Original Article

Comparative Assessment of Peritoneal Membrane Characteristics in Patients on Continuous Ambulatory Peritoneal Dialysis Using Standard Peritoneal Equilibration Test and Fast Peritoneal Equilibration Test

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Abstract

Background: Evaluation of peritoneal membrane permeability in patients on continuous ambulatory peritoneal dialysis (CAPD) is crucial in prescribing treatment regimens. This study evaluated peritoneal membrane characteristics in patients on CAPD using standard peritoneal equilibration test (PET) and fast PET. **Methods:** A prospective observational longitudinal study included patients on CAPD with no symptoms of peritonitis for at least 4 weeks before the PET. Both, standard and fast PET were performed using 2.5% glucose-containing dialysate. The dialysate and plasma (D/P) creatinine ratios at each time point (i.e., 0 h, 2nd h, and 4th h) in standard and at 4th hour only in fast PET were determined. Patients were classified according to D/P creatinine value as high, high-average, low-average, low transporter. The follow-up period was 6 months and changes in membrane characteristics were compared again to revalidate the efficacy of fast PET. **Results:** A total of 50 patients between 41 and 70 years of age were enrolled. The majority had diabetic nephropathy (40%) and chronic glomerulonephritis (28%). Based on transport type, a significant positive correlation was observed between the D/P creatinine ratio of baseline standard PET I and fast PET I (r = 0.992, $P \leq 0.05$) and standard PET II and fast PET II (r = 0.969, $P \leq 0.05$) done after 6 months. The results of the PET and transport category after 6 months were similar in 82% cases determined by fast PET and 98% cases determined by the standard pet. There was significant agreement between both the methods of PET (K value = 0.872, $P < 0.001$). A significant ($P \leq 0.001$) correlation was observed between standard PET I and standard PET II transport status. **Conclusion:** Fast PET is a good alternative for assessing peritoneal membrane characteristics especially in the setting of less availability of resources and is a less cumbersome procedure as compared to standard PET.

Keywords: *D/P creatinine ratio, permeability category, solute (creatinine) transfer, transporter type*

Introduction

In peritoneal dialysis (PD), the peritoneal membrane is used as a semipermeable membrane for solute transfer and ultrafiltration. The prescribing treatment of patients on dialysis is dependent on the transport properties of this membrane, which vary among individuals as well as within the same individual over time.[1] The peritoneal equilibration test (PET) is a preferred and frequently used method to evaluate these transport characteristics of the peritoneal membrane, which ultimately helps in deciding optimal treatment regimen in patients on PD and to follow the evolution of peritoneal membrane function over time.[2,3]

Standard PET is a long procedure, technically challenging and involves assessment of the solute (creatinine, sodium, urea, glucose) transport rates using the rate of their equilibration between the dialysate and the peritoneal capillaries. Previous reports did not support the notion that PET measurements affect the outcome in patients using continuous ambulatory PD (CAPD). A recent retrospective study demonstrated that all patients with end-stage renal disease can safely begin standard CAPD without PET, which only needs to be performed if the patient encounters trouble in total dialysis clearance or fluid removal.[4] However, observations of a pilot study indicated fast PET as a potential

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screening tool to evaluate peritoneal membrane permeability in patients on PD. Cost-effectiveness and technically easy procedure to evaluate membrane permeability are the benefits of fast PET over standard PET.[5]

To our knowledge, there is no Indian study that assessed the potential of fast PET in comparison with standard PET in investigating the peritoneal membrane permeability in patients on CAPD. The present study aimed to evaluate the characteristics of peritoneal membrane in patients on CAPD using standard and fast PET and to determine if fast PET can replace the standard PET for assessment of peritoneal membrane characteristics.

Methods

This was a hospital-based prospective observational longitudinal study conducted at the nephrology outpatient department (OPD), Global hospital, Hyderabad, between December 2015 and November 2016. Patients on CAPD with no symptoms of peritonitis for at least 4 weeks before the period of the test were included in the analysis. Patients who withdrew from the second PET after 6 months due to any reason were excluded.

The study protocol was approved by the institutional ethics committee (14 Feb 2014) and the study principles had their origin in accordance with the Declaration of Helsinki. Informed consent was obtained from every participant before their enrolment in the study.

The patients were subjected to commercially available PD solutions and both PET tests were performed using 2.5% glucose-containing dialysate. In eligible patients undergoing standard PET, the overnight dwell drained for 20 min and then 2 L of 2.5% glucose dialysate was infused over 10 min. A 10 mL of dialysate sample was drawn at 0, 2nd, and 4th hour (h) for evaluating glucose and creatinine values. At 2nd h, the blood sample was drawn to determine glucose and creatinine values. After the 4th h sample, the effluent was drained completely for at least 20 min and plasma (D/P) creatinine ratios measured at each time point and transport category were determined. For fast PET, after 48 h, the same procedure was followed as standard PET except for the D/P samples for the 0th and 2nd h were omitted. The D/P glucose and creatinine values were analyzed only at 4th h, thereafter determining the transport type. PET I was performed at the start of the study and PET II after 6 months.

Patients were classified according to D/P creatinine value as high, high-average, low-average, and low. Patients were categorized as low transporter when D/P creatinine range was 0.34–0.49; low average transporter, when D/P creatinine range was 0.50–0.65; high average transporter, when D/P creatinine range was 0.66–0.80 and high transporter, when D/P creatinine range was 0.81–1.03 in both standard and fast PET. The follow-up period was 6 months and changes in membrane characteristics were noted and compared.

Data were analyzed using SPSS version 17. Continuous variables were expressed as mean (SD). An appropriate statistical test was used to evaluate peritoneal membrane characteristics and compare the results in CAPD patients using standard PET and fast PET during initiation of study and re-evaluation after 6 months. The co-relation between standard PET and fast PET results were analyzed using the class correlation coefficient in a 95% confidence interval. Categorical variables were evaluated by the weighted Kappa test and t-test. Sensitivity, specificity, positive, and negative likelihood ratios were also evaluated. The P value <0.05 was considered to be statistically significant.

Results

A total of 50 patients were enrolled in the analysis. The majority of the patients were between the ages group 41 and 70 years. Only two patients (4%) were aged ≤30 years and four (8%) were ≥71 years. The mean (SD) age of the study population was 54.2 (14.24) years. Number of males (n = 33, 66%) were almost double than females (n = 17, 34%) and the ratio of male: female was 1.9: 1. The mean (SD) duration of CAPD was 16.66 (13.82) months. Of the 50 patients, majority had diabetic nephropathy (40%), chronic glomerulonephritis (28%), chronic interstitial nephritis (22%), followed by polycystic kidney disease (4%), primary amyloidosis (2%), postinfectious glomerulonephritis (2%), and vesico-ureteric reflux (2%) [Table 1].

Based on transport type, a significant positive correlation was observed between the D/P creatinine ratio of standard PET I and fast PET I (r = 0.992, $P \leq 0.05$) and standard PET II and fast PET II (r = 0.969, $P \leq 0.05$). Among 50 patients, 98% had similar PET findings after six months and only 2% had variability, one patient of low average in standard PET I was changed to low in standard PET II. Similarly, on comparing fast PET I and II transport, 82% patients had similar PET findings after 6 months and 18% variability was observed in PET II compared to PET I. Two patients showed change from high transport type to high average, three of them changed from high average to low average, one of them changed from low average to high average and three with low average were changed to low. However, the changes between standard PET I and PET II and fast PET I and PET II showed no statistical significance ($P \geq 0.05$) [Table 2].

The measure of agreement between both standard and fast PET I transport by using Cohen's kappa showed that there was significant agreement between both the methods of PET (K value = 0.872 and $P < 0.001$. Fast PET results were identical in 46 (92%) patients and the variability was reported in four (8%) patients. The variability between standard and fast PET I was 40% who were high average in standard PET I and high transporter in fast PET I, 8.3% who were low average in standard PET I were reported high average in fast PET I and 3.7% were low in standard PET

I and low average in fast PET I. A significant ($P \leq 0.001$) correlation was observed between standard PET I and standard PET II transport. It was observed that 7.7% of patients who were high average in standard PET I were reported as low average in standard PET II. Similarly, 3.7% were low average at PET I and high average at PET II, 7.4% of patients were reported as low average in PET I and low in PET II, 14.3% patients were low in PET I and low average in PET II transport. The results were found to be similar in 45 (90%) patients and only five (10%) of them had variability [Table 3].

Comparison of PET I analysis at the initiation of the study and PET II after 6 months showed no significant mean difference in dialysate creatinine at 0 h, dialysate glucose at 2nd h, dialysate glucose at 4th h, dialysate fresh creatinine sample, dialysate fresh glucose, plasma glucose at 2nd h, plasma glucose at 4th h, D/P creatinine in standard and fast PET ($P \geq 0.05$). However, a significant difference was observed between PET I and PET II in dialysate glucose at 0 h, dialysate creatinine at 2nd h, dialysate creatinine at 4th h, plasma creatinine at 2nd h and plasma creatinine at 4th h [Table 4].

Table 1: Demographics and clinical characteristics

Parameter	*n*=50
Age (years), mean (SD)	54.2 (14.2)
Age group (years)	
≤30	2 (4.0)
31-40	7 (14.0)
41-50	10 (20.0)
51-60	13 (26.0)
61-70	14 (28.0)
≥71	4 (8.0)
Gender	
Male	33 (66.0)
Female	17 (34.0)
CAPD duration, mean (SD)	16.66 (13.8)
Distribution of patients based on diagnosis	
Primary amyloidosis	1 (2.0)
Chronic interstitial nephritis	11 (22.0)
Chronic glomerulonephritis	14 (28.0)
Diabetic nephropathy	20 (40.0)
Postinfectious glomerulonephritis	1 (2.0)
Vesico ureteric reflux	1 (2.0)
Polycystic kidney disease	2 (4.0)

Data presented as *n* (%), unless otherwise specified. APD: continuous ambulatory peritoneal dialysis; SD: standard deviation

Discussion

The present study demonstrated that the results of the fast PET were similar to that of the standard PET. The categorization of peritoneal transporters between the two PETs was similar to the previous studies.[5,6] In this study, 28% patients were from the age group of 61–70 years followed by 26% patients from the age group of 51–60 years, 20% from the age group of 41–50 years, 14% from the age group of 31–40 years, 8% above 71 years, and 4% less than 30 years. The mean age of the study patients was 54.2 years and was consistent with the study of Kazancioğlu *et al*.[5] The majority of patients had diabetic nephropathy and chronic glomerulonephritis, total accounting for 68% of patients with CKD, which is consistent with the study conducted by Varma *et al*.[7]

PET I at the initiation of the study showed that 6% of patients as high transporter, 26% as high average, 54% as low average, and 14% as low transporters. The variability in the results of the transporter category of standard versus fast PET for high, high average, and low transporter was 4%, 2%, and 2%, respectively. A significant positive correlation between the transport category determined by standard PET as well as fast PET was observed (r = 0.942, $P < 0.05$). These results were consistent with previous studies.[5,6] A significant positive correlation between the D/P creatinine ratio of standard PET and fast PET (r = 0.992, $P < 0.05$) suggested that both types of PET had a good correlation in terms of detecting the solute (creatinine) transfer across the peritoneal membrane as calculated by D/P creatinine. These observations are in concordance with the results shown in the previous study.[6] A recent study by Akdam *et al*. evaluated the concordance between the 1-h, 2-h, and 4-h (classical) test results of the fast PET and reported that four patients were in the high permeability category, 13 patients were in the high-average permeability category, 11 patients were in the low-average permeability category, and four patients were in the low permeability category. They concluded 2-h fast PET gave promising results.[8]

The present study reported a significant agreement in both the methods of PET with k value 0.872 and $P < 0.001$. Fast PET results were identical to standard PET in 46 (92%) patients. These results indicate that both methods had similar outcomes and no method was superior to others. Studies by Kazancioğlu *et al*., Adcock *et al*., and Twardowski corroborate these observations.[5,6,9]

Table 2: Comparison between standard and fast PET I vs PET II, standard PET I vs PET II and fast PET I vs PET II

Distribution based on transport type	Standard PET I*	Standard PET II	*P*	Fast PET I*	Fast PET II	*P*
High	3 (6)	3 (6)	0.994	5 (10)	3 (6)	0.773
High average	13 (26)	13 (26)		12 (24)	12 (24)	
Low average	27 (54)	26 (52)		27 (54)	26 (52)	
Low	7 (14)	8 (16)		6 (12)	9 (18)	

Data presented as *n* (%). PET: peritoneal equilibrium test. *Standard PET I vs fast PET I and standard PET II vs fast PET II $P \leq 0.05$

Table 3: Measurement of agreement between standard PET I vs fast PET I and standard PET I vs standard PET II transport

Standard PET I transport	Fast PET I transport				*P*
	High transporter	High average	Low average	Low	
High transporter	3 (60)	0	0	0	<0.001
High average	2 (40)	11 (91.7)	0	0	
Low average	0	1 (8.3)	26 (96.3)	0	
Low	0	0	1 (3.7)	6 (100)	
Standard PET I transport	**Standard PET II transport**				
High transporter	3 (100)	0	0	0	<0.001
High average	0	12 (92.3)	1 (7.7)	0	
Low average	0	1 (3.7)	24 (88.9)	2 (7.4)	
Low	0	0	1 (14.3)	6 (85.7)	

Data presented as *n* (%). PET: peritoneal equilibrium test

Table 4: Comparison of PET I and PET II by using paired *t*-test

Parameter	PET I	PET II	*t*	*P*
Dc0	0.93 (0.75)	0.87 (0.53)	0.950	0.347
Dg0	2022.76 (164.84)	1921.64 (131.21)	5.103	<0.001
Dc2	4.15 (1.86)	3.00 (1.09)	6.168	<0.001
Dg2	1327.26 (232.26)	1357.52 (169.06)	1.130	0.264
Dc4	5.83 (2.59)	4.73 (1.41)	5.113	<0.001
Dg4	929.32 (208.38)	947.18 (124.90)	0.744	0.460
DcF	0.30 (0.12)	0.30 (0.09)	0.322	0.749
DgF	2161.90 (133.13)	2168.48 (77.54)	0.380	0.705
Pc2	9.48 (3.87)	7.79 (1.96)	5.024	<0.001
Pg2	153.48 (92.16)	134.26 (47.95)	1.954	0.056
Pc4	9.41 (3.83)	7.77 (1.97)	4.882	<0.001
Pg4	162.38 (79.98)	150.22 (53.09)	1.685	0.098
[D/P] C standard	0.62 (0.14)	0.61 (0.11)	0.676	0.502
[D/P] C Fast	0.62 (0.13)	0.61 (0.11)	0.934	0.355

Data presented as mean (SD). Dc2: dialysate creatinine 2nd h; Dc4: 4th h; DcF: dialysate fresh creatinine; DgF: dialysate fresh glucose; Dg0: dialysate glucose 0 h; [D/P] C: dialysate plasma creatinine ratio; Pc: plasma creatinine; Pg: plasma glucose; PET: peritoneal equilibrium test

The present study further evaluated the change in the PET characteristics after 6 months, for which PET II was done using standard PET and fast PET and results of PET II were compared with PET I. When the PET II was performed, the distribution based on transporter type as per standard PET was high transporter in 6%, high average in 26%, low average in 52%, and low transporter in 16%. It was observed that 7.7% patients which were high average in PET I moved to low average in PET II, 3.7% patients of low average in PET I moved to high average in PET II, 7.4% cases of low average moved to low category in PET II, 14.3% cases moved from low to low average. A significant correlation between the transport type of standard PET between PET I and PET II was observed ($P < 0.001$).

On comparison of standard transport type in PET I and PET II, out of 50 patients, 98% patient had similar PET results after 6 months and only 2% of patients had changes in PET status compared to PET I ($P > 0.05$). Thus, signifying that characteristics of membrane had not changed over 6 months in the majority with few exceptions, where the changes were in the adjacent group like changing from low average to high average or vice versa or low to low average and vice versa. But there was no major shift such as high to low or low average to high in the span of 6 months. These results are in line with the results of studies by Balasubramaniyam *et al*. and Johnson *et al*.[10,11] Analysis of the data after 6 months also suggested that patient PET characteristics had a centripetal movement; that is, from high category to high average and from low to low average, although the difference was not statistically significant. The previous study also demonstrated such centripetal movement.[12]

Similarly, in comparison of fast transport type in PET I and PET II, 82% of patients had similar PET results after 6 months. On comparison of standard PET and fast PET of PET II, the variability in results of fast PET was 2% in the high average group and 2% in the low group. The significant positive correlation for transport type determination between standard and fast PET II ($r = 0.969$, $P < 0.05$) and for the D/P creatinine ratio between standard PET II and fast PET II ($r = 0.99$, $P < 0.001$) suggests that changes in peritoneal membrane characteristics occurred during span of 6 months, which were diagnosed by standard PET, were also correlated with fast PET.

In the present study, there was a significant correlation between the analyses of PET I and PET II. The D/P creatinine ratio of standard PET between PET I and PET II has a correlation value 0.87; $P < 0.05$ and the D/P creatinine ratio of fast PET between PET I and PET II has a correlation of 0.85; $P < 0.05$. Thus, the results of PET I and PET II were correlated. And the analysis by paired t-test showed that there was no significant mean difference in D/P creatinine value of standard PET and fast PET in PET I as well as PET II.

Baştuğ *et al*. study demonstrated concordance between the mini-PET and original PET in children. They concluded

that 3.86% mini-PET is a simple and fast method to assess free-water transport. This also gives information about total ultrafiltration and small solute transports and it is in good agreement with the original PET.[13]

The authors acknowledged a few limitations of this study. It provides limited data. While prescribing CAPD, intermediate points at 1, 2, and 3 h are lacking. A single D/P creatinine ratio will not be adequate for computerized models, which are increasingly used by PD staff for calculating peritoneal mass transport and governing PD prescription. For determining the long-term changes in the peritoneal membrane characteristics, 6 months study seems to be a short period.

Conclusion

Overall observations of the study suggest that fast PET is a good alternative for assessing peritoneal membrane characteristics especially in the setting of less availability of resources and is a less cumbersome procedure as compared to standard PET. So, fast PET can be promoted as a tool to assess peritoneal membrane characteristics.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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