialysis patients, and serum albumin is generally accepted as an indicator of inflammation (12). Cueto-Manzano and Correa-Rotter showed that diabetes mellitus was significantly more frequent in high transporters, and was the most important risk factor for mortality while on CAPD (10). In the present study, however, we found no significant difference in the proportion of diabetics among different transport groups. Of our 40% diabetic's patients, 58% had CVD. Some diabetic patients had more than one comorbid disease. The high rate of comorbid disease in diabetes explains why diabetes is not an independent risk factor for mortality, while CVD and respiratory disease are.

## CONCLUSION

The proper classification of patient peritoneal transport type is an important issue in the practice of peritoneal dialysis. The patients classified as high transporters have more comorbide diseases, lower initial serum albumin, lower D<sub>4</sub>/D<sub>0</sub> glucose, lower drained volume and a higher mortality risk than patients classified in other transport categories.

### List of Abbreviations

CAPD	- continuous ambulatory peritoneal dialysis
PET	- peritoneal equilibration test
D	- dialysate
Cr	- creatinine
H	- high transporter
HA	- high-average transporter
LA	- low -average transporter
L	- low transporter
CVD	- cardiovascular disease

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