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The Peritoneal Equilibration Test (PET) in Children

Çocuklarda peritoneal eşitlenme testi (PET)

Yavaşcan Ö Kara O D Anıl M Aksu N

Tepecik Teaching and Research Hospital, Department of Nephrology, Yenişehir-İZMİR

Summary

Introduction: Peritoneal transport characteristics in children treated with continue ambulatory peritoneal dialysis (CAPD) differ from adults. It is known that peritoneal area in infants per unit weight is twice that of the adult. Multiple experiences with the peritoneal equilibrium test (PET) in children have been published but there is little information available on the use of standardized PET in childhood. In this study we wanted to represent the PET results in children treated with CAPD.

Materials Methods: We performed a PET on 21 children (12 boys, 9 girls) aged 23 months to 14 years (average: 10.1±4.32 years) using a dwell volume of 30-50 ml/kg of 2.27 % glucose dialysate. The mean duration of CAPD treatment was 12.88±6.69 months (range 2 to 22 months). No patient had suffered from an episode of peritonitis within a month prior to the study. Dialysate to plasma ratios for creatinine (D/P_{creat}) were calculated at 0, 2 and 4 hours as were the ratios of dialysate glucose at time 0 ($D/D0_{glu}$). Statistical evaluation was made by using t-test and Pearson correlation analysis.

Results: The average D/P_{creat} after a 4-hour dwell was 0.69±0.13 in 21 pediatric patients. Similarly, the mean $D/D0_{glu}$ a 4-hour dwell was 0.39±0.13. When children are evaluated according to adult standards, the majority of patients fit into the high and high average solute transport categories. Mean weekly KT/V_{urea} values were 2.68±1.16.

Conclusion: PET should be done in children with CAPD to choose the most efficient PD regimen. Since ultrafiltration is inadequate in children, rapid exchanges and/or usage of automated peritoneal dialysis should be encouraged

Key words: Children, peritoneal equilibrium test, dialysis adequacy, ultrafiltration.

Özet

Giriş: *Sürekli ayaktan periton diyalizinde (SAPD) peritoneal eşitlenme testi (PET) ile belirlenen periton membranının transport özelliği çocuk ve erişkin hastalar arasında büyük değişiklikler göstermektedir. Çocuklarda peritoneal yüzey alanının erişkinlerin iki katı olduğu bilinmektedir. Pek çok çalışma olmasına karşın çocuklarda PET standardizasyonu konusunda henüz fikir birliğine varılmamıştır. Bu çalışmada SAPD uygulanan çocuklarda PET sonuçlarını vermeyi amaçladık.*

Gereç ve Yöntem: *SAPD programında izlenen 21 hastaya (21 erkek, 9 kız) standart PET uygulanmıştır. Olguların yaş dağılımı 23 ay ile 14 yaş arasında olup, yaş ortalaması 10.1±4.32 yıldır. İzlem süreleri 2 ay ile 22 ay arasında değişmekte olup, ortalama izlem süresi 12.88±6.69 aydır. Olguların 9'unda PET 6 ay sonra yinelenmiştir. Bir ay içerisinde peritonit saptanan olgularda test yapılmamıştır. Hastalarda %2.27 glukoz içeren diyaliz solüsyonu 30-50 ml/kg olacak şekilde verilmiştir. Kreatinin için Diyalizat Plazma (D/P_{kreat}) oranları 0., 2., 4. saatte ve 2., 4. saatteki Diyalizat glukozunun 0. saatteki diyalizat glukozuna oranları ($D/D0_{glu}$) hesaplanmıştır. İstatistiksel değerlendirme t-testi ve korelasyon analizi ile yapılmıştır.*

Bulgular: *Çalışmamızda 21 hastanın 4. saat sonundaki ortalama D/P_{kreat} değerleri 0.69±0.13 olarak hesaplanmıştır. Benzer şekilde 4.saatteki D/D0glukoz oranı 0.39±0.13 olarak bulunmuştur. Ayrıca 9 hastada 6 ay sonra yinelenen PET değerleri istatistiksel bir farklılık göstermemiştir. Ortalama haftalık $KT/V_{üre}$ değerleri ise 2.68±1.16 olarak saptanmıştır. Çalışma grubumuzun membran permeabilite özellikleri erişkin standartları ile karşılaştırıldığında, D/P_{kreat} ve $D/D0_{glu}$ değerleri açısından hastalarımızın çoğu yüksek ve yükseğe yakın orta solüt transport özelliği göstermektedir.*

Sonuç: *SAPD programındaki çocuklarda en etkin diyaliz yönteminin seçimi için PET mutlaka yapılmalıdır. Ayrıca, çocukluk yaş grubunda ultrafiltrasyon yetersiz olduğundan sık değişim ve/veya aletli diyaliz uygulaması yaygınlaştırılmalıdır.*

Anahtar Kelimeler: *Çocukluk çağı, Peritoneal dengeleme testi, Diyaliz yeterliliği, Ultrafiltrasyon*

Yazışma Adresi: Önder Yavaşcan, 9105/14 sokak No: 9/5 Serdar Apartmanı Akevler 35370 Yeşilyurt-İZMİR

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Introduction

It is now generally accepted that chronic peritoneal dialysis (PD) is the first choice dialysis modality in children with end-stage renal failure. Which chronic PD modality option serves best the metabolic needs of a patient depends on the individual functional characteristics of the peritoneal membrane (1,2). In adults, using a standardized peritoneal equilibration test (PET), Twardowski et al (3) have shown that patients can be categorized as having rapid, normal or slow peritoneal solute transport characteristics. Also, different peritoneal dialysis modalities are optimal for adult patients in each category, such as patients in rapid solute transport category are best dialyzed using rapid exchanges. Peritoneal transport characteristics in children treated with continuous ambulatory peritoneal dialysis (CAPD) differ from adults. It is known that peritoneal surface area in infants per unit weight is twice that of the adult. Since peritoneal surface area and peritoneal kinetics change with age and body size, it is difficult to obtain standardized PET results in pediatric PD patients (1,4). Lack of reference curves, determined with the PET impedes to individualize the dialysis prescription in children.

In this study, we wanted to represent the PET results in children treated with CAPD. Also, we wished to see if the PET results might help to decide on a particular PD modality in children of different ages.

Material and Methods

Twenty-one children (12 boys, 9 girls) with end-stage renal disease were studied. Age of the patients' ranged between 23 months and 14 years (avarege 10.1±4.32 years). The mean duration of CAPD treatment was 12.88±6.69 months (range 2 to 22 months). Underlying diseases are listed in Table 1.

Table 1. Causes of end-satage renal disease in chidren treated with CAPD

Disorders	No. of patients
Reflux nephropathy	6
Focal segmental glomerulosclerosis	4
Choronic pyelonephritis	3
Membranoproliferative glomerulonephritis	1
Membranous glomerulopathy	1
Primary hyperoxaluria	1
Cresentic glomerulonephritis	1
Alport's syndrome	1
Polycystic kidney disease	1
Posterior urethral valve	1
Hemolytic uremic syndrome	1
Total	**21**

PET was performed on 15 of 21 patients at any time of the follow-up period and 6 of them at the beginning of CAPD treatment. Test was repeated in 9 patients after 6 months. No patient was studied within the month following an episode of peritonitis. Evaluation

was made for the total group of patient (n=21) and for 3 subgroups (<5 years; n=3, 5-10 years; n=6, >10 years; n=12).

The PET was performed in the morning following a 8 hour overnight dwell, using 30-50 ml/kg of 2.27 % dialysate (Dianeal 2.27 %-Baxter). The dialysate was infused over 10 minutes with the patient supine and rolling from side to side intermittently. Zero dwell time was the time the infusion was finished. Immediately after infusion, completed 100 ml of the instilled volume was drained into empty bag, mixed by shaking of the bag and a 2 ml dialysate sample was obtained and stored. The remaining dialysate was reinfused. This procedure was repeated after 120 and 240 min dwell time. After 4 hours the patient was drained completely and ultrafiltration (UF) determined by weighing the bag. After 120 min dwell time, a single blood sample was obtained. All dialysate and serum samples were analyzed for glucose (enzymatic reaction) and creatinine (modified Jaffe reaction) content. Dialysate (D) to plasma (P) ratios of creatinine (D/P_{creat}) and dialysate glucose to dialysate glucose at time 0 ($D/D0_{glu}$) ratios were calculated for every patient for each time point. Dialysis adequacy was determined by weekly KT/V_{urea} using a-week dialysate and urine collections for urea. Statistical evaluation was made by using student's t-test and Pearson correlation analysis.

Results

The D/P and ($D/D0_{glu}$). ratios and the net UF volumes for the total group of patients and for 3 subgroups are shown in Table 2

The mean and standard deviation values for D/P_{creat} and $D/D0_{glu}$ at four hours were 0.69±0.13 and 0.39±0.13 in 21 children, respectively. Similarly, the mean UF volume after a 4-hour dwell was 129.6±154.6 ml. There were no significant differences between the groups (p>0.05). Follow-up D/P_{creat} and $D/D0_{glu}$ values for 9 patients after 6 months were not significantly different (p>0.05) (Table 3). When children were characterized according to adult standards, the majority of patients fit into the high and high average solute transport categories (Table 4). Weekly KT/V_{urea} was 2.68±1.16. There were no significant differences between the groups of different ages (p>0.05) (Table 5). Mean residual urine was 683±670 ml in 21 children (2500 ml in 1 patient and 5 were anuric). There were no correlation between the parameters of D/P_{creat}, (r=-0.173, p>0.05), D/D0gluc (r=0.013, p>0.05) KT/V_{urea}

(r=-0.291, p>0.05) UF (r=0.301, p>0.05) and residual urine (r=-0.049, p>0.05). However, D/P_{creat} (r=0.720, p<0.05) and $D/D0_{glu}$ (r=0.786, p<0.05) ratios tended to be inversely correlated with children of younger ages

Table 2.. D/P_{creat}, $D/D0_{glu}$,ultrafilration and weight values for 21 patients and for 3 subgroups

		UF (ml)	Weight (ml)	D/P_{creat} 0h	D/P_{creat} 2h	D/P_{creat} 4h	$D/D0_{glu}$ 2h	$D/D0_{glu}$ 4h
All patients	Mean	129.68	26.8	0.202	0.566	0.696	0.570	0.394
(n=21)	±SD	154.68	12.7	0.080	0.159	0.133	0.157	0.134
<5 years	Mean	131.66	14.6	0.232	0.676	0.760	0.420	0.250
(n=21)	±SD	137.87	2.51	0.155	0.123	0.157	0.040	0.090
5-10 years	Mean	116.66	16.58	0.235	0.563	0.670	0.566	0.396
(n=21)	±SD	157.05	2.93	0.050	0.060	0.080	0.100	0.020
>10 years	Mean	191.66	34.95	0.177	0.540	0.694	0.610	0.421
(n=21)	±SD	162.80	10.95	0.080	0.192	0.151	0.170	0.162

Table 3.. D/P_{creat} and $D/D0_{glu}$ values at 0 and 6 months for 9 patients

		D/P_{creat}						$D/D0_{glu}$				P value
		Before (n=21)			After (n=9)			Before (n=21)		After (n=9)		
Age		0h	2h	4h	0h	2h	4h	2h	4h	2h	4h	
All patients	Mean	0.202	0.566	0.696	0.200	0.580	0.708	0.570	0.394	0.521	0.366	>0.05
(n=21)	±SD	0.089	0.159	0.133	0.071	0.145	0.135	0.157	0.134	0.105	0.101	
<5 years	Mean	0.236	0.676	0.760	0.250	0.660	0.780	0.420	0.280	0.460	0.290	>0.05
(n=21)	±SD	0.155	0.123	0.157	-	-	-	0.040	0.009	-	-	
5-10 years	Mean	0.235	0.563	0.670	0.216	0.566	0.683	0.566	0.396	0.526	0.383	>0.05
(n=21)	±SD	0.050	0.060	0.080	0.050	0.083	0.100	0.100	0.027	0.065	0.083	
>10 years	Mean	0.177	0.540	0.694	1.180	0.578	0.710	0.610	0.421	0.530	0.372	>0.05
(n=21)	±SD	0.085	0.192	0.151	0.086	0.192	0.172	0.179	0.162	0.138	0.123	

Table 4.. Characterization of children's membrane permeability according to adult's standarts for D/P_{creat} and $D/D0_{glu}$.

	D/P_{creat}		$D/D0_{glu}$	
Permeability	Adult Standart	No. of children	Adult Standart	No. of children
High	>0.81	5	<0.26	4
High average	0.65-0.81	8	0.26-0.38	12
Low average	0.50-0.64	7	0.38-0.49	2
Low	<0.50	1	>0.49	3

Table 5. Mean and stnadart deviation values of weekly KT/V_{urea} for 21 patients and for 3 subgroups

Subgroups	Weekly KT/V_{urea}
All patients	2.684±1.162
< 5 years	2.300±0.010
5-10 years	2.700±0.897
> 10 years	2.740±1.374

Discussion

Continuous ambulatory peritoneal dialysis (CAPD) is now the first choice dialysis modality in many pediatric dialysis patients (1). A standardized PET curves, introduced by Twardowski (3), allow categorization of peritoneal kinetics and provide guideline for individual PD prescription in adults. Since peritoneal surface area and peritoneal kinetics change with age and body size, it is difficult to obtain standardized PET curves in children. Lack of reference curves determined with the PET impedes to individualize the dialysis prescription (5). It is controversial whether peritoneal transport characteristics in children treated with CAPD differ from adults (4,6). Schaefer et al. (1) have reported that increased D/P_{creat} ratio and slightly decreased $D/D0_{glu}$ ratio in children, compared to adults. Two other studies have been reported that increased glucose absorption in children (7,8). On the other hand, Geary et al. showed no age dependency of peritoneal diffusion and clearances of different solutes (5). In our study, the average D/P_{creat} and $D/D0_{glu}$ ratios after a 4-hour dwell were 0.69 and 0.39 in the 21 pediatric patients as compared to 0.65 and 0.38 in the adult study, respectively. These results were not markedly different from the PET values reported in adults. However, the mean values were found 0.76 for D/P_{creat} and 0.25 for $D/D0_{glu}$ in 3 children under the age at 5 years at four hours. These findings suggest that more rapid transport of creatinine and glucose seems to be present in the younger age group.

Which PD modality serves best for the metabolic needs of a child depends on the individual functional characteristics of the peritoneal membrane (1). The standard equilibrium curves, reported by Twardowski (3), help us to predict the optimal dialysis schedule. For example, patients with high peritoneal permeability may achieve adequate dialysis with continuous cyclic peritoneal dialysis (CCPD). In this study, when children on peritoneal dialysis were categorized to according to adult standards, we found that the majority of pediatric patients fit into the high and high average solute transport categories. This suggests that it is difficult to achieve satisfactory UF with standard CAPD in childhood and those children often require rapid exchanges to achieve adequate UF or may be most suited to dialysis using a cycling machine.

It has been reported that the duration of CAPD influenced membrane transport characteristics (9,10) although preservation of peritoneal solute clearances with time have also been reported (4,11,12,15,16). In our study, follow up D/P_{creat} and $D/D0_{glu}$ values for 9 patients after 6 months were not significantly different. These results do not indicate any influence of duration of CAPD on PET. Urea kinetic modeling has become the standard measuring adequacy of dialysis. It has been recommended that high KT/V values are necessary to achieve adequate dialysis (13,14). In this study, mean weekly KT/V_{urea} was 2.68±1.16. There were no significant differences between the groups of different ages. High KT/V values in our study may be related to a higher protein catabolic rate and to the higher caloric intake.

We have found no correlation between the parameters of D/P_{creat}, $D/D0_{glu}$, weekly KT/V_{urea}, UF and residual urine volume. However, D/P_{creat} and $D/D0_{glu}$ ratios tented to be inversely correlated with children of younger ages.

In summary, individualization of dialysis treatment is necessary in children treated with CAPD. Greater solute transport rates seem to be present in children of younger ages. Thus, in children with a poor UF and high glucose absorption, automated PD with short dwell times might be recommended. We can also speculate that high weekly KT/V_{urea} values in pediatric patients on CAPD are associated with increased patient survival and well nutritional status.

References

1. Schaefer F, Langenbeck D, Heckert KH, Scharer K, Mehls O. Evaluation of peritoneal solute transfer by the peritoneal equilibration test in children. Adv Perit Dial 1992;8:410-415.
2. Mendley SR, Umans JG, Majkowski NL. Measurement of peritoneal dialysis delivery in children. Pediatr Nephrol 1993;7:284-289.
3. Twardowski ZJ. Clinical value of standardized equilibration tests in CAPD patients. Blood Purif 1989;7:95-108.
4. Schroder CH, van Dreumel MJ, Reddingius R, Theeuwes AG, Willems HL, de Jong MC, Monnens LA. Peritoneal transport kinetics of glucose, urea, and creatinine during infancy and childhood. Perit Dial Int 1991;11:322-325.
5. Geary DF, Harvey EA, MacMillan JH, Goodman Y, Scott M, Balfe JW. The peritoneal equilibration test in children. Kidney Int 1992;42:102-105.
6. Fischbach M, Mengus L, Birmele B, Hamel G, Simeoni U, Geisert J. Solute equilibration curves, crossing time for urea and glucose during peritoneal dialysis: a function of age in children. Adv Perit Dial 1991;7:262-265.
7. Kohaut EC, Alexander SR. Ultrafiltration in the young patient on CAPD. In: Moncrief JW, Popovich RP, eds. CAPD Update: New York: Masson Publishers, 1981:221-226.
8. Balfe JW, Vigneux A, Willumsen J, Hardy B. The use of CAPD in the treatment of children with end stage renal disease. Perit Dial Bull 1981,l ;35-38.
9. Slingeneyer A, Canaud B, Mion C. Permanent loss of ultrafiltration capacity of the peritoneum in long-term peritoneal dialysis: an epidemiological study. Nephron 1983;33:133-138.
10. Lamb EJ, Worrall J, Buhler R, Harwood S, Cattell WR, Dawnay AB. Effect of diabetes and peritonitis on the peritoneal equilibration test. Kidney Int 1995;47:1760-1767.
11. Goel S, Kathuria P, Moore HL, Prowant BF, Nolph KD. The effect of peritonitis on the peritoneal membrane transport properties in patients on CAPD. Adv Perit Dial 1996;12:181-184.
12. Lo WK, Brendolan A, Prowant BF, Moore HL, Khanna R, Twardowski ZJ, Nolph KD. Changes in the peritoneal equilibration test in selected chronic peritoneal dialysis patients. J Am Soc Nephrol 1994;4:1466-1474.
13. Manuel A, Gray B, Coulis N, Brunier G, Desson F, Paton MA, Tobe S. Designing dialysis prescriptions. Adv Perit Dial 1996;12:136-142.
14. Fischbach M, Terzic J, Lahlou A, Burger MC, Eyer D, Desprez P, Geisert J. Nutritional effects of KT/V in children on peritoneal dialysis: are there benefits from larger dialysis doses? Adv Perit Dial 1995;11:306-308.
15. Cano FJ, Marin VS, Azocar MA, Delucchi MA, Rodriguez EE, Diaz ED, Villegas RC. Adequacy and nutrition in pediatric peritoneal dialysis. Adv Perit Dial 2003;19:273-278.
16. Arbeiter K, Stemberger R, Greenbaum L, Mueller T, Konstantin A, Herkner K, Aufricht C. Peritoneal transport kinetics of proteins in children on chronic peritoneal dialysis. Perit Dial Int 2003;23:162-168.