Determination of Peritoneal Membrane Transport Characteristics with Dialysis Adequacy and Transport Test in Thai Patients

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Objective: *The characteristics of peritoneal membrane transport are useful for the determination of dialysis treatment prescription. The peritoneal equilibration test (PET) is accepted as a gold standard tool for identification of these characteristics. Unfortunately, the process of PET is troublesome and unsuitable for clinical practice. Dialysis adequacy and transport test (DATT), which is easier and more convenient method, is proposed as an alternative test. The aim of the present study was to evaluate the accuracy of the DATT in determination of membrane characteristics in Thai patients.*

Material and Method*: Fifteen patients underwent both DATT and PET on the same day. The second DATT was performed. The 24-hour dialysate-to-plasma ratio of creatinine (D/Pcr) from each DATT was compared with the adjusted 4-hour D/Pcr from the corresponding PET. The types of membrane solute transport were classified using the PET proposed by Twardowski and the DATT suggested by Rocco into high, high average, low average, and low transporter.*

Results: *The mean age was 48.1 $\pm$ 16.4 years. The mean value of D/Pcr derived from DATT was higher than PET (0.80 $\pm$ 0.10 vs. 0.74 $\pm$ 0.14). The results of both D/Pcr were correlated (r = 0.78, p = 0.001). However, determinations of characteristics of membrane transport were discordant (kappa coefficient = 0.25). The results of the repeated D/Pcr were not different and the classification of membrane transport properties were concordant (kappa coefficient = 0.68).*

Conclusion: *The results of D/Pcr derived from both tests were correlated. However, determinations of characteristics of membrane transport were discordant.*

Keywords: *Dialysis adequacy and transport test, Peritoneal equilibration test, PET, CAPD*

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Continuous ambulatory peritoneal dialysis (CAPD) is the treatment using a peritoneal membrane to remove waste product and to keep body homeostasis. The properties of peritoneal membrane are varied and changeable overtime. The Nephrology Society of Thailand (NST)[1] suggests evaluating the peritoneal membrane properties with peritoneal equilibration test (PET) within 4 weeks after starting dialysis and then annually.

The PET proposed by Twardowski et al[2] has been accepted as the "gold standard" for determining the membrane transport characteristics. The results of the PET depend upon the permeability of small molecule, such as creatinine, through the peritoneal pores between blood compartment and peritoneal dialysis solution. Values of the PET are the ratio between creatinine in dialysis solution and plasma at certain hour (D/Pcr). According to this ratio, the characteristics of membrane can be classified as high, high average, low average, and low solute transporters. These characteristics are considered to determine the dialysis treatment prescription and the patient's prognostic index. At high D/Pcr, the peritoneal permeability of creatinine is high, so-called high solute transporter. In high solute transporter, the survival is unfavorable[3].

Although PET is widely recommended as a sensitive investigation for monitoring peritoneal membrane transport. This test is not routinely used in

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clinical practice because of some drawbacks. The disadvantages of the PET are time-consuming, requirement of staff support and many laboratory specimens. Rocco et al[4] introduced the dialysis adequacy and transport test (DATT) for determining membrane transport characteristics. The primary needs of DATT are only a serum sample and an aliquot obtained from a 24-hour dialysate collection. Available data showed that D/Pcr derived from DATT was significantly correlated with the D/Pcr value derived from the PET[5-7]. Indeed, DATT is easier and more convenient to perform than PET. Furthermore, DATT was preferred by patients over PET[6]. However, results in determining membrane characteristics obtained from DATT and PET failed to agree in some cases[6].

The aim of the present study was to evaluate the accuracy of DATT as compared with PET for categorization of membrane transport characteristics in Thai CAPD patients.

Material and Method

The authors studied in 15 CAPD patients who underwent simultaneous DATT and PET procedures on the same day. All patients had been treated with CAPD for more than 1 month and had been free of peritonitis for at least 1 month prior to the study. All patients were asked for the second DATT.

A.DATT was performed as described by Rocco and colleagues[4].

1. Patients did dialysis without changing their usual schedule.

2. Patients went to the dialysis unit and brought all the bags of spent dialysate used during the preceding 24 hours, then measured and recorded all the effluent.

3. Dialysis solution within peritoneal cavity was drained, then measured and recorded.

4. The effluent from all bags was mixed well in a container. The total volume of the dialysate was recorded, and a 10 ml sample was obtained for creatinine measurement.

5. Blood was collected for creatinine.

B. PET procedure was performed as described by Twardowski et al[2], using 2 L of 2.5% glucose dialysate. Each patient underwent PET immediately after the 24-hour dialysate collection was completed.

1. After dialysate in abdominal cavity was drained, two liters of fresh dialysate with dextrose 2.5% was replaced. The time was recorded as 0.

2. At the end of the 2nd hour, plasma collection and measurement for creatinine were performed.

3. At the end of the 4th hour, dialysate was drained, then measured and recorded; 10 ml of fluid was collected and sent for glucose and creatinine measurements.

Calculation and classification of peritoneal membrane solute transport characteristics

The 4 hr D/Pcr, the ratio between dialysate creatinine at the end of the 4th hour and plasma creatinine, was calculated after correction of glucose interference. Creatinine correction due to the interference of glucose was calculated with following formula: Cr (mg/dl) = (1.005*measured Dcr (mg/dl)) -0.0002113*D-glucose (mg/dl) + 0.2627[8]. Classification of membrane transport characteristics was based upon the criteria proposed by Twardowski et al[2] into high, high average, low average, and low transporter, when the 4 hr D/Pcr were > 0.81, 0.65-0.81, 0.50-0.65, and < 0.50 respectively.

The 24 hr D/Pcr, the ratio between 24 hour-collected dialysate creatinine concentrations derived from DATT and plasma creatinine, was estimated without correction of glucose interference. The classification of membrane transport characteristics was based on the criteria suggested by Rocco et al[4] into high, high average, low average, and low transporter, when the 24 hr D/Pcr > 0.74, 0.64-0.74, 0.54-0.64, and < 0.54, respectively.

Sample measurement

Creatinine and glucose in dialysate and plasma were measured by Konelab PRIME 60 Analyzer (Thermo Scientific, Finland). Creatinine was measured using Jaffe alkaline picrate reaction, while glucose was measured using enzymatic glucose oxidase method.

Statistical analysis

The data were displayed as mean $\pm$ standard deviation. The Pearson correlation coefficient and Student t-test were used in the statistical analysis. Statistical significance was attained when $p < 0.05$. The concordance of determination of membrane transport characteristic was evaluated by kappa concordance coefficient. The authors used the statistical software program R for Windows, version 2.12.0.

Results

Demographic data

Fifteen patients were studied, 8 were males (53%). The mean age of the patients was 48.1 $\pm$ 16.4 (range 19-72) years (Table 1). The causes of end stage

renal disease were hypertensive nephrosclerosis in 9 (60%), diabetic kidney disease in 4 (26%), chronic glomerulonephritis in 1 (7%), and renal calculi in 1 (7%). The mean duration of CAPD before the study was 17.4 ± 13.2 (range 2-50) months. Thirteen patients performed dialysis treatment using dialysis solution with glucose 1.5% for 4 cycles a day. One patient obtained dialysis using glucose 2.5% for 4 cycles a day. The remaining patient received dialysis using glucose 1.5% for 3 cycles a day.

Correlation between the 4 hr D/Pcr by PET and the 24 hr D/Pcr by DATT

The mean value of 24 hr D/Pcr derived from DATT was 0.81 ± 0.10 (range 0.62-0.98). The mean value of 4 hr D/Pcr derived from PET was 0.74 ± 0.14 (range 0.54-1.06). The results obtained from both methods were significantly different (0.06 ± 0.02, p = 0.02). Scattered plot demonstrated a relationship between the DATT and the PET (Fig. 1). The Pearson's correlation coefficient between the two variables was 0.78 (p = 0.001).

Classification of peritoneal membrane solute transport characteristics

Determination of membrane transport characteristics obtained from DATT and PET showed discrepancy in 8 cases (53%). In eleven patients who classified as high transporter by the DATT criteria, only three were diagnosed as high transporter, seven were classified as high average transporter, and one patient was considered as low average transporter by the PET criteria. On the other hand, determination as high average and low average was concordance (Table 2). However, the kappa concordant coefficient was 0.25 when 13 patients, using dialysis solution with glucose 1.5% for 4 cycles a day, were considered. The kappa concordant coefficient was increased to only 0.28.

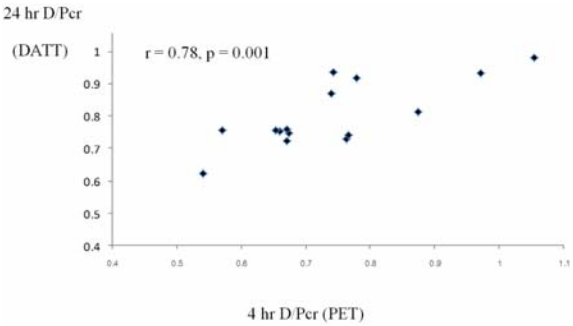

Fig. 1 Scattered plot between the 24 hr D/Pcr by DATT and the 4 hr D/Pcr by PET

The second DATT test

Fourteen patients was re-evaluated for DATT after the first test 2.2 ± 1.1 (range 0.7-4.5) months. However, one patient did not perform because of out of CAPD program before appointment for the second DATT. The 24 hr D/Pcr of these patients obtained from two performances were 0.81 ± 0.10 and 0.80 ± 0.15, respectively. These results were not significantly different (0.01 ± 0.02, p = 0.83) and kappa coefficient was 0.68.

Discussion

In the present study, the authors found that 24 hr D/Pcr derived from DATT was correlated significantly with 4 hr D/Pcr derived from the PET. However, the association in determination of membrane transport characteristics between using the DATT and the PET was low.

Determining an appropriate prescription for patients on CAPD requires knowledge about peritoneal membrane transport characteristics and solute

Table 1. Demographic data of CAPD patients (n = 15)

Age (years)	48.1 ±16.4
Body weight (kg)	58.6 ± 15.2
Height (cm)	161.7 ± 9.5
Body surface area (m^2)	1.61 ± 0.24
Blood parameters	
□ BUN (mg/dl)	43.4 ± 14.3
□ creatinine (mg/dl)	9.2 ± 3.9
□ albumin (gm/dl)	3.6 ± 0.4
□ glucose (mg/dl)	127 ± 49
Ultrafiltration volume with the PET (ml)	473 ± 198 (100-800)

Table 2. The characteristics of membrane transport according to the DATT and the PET

		PET		
		H	HA	LA
DATT	H	3	7	1
	HA	0	3	0
	LA	0	0	1

Abbreviations: H = high transporter, HA = high average transporter, LA = low average transporter

clearance. The PET is widely accepted as a routine tool for monitoring peritoneal membrane transport. Unfortunately, the true dialysis solute clearance has not been obtained by using PET. This procedure is troublesome and high cost, 900 baht per test. It also takes time about 5 hours per test. Moreover, PET might induce peritonitis, because the test requires several dialysate samples. Therefore, the number of centers did not follow NST's recommendation, particularly in institute with high volume of patients and shortage of personnel.

On the other hand, DATT is much easier and more convenient to perform than PET. Furthermore, a clinician can obtain not only information about peritoneal membrane transport, but also a true measurement of the patient's daily solute clearance and ultrafiltration volume from dialysis by using DATT. Of interest, DATT is also less expensive, 200 baht per test, and is preferred over the PET by patients and personnel. Available studies suggested that DATT can be used instead of PET to determine peritoneal transport[6,7,9].

In the present study, 24 hr D/Pcr derived from DATT was higher than 4 hr D/Pcr derived from the PET about 0.06 points. This result was in agreement with the study reported by Rocco et al[4]. Indeed, the value of 24-hour D/Pcr was achieved from a pooled collection with varying equilibrations occurring over periods ranging from 5 to 9 hours[10]. The dialysate creatinine concentration inevitably increases as the dwell time becomes longer. As such, the higher values of D/Pcr derived from DATT as compared with PET, are likely the result of longer dwell times. Although, there was no standardization for DATT procedure, the D/Pcr derived from both tests showed statistical correlation, r = 0.78, which was similar to previous studies[6,7]. Furthermore, the results of re-evaluation of DATT in the present study was reproducible and consistent in determination of peritoneal membrane transport (the kappa coefficient = 0.68). In general, statisticians accept the kappa coefficient > 0.6-0.7 as a good correlation between 2 raters. As described by Rocco and colleagues, DATT was validated only for patients with a fixed CAPD schedule of 4 exchanges of 2 L daily. Of interest, the results from the present study and an earlier study demonstrated that DATT can be used in patients for who dwell times, dextrose concentrations, dwell volumes vary. The data from DATT may be generalized to patients receiving varying dialysis prescriptions.

The present study demonstrated that the categorization based on two tests was discordant. Fifty three percent of patients were categorized differently. The kappa coefficient is low. This result concurred with a previous study[7]. Eight patients who classified as high transporter by the DATT criteria was considered as either high average or low average transporter based on PET (Table 2). This misclassification would make an error in decision making. The explanation of such discordance was bewildered. In the present study, 73% of patients were classified as high solute transporter according to DATT criteria. However, only 20% of patients were categorized as high solute transporter using PET criteria. These results were reasonably similar to other studies range 10-15%[6]. Thus, one of the explanations for the discordance was the criteria of the determination of membrane solute transport characteristics. According to the PET criteria, the incidence of high solute transporter based on the Rocco's criteria[4] was higher than that on the Paniagua[6] and Twardoski' s references[2] (Table 3). Determination of peritoneal membrane characteristics based on DATT faced the same problem. According to Rocco's definition[4], the number of patients who were classified as high, high average, and low average transporter were 11, 3, and 1, respectively, while were 5, 9, and 1, respectively when using Papanigua's criteria.

To solve this discordance in determination of membrane characteristics, it needs to determine the appropriate criteria which would be reasonable to apply for Thai people. Paniagua et al[6] demonstrated that

Table 3. The criteria and number of characteristic of membrane transport with various studies

Membrane characteristics	Twardowski[2]		Rocco[4]		Paniagua[6]	
	criteria	number (%)	criteria	number (%)	criteria	number (%)
High	> 0.81	3 (20)	> 0.75	6 (40)	> 0.81	3 (20)
High average	0.65-0.81	10 (67)	0.64-0.75	6 (40)	0.69-0.81	5 (33)
Low average	0.50-0.65	2 (13)	0.54-0.64	3 (20)	0.57-0.69	1 (7)
Low	< 0.50	0	< 0.54	0	< 0.57	6 (40)

membrane solute transport characteristics were concordant when using their own criteria (the kappa coefficient = 0.82). Furthermore, the results of the 24 hr-D/Pcr derived from DATT obtained from usual protocol with some modification. The dialysate creatinine depends on the dwelling time and type of dialysate solution. Standardization of daily dialysis prescription of exchanges and dwell volume would be potentially helpful.

Conclusion

The present study found that the results obtained from DATT was significantly correlated with PET. However, determination of peritoneal membrane transport characteristics was discordant between the two methods. DATT was an easy, convenient, and potentially useful method for identifying peritoneal membrane transport. However, further studies concerning the usage of DATT to improve the accuracy in determination of membrane transport characteristics are required.

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Potential conflicts of interest

None.

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การทดสอบคุณสมบัติในการแลกเปลี่ยนสารของเยื่อบุช่องท้องด้วยวิธีแดทในคนไทย

เจริญ เกียรติวัชรชัย, จารุดา แอเด็น, เขมณัฏฐ์ กองคิด, ธารทิพย์ กิจไพบูลย์ชัย, สมถวิล เกียรติวัชรชัย

วัตถุประสงค์: *คุณสมบัติในการแลกเปลี่ยนสารของเยื่อบุช่องท้องมีบทบาทในการเลือกวิธีการรักษาด้วยการล้างไตทางช่องท้องให้เหมาะสมสำหรับผู้ป่วยแต่ละราย การตรวจด้วยวิธีเพ็ท ซึ่งเป็นการตรวจมาตรฐาน มีความยุ่งยากในทางปฏิบัติการทดสอบด้วยวิธีแดท ซึ่งมีวิธีการที่สะดวกกว่าจึงอาจเป็นทางเลือกที่ดีกว่าการศึกษานี้เพื่อประเมินความถูกต้องของการใช้วิธีแดทในการจำแนกคุณสมบัติการแลกเปลี่ยนสารในคนไทย*

วัสดุและวิธีการ: *ผู้ป่วย 15 ราย ร่วมการศึกษาได้รับการทดสอบด้วยวิธีแดทและวิธีเพ็ทในวันเดียวกัน จากนั้นทดสอบด้วยวิธีแดทซ้ำ โดยเปรียบเทียบค่าสัดส่วนของคริอะตินีนในน้ำยาล้างไตที่แช่ในช่องท้อง 24 ชั่วโมงต่อคริอะตินีนในพลาสมา ในการทดสอบวิธีแดทกับค่าสัดส่วนของคริอะตินีนในน้ำยาล้างไตที่แช่ในช่องท้อง 24 ชั่วโมงต่อคริอะตินีนในพลาสมา ในน้ำยาที่แช่ในช่องท้อง 4 ชั่วโมง ในการทดสอบวิธีเพ็ทโดยอาศัยเกณฑ์ของการทดสอบวิธีเพ็ท*

ผลการศึกษา: *อายุเฉลี่ย 48.1 $\pm$ 16.4 ปี ค่าเฉลี่ยของค่าสัดส่วนของคริอะตินีนในน้ำยาล้างไตที่แช่ในช่องท้อง 24 ชั่วโมง ต่อคริอะตินีนในพลาสมา จากการทดสอบวิธีแดทเท่ากับ 0.80 $\pm$ 0.10 และค่าเฉลี่ยของค่าสัดส่วนของคริอะตินีนในน้ำยาล้างไตที่แช่ในช่องท้อง 24 ชั่วโมง ต่อคริอะตินีนในพลาสมา จากการทดสอบวิธีเพ็ทเท่ากับ 0.74 $\pm$ 0.14 ค่าทั้งสอง มีความสัมพันพันธ์กันอย่างมีนัยสำคัญทางถิติ ($r = 0.78$, $p = 0.001$) การจำแนกชนิดของเยื่อบุช่องท้องในการแลกเปลี่ยนสารด้วยการทดสอบทั้งสองไม่สอดคล้องกัน การทดสอบวิธีแดททั้งสองครั้งพบว่าค่าเฉลี่ยของค่าสัดส่วนของคริอะตินีนในน้ำยาล้างไตที่แช่ในช่องท้อง 24 ชั่วโมงต่อคริอะตินีนในพลาสมาไม่แตกต่างกันและการจำแนกชนิดชนิดของเยื่อบุช่องท้องสอดคล้องกัน*

สรุป: *การประเมินคุณสมบัติของเยื่อบุช่องท้องในการแลกเปลี่ยนสารด้วยการทดสอบวิธีเพ็ท และวิธีแดทมีความสัมพันธ์กัน แต่การจำแนกชนิดของเยื่อบุช่องท้องในการแลกเปลี่ยนสารยังมีความคลาดเคลื่อน*