

A PROSPECTIVE, RANDOMIZED MULTICENTER STUDY COMPARING APD AND CAPD TREATMENT

Susanne Bro,¹ Jakob B. Bjorner,² Pernille Tofte-Jensen,¹ Susanne Klem,¹ Birte Almtoft,³
Henning Danielsen,³ Margot Meincke,⁴ Michael Friedberg,⁴ and Bo Feldt-Rasmussen¹

Department of Nephrology,¹ Rigshospitalet; Department of Health Services Research,²
University of Copenhagen, Copenhagen; Division of Nephrology,³ Department of
Medicine, Viborg County Hospital, Viborg; Department of Nephrology,⁴
Hvidovre University Hospital, Hvidovre, Denmark

◆ **Objective:** The goals for maintenance dialysis treatment are to improve patient survival, reduce patient morbidity, and improve patient quality of life. This is the first randomized prospective study comparing automated peritoneal dialysis (APD) and continuous ambulatory peritoneal dialysis (CAPD) treatment with respect to quality of life and clinical outcomes in relation to therapy costs.

◆ **Design:** A prospective, randomized multicenter study.

◆ **Setting:** Three Danish CAPD units.

◆ **Patients:** Thirty-four adequately dialyzed patients with high or high-average peritoneal transport characteristics were included in the study. Twenty-five patients completed the study.

◆ **Interventions:** After randomization, 17 patients were allocated to APD treatment and 17 patients to CAPD treatment for a period of 6 months. Medical and biochemical parameters were evaluated at monthly controls in the CAPD units. Quality-of-life parameters were assessed at baseline and after 6 months by the self-administered short-form SF-36 generic health survey questionnaire supplemented with disease- and treatment-specific questions. Therapy costs were compared by evaluating dialysis-related expenses.

◆ **Main Outcome Measures:** Quality-of-life parameters, dialysis-related complications, dialysis-related expenses.

◆ **Results:** The quality-of-life studies showed that significantly more time for work, family, and social activities was available to patients on APD compared to those on CAPD ($p < 0.001$). Although the difference was not significant, there was a tendency for less physical and emotional discomfort caused by dialysis fluid in the APD group. Sleep problems, on the other hand, tended to be more marked in the APD group. Any positive effect of APD compared to CAPD on dialysis-related hospital days or complication rates could not be confirmed. With larger patient samples, it is possible, however, that a significant difference might have been achieved. The running costs for

APD treatment were US \$75 per day and for CAPD treatment US \$61 per day.

◆ **Conclusion:** If APD treatment can help to keep selected patients vocationally or socially active, paying the extra cost seems reasonable.

KEY WORDS: APD; quality of life; SF-36; dialysis-related complications; dialysis-related expenses.

With the prospects of a growing population of patients with end-stage renal disease (ESRD) and a continuing worldwide lack of donor kidneys, quality-of-life (QoL) aspects of dialysis treatment have become the focus of attention of kidney foundations and nephrologic societies. Although dialysis modality selection is believed to have an important impact on QoL factors, this issue has not been the object of any randomized studies until now. This multicenter study is the first prospective randomized study intended to assess the impact of automated peritoneal dialysis (APD) compared to continuous ambulatory peritoneal dialysis (CAPD) treatment on physical and psychosocial functioning of chronic peritoneal dialysis (PD) patients.

The SF-36, a multidimensional index that measures physical, mental, social, and general health (1,2), was used for comparison of patients allocated to APD or CAPD treatment. Using the framework of SF-36, a supplementary disease- and treatment-specific questionnaire was constructed to measure the influence of dialysis modality selection on ESRD-related symptoms and on patient satisfaction with treatment.

A number of previous studies have indicated a positive effect of APD compared to CAPD on dialysis-related complications (3-7). Only de Fijter *et al.* (8), however, have compared clinical outcomes in patients allocated at random to APD or CAPD treatment. The present randomized study was designed to test the hypothesis that there should be a difference between

Correspondence to: S. Bro, Nephrological Department P 2131, Rigshospitalet, 9 Blegdamsvej, DK-2100 Copenhagen, Denmark.

Received 26 April 1999; accepted 19 October 1999.

the effects of APD compared to CAPD on QoL as well as clinical outcomes. Moreover, an evaluation of costs of the therapies was incorporated into the study.

SUBJECTS AND METHODS

SETTING

The sampling frame for this study was three Danish CAPD units.

SUBJECTS

Inclusion criteria were age ≥ 18 years, minimum of 1 month of CAPD treatment, consideration by staff that patient would be able to learn to use the APD machine, a recent (within 3 months) peritoneal equilibration test (PET) showing high or high-average peritoneal transport characteristics, and an adequacy test showing a normalized urea clearance (Kt/V) ≥ 1.70 /week and a total creatinine clearance ≥ 50 L/week/1.73 m² body surface. The study was limited to high and high-average transporters in order to secure sufficient dialysis for patients randomized to APD.

Exclusion criteria were age < 18 years, pregnancy, lactation, mental retardation or dementia, psychiatric illness, inability to speak Danish, any major medical or surgical event in the previous 3 months, malignancy, a recent (within 3 months) PET showing low or low-average peritoneal transport characteristics, an adequacy test showing Kt/V < 1.70 /week and/or a total creatinine clearance < 50 L/week/1.73 m² body surface, and finally, ultrafiltration failure despite optimized CAPD treatment.

The study was approved by The Danish Ethical Committee for Clinical Research (Copenhagen and North Jutland). All patients gave their informed written consent.

STUDY DESIGN

The design of the study was a prospective, randomized, open multicenter trial. After inclusion, the patients were randomly allocated to treatment with either APD (study group) or continued CAPD (control group). Sealed envelopes containing the treatment allocation were arranged in groups of 10 and used for the randomization procedure, which took place at the main center (Rigshospitalet in Copenhagen). The study period was 6 months.

TREATMENT SCHEDULE

Patients allocated to APD treatment were trained by skilled PD nurses to handle a cycler (HomeChoice, Baxter Healthcare Corporation, McGaw Park, IL,

U.S.A.). Dialysis prescriptions for patients changed to APD treatment were calculated with the PD ADEQUEST program (Baxter), using peritoneal membrane transport characteristics as assessed by a PET prior to inclusion into the study. The goal of the treatment was to maintain a weekly Kt/V ≥ 1.70 and a total creatinine clearance ≥ 50 L/week/1.73 m² body surface. If this could not be obtained by nightly intermittent peritoneal dialysis (NIPD) treatment alone, the treatment was supplemented with a last bag in the morning, or a last bag in the morning plus an additional manual exchange in the afternoon (continuous cyclic peritoneal dialysis, CCPD).

PATIENT MONITORING

During the study, patients were seen at monthly controls in the CAPD unit. Adequacy tests were performed every 3 months. Quality of life was assessed at baseline and after 6 months by the self-administered health survey questionnaire SF-36 with added disease- and treatment-specific questions.

BIOCHEMICAL DATA

Blood hemoglobin, plasma creatinine, urea, glucose, potassium, sodium, ionized calcium, phosphate, albumin, standard bicarbonate, dialysate creatinine, urea, and glucose were measured by standard laboratory techniques. Plasma intact parathyroid hormone was determined by a two-site immunoradiometric assay (Allegro, Nichols Institute Diagnostics, San Juan, CA, U.S.A.).

PET AND ESTIMATES OF DIALYSIS ADEQUACY

PET: The PET quantifies ultrafiltration as well as rate of transport of glucose and creatinine (9). Using a glucose concentration of 2.27%, 2 L of dialysis solution was infused over a 10-minute period. A 10-mL sample of dialysate was removed at 0, 2, and 4 hours. The total dialysate outflow volume was registered after abdominal emptying at 4 hours. A venous blood sample was obtained on the same day as the PET. Dialysate and plasma were analyzed for creatinine and glucose. Patients were classified as low, low-average, high-average, and high transporters on the basis of their degree of dialysate-to-plasma creatinine equilibration and glucose absorption after the 4-hour dwell (PD ADEQUEST program, Baxter). No patient who underwent the PET had an episode of peritonitis in the 2 months prior to the completion of the test.

Adequacy: This test comprised measurement of total weekly normalized urea clearance, Kt/V, and total weekly creatinine clearance, normalized to body sur-

face area, when patients were dialyzed on their habitual regimen. Dialysate and urine were collected over a 24-hour period. Large outflow bags or wheeled plastic containers were provided for collection of large dialysate volumes from APD-treated patients. Total dialysate outflow and urine volume were registered, and samples were obtained from mixed dialysate and urine, respectively. A blood sample was drawn at the end of the collection period. Twenty-four hour peritoneal clearances for urea and creatinine were calculated by multiplying the dialysate volume and the dialysate-to-plasma ratio for urea and creatinine, respectively. Kt/V urea was calculated from total (peritoneal and renal) clearance of urea divided by the volume of distribution of urea in the body, according to Watson (10). Total creatinine clearance (peritoneal plus averaged renal creatinine and urea clearance) was normalized to body surface area. The Kt/V value and the total creatinine clearance were multiplied by 7 to express the weekly values.

ASSESSMENT OF QoL

Quality-of-life parameters were assessed by the short-form SF-36 generic health survey questionnaire (1,2) supplemented with a disease- and treatment-specific questionnaire. The SF-36 questionnaire includes 36 items that assess 8 health concepts: (1) limitations in physical activities because of health problems, (2) limitations in usual role activities because of physical health problems, (3) bodily pain, (4) general health perceptions, (5) vitality (energy and fatigue), (6) limitations in social activities because of physical or emotional problems, (7) limitations in usual role activities because of emotional problems, and (8) general mental health (psychological distress and well-being). In six of the eight dimensions, patients are asked to rate their responses on 3- to 6-point scales (box) rather than simply responding yes or no. For each dimension, item scores are coded and summed. The SF-36 is suitable for self-administration. It takes about 5 – 10 minutes to complete. The SF-36 questionnaire has been extensively evaluated with respect to validity, test–retest reproducibility, and responsiveness in different disease groups including patients with ESRD (1,2,11–19).

Using the framework of SF-36, a disease-specific questionnaire, including 23 items relating to organ system function [central nervous system, gastrointestinal, cardiovascular, joints/bone, skin (Appendix A)], and a treatment-specific questionnaire, including 11 items concerning time available for other activities, discomfort due to dialysis fluid, impact of treatment on appetite, and quality of sleep (Table 1), were constructed to measure ESRD-related symptoms and patient satisfaction with treatment. The responses

to all items relating to organ dysfunction were rated on 5-point scales (higher scores meant more severe symptoms), coded, and summed for a single dimension. The items concerning patient satisfaction with treatment were grouped into 5 dimensions (Table 1). Responses were rated on 5-point scales and scores relating to items grouped within the same dimension were summed (for interpretation of scores, see note in Table 1). Before the present study was undertaken, the disease- and treatment-specific questionnaires were tested in a pilot study (10 patients) with respect to comprehensibility and test–retest reproducibility. Upon collection of data (25 patients), the scale structure was tested through multitrait analyses (20).

STATISTICAL ANALYSIS

Data are expressed as mean \pm SEM unless stated otherwise. Clinical and biochemical data were evaluated statistically using the Student's *t*-test or a Mann–Whitney test for paired or unpaired data as appropriate (GraphPad program, version 2, 1995; GraphPad Software, Inc, San Diego, CA, U.S.A.). The Wilcoxon rank-sum test was applied for comparisons of scores from the QoL assessment (SAS Statistical Software, version 6.12, 1997; SAS Institute, Cary, NC, U.S.A.). For SF-36 and patient-reported disease-specific data, individual changes in scores from start to end of the study were considered. For patient-reported treatment-specific data, only scores at the end of the study were considered. A *p* value less than 0.05 was considered significant.

RESULTS

SUBJECT CHARACTERISTICS

The study population was recruited from three CAPD units with a total of 118 patients on PD at the start of the study. Thirty-four patients fulfilled the inclusion criteria and all agreed to participate in the study.

From the CAPD arm, four patients terminated prematurely: 1 received a kidney transplant after 12 days; 2 were changed to hemodialysis after 2 months, 1 because of edema of the scrotum, the other because of peritoneal catheter dysfunction and sepsis. The fourth patient never started the study because of a sudden deterioration of the general health status. From the APD arm, 5 patients dropped out before the end of the study: 1 received a kidney transplant after 2 months, 1 wished to stop APD treatment after 14 days because of psychosocial factors, 1 stopped after 2 months because of a subjective feeling of inadequate dialysis, 1 stopped APD treatment

TABLE 1
Treatment-Specific Questionnaire

	Scale scores ^a (mean±SD)		p Value
	APD (n=12)	CAPD (n=13)	
More time for work, family, and social activities	3.2±1.2	1.2±0.5	0.0005
Discomfort (physical) caused by the dialysis fluid	1.9±1.0	2.2±1.3	NS
Discomfort (emotional) caused by the dialysis fluid	1.8±1.0	2.2±1.4	NS
Appetite (reduced)	2.8±1.3	2.9±0.6	NS
Sleep problems	2.3±0.9	1.8±1.3	NS

NS = not significant.

^a Higher scale score values mean more time available, more discomfort, more reduced appetite, more sleep problems.

after 15 days due to inability to handle theycler. The fifth patient never started the study because of a sudden impairment of visual acuity.

The mean age of the patients who dropped out was higher in the APD group compared to the CAPD group, but the difference did not reach statistical significance (59 ± 10 years vs 50 ± 5 years, $p = 0.41$).

Of the 25 patients who completed the study, 13 were allocated to CAPD and 12 to APD treatment. Baseline sociodemographic data and clinical characteristics of these patients are shown in Table 2. The two treatment groups did not differ significantly with respect to sex distribution, primary kidney disease, comorbidity, and family conditions. There was a tendency for patients on APD treatment to be younger, to have shorter time on CAPD treatment, and to be vocationally more active, but the only difference reaching the significance level was the number of years spent on education, which was a little higher for APD patients (13.0 ± 0.7 years vs 10.2 ± 0.9 years, $p < 0.05$).

CLINICAL OUTCOMES

Among the patients on APD, 6 could do with NIPD, whereas the other 6 needed CCPD to meet the treatment goals. One patient on CAPD needed an additional exchange during the night in order to achieve the target dialysis dose. This was performed automatically by a night exchange system (Quantum PD, Baxter). Both the APD and CAPD study groups showed a mean Kt/V and a mean total creatinine clearance well above the target dialysis dose (Table 3).

Table 3 shows clinical and biochemical data for patients treated with CAPD and APD after 6 months of study. Body weight, blood pressure, residual renal clearance, and routine blood tests, including serum creatinine, urea, hemoglobin, albumin, potassium, standard bicarbonate, phosphate, ionized calcium, and parathyroid hormone (PTH), did not differ between the two groups. (Both absolute values at 6 months

and individual changes from start to end of the study were considered for statistical analysis.)

During the study period of 6 months, 3 of the 13 patients on CAPD and 5 of the 12 patients on APD were admitted to hospital for a total of 12 and 11 days, respectively, due to dialysis-related disease (0.15 dialysis-related days in hospital per patient-month for each study group).

The number of dialysis-related complications was very low:

Peritonitis: Two cases occurred in the CAPD group (0.31 episodes per patient-year); one occurred in the APD group (0.17 epi/pt-yr).

Exit-Site Infection: One case occurred in the CAPD group (this patient also had an episode of peritonitis) (0.15 epi/pt-yr); one occurred in the APD group (0.17 epi/pt-yr).

Tunnel Infection: None occurred in the CAPD group; there was one case in the APD group (0.17 epi/pt-yr).

Leakage: There were no occurrences in the CAPD group; there was one case in the APD group (0.17 epi/pt-yr).

Hernia: There were none in the CAPD group; there was one case in the APD group (0.17 epi/pt-yr).

Overhydration (> 2 kg): There were none in the CAPD group; there were two in the APD group (0.33 epi/pt-yr).

No proper statistics could be applied due to the low numbers of patients and events.

QoL OUTCOMES

SF-36: No difference in the changes of scores from start to end of the study was found between APD and CAPD patients. The scores for each of the eight dimensions in SF-36 were transformed to a scale from 0 (worst health) to 100 (best health). Figure 1 shows the transformed scores for APD and CAPD patients. For comparison, the scores of the normal Danish population (The Danish Institute of Clinical Epidemiology, Rasmussen, personal communication, 1994) are

TABLE 2
Baseline Sociodemographic Data and Clinical Characteristics for Patients Completing the Study

Allocation	CAPD	APD
Number of patients	13	12
Age (years)	54.2±4.2	50.2±4.6
Number of females/males	5/8	4/8
Primary kidney disease (no. of patients)		
Diabetes	3	4
Hypertension	1	1
Glomerulonephritis	5	3
Interstitial nephritis	0	1
Polycystic kidney disease	0	1
Other/unknown	4	2
Time on CAPD [months, median (range)]	15 (3–155)	12 (2–60)
Prior renal transplantation (no. of patients)	2	2
Comorbidity, no. of patients with a history of		
Hypertension	8	7
Ischemic heart disease	1	2
Claudication	1	1
Diabetes mellitus	1	0
Other	3	1
Living with partner or family/living alone (no. of patients)	12/1	12/0
Years of education	10.2±0.9	13.0±0.7 ^a
Current vocational function (no. of patients)		
Working full-time	1	3
Working part-time	0	1
In training position	1	0
Pensioned	11	8

Data are mean values ±SEM, or median values with ranges. Statistical tests used were unpaired *t*-test or Mann–Whitney. ^a *p* < 0.05.

also shown. It can be seen that patients on PD scored lower than the normal Danish population for 6 of the 8 dimensions. Only for the two dimensions termed “Bodily pain” and “Mental health” did patients on PD score as high as the normal Danish population.

ESRD-Related Symptoms: No difference in the changes of scores from start to end of the study was found between APD and CAPD patients.

Patient Satisfaction with Treatment at the End of Study: As shown in Table 1, significantly more time for work, family, and social activities was available for patients on APD compared to those on CAPD (*p* < 0.0005). Although the difference was not significant, there was a tendency for less physical and emotional discomfort caused by the dialysis fluid in the APD group. Sleep problems, on the other hand, tended to be more marked in the APD group.

Upon completion of the study, all patients on APD were free to choose between APD and CAPD treatment. They all preferred to continue on APD. With respect to the patients on CAPD, they were not free to choose between APD and CAPD treatment (for reasons of economy). Almost all of the patients entering the study had, however, hoped to be allocated to APD treatment.

ECONOMIC OUTCOMES

As shown in Table 3, significantly larger dialysis fluid volume was used for APD compared to CAPD treatment (13.7 ± 0.5 L/day vs 8.1 ± 0.4 L/day, *p* < 0.0001).

In Denmark, HomeChoice is provided free of charge by Baxter when dialysis fluids from Baxter are used. In addition to the cyclor and dialysis fluids, APD treatment requires disposables such as tubing sets, disconnect caps, and iodine connection shields.

For CAPD, a heater is provided free of charge when dialysis fluids from Baxter are used. Disconnect caps are needed in addition to dialysis fluids.

The running costs (average daily expenses) for APD treatment were 452 Dkr (US \$75) per day and for CAPD treatment 369 Dkr (US \$61) per day.

The vocational status remained unchanged for all study subjects. Thus, taking into consideration that, in the present study, APD treatment did not lead to a reduced incidence of adverse events and hospitalizations, nor to any change of vocational status, it can be concluded that APD was 1.22 times (22.3%) more expensive than CAPD treatment.

TABLE 3
Comparison of Clinical and Biochemical Data after 6 Months

	CAPD	APD
Number of patients	13	12
Body weight (kg)	74.3±4.2	72.9±2.9
Blood pressure (mmHg)		
Systolic	141±5	147±9
Diastolic	86±2	92±6
Urine volume (mL/day)	1014±219	802±199
Residual renal clearance (mL/min)	3.5±0.7	3.0±0.7
Anuric patients (N)	2/13	3/12
Dialysis fluid volume (mL/day)	8077±366	13 710±545 ^a
Net ultrafiltration (mL/day)	1190±343	1092±442
Kt/V (weekly)	2.3±0.1	2.3±0.2
Total creatinine clearance (L/week/1.73 m ²)	76±6	74±8
P-Creatinine (μmol/L)	742±57	800±77
P-Urea (mmol/L)	19±1.5	18±1.7
P-Standard bicarbonate (mmol/L)	24.5±0.5	24.0±0.7
Hemoglobin (mmol/L)	7.2±0.2	6.9±0.2
Hematocrit	0.34±0.01	0.33±0.01
P-Potassium (mmol/L)	3.9±0.1	4.2±0.1
P-Phosphate (mmol/L)	1.5±0.1	1.8±0.1
P-Ionized calcium (mmol/L)	1.28±0.02	1.32±0.07
P-Albumin (μmol/L)	515±20	502±20
P-PTH (pg/mL)	136±37	160±30

P = plasma; PTH = parathyroid hormone.

Data are mean values ±SEM. Statistical test used is an unpaired *t*-test.

^a *p* < 0.0001.

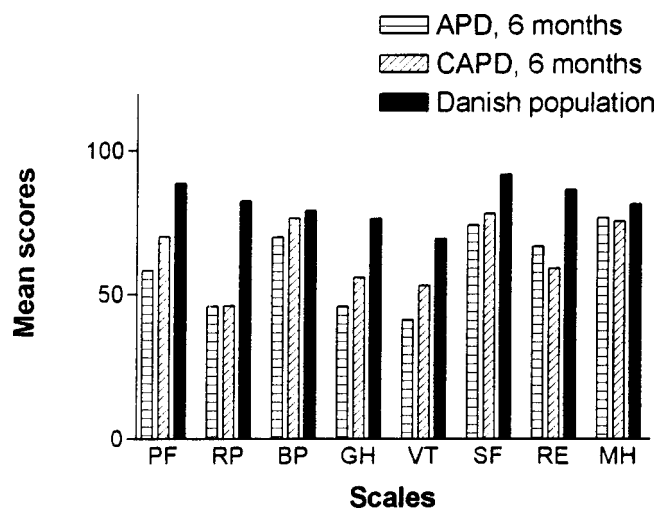


Figure 1 — Average SF-36 scale scores for APD (*n* = 13) and CAPD (*n* = 12) patients versus the normal Danish population (*n* = 1632 in 1994). PF = physical functioning; RP = role (physical); BP = bodily pain; GH = general health; VT = vitality; SF = social functioning; RE = role (emotional); MH = mental health.

DISCUSSION

This study was designed to test the hypothesis that there should be a difference between the ef-

fects of APD compared to CAPD on QoL and clinical outcomes.

Since the majority of CAPD patients were classified as low or low-average transporters, less than 30% met the inclusion criteria.

In 1995 when this study was designed, it was recommended that patients on PD should receive dialysis that provided a Kt/V ≥ 1.70 per week and a total creatinine clearance ≥ 50 L/week/1.73 m² body surface (19,21). The inclusion criteria with reference to dialysis adequacy were based on these recommendations. Since both the APD and CAPD study groups showed a mean Kt/V of 2.3 per week and a mean total creatinine clearance ≥ 74 L/week/1.73 m² body surface, they both met the presently recommended target doses for PD, which are a Kt/V ≥ 2.0 per week and a total creatinine clearance ≥ 60 L/week/1.73 m² for CAPD, and a Kt/V ≥ 2.2 per week and a total creatinine clearance ≥ 66 L/week/1.73 m² for NIPD (22).

Considering individual values, 2 of 13 patients (15%) in the CAPD group had a Kt/V < 2.0 per week, and 4 (31%) had a creatinine clearance < 60 L/week/1.73 m². Among the 12 patients on APD, 4 (33%) had a Kt/V < 2.2 and 3 (25%) had a creatinine clearance < 66 L/week/1.73 m².

Clearances and ultrafiltration rates depend on the actual dialysis prescriptions. Since there was no in-

tention in the present study to maximize clearances and ultrafiltration rates, it would not be meaningful to compare clearances and ultrafiltration rates achieved in the two PD modalities.

The APD patients who completed the study tended to be younger and vocationally more active than the CAPD patients. This trend is a reflection of the circumstance that more elderly people terminated prematurely from the APD group. Of the 5 patients who dropped out of APD treatment, however, only 1 patient, aged 77 years, was not able to manage handling of the cyclor.

The randomized study by de Fijter *et al.* (8) confirmed most of the findings from earlier uncontrolled studies: a lower rate of dialysis-related hospital admissions in APD compared to CAPD (6), a similar exit-site and tunnel infection rate for APD and CAPD, but a lower peritonitis rate for APD-treated patients (3–7). de Fijter *et al.* (8) could not, however, confirm the reports from uncontrolled studies of lower frequencies of hernias and leakages in APD compared to CAPD.

The present study showed similar complication rates in PD-treated patients as those reported by others (3–8). Taking into consideration that the number of patients and events was so low, however, no proper statistics could be applied for a comparison between APD and CAPD treatment.

A power analysis demonstrated that, based on the number of dialysis-related hospital days after 6 months of study, a minimum of 55 patients would have been needed in each group to show a significant difference ($p < 0.05$) with 50% power. Thus the lack of a significant difference between the treatment groups at 6 months does not exclude the presence of a difference.

Only the 25 patients completing the study formed the basis for the analysis. An “intention-to-treat” analysis was not possible because the majority of patients terminating prematurely dropped out within 2 weeks from the start of the study.

The part of the QoL assessment related to patient satisfaction with the treatment demonstrated that more time was available for work, family, and social activities for patients treated with APD. A large proportion of the patients was already receiving a social pension at the time of entry. However, 4 of 12 patients on APD treatment were still working at the end of the study period compared to 1 of 13 patients on CAPD treatment. The higher education level for APD patients may, in part, explain the higher number working. It cannot be excluded that some of the patients would have been compelled to resign from their job if they had not been randomized to APD.

There was a tendency for less physical and emotional discomfort caused by the dialysis fluid, but more sleep problems, in the APD group. With larger pa-

tient samples, these changes might have reached statistical significance. This impression is supported by the fact that all APD patients who completed the study wished to continue on APD.

With respect to the questionnaires on general health (SF-36) and ESRD-related symptoms, these surveys did not reveal any differences between the two patient groups. This is not surprising, however, since the APD- and CAPD-treated patients showed the same prevalence of comorbidity. Further, both groups were adequately dialyzed according to the most recent Dialysis Outcomes Quality Initiative recommendations (22). When compared to the normal population, the PD patients scored lower in 6 of the 8 dimensions in SF-36. This is in accordance with findings from other studies of dialysis patients (15–18).

In conclusion, this randomized prospective study showed APD to be advantageous to CAPD treatment, due first of all to increased freedom. Any positive effect of APD compared to CAPD on complication rates could not be confirmed. With larger patient samples, it is possible, however, that a significant difference might have been achieved. In the present study, APD treatment was showed to be 1.2 times (22.3%) more expensive than CAPD. If APD treatment can help keep selected patients vocationally or socially active, paying the extra cost seems reasonable.

APPENDIX A

ESRD-RELATED SYMPTOMS

Patients were asked to circle a number on a 1-to-5 scale corresponding to the frequency with which they had experienced specific symptoms in the previous 4 weeks. The scale was labeled

1. Not at all
2. Slightly
3. Moderately
4. Quite a bit
5. Extremely.

The list of symptoms included

1. More tired than usual during daytime
2. Headache
3. Reduced power of concentration
4. Impaired memory
5. Restless legs
6. Itching
7. Prickly sensation in feet/hands
8. Low back pain
9. Pains in bones or joints
10. Nausea
11. Pyrosis
12. Vomiting or nearly vomiting

13. Appetite (scale labeling slightly modified)
14. Gustatory sense (scale labeling slightly modified)
15. Obstipation
16. Diarrhea
17. Suppression of thirst
18. Problems maintaining fluid restriction
19. Swelling of the legs
20. Shortness of breath with exercise
21. Shortness of breath when lying down flat
22. Cough
23. Chest discomfort/pain.

ACKNOWLEDGMENT

This work was supported by the Danish Society of Nephrology Research Foundation.

REFERENCES

1. Ware JE, Sherbourne CD. The MOS 36-item short-form health status survey (SF-36). I. Conceptual framework and item selection. *Med Care* 1992; 30:MS473-81.
2. Ware JE, Snow KK, Kosinski M, Gandek B. SF-36 health survey manual and interpretation guide. Boston: New England Medical Center, The Health Institute, 1993.
3. Diaz-Buxo JA, Suki WN. Automated peritoneal dialysis. In: Gokal R, Nolph KD, eds. The textbook of peritoneal dialysis. Dordrecht: Kluwer Academic Publishers, 1994:399-418.
4. Holley JL, Bernardini J, Piraino B. Continuous cycling peritoneal dialysis is associated with lower rates of catheter infections than continuous ambulatory peritoneal dialysis. *Am J Kidney Dis* 1990; XVI:133-6.
5. Brunkhorst R, Wrenger E, Krautzig S, Ehlerding G, Mahiout A, Koch K-M. Clinical experience with home automated peritoneal dialysis. *Kidney Int* 1994; 46(Suppl 48):S25-30.
6. King LK, Kingswood JC, Sharpstone P. Comparison of the efficacy cost and complication rate of APD and CAPD as long-term outpatient treatments for renal failure. In: Khanna R, Nolph KD, Prowant BF, Twardowski ZJ, Oreopoulos DG, eds. Advances in peritoneal dialysis. Toronto: Peritoneal Dialysis Bulletin, 1992; 8:123-6.
7. Woodrow G, Turney JH, Cook JA, Gibson J, Fletcher S, Stewart AJ, et al. Nocturnal intermittent peritoneal dialysis. *Nephrol Dial Transplant* 1994; 9:399-403.
8. de Fijter CWH, Oe LP, Nauta JJP, van der Meulen J, Verbrugh HA, Verhoef J, et al. Clinical efficacy and morbidity associated with continuous cyclic compared with continuous ambulatory peritoneal dialysis. *Ann Intern Med* 1994; 120:264-71.
9. Twardowski ZJ, Nolph KD, Khanna R, Prowant BF, Ryan LP, Moore HL, et al. Peritoneal equilibration test. *Perit Dial Bull* 1987; 7:138-47.
10. Watson PE, Watson ID, Batt RD, Phil D. Total body water volumes for adult males and females estimated from simple anthropometric measurements. *Am J Clin Nutr* 1980; 33:27-39.
11. Brazier JE, Harper R, Jones NMB, O'Cathain A, Thomas KJ, Usherwood T, et al. Validating the SF-36 health survey questionnaire: new outcome measure for primary care. *BMJ* 1992; 305:160-4.
12. McHorney CA, Ware JE, Raczek AR. The MOS 36-item short-form health survey (SF-36). II. Psychometric and clinical tests of validity in measuring physical and mental health constructs. *Med Care* 1993; 31:247-63.
13. McHorney CA, Ware JE, Lu JFR, Sherbourne CD. The MOS 36-item short-form health survey (SF-36). III. Tests of data quality, scaling assumptions and reliability across diverse patient groups. *Med Care* 1994; 32:40-66.
14. Kurtin PS, Davies AR, Meyer KB, DeGiacomo JM, Kantz ME. Patient-based health status measures in outpatient dialysis. *Med Care* 1992; 30:MS136-49.
15. Meyer KB, Espindle DM, DeGiacomo JM, Jenuleson CS, Kurtin PS, Davies AR. Monitoring dialysis patients' health status. *Am J Kidney Dis* 1994; 24:267-79.
16. Khan IH, Garratt AM, Kumar A, Cody DJ, Catto GRD, Edward N, et al. Patients' perception of health on renal replacement therapy: evaluation using a new instrument. *Nephrol Dial Transplant* 1995; 10:684-9.
17. Beusterien KM, Nissenson AR, Port FK, Kelly M, Steinwald B, Ware JE. The effects of recombinant human erythropoietin on functional health and well-being in chronic dialysis patients. *J Am Soc Nephrol* 1996; 7:763-73.
18. Merkus MP, Jager KJ, Dekker FW, Boeschoten EW, Stevens P, Krediet RT, and The Necosad Study Group. Quality of life in patients on chronic dialysis: self-assessment 3 months after the start of treatment. *Am J Kidney Dis* 1997; 29:584-92.
19. Teehan BP, Schleifer CR, Brown J. Urea kinetic modeling is an appropriate assessment of adequacy. *Semin Dial* 1992; 5:189-92.
20. Stewart AL, Hays RD, Ware JE. Methods of constructing health measures. In: Stewart AL, Ware JE, eds. Measuring functioning and well-being: the medical outcomes study approach. London: Duke University Press, 1992:67-85.
21. Keshaviah P. Adequacy of peritoneal dialysis. In: Gokal R, Nolph KD, eds. The textbook of peritoneal dialysis. Dordrecht: Kluwer Academic Publishers, 1994:419-42.
22. NKF-DOQI Clinical practice guidelines for peritoneal dialysis adequacy. NY: National Kidney Foundation's Dialysis Outcomes Quality Initiative, 1997.