Original Article
Metabolic status and personality affect the prognosis of patients with continuous ambulatory peritoneal dialysis

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Abstract: Continuous ambulatory peritoneal dialysis (CAPD) is recognized as an effective and economical therapy for end-stage renal disease (ESRD). However, the drop-out and mortality rates of this treatment remain high. The aim of the present study was to investigate the potential effects of metabolic status and personality on the prognosis of ESRD patients receiving CAPD. A total of 835 patients (455 men and 380 women) were enrolled in the cross-sectional survey. Analysis of variance and Spearman correlations were used to analyze variables in two groups of ESRD patients: group L (dialysis duration < 3 years) and group H (dialysis duration ≥ 3 years). The variables included gender, age, duration of dialysis, primary diseases, blood pressure, body mass index (BMI), hemoglobin (Hb), serum albumin, Subjective Global Assessment (SGA), blood lipids, fasting blood glucose, renal function, immunoreactive parathyroid hormone (iPTH), serum phosphorus and calcium, erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), Kt/V, and Life Orientation Test-Revised (LOT-R) scores. Levels of DBP, BUN, glucose, CRP, SBP, SGA, TG, LDL, creatinine, iPTH, ESR, and LOT-R scores were significantly higher in group H than in Group L, whereas Hb and Kt/V were significantly lower in group H. The dialysis duration was positively correlated with the blood pressure, SGA scores, TG, LDL, PTH, CRP, and LOT-R scores, but negatively correlated with Kt/V. Our results suggest that hypertension, anemia, hypoproteinemia, SGA, TG, LDL, iPTH, CRP, Kt/V, and personalities are potentially important factors affecting the prognosis of ERSD patients with CAPD.

Keywords: Continuous ambulatory peritoneal dialysis, nutrition, inflammation, dialysis adequacy, personality
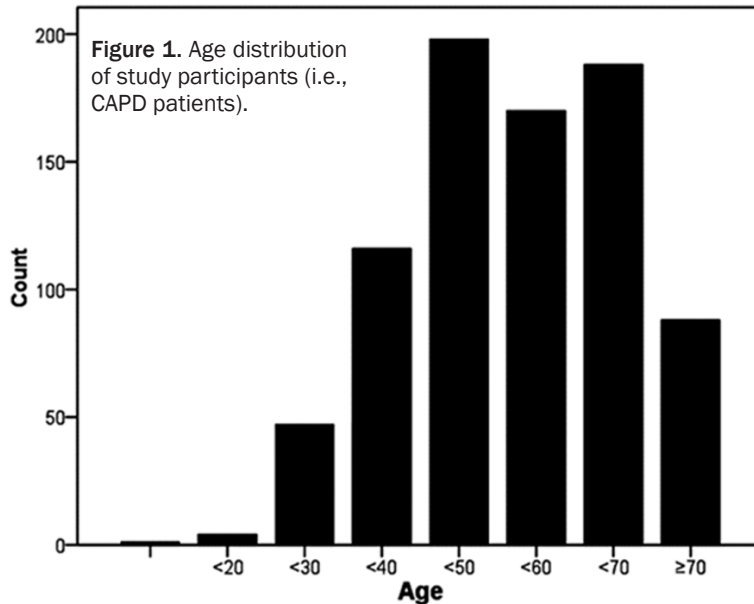
Introduction

According to the United States Renal Disease System (USRDS) Annual Report, there were 115,643 end-stage renal disease (ESRD) patients in the US in 2011. In 2010, ESRD was found to affect 1-2 million patients in China [1], and it is considered to be a heavy burden on families and society. In the early 1980s, continuous ambulatory peritoneal dialysis (CAPD) was promoted as an effective and economical therapy for ESRD in China that would save medical resources. Along with technological advancements over time and the increase in the number of patients requiring treatment, peritoneal dialysis catheter placement tech-

niques and the prevention and treatment of peritoneal dialysis-related peritonitis have improved greatly. However, there has been little change in the high drop-out rate from CAPD and mortality. The lifespan and the quality of life of patients on CAPD still needs to be improved, and these are the major concerns of nephrologists internationally.

Sinangil et al. conducted a retrospective study of CAPD patients in Turkey and found that anemia, hypoproteinemia, and inflammation were responsible for elevated mortality in 301 patients with CAPD [2]. In a prospective study conducted by Huang, diminished appetite, diabetes mellitus, and hypoproteinemia were

Figure 1. Age distribution of study participants (i.e., CAPD patients).

Hospital of Shaoyang, Central Hospital of Yiyang, Central Hospital of Chenzhou, First Renmin Hospital of Huihua, and Central hospital of Xiangtan. All the participants signed written informed consent forms before their participation in the study. The average time of therapy with CAPD in the region is 3 years. Therefore, the participants were divided into two groups according to the duration of dialysis: group L (< 3 years) and group H (≥ 3 years).

Patients who met the following inclusion criteria were recruited to the study: (1) patients undergoing CAPD for ≥ 3 months; and (2) the CAPD delivery system consisted of dianeal PD-2 and low calcium peritoneal dialysis solutions using an ultrabag system (Baxter, US), with a 1.5% or 2.5% solution of glucose and a daily dialysis volume of over 6 L. Patients were excluded from the study if they met any of the following exclusion criteria: (1) peritonitis within 1 month before the commencement of data collection; (2) severe heart failure, severe cerebrovascular disease, active hepatitis, unstable angina, acute pulmonary edema, or accidents, such as trauma or surgery; or (3) mental disorders or severe hearing and/or vision dysfunction.

found to be independent predictors of mortality in 98 patients receiving PD in Beijing, China [3]. Leinig et al., who studied CAPD in 199 Brazilian patients, found that nutritional markers, such as SGA and Alb, were related to mortality rates [4]. In another study, severe hypocalcemia was found to be a risk factor for heart failure and pulmonary edema to affect the mortality rate [5]. Interestingly, studies have noted that the personality of patients undergoing PD was associated with their hospitalization rate, quality of life, and prognosis [6-8]. Thus, the potential factors affecting the prognosis of patients receiving PD may be their nutritional status, calcium and phosphorus metabolism, inflammation status, dialysis adequacy, and psychological factors. Yet, there has been no investigation that has included all these factors in patients receiving PD in China. Here, we conducted a cross-sectional survey of the general conditions, nutritional status, inflammation levels, dialysis adequacy, and personality of patients on CAPD in six PD centers in Hunan China.

Materials and methods

Subjects

We recruited 835 patients with CAPD who visited six peritoneal dialysis centers in Hunan, China, from September to December 2012. The dialysis centers were affiliated with the Third Xiangya Hospital of Hunan, Central

Data collection

1. Patient data, including gender, age, academic degree, duration of PD, primary diseases, and blood pressure levels at follow-up, were collected.

2. Peripheral blood samples (4 mL) were obtained from each patient to perform the following measurements: serum albumin levels using an automatic biochemical analyzer; renal functional analyses; and serum lipid levels. Blood urea nitrogen (BUN) and creatinine (CR) levels were measured in 24-h PD fluid and urine. The Kt/V value was calculated, and the levels of intact parathyroid hormone (iPTH) and hypersensitive CRP were determined by chemiluminescence.
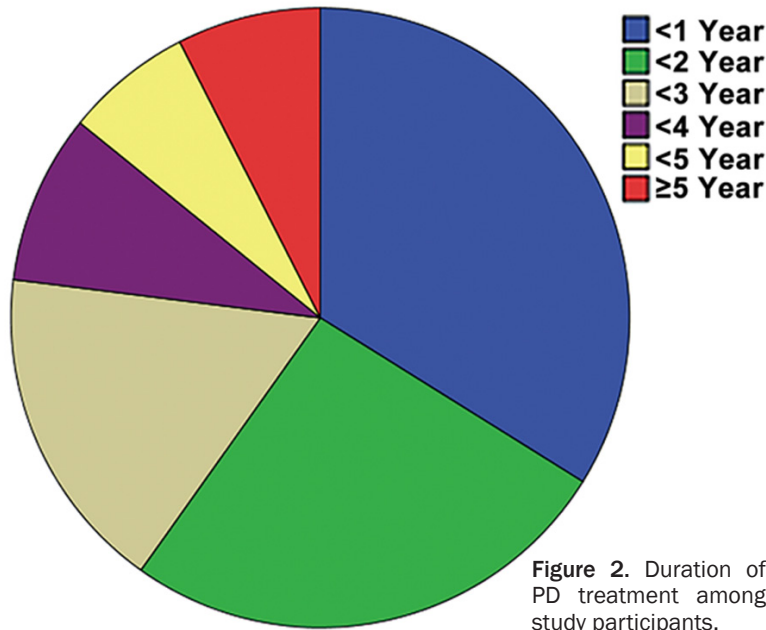
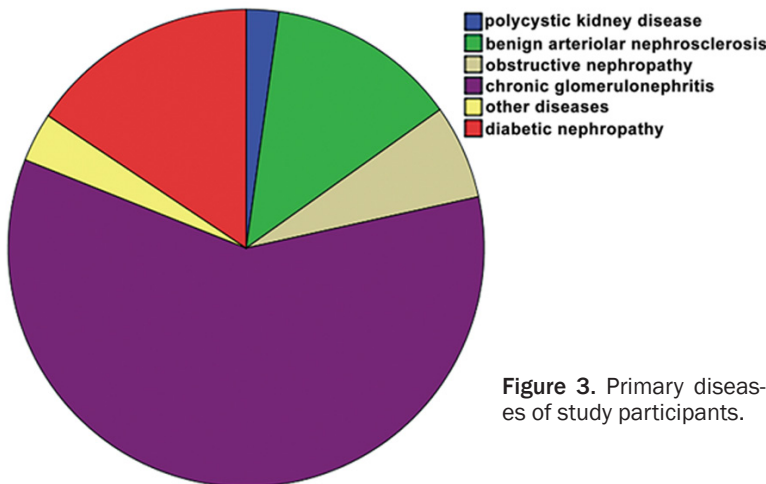Figure 2. Duration of PD treatment among study participants.

Figure 3. Primary diseases of study participants.

ables were presented as means ± SD, and comparisons between groups were tested by one-way analysis of variance (ANOVA). Spearman's correlations were performed between the duration of dialysis treatment and each of the other variables.

Results

General characteristics

The ratio of male to female participants was 1.2:1, with 455 men and 380 women. The mean age of the participants was 51.9 ± 14.3 years. **Figure 1** presents the age distribution of the sample. The median duration of dialysis was 23.6 ± 19.7 months (see **Figure 2**). The most common primary disease was chronic glomerulonephritis (59.2%), followed by diabetic nephropathy (15.6%), benign arteriolar nephrosclerosis (12.7%), obstructive nephropathy (6.0%), polycystic kidney disease (2.3%), and other diseases, such as gouty nephropathy, Sjogren's syndrome, systemic lupus erythematosus, hepatitis B virus-associated nephropathy, vasculitis, sponge kidney, and congenital kidney malformations (4.2%), as shown in

3. The improved SGA form [9] was completed by recording patient parameters, such as BMI, diet changes, gastrointestinal symptoms, activities, the results of a physical examination. Higher scores represent poorer nutritional status.

4. A modified LOT-R scale form was completed. The form was scored on a scale of 0-6 with "Yes" or "No" options. A higher score on the LOT-R scale indicates a more optimistic personality [10].

Statistical analysis

All statistical analyses were performed using SPSS 19.0 software. Normally distributed vari-

Figure 3. The mean SBP and DBP were 143 ± 15 mmHg and 84 ± 11 mmHg, respectively. The blood pressure of approximately 35.2% of the patients was controlled under 140/90 mmHg. An ANOVA found that the mean blood pressure in the group H patients was significantly higher than in the group L patients ($P < 0.05$) (**Table 1**).

Nutritional status

The mean BMI of the patients was 22.6 ± 3.0 kg/m^2; and the BMI of 6% of the patients was < 18.5 (**Table 1**). The mean Hb level was 90.8 ± 19.4 g/L and the incidence of anemia was 83.3% (**Figure 4**). The serum albumin level was 33.1 ± 6.6 g/L, and the incidence of hypopro-

Table 1. General and clinical characteristics of patients on CAPD in peritoneal dialysis centers

	Total	Group L (n)	Group H (n)	P
Gender (male:female)	462:373	319:256 (575)	143:117 (260)	0.492
Age (years)	51.9 ± 14.3	50.6 ± 14.4 (575)	53.3 ± 14.0 (260)	0.098
SBP	143 ± 15	140.7 ± 14.8 (575)	148.4 ± 15.2 (260)	0.005Δ
DBP	84 ± 11	83.1 ± 10.1 (575)	86.5 ± 11.6 (260)	0.045*
BMI (kg/m^2)	22.6 ± 3.0	22.5 ± 2.9 (560)	23.2 ± 3.8 (237)	0.407
Hb (g/L)	90.8 ± 19.4	93.7 ± 20.1 (575)	86.9 ± 17.9 (260)	0.024*
Alb (g/L)	33.1 ± 6.6	33.3 ± 6.5 (558)	33.0 ± 6.8 (221)	0.891
GLU (mmol/L)	5.5 ± 2.4	5.4 ± 2.1 (575)	6.0 ± 3.0 (260)	0.017*
BUN (mmol/L)	18.1 ± 5.6	17.8 ± 5.4 (575)	18.8 ± 6.0 (260)	0.03*
CRE (μmol/L)	903 ± 347	856±343 (575)	1014 ± 329 (260)	0.00Δ
SGA	12.0 ± 4.8	11.9±3.2 (575)	13.6 ± 2.6 (260)	0.00Δ
Total cholesterol	4.3 ± 1.5	4.3 ± 1.4 (485)	4.5 ± 1.7 (205)	0.128
Triglycerides (mmol/L)	1.8 ± 0.9	1.6 ± 1.1 (485)	2.3 ± 2.0 (205)	0.00Δ
LDL (mmol/L)	2.4 ± 1.0	2.4 ± 1.0 (575)	2.7 ± 1.2 (260)	0.006Δ
iPTH (pg/mL)	298.4 ± 239.4	282.6 ± 229.9 (536)	473.7 ± 359.2 (235)	0.00Δ
P (mmol/L)	1.6 ± 0.3	1.6 ± 0.3 (335)	1.6 ± 0.3 (160)	0.603
Calcium phosphorus product (mg^2/dl^2)	39.8 ± 8.8	39.7± 8.8 (450)	39.9 ± 8.6 (220)	0.894
Ca (mmol/L)	2.1 ± 0.2	2.1 ± 0.2 (335)	2.1 ± 0.2 (160)	0.711
CRP (mg/L)	3.6 ± 2.3	3.4 ± 2.3 (502)	3.9 ± 2.0 (189)	0.018*
ESR (mm/h)	73.5 ± 28.3	70.2 ± 27.6 (462)	87.2 ± 27.1 (229)	0.002Δ
Kt/V	2.0 ± 0.4	2.4 ± 1.0 (466)	1.9 ± 0.5 (201)	0.00Δ
LOT score	3.5 ± 0.9	3.5 ± 0.9 (467)	3.7 ± 0.9 (204)	0.005Δ

Note: *represents $P < 0.05$; Δrepresents $P < 0.01$.

teinemia was 55.7%. The SGA score was 12.0 ± 4.8, and about 14.1% of the population had a score of ≥ 16 (**Figure 5**). The TG level was 1.8 ± 0.9 mmol/L, the total cholesterol level was 4.3 ± 1.5 mmol/L; LDL, 2.4 ± 1.0 mmol/L, and fasting blood glucose was 5.5 ± 2.4 mmol/L. The renal functional indicators BUN and CR were 18.1 ± 5.6 mmol/L and 903 ± 347 mmol/L, respectively. The incidence of dyslipidemia was 54.7%. ANOVAs found that compared to patients in group L, patients in group H had reduced Hb levels ($P < 0.05$), but higher levels of GLU, BUN ($P < 0.05$), SGA, TG, LDL, and CR ($P < 0.01$) (**Table 1**).

Calcium and phosphorus metabolism

The average iPTH level in PD patients was 298.4 ± 239.4 pg/mL. Of these, the iPTH levels of 22.0% were < 150 pg/mL, and those of 45.8% were > 300 pg/mL. The serum phosphorus level was 1.6 ± 0.3 mmol/L, with a control compliance rate of 53%. The serum calcium level was 2.01 ± 0.2 mmol/L, with a control compliance rate of 48.6% (**Table 1**).

The calcium-phosphate product was 39.8 ± 8.8 mg^2/dl^2. ANOVAs found that iPTH levels were significantly higher in group H than in group L (**Table 1**).

Inflammation status

The mean ESR level was 73.5 ± 28.3 mm/h, and the average CRP value was 3.6 ± 2.3 mg/L. ANOVAs found that the ESR ($P < 0.01$) and CRP ($P < 0.05$) levels were significantly higher in group H patients than in group L patients (**Table 1**).

Dialysis adequacy

The average value of urea clearance Kt/V was 2.0 ± 0.4, and ANOVAs found that the average value of urea clearance was significantly lower in group H than in group L ($P < 0.01$) (**Table 1**).

Personality

The LOT-R score was significantly higher in the healthy population without chronic diseases
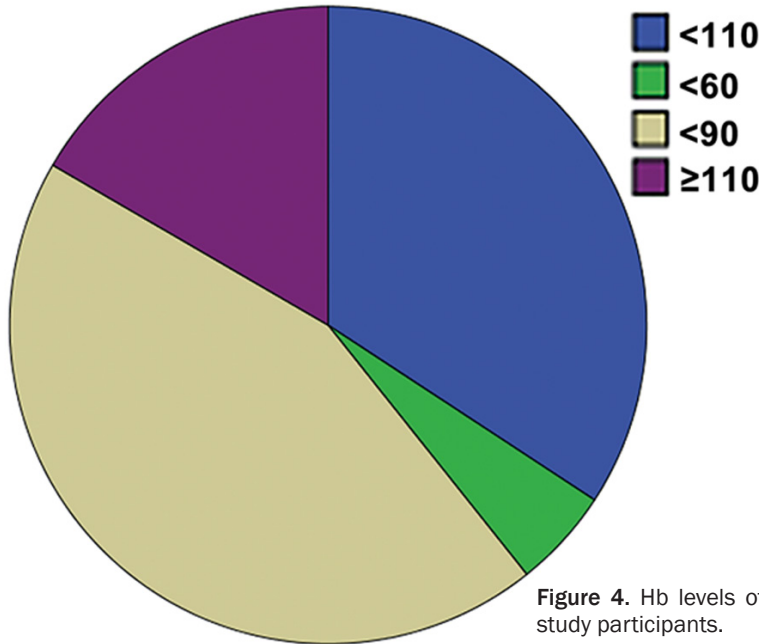
Figure 4. Hb levels of study participants.
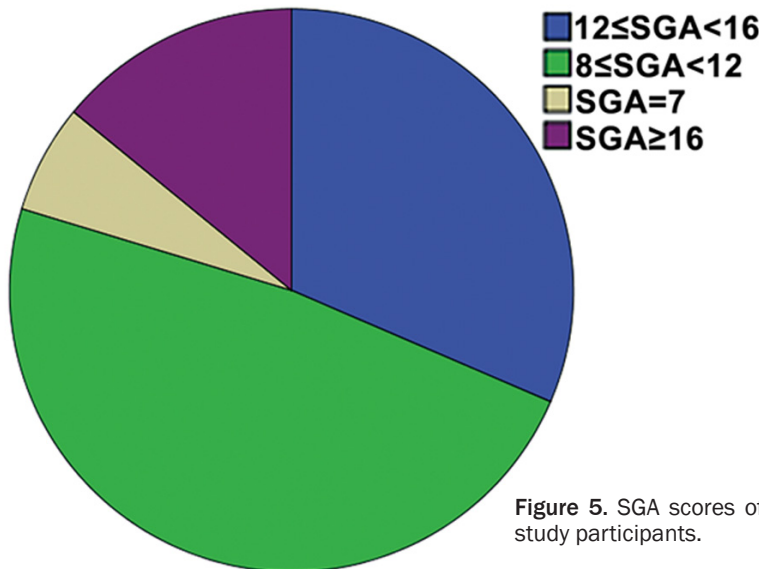
Figure 5. SGA scores of study participants.

the SBP (*rho* = 0.247, *P* < 0.001), DBP (*rho* = 0.165, *P* < 0.001), SGA scores (*rho* = 0.247, *P* < 0.001), TG (*rho* = 0.139, *P* < 0.01), LDL (*rho* = 0.112, *P* < 0.05), PTH (*rho* = 0.102, *P* < 0.01), CRP (*rho* = 0.160, *P* < 0.001), and LOT-R scores (*rho* = 0.102, *P* < 0.05), but negatively correlated with Kt/V (*rho* = -0.101, *P* < 0.05) (**Table 2**).

Discussion

According to an unofficial report from Baxter (China) Investment Co. Ltd, Hunan Province is the sixth highest province in China in terms of the number of patients receiving PD. We aimed to investigate the metabolic status and personalities of patients on CAPD and analyze the variables that potentially affect the prognosis of patients on CAPD in order to devise corresponding strategies and construct appropriate regulations based on the results of the investigation.

The compliance rate for blood pressure control was 35.2% in our province, which is lower than that reported by Huashan Hospital of Fudan University in Shanghai [11]. This might be due to the excess dietary sodium intake among residents of this region, which is approximately 12 g per day [12]. Blood pressure levels were much higher in group H than in group L, and they were positively correlated with the duration of dialysis, indicating that patients with a longer duration of PD might experience increased sodium and water retention, further activation of the RAS system, hardening of the arteries, reduction of residual renal function, and decreased levels of vasodilating agents, all of which may have contributed to the considerably higher blood pressure levels in the Group H. Hypertension is one of the factors that indicates the volume status

(4.4 ± 1.1) than in the patients on CAPD (*P* < 0.01). In the current study, the CAPD patients scored 3.5 ± 0.9, and ANOVAs found that the LOT-R score was significantly elevated in group H compared to the score in group L (*P* < 0.01) (**Table 1**).

Correlations between peritoneal dialysis duration and other variables

Spearman correlations revealed that the duration of dialysis was positively correlated with

Table 2. Spearman correlations between dialysis duration and each of the other variables

	rho	P
SBP	0.247	0.000
DBP	0.165	0.000
SGA	0.247	0.000
TG	0.139	0.003
LDL	0.112	0.012
PTH	0.102	0.008
CRP	0.160	0.000
LOT-R	0.102	0.046
Kt/V	-0.101	0.035

of patients on CAPD, and it is strongly correlated with the development of renal diseases, cardiovascular complications, and long-term prognosis [13, 14]. It is essential to strengthen our management of sodium and water intake, preserve residual renal function, and monitor hardening of the arteries in CAPD patients to control blood pressure.

The mean Hb level in our study participants was 90.8 ± 19.4 g/L, whereas the annual USRDS report stated that the value was 97 g/L in CAPD patients. Compared to patients in group L, those in group H had reduced Hb levels ($P < 0.05$). Anemia may result in cacochylia, hypoxia, and cardiac function insufficiency, affecting the prognosis of patients [15], although the level of anemia is not correlated with dialysis treatment duration. The level of anemia is also related to the use of anti-anemia drugs. The "Kidney Disease Outcomes Quality Initiative" guidelines (KDOQI guidelines) of the National Kidney Foundation that were published in 2009 emphasized the importance of intravenous (IV) iron therapy. However, this has been applied in less than 70% of CAPD patients in our province. The guidelines also recommended subcutaneous injection of 100-120 IU/kg per week of recombinant human erythropoietin (hEPO). However, less than 85% of the patients in our study used recombinant hEPO, and the applied dosage was less than 4,000 units/week. Therefore, we should improve information dissemination and education about the importance of anti-anemia drugs and monitor their actual application in clinical practice.

Hypoproteinemia is another problem in patients on CAPD. A recent multicenter research in Honking University indicated that the average

serum albumin level was 36.8 ± 3.6 g/L in PD patients in Tung Wahl Hospital [16]. In our province, the average serum albumin was found to be 33.1 ± 6.6 g/L, and the incidence of hypoproteinemia in CAPD patients was 55.7%. Although there were no differences between the Group L and H and no correlation with dialysis duration, hypoproteinemia is also one of the potential factors affecting the prognosis of patients. Because hypoproteinemia is associated not only with malnutrition, but also with volume capacity, loss of the proteins in dialysis solutions, and inflammation, it plays a role in mortality among patients receiving CAPD [17-19]. Therefore, clinicians should diagnose the primary diseases as early as possible and administer treatment as appropriate, once hypoproteinemia is identified in CAPD patients.

The SGA method is based on a patient's history and a physical examination to evaluate nutritional status, and it is a highly reliable method for assessing nutrition-associated complications. It is simple, easy to use, has few affecting factors, and fulfills the requirements of testing. Thus, it is widely used in the nutritional assessment of CAPD patients [20]. Jia et al. evaluated SGA scores in 87 patients on CAPD and found that 11.49% of them had severe malnutrition [21]. In our study, 15.7% of CAPD patients suffered from severe malnutrition. The group H patients showed significantly higher scores than the group L patients and the scores are correlated with dialysis duration. The SGA method mainly serves as a subjective method of assessing nutrition to assist clinical judgment. In our investigation, the TG and LDL were significantly higher in Group H and were positively correlated with dialysis duration. Seirafian found the that serum leptin level was positively correlated with renal Cr Cl in CAPD patients, and it was associated with the prognosis of the CAPD patients [22].

There were 46.96% and 45.8% of patients with hyperparathyroidism in the First Affiliated Hospital of Zhongshan University and in our province, respectively [15]. According to the KDOQI guidelines published in 2009, the compliance rates for serum phosphorus and calcium control were 53% and 48.6%, respectively, and 32.2% of patients had their iPTH levels under control. Along with the PD duration, serum phosphorus and calcium were not significantly different in our sample, but iPTH lev-

els increased significantly and were positively correlated with dialysis duration. Research has indicated that lower and higher PTH concentrations are both associated with the risk of death in PD patients [23]. It is one factor affecting the prognosis. In our peritoneal dialysis center, calcitriol treatment is regularly used, which can subsequently reduce the general symptoms of PD patients, such as itching and rash, and facilitate the improvement of quality of life.

Our study found that CRP was significantly higher in Group H, and it was positively correlated with dialysis duration. The results of the present study show the importance of HS-CRP in the prediction of 2-year mortality and treatment survival in PD patients independent of age, diabetes, hypoalbuminemia, and the occurrence of cardiovascular events [24].

Kt/V is the index that indicates the efficacy of CAPD. Our study shows that Kt/V is significantly lower in Group H and negatively correlated with dialysis duration. Therefore, it is one of the factors that can potentially affect the prognosis of CAPD patients.

A study by García demonstrated that PD patients with optimistic personality were more likely to be healthier [8]. Our study indicated that LOT-R scores were significantly and positively correlated with duration of dialysis, and that the patients in group H, which had a longer PD duration, had a tendency to have a more optimistic personality than the patients in group L. We presume that having an optimistic personality helped patients to overcome difficulties during CAPD treatment, promoted patient compliance, contributed to prolonged lifespan, and improved quality of life. It is necessary to observe the patient's mental status during CAPD treatment and provide appropriate humane care, consistent with different personalities, to increase patient compliance.

Overall, based on the findings of our study, we conclude that hypertension, anemia, hypoproteinemia, SGA, TG, LDL, iPTH, CRP, Kt/V, and personality are potential factors affecting the prognosis of patients on PD. Thus, the management of anemia, nutrition, and sodium-water electrolyte homeostasis in patients on CAPD should be improved in peritoneal dialysis centers. Moreover, we should give more attentions to the psychological status of CAPD patients.

Disclosure of conflict of interest

None.

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