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Original Article

Differences in Type Characteristics of Peritoneal Membrane Using Peritoneal Equilibrium Test in End Stage Renal Disease Patients Undergoing Peritoneal Dialysis at Hasan Sadikin Hospital, Bandung

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ABSTRACT

Background: Peritoneal dialysis (PD) clears solutes and removes fluids from the patient's body. PD failure is primarily due to the clearing of solutes and the removal of fluids. Due to overhydration, the high peritoneal equilibrium test (PET) group is at greater risk of technical failure and death than other groups.
Objective: This study aimed to to determine the characteristics of PET in patients with end-stage renal failure undergoing peritoneal dialysis (PD) at Hasan Sadikin Hospital, Bandung.
Methods: This study is a retrospective, descriptive, and cross-sectional investigation.
Results: Of the 34 PD patients, the PET results were as follows: 47.1% for high average, 14.7% for high, 35.3% for low average, and 2.9% for low. There were no significant differences in most variables analyzed between the PET groups, including age, gender, etiology, comorbid diseases, history of hemodialysis (HD), residual renal function, and laboratory parameters such as hemoglobin, urea, creatinine, and albumin. The current blood glucose and body mass index (BMI) levels in the high PET group showed higher values and significant differences ($p = 0.019$ and $p = 0.043$, respectively).
Conclusion: Blood glucose and BMI may be important factors that distinguish patients with high PET from other PET groups.
Keywords: Peritoneal Equilibrium Test, Peritoneal Dialysis, End Stage Renal Disease.

Introduction

Peritoneal dialysis (PD) is a method used to remove waste products and excess fluids from the patient's body. PD failure is mainly in removing solutes and fluids. Ultrafiltration failure can be seen with clinical findings of volume overload. Several factors should be considered when assessing ultrafiltration failure, including non-compliance with the diet or dialysis regimen, as well as abnormalities at the dialysis access site.[1]

Many studies have found that patients in the high transporter group have a higher chance of death than the other groups. A recent study in China found that patients who were high transporters had a higher chance of death than others, reaching 2.35 times (95% CI 1.30-4.25, p = 0.01). As mentioned by the CANUSA Study, the 2-year survival rates for the low transporter, low average, high average, and high transporter groups were 91%, 80%, 72%, and 71%, respectively. The high PET group had a higher risk of technical failure and mortality compared with the other groups due to decreased water withdrawal and overhydration.[2]

The CANUSA study in high transporter found a rate of 15.311%, while studies in

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Australia and New Zealand found rates of 15.2%. A recent study in the United States also found a high transporter rate of 15.4%. A study involving a dialysis patient group monitored in the Netherlands showed a significant rate of technique failure, as merely 64% of participants remained on peritoneal dialysis 2 years later. The predictors identified among the free determinants included excretion capacity, peritoneal ultrafiltration, and systolic blood pressure. Research conducted in Japan revealed that ultrafiltration failure was recognized as the primary cause for subjects interrupting continuous ambulatory peritoneal dialysis (CAPD).

The peritoneal equilibration test (PET) is used to rapidly assess peritoneal function and to monitor changes in peritoneal function under various conditions. Changes in the peritoneal membrane may necessitate adjustments to the break-up medicine. A common problem is when fluid is not removed as it should be, which can be caused by a fast peritoneal solute transfer rate. Another problem is membrane dysfunction, which occurs when the peritoneal membrane fails to function properly. If membrane dysfunction worsens over time, the individual may need to switch to hemodialysis treatment. Regular evaluation of membrane function is required.[2–4]

Prolonged exposure to hypertonic glucose solutions alters the transport characteristics of the peritoneal membranes. Those classified as low or average transporters may transition to a high transporter status, potentially leading to an increased use of high-strength dextrose solutions. Factors contributing to volume overload can include not only dysfunction of the peritoneal membrane but also dietary choices, inadequate dialysis prescriptions, excessive sodium and fluid intake, and a decline in remaining kidney function without corresponding adjustments in dialysis treatment. Issues with catheters are frequently responsible for inadequate volume management.[5]

Diabetes mellitus represents the most critical risk factor for mortality in dialysis, including those in PD. A high peritoneal transport rate has likewise been revealed to be associated with mortality. Still, its role seems to be related to permeability and mortality in PD caused by diabetes mellitus. The role of higher serum creatinine in predicting better survival may be related to better nutritional status.

The process of selecting a peritoneal dialysis modality is complex. It depends on the patient's individual physical characteristics and the transporter status of the peritoneal membrane, not only on lifestyle considerations. Several key determinants must be considered when selecting the right PD formula for a patient. These factors include the patient's lifestyle, transporter status, body size and habitus, and degree of residual renal function, as well as specific contraindications or indications favouring one modality more than another. In patients with significant residual renal function, periodic measurement is essential to adjust the appropriate dialysis prescription. The transporter characteristics of the peritoneal membrane are unknown when the initial DP prescription is chosen. Consequently, the initial prescription is empirically assumed that the patient is an 'average' transporter.[6]

Patients with a high-transporter membrane type (4-hour dialysate/plasma creatinine [D/P] > 0.81) typically achieve adequate peritoneal clearance when using a standard PD regimen, but often experience impaired ultrafiltration (UF). This occurs due to rapid glucose reabsorption, which reduces the osmotic gradient required for UF. In this case, if the dwell times are prolonged, there will be sufficient fluid absorption such that the net UF during the dwell becomes minimal or even negative.[7,8]

Non-infectious complications were observed in 40% of PD patients, with ultrafiltration failure being the most frequent (15.5%). Patients who develop ultrafiltration failure switch to hemodialysis or undergo renal transplantation. The majority of complications (62%) do not affect catheter survival. Ultrafiltration failure and volume overload are the main causes of PD failure. Ultrafiltration

failure can be caused by various factors such as decreased filtration rate, increased salt and water intake, and excessive weight gain. The reported prevalence of ultrafiltration failure as a reason for PD discontinuation varies from 1.7% to 13.7%.[9,10]

Methods

This study is a retrospective, descriptive, cross-sectional study to determine the characteristics of the type of peritoneal membrane using the PET in patients with end-stage renal disease undergoing PD at Hasan Sadikin Hospital, Bandung.

Results

In a study conducted at Hasan Sadikin Hospital related to end-stage renal disease patients undergoing PD, Baseline characteristics between groups were compared with the PET.

From the 34 PD patients, the results of PET were low in one person (2.9%), low average in 12 people (35.3%), high in 5 people (14.7%), and high average in 16 people (47.1%). The age range in low PET was 23 years old, the average age in low PET was 39.4 ± 9.5 years old, the average age in high PET was 41.8 ± 27.0, and the average age in high PET was 42.3 ± 20. There was no significant difference in the age criteria on PET results in each group. From the gender perspective, a high average PET was observed in 12 (35.3%) of the 23 male patients, and 6 (17.6%) of the patients had a low average PET; however, there was no significant difference between the groups. Based on the education level criteria, there is no significant difference among the groups. Etiology: End-stage renal disease (ESRD) was accounted to diabetic nephropathy in 6 (17.6%) patients, and non-diabetic nephropathy in 28 (82.3%) patients. There were no significant differences between the groups. Patients underwent hemodialysis (HD) for <3 months before converting to PD, 28 (82.3%) patients were found.

The KT/V data were highest in the low average PET with a value of 1.9 ± 0.5, but there was no significant difference when compared to the other groups. Similarly, the highest urine volume was observed in the low average PET group, at 95.8 ± 213.7 ml/day, but there was no significant difference compared to the other groups. Hemoglobin laboratory examination in the high PET group was found to be 9.2 ± 7.5, with no significant difference compared to the other groups. The results of the urea examination on high PET were as follows: 146 ± 129, creatinine 13.3 ± 7.1, sodium 136.2 ± 133.0, potassium 4.5 ± 3.5, albumin 3.0 ± 2.5, serum iron 84.2 ± 27.0, and TIBC 186.8 ± 135.0. No significant difference was observed in any of the PET groups.

Blood glucose levels in the high PET group, ranging from 98 to 616, were the highest compared to all other groups and showed a significant difference between groups ($p = 0.019$). The BMI obtained in the high PET group was 25.6 ± 20.2, which tended to be higher than in the other groups ($p = 0.043$). Additionally, the BMI criteria also showed a significant difference between groups ($p = 0.047$). Peritonitis was observed in 18 (52,9%) patients during the study, but there was no significant association between the groups. (Table 1)

Table 1. Differences in PET Characteristics in End-stage Renal Disease Patients with PD at Hasan Sadikin Hospital

Variables	PET				p
	Low n=1	Low Average n=12	High Average n=16	High N=5	
Age (years), Mean ± SD	23.0	39.4 ± 9.5	42.3 ± 20.0	41.8 ± 27.0	0.545[a]
Age Criteria, n (%)					0.672[c]
<55 years	1 (100)	11 (91.7)	12 (75)	4 (80)	
≥55 years	0 (0)	1 (8.3)	4 (25)	1 (20)	
Gender, n (%)					0.403[c]
Male	1 (100)	6 (50)	12 (75)	4 (80)	
Female	0 (0)	6 (50)	4 (25)	1 (20)	
Education level, n (%)					0.100[c]
High School	1 (100)	5 (41.7)	13 (81.3)	2 (40)	
College	0 (0)	7 (58.3)	3 (18.8)	3 (60)	
Etiology of ESRD, n (%)					0.672[c]
Diabetic Nephropathy	0 (0)	1 (8.3)	4 (25)	1 (20)	
Non Diabetic nephropathy	1 (100)	11(91.7)	12 (75)	4 (80)	
HD History, n (%)					0.763[c]
≤3 months	1 (100)	8 (66.7)	14 (87.5)	5 (100)	0.307[c]
>3 months	0 (0)	4 (33.3)	2 (12.5)	0 (0)	
Dialysis Adequacy, Mean ± SD					
Kt/V, n=30	0.5	1.9 ± 0.5	1.8 ± 0.8	1.8 ± 1.3	0.059[a]
Urine Volume (mL/day), Mean ± SD	0.0	95.8 ± 213.7	46.9 ± 0.0	0.0 ± 0.0	0.708[a]
Residual kidney function, n (%)					
Urine Volume ≥250 ml/day	0 (0)	2 (16.7)	1 (6.3)	0 (0)	0.653[c]
Urine Volume <250 ml/day	1 (100)	10 (83.3)	15 (93.8)	5 (100)	
Laboratory, Mean ± SD					
Haemoglobin (gr/dL)	9.5	9.2 ± 1.3	9.3 ± 5.5	9.2 ± 7.5	0.998[a]
Blood glucose (mg/dL), n=30	63	87 (77 – 117)	94 (73 – 255)	132 (98 – 616)	**0.019*[a]**
Urea (mg/dL)	149.7	88.6 ± 38.5	127.1 ± 43.5	146.4 ± 129.0	0.072[a]
Creatinine (mg/dL)	18.7	10.2 ± 3.2	11.7 ± 5.6	13.3 ± 7.1	0.093[a]
Sodium (mEq/L)	136.0	135.8 ± 4.7	136.4 ± 130.0	136.2 ± 133.0	0.970[a]
Potassium (mEq/L)	2.9	3.5 ± 0.8	4.0 ± 2.6	4.5 ± 3.5	0.141[a]
Albumin (gr/dL)	3.4	3.2 ± 0.5	3.2 ± 2.0	3.0 ± 2.5	0.853[a]
Serum iron (ug/dL), n=30	83.0	68.4 ± 23.9	74.1 ± 23.0	84.2 ± 27.0	0.890[a]

Variables	PET				p
	Low n=1	Low Average n=12	High Average n=16	High N=5	
TIBC (ug/dL), n=30	220.0	216.6 ± 46.2	226.4 ± 168.0	186.8 ± 135.0	0.441[a]
Anemia, n (%)					0.402[c]
Yes (Hemoglobin ≤9 gr/dL)	0 (0)	9 (75)	12 (75)	3 (60)	
No (Hemoglobin >9 gr/dL)	1 (100)	3 (25)	4 (25)	2 (40)	
BMI (kg/m2), Mean ± SD	19.6	19.6 ± 1.4	20.9 ± 17.6	25.6 ± 20.2	**0.043*[b]**
BMI criteria, n (%)					**0.047*[c]**
<20 kg/m2	1 (100)	8 (66.7)	6 (37.5)	0 (0)	
≥20 kg/m2	0 (0)	4 (33.3)	10 (62.5)	5 (100)	
Incidence of Peritonitis, n (%)					0.895[b]
No	1 (100)	5 (41.7)	8 (50.0)	2 (40.0)	
Yes	0 (0)	7 (58.3)	8 (50.0)	3 (60.0)	

Note: n = frequency, %=percentage, SD = Standard Deviation, Analysis using [a] One Way ANOVA, [b]Chi Square, [c]Fisher Exact, *significant p<0.05

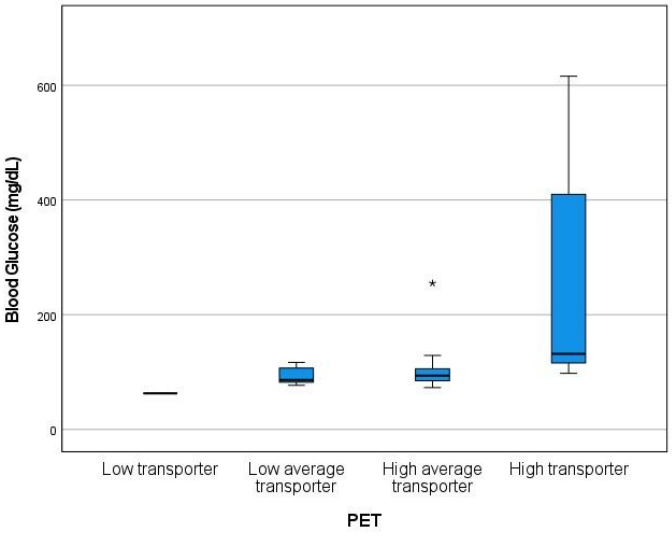

Figure 1. Blood Glucose in the PET Group

Discussion

The results obtained in this study were as follows: low PET, 2.9%; low average, 35.3%; high, 14.7%; and high average, 47.1%. The CANUSA study in high transporters PET found 15.3% of research in Australia and New Zealand, and a recent study in the United States found high transporters at 15.4%. This study demonstrated no significant differences among the groups for most analyzed variables, including age, gender, education level, ESRD etiology, comorbid diseases, history of dialysis, residual renal function, and specific laboratory parameters such as hemoglobin, urea, creatinine, and albumin. Some of the variables showed significant differences; for example, baseline blood glucose ($p = 0.019$) exhibited an essential difference between the groups, with the PET high group having higher values. BMI ($p = 0.043$) and BMI criteria ($p = 0.047$) also showed significant differences, with the high PET group having a higher BMI. The CANUSA study identified a risk factor for high PET as an 11% decrease in blood albumin value. However, studies in Turkey and China found other risk factors, including male gender, high albumin levels, low blood count, diabetes, and vascular disease. Research conducted by Intarawongchot in Thailand found that age over 60 years was the only factor significantly associated with high transporters ($p = 0.003$, odds ratio 18.127, 95% CI 2.697-121.835).[2]

Research conducted by Edmund J. Lamb showed that diabetes can affect peritoneal membrane transport, and ultrafiltration will be lower in diabetic patients if there is no adequate glucose control. Factors that affect PD success include systolic blood pressure, urine volume, and peritoneal ultrafiltration rate.[11]

Studies have indicated that ultrafiltration failure is the primary cause for discontinuing CAPD in patients who have been on PD for an additional 6 years. Long-term exposure to hypertonic dextrose solution may alter the peritoneum' characteristics, thereby affecting the transport of substances across the peritoneal membrane. Additionally, volume overload can also be caused by other factors such as dietary inattention, excessive fluid and sodium intake, inadequate dialysis prescription, and catheter damage. Ultrafiltration failure/volume status, glucose, and an osmotic agent in standard PD solutions cause progressive membrane changes that ultimately result in membrane failure. More recent biocompatible solutions without dextrose have shown reduced membrane damage and may contribute to improved preservation of the peritoneal membrane. In a Japanese cohort of over 7000 patients, the PD failure rate among those using Icodextrin (8.9%) was significantly lower than that of those using dextrose (14.5%) ($P < 0.0001$) [43]. In a double-blind randomized trial, DP patients were treated with Icodextrin for a prolonged period compared to standard treatment.[10]

Conclusion

Blood glucose and body mass index (BMI) may be important factors that distinguish patients with high PET from other PET groups.

Limitations of the Study

The weakness of this study is the small number of patients studied, 34 patients; more patients are needed so that each PET group has an adequate number. The patient's BMI is calculated solely based on weight and height, so it is not known whether the patient is in a state of excess body fluid. A bio-electrical Impedance Analysis (BIA) examination is recommended to confirm the patient's body composition.

Declarations

Ethics approval and consent to participate

This study received approval from the Ethics Committee of the Hasan Sadikin Hospital Bandung under reference number DP.04.03/D.XIV.6.5/371/2024.

Competing interests

There are no conflicts of interest in writing this article.

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Author's Contribution

Idea/concept: MFB. Design: MFB. Control/supervision: AFT, RA. Data collection/ processing: MFB. Analysis/interpretation: MFB, AFT, RA. Literature review: - Writing the article: MFB. Critical review: - All authors have critically reviewed and approved the final draft and are responsible for the content and similarity index of the manuscript.

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