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Fluid status of patients during the early stages of continuous ambulatory peritoneal dialysis

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Abstract. – **OBJECTIVE:** The purpose of this paper is to investigate the fluid status of patients in the early stages of continuous ambulatory peritoneal dialysis (CAPD).

PATIENTS AND METHODS: A total of 36 patients (13 males and 23 females), hospitalized in the Nephrology CAPD Center, Peking University Third Hospital, and undergoing intubation and CAPD treatment, were recruited in this study. By utilize a bioelectrical impedance analyzer, changes in extracellular fluid and intracellular fluid within the patients' cells, and overall fluid changes were monitored throughout six months following CAPD treatment. Blood pressure was taken before dialysis and during six months following dialysis. Dietary assessment was also performed by recording and analyzing the patients' dietary protein and caloric intake during this six months period.

RESULTS: Over a six-month period, following CAPD treatment, the fluid status of the patients displayed a rising trend, indicated by weight gain, increasing extracellular fluid (ECW), intracellular fluid (ICW), overall water (TBW) and standardized extracellular fluid (NECW). Peritoneal ultrafiltration volume, and residual urine volume, showed no significant difference before or after treatment. During the six-month period, the dietary caloric intake of patients increased. Prior to CAPD, the patients' systolic blood pressure level was higher than normal. Following treatment, it returned to normal, and, due to the patients' rising fluid status, no change occurred during the six-month monitoring period.

CONCLUSIONS: During the early stages of CAPD treatment, patients' fluid status increased, as a result of dietary improvement and the increased intake of water and salt. However, weight gain, in the early stages of the CAPD, is more likely due to rising fluid status than nutritional improvement. Early control of water and salt intake is of crucial importance for CAPD patients.

Key Words:
CAPD, Fluid status, Bioelectrical impedance, Intracellular fluid, Extracellular fluid.

Introduction

Conventionally, it has been accepted that patients who receive continuous ambulatory peritoneal dialysis (CAPD) can take in water and salt at will. Thus, water and salt intake have not been given sufficient attention in CAPD therapy. However, clinical reports showed that overloaded fluid status is prevalent in CAPD patients, and is responsible for high blood pressure and cardiovascular complications[1-4]. It is also a significant cause of poor patient compliance to long-term treatment by CAPD[5].

Reliable literature reports that the fluid status of CAPD patients is significantly higher than patients with hemodialysis[6-8]. Fluid status overload, in CAPD patients, is too often a chronic process[9]. Following long-term dialysis, these patients typically have a high rate of fluid status overload, and high blood pressure[10-12]. Following short-term dialysis, they often have better control over blood pressure and fluid status[13-15].

Currently, relevant clinical evidence is lacking concerning the overload fluid-status and blood pressure conditions of patients in the early stages of CAPD. To this end, a total of 36 patients, consisting of 13 males and 23 females, who underwent CAPD treatment, were recruited in this study. We used a bio-impedance analyzer to observe the dynamic fluid status of patients and to record their blood pressure conditions during the early stages. Results of this work may advance present understanding on risk factors

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that compromise clinical compliance of CAPD, and provide information on taking measures for early prevention of cardiovascular complications.

Patients and Methods

Patients

This study was approved by the Ethical Committee of Peking University Third Hospital. Written informed consent was obtained from all patients and/or their close relatives for participating in this study.

A total of 36 patients, consisting of 13 males and 23 females, were recruited in this study. These patients were hospitalized in the Nephrology CAPD Center, Peking University Third Hospital and underwent intubation and CAPD treatment. The primary condition of these subjects was as follows: 10 had chronic glomerulonephritis, 33 were diabetic, 4 had hypertensive renal disease, 1 had polycystic kidney disease, 2 had tubular interstitial disease, another 2 had other diseases that led to chronic renal insufficiency, and the primary disease was not identified for the remaining 4 patients. All peritoneal dialysis solutions used in these study participants were produced by Baxter, (Deerfield, IL, USA).

Methods

Fluid status index measurement: Accurate measurements of height and net weight were taken from each patient by excluding the weight of clothes and peritoneal fluid in the abdominal cavity. The overall wrist-ankle method was applied to assess CAPD patients' fluid status once a month before and after dialysis by using the Xitron4200 bioelectrical impedance analyzer (Xitron Technologies, San Diego, CA, USA). Details are as follows. First, the patients remained supine for 5 minutes, with an upper limb abduction of 15 degrees, lower limbs apart and no body parts in contact with one another. Two electrodes were placed in the dorsal metacarpophalangeal/toe joints. Prior to electrode placement, alcohol was applied to clean the skin thoroughly and to reduce skin contact resistance. Next, the patients' extracellular fluid (ECW), intracellular fluid (ICW) and overall water (TBW) were measured. Last, the extracellular fluid (ECW) was marked on the body surface area. Additionally, peritoneal ultrafiltration volume and residual urine volume were also recorded on a 24-hours basis.

Blood pressure measurement: Measurements of blood pressure, including the systolic blood pressure (SBP), the diastolic blood pressure (DBP), and mean arterial blood pressure (MBP), were taken, using a mercury sphygmomanometer, before insertion of the pre-dialysis catheter, and, one month after dialysis. Fluid status and blood pressure were measured monthly, at the same time.

Dietary protein and energy intake assessment: Patients were instructed on how to keep a detailed diet record of daily food intake over a period of three consecutive days. Nutritionists checked patients' diets utilizing food mold, and computer software to analyze the ingredients, to derive a daily average of total protein intake (TPI) and total caloric (or energy) intake (TEI).

Statistical Analysis

Statistical analyses were performed using the SPSS 11.0 statistical package (SPSS Inc., Chicago, IL, USA). All numerical data were presented as mean ± standard deviation. Differences in patients' fluid status before and after CAPD were evaluated by paired *t*-test. Comparison between groups was done using One-way ANOVA test followed by Post Hoc Test (Least Significant Difference). $p < 0.05$ is considered statistically significant.

Results

Fluid Status

The patients' fluid status index, before and after CAPD, were listed in Table I. After one month of CAPD treatment, patients' body weight (weight), extracellular fluid (ECW), overall water (TBW) and marked extracellular fluid (NECW) decreased significantly compared to their pre-treatment status ($p<0.01$ or $p<0.05$. See Table 1). However, a comparison of data collected one month after CAPD with those of six months later showed fluid status rising, and manifested as significantly higher body weight six months after CAPD. For instance, the average weight recorded at one and six months was 56.86±10.47 kg and 58.97±11.01 kg, respectively ($p<0.01$). As well, extracellular fluid (ECW), overall water (TBW) and marked extracellular fluid (NECW) were all significantly increased ($p<0.01$ or $p<0.05$). Regular observation showed that the fluid status index (weight, ECW, TBW, NECW) of continuously ambulatory CAPD patients

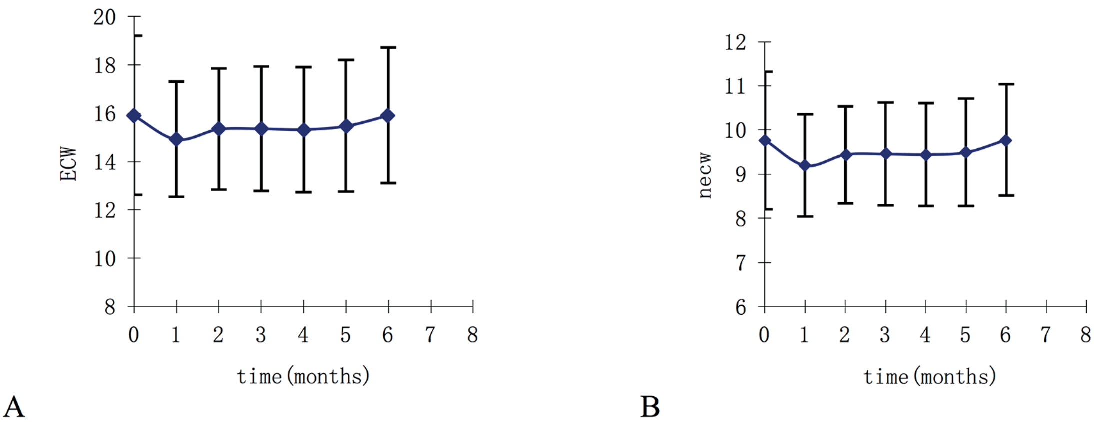

Figure 1. Changes in extracellular fluid *(A)* and marked extracellular fluid *(B)* in patients undergoing CAPD for up to six months.

Table I. Comparison of water load status, blood pressure and diet conditions before and after CAPD in recruited patients (N=36).

	Before CAPD	One month after CAPD	Six months after CAPD
Weight (kg)	60.62 ± 11.80	56.86 ± 10.47$^{\circ\circ}$	58.97 ± 11.01$^{\Delta\Delta}$
ECW	15.91 ± 4.30	14.92 ± 2.87°	15.91 ± 3.48$^{\Delta}$
ICW	13.63 ± 4.10**	13.71 ± 4.21	14.69 ± 4.24$^{\Delta\Delta}$
TBW	30.60 ± 6.79	28.63 ± 6.32$^{\circ\circ}$	30.55 ± 6.77$^{\Delta\Delta}$
NECW	9.77 ± 1.62	9.20 ± 1.37$^{\circ\circ}$	9.73 ± 1.61$^{\Delta\Delta}$
SBP (mmHg)	150.53 ± 24.35**	137.08 ± 18.19$^{\circ\circ}$	138.81 ± 17.96
DBP (mmHg)	81.83 ± 14.12	79.19 ± 13.31	84.31 ± 11.67
MBP (mmHg)	104.73 ± 15.55	98.49 ± 12.16°	102.47 ± 11.68
24-hr ultrafiltration volume (ml)		347.22 ± 511.47	393.83 ± 408.00
24-hr Urine volume (ml)		839.39 ± 471.86	935.78 ± 662.53
24-hr Total fluid volume (ml)		1181.89 ± 576.60	1329.61 ± 579.05
TEI (kcal/d)		1326.79 ± 536.17	1663.48 ± 696.92$^{\Delta}$
TPI (g/d)		52.96 ± 21.95	55.09 ± 16.21

$^{**}p<0.01$ and $^{*}p<0.05$, comparing one month after CAPD with before CAPD.
$^{\Delta\Delta}p<0.01$ and $^{\Delta}p<0.05$, comparing one month after CAPD with six months after CAPD.
$^{\circ\circ}p<0.01$ and $^{\circ}p<0.05$, comparing before CAPD with six months after CAPD.

declined one month after dialysis. No significant change in ICW was observed. As shown in Figures 1 and 2, over the subsequent five months of dialysis, the weight, ECW, ICW, TBW and NECW levels displayed a revived upward trend.

Changes in Blood Pressure

One month after CAPD, patients' systolic and mean arterial blood pressure returned to normal (SBPpre = 150.53 ± 24.35mmHg and SBPpost = 137.08 ± 18.19 mmHg, $p<0.01$. MBPpre = 104.73 ± 15.55 mmHg and MBPpost = 98.49 ± 12.16 mmHg, $p<0.05$). Over the subsequent five months, SBP, diastolic blood pressure, and mean arterial pressure remained stable at normal levels (Figure 3). Also, both the use and dosage of antihypertensive drugs decreased following dialysis (data not shown).

Peritoneal Ultrafiltration and Residual urine Volume

Compared the date collected two months after the CAPD and that of six months after, there was no significant difference in the peritoneal ultrafiltration, urine volume and the total fluid production on a 24 hours' base ($p>0.05$. Data not shown).

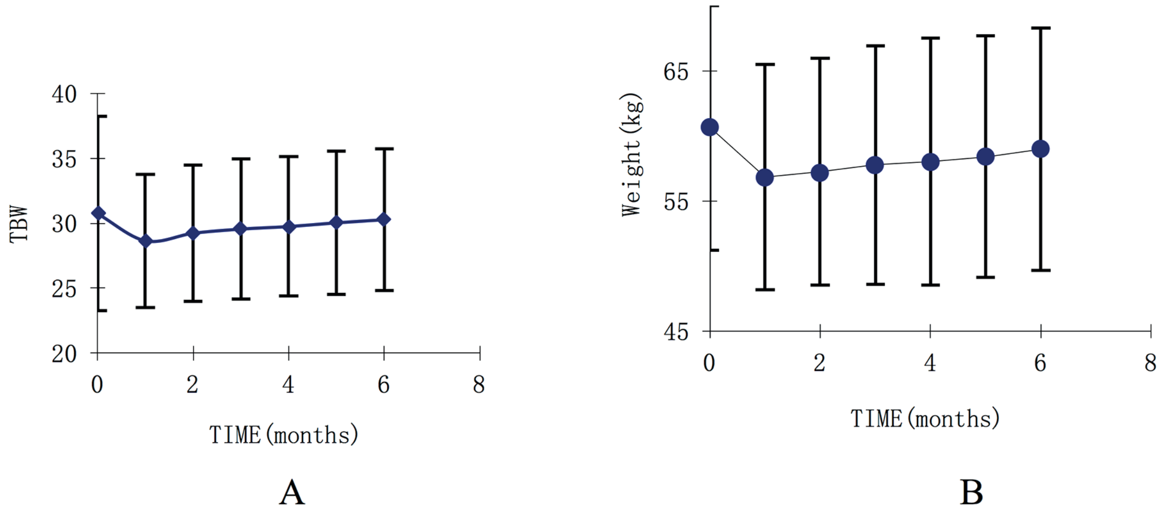

Figure 2. Changes in total body water ***(A)*** and weight ***(B)*** in patients undergoing CAPD for up to six months.

Intake of Dietary Protein and Calories

Our data from monthly dietary assessment showed no significant difference in the total daily dietary protein intake in patients between the second month and the sixth month after dialysis ($p>0.05$, Figure 4A). As illustrated in Figure 4B, the caloric intake in the sixth month was significantly higher than that in the second month following dialysis (1663.48±696.92 Kcal/d *vs.* 1326.79±536.17 Kcal/d, $p<0.05$).

Discussion

For many years, the adequacy of peritoneal dialysis has been focused on solute clearance. However, since most peritoneal dialysis patients that die do so from complications of cardiovascular disease, attention has gradually shifted toward the fluid status of CAPD patients. Water balance has become an important part of peritoneal dialysis adequacy. Many researches have showed that it is very sensible to apply bioelectrical impedance to continuously monitor dynamic variations of intracellular fluid and extracellular fluid, and quite proper to use it in the detection of changes in body fluids[16,17].

It is generally accepted that in the early stages of CAPD, water balance is easier to control due to the presence of residual renal function. Only when residual renal function is in decline, or at a loss, does a patient's water balance start to display obvious disorders. Previous studies have also found that CAPD patients have well-controlled blood pressure in the early stages, but when residual renal function declines, patients are prone to high blood pressure. This work used the bioelectrical impedance method to continuously monitor intracellular fluid and extracellular fluid changes in patients who underwent CAPD treatment for no less than six months. Results show that within six months of peritoneal dialysis treatment, the

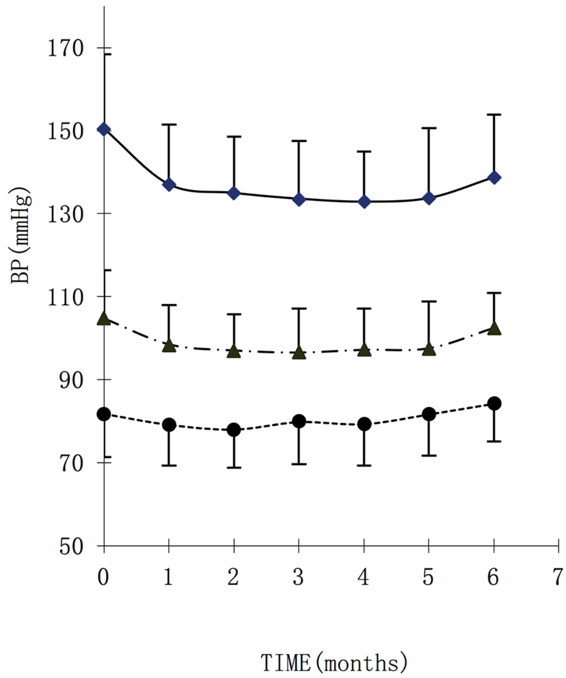

Figure 3. Changes in blood pressure in patients undergoing CAPD for up to six months.

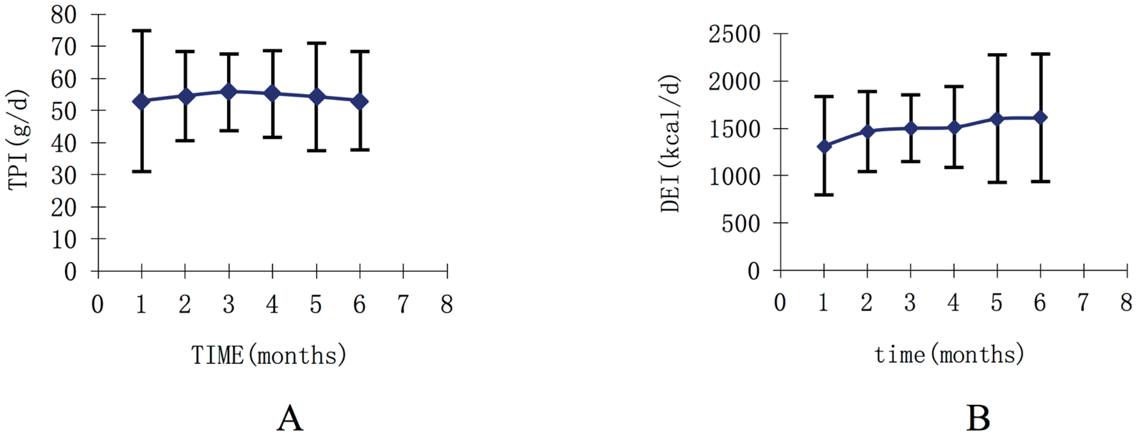

Figure 4. Profiles of dietary protein intake (A) and calorie intake (B) in patients undergoing CAPD for up to six months.

majority of patients' fluid status demonstrates a progressive increase, specifically indicated by progressive weight gain, intracellular fluid, extracellular fluid, general fluid and marked extracellular fluid (Figure 2). Dietary assessment showed that within six months after CAPD, patients' dietary protein intake was relatively stable, and caloric intake increased progressively. Changes in calorie intake recorded 1 month and 6 months after treatment were significantly different ($p<0.05$, Table I). However, total water discharge (including peritoneal and residual renal), on a 24 hours' basis, within six months after CAPD, showed no significant difference.

The results of this paper suggest that, in the early stages, CAPD patients' increased water load is related to increased dietary intake. For those patients who had chronic renal failure, symptoms of uremia were significantly improved, since large amounts of toxins were cleared from the body during the early stages of this treatment, following the initial non-dialysis period. Patients' gastrointestinal symptoms disappeared, appetite improved, dietary intake increased, and, accordingly, water and salt intake may also increase. These are common phenomena. Weight gain can easily be considered a pure result of improvement in the patients' nutritional status. However, our data also show that patients' overall fluid volume and marked extracellular fluid significantly increased within six months following dialysis ($p<0.05$, Table I). Therefore, although weight gain is partially attributable to improved nutritional status, water overload is also a significant contributing factor.

Continuous observation of blood pressure showed that, one month after receiving CAPD treatment, for patients with chronic renal insufficiency and uremia, systolic blood pressure was significantly lower than before dialysis ($p<0.05$, Table I), as fluid overload status improved. However, between the second month and sixth months following the dialysis, although water load was increasing, blood pressure was not on the rise but stabilized at normal blood pressure range. There was no relationship between this phenomenon and the use of antihypertensive drugs. It was generally believed that the water load capacity of CAPD patients was closely related to the blood pressure. Currently, there is no satisfactory explanation for the disconnection between increased water overload and blood pressure in our study, but it is worth further investigation.

Conclusions

The results of this study indicate that during the early stages of peritoneal dialysis, CAPD patients' water load increases with the improvement of uremic symptoms, the disappearance of gastrointestinal symptoms and the increase of caloric intake. Weight gain, in the early stages of the CAPD treatment, is more likely a result of increased water load rather than entirely a result of improved nutrition. These findings suggest that early control of water and salt intake is important for CAPD patients and will help reduce the prevalence of cardiovascular complications.

Acknowledgements

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Conflict of interest

The authors declare no conflicts of interest.

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