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Continuous ambulatory and continuous cycling peritoneal dialysis in children. A report of the Southwest Pediatric Nephrology Study Group[1]

Continuous ambulatory and continuous cycling peritoneal dialysis in children. A report of the Southwest Pediatric Nephrology Study Group. Continuous ambulatory peritoneal dialysis (CAPD) and continuous cycling peritoneal dialysis (CCPD) have become acceptable methods of treatment for children with endstage renal disease (ESRD). In this study we have compared the effectiveness of these two modalities of prolonged dwell peritoneal dialysis in 82 children treated at home with CAPD and/or CCPD for a mean of 10.2 months. Forty variables were evaluated during 92 patient periods (63 CAPD, 29 CCPD). There was no difference between the two groups with regard to sex, race, original disease, duration of dialysis, or volume of dialysis fluid. The only difference in biochemical profiles between the two groups was a higher serum creatinine in CCPD patients due in part to this group's greater age. The rate of peritonitis was not different (CAPD 1/4.6, CCPD 1/5.2 months), but the number of patient periods devoid of peritonitis was greater in the CCPD group (14/29 vs. 17/63, $P = 0.04$). Growth velocity index (GVI) and standard deviation scores (SD scores) were used to evaluate growth in the total group and subsets according to age. Overall GVI was 88% of expected and did not differ between PD groups (CAPD 88% vs. CCPD 89%). There were no significant changes in SD scores for growth during the course of prolonged dwell peritoneal dialysis indicating that the children did not experience further deterioration in growth. Children less than 4 years of age also did not have significant changes in SD scores. We conclude that CAPD and CCPD provide acceptable and comparable modes of dialytic therapy for children with ESRD.

Dialyse péritonéale continue ambulatoire et recyclage continu chez des enfants. Rapport du Southwest Pediatric Nephrology Study Group. La dialyse péritonéale continue ambulatoire (CAPD) et la dialyse péritonéale recyclage continu (CCPD) sont devenues des méthodes acceptables chez les enfants en ESRD. Dans cette étude, nous avons comparé l'efficacité de ces deux modalités de dialyse péritonéale à demeure prolongée chez 82 enfants traités à domicile par CAPD et/ou CCPD pendant 10,2 mois en moyenne. Quarante variables ont été évaluées pendant 92 périodes-malades (63 CAPD, 29 CCPD). Il n'y avait pas de différence entre les deux groupes quant au sexe, la race, la maladie initiale, la durée de dialyse ou le volume de liquide de dialyse. La seule différence dans les profils biochimiques entre les deux groupes était une créatininémie plus élevée chez les malades en CCPD, en partie à cause du plus grand âge de ce groupe. Le taux de péritonite n'était pas différent (CAPD 1/4,6, CCPD 1/5,2 mois), mais le nombre de malades sans épisode de péritonite était plus élevé dans le groupe CCPD (14/29 contre 17/62, $P = 0,04$). L'index de vitesse de croissance (GVI) et les scores de déviation standard (SD/scores) ont été utilisés pour évaluer la croissance chez les enfants et les sous-groupes en fonction de l'âge. Globalement, GVI était 84% de la valeur attendue, et ne différait pas entre les groupes PD (CAPD 88% contre CCPD 89%). Il n'existait pas de modification significative des scores de SD pour la croissance au cours de la dialyse péritonéale à demeure prolongée, indiquant que les enfants n'avaient pas eu de dégradation supplémentaire de leur croissance. Les enfants âgés de moins de 4 ans n'avaient pas non plus de changements significatifs des scores de SD. Nous concluons que la CAPD et la CCPD constituent des modes acceptables et comparables de traitement dialytique chez les enfants en ESRD.

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Although it is generally accepted that renal transplantation provides the optimal therapy for children with endstage renal disease [1, 2], there is still uncertainty regarding the most suitable form of dialysis for children awaiting transplantation or for chronic therapy in children in whom transplantation is either not possible or unsuccessful. The therapeutic results of chronic maintenance hemodialysis in children with endstage renal disease (ESRD) have been unsatisfactory because of poor tolerance of the procedure, complications of the intermittent nature of the dialysis, and insufficient growth [2–7]. The recent development of techniques using "prolonged dwell" peritoneal dialysis, continuous ambulatory peritoneal dialysis (CAPD), and continuous cycling peritoneal dialysis (CCPD), has received a great deal of attention because of encouraging reports in adults [8–10]. Their use in pediatrics is increasing, with the hope that they may offer significant therapeutic advantages for children with ESRD [11–13]. However, publications describing experience with CAPD in children have involved only small numbers of children with limited information on therapeutic benefit. Even less information is available on CCPD in children.

To compare the relative benefits of CAPD and CCPD in

Table 1. Clinical and laboratory variables evaluated in patients on CAPD and CCPD

(1) Dialysis type: CAPD, CCPD
(2) Sex
(3) Race
(4) Age dialysis begun
(5) Duration of dialytic therapy
(6) Type of catheter
(7) Method of placement: surgeon or nephrologist
(8) Dialysis vol/cycle, *ml/kg*
(9) No. catheters/No. catheter problems
(10) No. episodes of peritonitis
(11) No. exit site infections
(12) Catheter life, *months*
(13) Frequency of peritonitis episodes
(14) Days of hospitalization for peritonitis
(15) Mean age of patient during dialysis period
(16) Height at onset
(17) Latest height
(18) Δ Height during PD therapy
(19) GVO = Growth velocity observed, Δ *ht/pt mo*
(20) GVCA = Growth velocity expected based on chronologic age, *months*
(21) GVI = growth velocity index.
(GVI = GVO/GVCA)
(22) Hematocrit
(23) Serum creatinine
(24) Blood urea nitrogen
(25) Serum sodium
(26) Serum potassium
(27) Serum chloride
(28) Serum carbon dioxide content
(29) Serum calcium
(30) Serum phosphorus
(31) Serum alkaline phosphatase
(32) Serum albumin
(33) Total serum protein
(34) Serum cholesterol
(35) Serum triglycerides
(36) Serum glucose
(37) Serum parathyroid hormone
(38) Original diagnosis
(39) Diagnosis code—congenital versus acquired lesion
(40) Current treatment:
1 = Recovered function
2 = Died
3 = Transplant
4 = CAPD
5 = CCPD
6 = IPD
7 = HD

children with endstage renal disease, a multicenter collaborative study was performed by members of the Southwest Pediatric Nephrology Study Group. The major aims of our study were:

- To compare the biochemical and hematologic profiles of a large series of children treated at home with CAPD and CCPD in 11 pediatric renal centers
- To compare rates and consequences of peritonitis in children treated at home with the two modalities
- To evaluate growth in these children and to examine variables which may influence the rate of growth.

Methods

Patient population

Patients with ESRD were entered into this retrospective analysis of prolonged dwell peritoneal dialysis if they were 18 years of age or less and had received CAPD or CCPD at home for a minimum of 3 months. Separate criteria were used for patients in whom growth data were analyzed.

Acquisition of data

Data were obtained from 11 pediatric renal centers. Standardized questionnaires were used for data acquisition on individual patients maintained for 3 months or longer on prolonged dwell peritoneal dialysis. Analysis was performed at the SPNSG Central Office of 40 representative clinical and laboratory variables shown in Table 1. Specific attention was directed toward the rate of peritonitis and the growth rates of children receiving either CAPD or CCPD. The biochemical profiles were performed in the clinical laboratories of each institution.

Definitions

Peritonitis was defined as the occurrence of fever, abdominal pain, and/or cloudy peritoneal effluent, which necessitated the use of intraperitoneal or parenteral antibiotics. This diagnosis, by definition, includes both bacterial and chemical peritonitis. All of the children were on home dialysis and some of the cultures were performed in peripheral hospitals. Data were obtained on the rates of peritonitis, exit site infections, days hospitalized because of peritonitis, and catheter life expectancy for each form of prolonged dwell PD.

Growth data

Growth data were obtained and analyzed on all children who had been on peritoneal dialysis 6 months or longer. Children over 14 years of age at the end of the study period were excluded from this analysis. This age was arbitrarily chosen as an age in children with chronic renal disease that would exclude those entering or past puberty.

A *growth velocity index* was calculated on each child using the formula:

$$\text{GVI} = \frac{\text{Actual growth velocity of patient (GV)}}{\text{Normal growth velocity for chronologic age (GVCA)}} \times 100 \quad (1)$$

A *standard deviation score* (SD score) was calculated using the formula:

$$\frac{\text{Patient's height} - \text{height at 50th percentile for age}}{\text{SD of height for age}} \quad (2)$$

Normal data were obtained from the National Center for Health Statistics 10-State Survey [14]. Chronologic age was used in these calculations rather than bone age due to the variability in interpretation of bone age between the different institutions. All data were calculated on the basis of one chronological year of growth. SD score at the beginning of peritoneal dialysis represents the pre-existing deviation from normal growth of the children when they started peritoneal dialysis. The change in growth rate was calculated by ΔSD ($\text{SD}_1 - \text{SD}_2$). A positive ΔSD would indicate the child grew at a more normal rate and experienced accelerated growth during peritoneal dialysis. Comparisons were made between males and females on CCPD

Table 2. CAPD versus CCPD: Patient population

	Overall group	CAPD	CCPD
Treatment periods, *number*	92	63	29
Sex (M:F)	47:45	33:30	14:15
Race (B:W:O[a])	13:63:16	7:43:13	6:20:3
Age, *years*	8.5 ± 5.2	7.7 ± 5.2	10.2 ± 4.7
Duration of treatment, *months*	10.2 ± 6.9	9.8 ± 7.1	11.1 ± 6.5
Volume per cycle, *ml/kg*	42.3 ± 18.0	41.8 ± 17.8	43.3 ± 18.7

[a] Black:White:Other.

Table 3. Original renal disorders of patients on CAPD and/or CCPD

	Overall	CAPD	CCPD
Obstructive uropathy	18%	16%	21%
Reflux nephropathy	7%	8%	7%
Renal hypoplasia/dysplasia	17%	17%	17%
Focal segmental glomerulosclerosis	15%	13%	17%
Other glomerulopathy	23%	22%	24%
Miscellaneous/unknown	20%	24%	14%

and CAPD, between each modality of therapy, and between age groups.

Statistical methods

The 40 variables listed in Table 1 were analyzed by a variety of statistical methods including Student t tests, χ^2 analysis, Spearman's correlation testing, Pearson's correlation testing, and Fisher's exact test (when appropriate). Statistical significance was defined as a P value equal to or less than 0.05. The results are expressed as the mean ± 1 SD in the text and tables.

Results

Eighty-two children, each treated for a minimum of 3 months with CAPD and/or CCPD, were evaluated. The 82 patients experienced a total of 92 treatment periods, 63 periods of CAPD, and 29 of CCPD. Demographic characteristics of the patients are shown in Table 2. The sex and racial characteristics did not differ between the two groups. Though the children treated with CCPD were slightly older, this difference was not statistically significant. There was no difference in the duration of the treatment interval on each modality of prolonged dwell peritoneal dialysis nor in the volume of dialysis solution used in each cycle.

The original renal disorders that led to endstage renal disease were comparable in the two treatment groups and are shown in Table 3. In this study, the combination of obstructive uropathy, reflux nephropathy, and renal dysplasia accounted for approximately 40% of the children on dialysis. Another 37% of the patients had ESRD secondary to glomerular diseases.

Representative hematological and biochemical profiles of the two subgroups and the overall population of patients are shown in Table 4. There were no differences in the biochemical profiles between children on CAPD and CCPD with the exception of the serum creatinine which was somewhat higher in the CCPD patients. The higher serum creatinine concentrations in the patients on CCPD paralleled the increased age of this group of patients, but we do not have data to indicate whether the higher serum creatinine in patients on CCPD is the result of larger muscle mass or decreased clearance efficiency. Ten children received both CAPD and CCPD. There were no differences in the hematological and biochemical profiles in this crossover group.

Peritonitis

The rate of peritonitis in the total population and in the two subgroups of patients is shown in Table 5. The overall frequency of peritonitis was one episode per 4.8 patient months and there was no significant difference in the rate of peritonitis observed between the CAPD and CCPD patient populations. Also shown in this table is the number of days of hospitalization per patient month which resulted from an episode of peritonitis. Although an apparent difference between the number of days of hospitalization is present, the data are skewed significantly by one patient who had a prolonged hospitalization and the number of days in the two groups is, in fact, not different statistically. Catheter placement was performed by surgeons in most patients, and, although the catheter life tended to be longer in the CCPD patients, this difference was not significant.

Ten of the children evaluated in this study were treated with both CAPD and CCPD; CAPD was the first form of therapy in seven patients and the second form in three patients. The total number of peritonitis episodes in this subset of patients was not significantly different for the two modalities of treatment (CAPD, 1/6.3 patient months; CCPD, 1/6.6 patient months). However, when the peritonitis rate was compared between the first modality of dialysis and the second, a significant difference was apparent. Twenty episodes of peritonitis occurred in 88 patient months during the first form of dialysis whereas only six episodes occurred over 83 patient months in the second form. Thus, the frequency of peritonitis was one episode per 4.4 patient months versus one episode per 14 patient months, respectively.

In the 182 episodes of peritonitis that occurred in the patients in this study, over one-third of the episodes were caused by staphylococci (Table 6). Twenty-one percent of the episodes appeared to be examples of "sterile peritonitis," but the lack of uniformity of culture methods makes this conclusion somewhat tenuous.

Growth

Growth data were analyzed on 53 children who were on prolonged dwell peritoneal dialysis for at least 6 months, 34 on CAPD, and 19 on CCPD. Growth velocity was not significantly different between patients receiving the two modalities of treatment (CAPD 0.46 ± 0.61 cm/month; CCPD 0.48 ± 0.40 cm/month). GVCA in patients receiving CAPD (0.58 ± 0.24 cm/month) was somewhat higher than that occurring in patients on CCPD (0.50 ± 0.19 cm/month) because the CCPD population was slightly older. Children starting prolonged dwell peritoneal dialysis were growing at a growth velocity index of 88 ± 8% of expected and were 2.6 ± 1.8 SDs below normal for height (Table 7). Weight gain was 75 ± 18% of expected, and the children were 1.5 ± 1.2 SDs below normal for weight at the start of peritoneal dialysis. At the end of a mean of 1.0 ± 0.6 years on

Table 4. Hematologic and biochemical profiles[a] of children on periods of CAPD or CCPD

	No. of treatment periods	Overall group	CAPD	CCPD
Hematocrit, *%*	88	24.5 ± 5.8	24.7 ± 6.4	24.1 ± 4.2
Creatinine, *mg/dl*	83	8.5 ± 4.2	7.7 ± 4.2	10.1 ± 3.8[b]
BUN, *mg/dl*	91	65.1 ± 25.7	64.4 ± 24.8	66.4 ± 28.1
Na, *mEq/liter*	91	137.9 ± 4.3	137.7 ± 4.4	138.3 ± 4.1
K, *mEq/liter*	92	4.4 ± 1.0	4.4 ± 1.0	4.5 ± 1.0
Cl, *mEq/liter*	91	100.5 ± 5.7	100.4 ± 5.8	100.6 ± 5.7
CO_2, *mM/liter*	90	23.1 ± 3.9	23.0 ± 4.3	23.4 ± 3.1
Calcium, *mg/dl*	91	9.5 ± 1.1	9.4 ± 1.2	9.8 ± 0.9
Phosphorus, *mg/dl*	89	5.1 ± 1.5	5.2 ± 1.5	5.0 ± 1.3
Alkaline phosphatase, *IU/liter*	72	328.9 ± 329.9	289.6 ± 205.9	394.2 ± 465.3
Serum albumin, *g/dl*	64	3.3 ± 0.7	3.4 ± 0.7	3.2 ± 0.6
Glucose, *mg/dl*	72	106.3 ± 23.8	107.0 ± 27.0	104.7 ± 15.9
Triglycerides, *mg/dl*	47	287.3 ± 152.0	307.7 ± 142.2	265.0 ± 157.3
Cholesterol, *mg/dl*	57	231.5 ± 69.7	218.4 ± 64.0	249.5 ± 74.5

[a] These profiles are expressed as serum concentrations.
[b] $P < 0.05$ between CAPD and CCPD.

Table 5. Rate of infection in children on CAPD or CCPD

	Overall	CAPD	CCPD
Frequency of peritonitis, *no. months/episode*	4.8 ± 6.8	4.6 ± 6.3	5.2 ± 7.7
Days of hospitalization per patient for peritonitis	9.3 ± 18.4	7.7 ± 5.2	3.4 ± 9.9
Method of catheter placement, *nephrologist vs. surgeon*	23:68	13:50	10:18
Catheter life, *months*	7.4 ± 5.3	6.5 ± 4.3	10.1 ± 6.8

Table 6. Micro-organisms identified during 182 episodes of peritonitis

Type	Number	Frequency %
Staphylococcus epidermidis	44	24
Staphylococcus aureus	21	12
Pseudomonas species	11	6
Escherichia coli	7	4
Enterobacter species	5	3
Acinobacter species	4	2
Candida species	4	2
Other organisms	31	17
Negative cultures	37	20
No culture data reported	18	10
Total	*182*	

prolonged dwell peritoneal dialysis, the children were growing at the same rate and had the same SD scores. Thus, although these children did not experience *catch up* growth during a year on peritoneal dialysis, they did maintain their relative position on the growth tables.

This series contained 38 children on prolonged dwell peritoneal dialysis who were 5 years of age or older and 15 children less than 5 years of age (Table 8). When the children less than 5 years of age were analyzed separately, their growth rate was found to be 89% of expected, and their SD scores did not decrease.

The growth data obtained on the patients are also depicted on Tanner-Whitehouse growth charts (Figs. 1 and 2). Figure 1 shows the growth velocity that was observed in individual females treated with either CAPD or CCPD. Although many patients attained excellent growth, there were some in whom minimal or no growth occurred. Figure 2 depicts similar data from the males that were treated with each of the forms of prolonged dwell peritoneal dialysis.

Correlations between growth and other variables

Percent of expected growth (GVI) in all the children on prolonged dwell peritoneal dialysis and in patient subgroups on CAPD and CCPD were analyzed for correlations between biochemical and hematological variables. Patients who were treated with CAPD showed a strong correlation between GVI and serum phosphorus concentrations. Patients with a GVI less than 80% had a mean serum phosphorus of 4.3 mg/dl ($N = 25$), whereas patients with GVI greater than or equal to 80% had a mean serum phosphorus of 5.7 mg/dl ($N = 18$, $P < 0.0001$). A significant correlation was seen also when GVI was compared with BUN. Children older than 5 years of age with a GVI less than 80% had a mean BUN of 45 ± 17 mg/dl, while children with a GVI greater than or equal to 80% had a BUN of 73 ± 10 mg/dl ($P = 0.009$). Children with GVI less than 80% had a mean serum creatinine of 11.5 mg/dl, while children with a GVI greater than 80% had a serum creatinine concentration of 8.3 mg/dl ($P = 0.03$).

Outcome of the patients

The current status of the children evaluated in this study is shown in Table 9. There is a trend for an increasing percentage of the children treated with prolonged dwell peritoneal dialysis to receive CCPD. In addition, the table shows that 17 of the patients received a renal transplant and 9 other patients died. Five patients can be defined as failures of prolonged dwell peritoneal dialysis because they returned to hemodialysis.

Table 7. Comparison of growth data in 53 children receiving CAPD or CCPD[a]

Variable	CAPD (34)			CCPD (19)			*P* diff
	Start	End	Δ	Start	End	Δ	
Age, *years*	6.9 ± 5.1	7.8 ± 5.0	1.0 ± 0.6	9.3 ± 4.7	10.4 ± 4.8	1.1 ± 0.6	NS
Height, *cm*	104.2 ± 31.0	109.4 ± 28.0	5.5 ± 5.7	118.2 ± 27.2	123.2 ± 24.7	5.0 ± 3.9	NS
% Expected growth, *height*	88 ± 8	88 ± 8	—	89 ± 7	88 ± 7	—	NS
SD scores, *height*	−2.6 ± 1.8	−2.7 ± 1.8	−0.1 ± 1.0	−2.4 ± 1.6	−2.5 ± 1.3	−0.2 ± 0.9	NS
Weight, *kg*	19.4 ± 13.2	21.2 ± 12.9	1.9 ± 2.6	27.2 ± 14.3	29.2 ± 13.6	2.0 ± 2.6	NS
% Expected growth, *weight*	75 ± 18	74 ± 19	—	81 ± 23	79 ± 19	—	NS
SD scores, *weight*	−1.5 ± 1.2	−1.6 ± 1.3	−0.2 ± 0.8	−1.2 ± 1.6	−1.1 ± 1.4	−0.02 ± 0.7	NS

[a] The number in parentheses denotes how many children were on CAPD and CCPD, respectively.

Table 8. Comparison of growth by age in 53 children receiving prolonged dwell peritoneal dialysis

Variable	Children <5 years of age (*N* = 15)			Children 5 years or older (*N* = 38)			*P*
	Start	End	Δ	Start	End	Δ	
% Expected growth, *height*	90 ± 9	89 ± 8	—	88 ± 8	87 ± 7	—	NS
SD scores, *height*	−2.7 ± 1.6	−2.8 ± 1.8	−0.1 ± 1.3	−2.5 ± 1.8	−2.6 ± 1.6	−0.1 ± 0.8	NS
% Expected growth, *weight*	75 ± 16	79 ± 20	—	78 ± 22	74 ± 18	—	0.02
SD scores, *weight*	−1.8 ± 2.2	−1.9 ± 2.0	0.2 ± 1.2	−1.0 ± 1.0	−1.2 ± 1.0	0.2 ± 0.6	NS

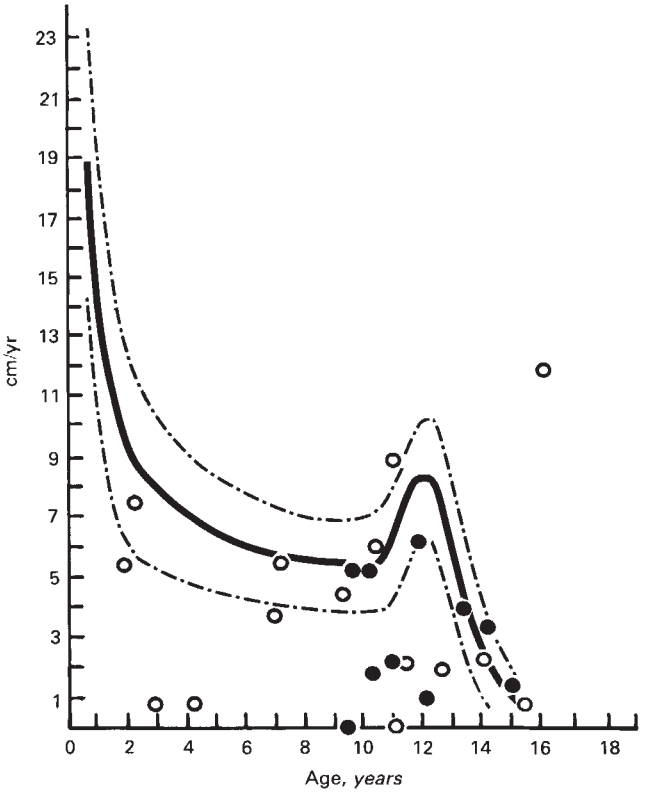

Fig. 1. *Growth velocity in female children treated with prolonged dwell peritoneal dialysis.* Symbols: ○, CAPD; ●, CCPD.

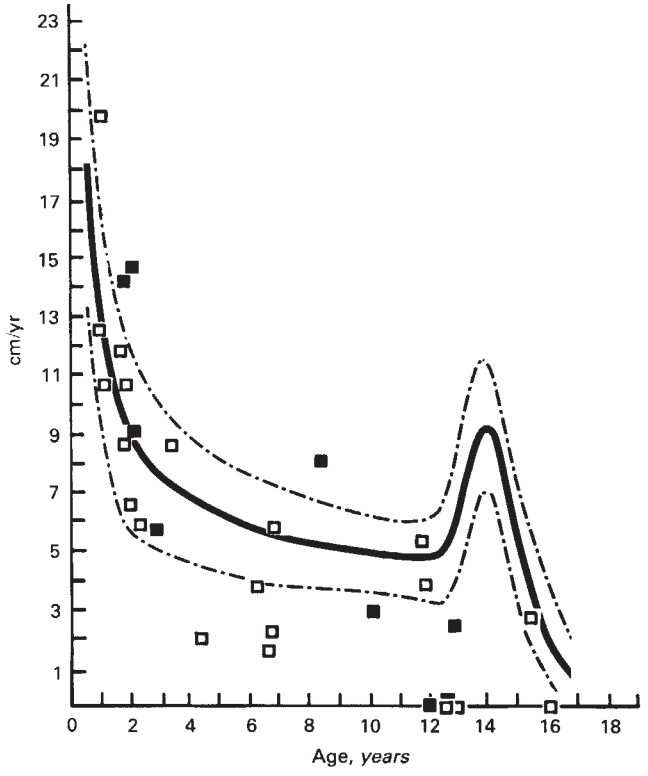

Fig. 2. *Growth velocity in male children treated with prolonged dwell peritoneal dialysis.* Symbols are: □, CAPD; ■, CCPD.

Discussion

The primary goal of the present study was to determine whether CAPD and CCPD confer equivalent therapeutic benefits to children with ESRD. Prior to the recent introduction of prolonged dwell peritoneal dialysis as a mode of therapy for ESRD patients, the three major treatment alternatives for such

Table 9. Current status of patients on CAPD or CCPD[a]

	Overall	CAPD	CCPD
Recovered	1	2	0
Died	9	9	1
Transplant	17	14	3
CAPD	31	29	5
CCPD	19	6	18
IPD	0	0	0
HD	5	3	2
Total	*82*	*63*	*29*

[a] This table reflects the treatment modalities used at the end of the study period for each of the 82 patients and following each of the 92 treatment periods.

children were renal transplantation, hemodialysis, or intermittent peritoneal dialysis. It is accepted by most authorities that a successful renal transplant is the optimal therapy for children with ESRD [1, 2]. However, the treatment available for interim therapy of children awaiting transplantation, or for chronic therapy in the event that renal transplantation is unsuccessful, has been unsatisfactory for a number of reasons. In particular, the growth that can be attained with either of these dialytic modes is inferior to that seen with renal transplants [2–4, 15–18]. The mechanisms involved in this growth retardation are multiple and have been discussed in detail previously [2, 3]. In addition intermittent peritoneal dialysis and hemodialysis are usually performed in dialysis units while CAPD and CCPD can be performed at home.

Since CAPD and CCPD were first introduced, many reports dealing with their relative efficacy in adults have been published [8–10]. Such studies suggest that the frequency of peritonitis may be reduced by the use of CCPD but that the biochemical profiles of the patients on the two forms of therapy are not different. A number of pediatric studies evaluating CAPD have been published and, in some cases, have compared the outcome and acceptability of such treatment to that observed with hemodialysis [5–7]. In our study, CAPD and CCPD were found to be equally satisfactory in the treatment of children with ESRD.

The frequency of peritonitis in children treated with prolonged dwell peritoneal dialysis has been reported to be somewhat higher than that seen in a comparable series of adults [19, 20]. In our children, the rate of peritonitis was also high—approximately one episode for every 5 patient months. This rate was not different between children receiving either CAPD or CCPD. As in other studies, our figures were skewed by occasional patients who had multiple episodes of peritonitis but in whom no alternative form of therapy was available. In this regard 11 of 63 (17%) patients in the CAPD group and 4 of 29 (14%) patients in the CCPD group had more than three episodes of peritonitis per year during the evaluation period. The organisms cultured from dialysis fluid in our children with peritonitis were similar to the spectra that have been observed by other authors and demonstrate the preponderance of skin pathogens [19]. The relative paucity of gram negative organisms in our study is comparable to that reported in other series [20]. It is felt that this experience is predictive of that obtained in large numbers of patients on home prolonged dwell peritoneal dialysis.

Our observations on ten patients who received both CAPD and CCPD are of interest. The frequency of peritonitis was not different between the two modes of dialysis in these patients, however, when comparisons were made between the rate of peritonitis during the first period of dialysis, regardless of modality, versus the second period, a significantly higher incidence of peritonitis was found during the first mode of treatment, suggesting that increased knowledge and skill in performing the various procedures involved in prolonged dwell peritoneal dialysis may result in a reduction in the frequency of peritonitis.

The growth rate observed in children receiving either form of prolonged dwell peritoneal dialysis was comparable to or better than that reported previously by other authors in children on hemodialysis. As in previous studies [5–7], we observed a wide disparity in the growth achieved among the children (Figs. 1 and 2). Of importance was the finding that children less than 5 years of age, which is the period of maximal growth, grew at a rate comparable to that seen in the older children in this study. The patients in whom severe bone abnormalities or inborn metabolic disturbances prevented the attainment of any growth obviously skew our results in a negative direction. However, in a retrospective study such as this, it is not considered appropriate to exclude patients on the basis of their underlying disease. As is true in other retrospective studies, our growth data were not optimal. The short period of time on dialysis until transplantation led us to use 6 months of growth for our calculations. There was no difference between growth measured after 6 or 12 months on dialysis. We chose to calculate growth using increase in stature for chronological age. We felt the addition of the variable of interpretation of bone age would further skew our results [2]. Finally, we arbitrarily chose 14 years as the age of onset of puberty in most children with endstage renal disease [2]. All our children were 14 years old or less at the end of the last period for growth data. Any prospective evaluation of growth in such children should have well defined exceptions before growth can be compared between two treatment groups of this type.

The biochemical variables associated with improved growth, that is, increased levels of BUN and serum phosphorus, appear somewhat surprising on first consideration. This is particularly true in view of the observation by Kohaut [11] that improved growth in children on CAPD is associated with a reduction in serum parathyroid hormone levels. However, the relevance of our findings to Kohaut's study cannot be evaluated directly since we were unable to determine the role of hyperparathyroidism. Rather, the increased BUN and serum phosphorus levels associated with higher growth rates seen in our children probably represent improved nutritional status. Those children ingesting adequate substrate grew more normally and have higher BUN and phosphorus concentrations. Unfortunately, due to the lack of uniformity of dietary observations within our different centers, we were unable to make comparisons between the caloric and protein intakes and other parameters.

The rationale for cooperative studies of patients on dialysis have been described elsewhere [21]. The conclusions that may be drawn from our cooperative study pertain to the comparison of the two forms of prolonged dwell peritoneal dialysis pres-

ently available for children with endstage renal disease. We conclude that home dialysis using prolonged dwell peritoneal dialysis is an acceptable modality of therapy for children with endstage renal disease. Both CAPD and CCPD provide equivalent biochemical and hematological profiles in children. It is apparent from the high frequency of peritonitis that much improvement is still necessary in use of these modalities in children. Likewise, it is apparent that growth rates, though still inadequate in some children, are equal to or better than growth rates observed in children treated with hemodialysis, particularly in children less than 4 years of age. Appropriate prospective studies should be performed to evaluate measures that may reduce the number of episodes of peritonitis and may provide further information about those variables that may improve growth in such children. Renal transplantation will remain the optimal therapy for children with endstage renal disease, but prolonged dwell peritoneal dialysis has the potential for providing a satisfactory alternative when successful renal transplantation is not possible.

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