Original Paper

Association Between Comprehensive Nutritional Scoring System (CNSS) and Outcomes of Continuous Ambulatory Peritoneal Dialysis Patients

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Key Words

Peritoneal dialysis • Nutritional marker • Scoring system • Outcome • Mortality

Abstract

Background/Aims: The presence of protein–energy wasting (PEW) among dialysis patients is a crucial risk factor for outcomes. The complicated pathogenesis of PEW makes it difficult to assess and treat. This single-center retrospective study focuses on the association between nutritional markers and the outcomes of continuous ambulatory peritoneal dialysis (CAPD) patients, aiming to establish a practical comprehensive nutritional scoring system for CAPD patients. **Methods:** 924 patients who initiated peritoneal dialysis in our center from January 1st, 2005 to December 31st, 2015 were enrolled. Comprehensive nutritional scoring system (CNSS) was based on items including SGA, BMI, ALB, TC, MAC and TSF. We divide patients into 3 groups according to their CNSS score. Outcomes including mortality, hospitalization days and hospitalization frequency were compared between 3 grades. **Results:** The CNSS grade correlated significantly with hospitalization days ($P < 0.05$). Both categorized CNSS grade (HR: 0.56; 95% CI: 0.41–0.78; $P = 0.001$) and continuous CNSS score (HR: 0.87; 95% CI: 0.80–0.94; $P = 0.001$) independently protect PD patients from all-cause mortality. **Conclusion:** CNSS provides an integrated scoring system with significant associations with hospitalization and mortality in PD patients. The CNSS grade differentiates patients with malnutritional risk and independently predicts high risk of morbidity and mortality.

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Introduction

The term protein-energy wasting (PEW), recommended by the panel from the International Society of Renal Nutrition and Metabolism (ISRNM), describes the status of 'malnutrition' among patients with chronic kidney disease (CKD) or acute kidney injury (AKI) [1]. According to different assessing methods, the prevalence of PEW in patients on dialysis ranges from 18% to 56% [1-5]. The causes of PEW in dialysis patients include inflammation, inadequate protein and calorie intake, suppressed appetite, loss of residual renal function (RRF), loss of protein during dialysis, psychosocial factors, physical inactivity and comorbid conditions [6-10]. The complicated pathogenesis of PEW makes it difficult to assess and treat. Accumulating evidence has indicated that PEW is an important predictor of morbidity and mortality in patients on dialysis and impairs quality of life [11-14]. Therefore, it is valuable for the patients on peritoneal dialysis to detect the PEW in early stage and appropriate intervention provided.

Traditional nutritional indicators include serum biochemical markers such as albumin (ALB), pre-albumin (Pre-ALB), total cholesterol (TC), transferrin and creatinine (Cr), anthropometric parameters such as triceps skinfold (TSF) and mid-arm circumference (MAC), body mass index (BMI), bioelectrical impedance analysis (BIA), and dietary investigation [15-27]. Most of these parameters have been widely used in clinical practice. However, there is a growing awareness that no single marker is viable to represent the nutritional status of an individual, for the inevitable influence of acute inflammation and body capacity fluctuation.

Subjective global assessment (SGA), standing for the subjective scoring system, has been widely used to assess the nutritional status of patients with end stage renal disease (ESRD). Consisting of medical history and physical examination [28], SGA is considered as a reliable and effective method to evaluate nutritional condition [29, 30]. Although recommended by K/DOQI in 2000 for evaluation of PEW in ESRD patients, SGA remains limited in clinical practice due to its semi-quantitative and completely subjective nature.

In 2001, Kalantar Zadeh et al. established a completely quantitative scoring system based on the SGA, named Malnutrition-Inflammation System (MIS). In the subsequent research studies, MIS, consistent with morbidity, mortality and a great number of nutritional markers including inflammation, anemia and insulin resistance, was proven to be a better nutritional indicator compared with SGA [31, 32]. Yet because of the complexity of MIS, it is not widely utilized around dialysis centers worldwide.

In 2008, ISRNM proposed that PEW is clinically diagnosed if at least three out of the four listed categories are satisfied: serum chemistry, body mass, muscle mass and dietary intake. Optimally, each criterion should be documented on at least three occasions, preferably 2-4 weeks apart [1]. In addition to the readily utilizable criteria, the panel also encouraged other potential tools for assessing and monitoring PEW in CKD patients as well as developing nutritional scoring system as alternative indicators.

Considering the significance of assessing PEW among PD patients and the current lack of standard diagnosing criteria, this study aims to screen out valuable markers or indicators and to design a new comprehensive nutritional scoring system (CNSS) for assessing and diagnosing PEW in patients undergoing peritoneal dialysis (PD).

Materials and Methods

Population

We enrolled all incident patients starting CAPD therapy at the First Affiliated Hospital of Zhejiang University between January 1, 2005 and December 30, 2015. The exclusion criteria were an age below 18 years at the initiation of PD therapy, a follow-up of less than 90 days, and lack of data of the nutritional components.

Clinical Data Collection

Clinical data were collected from our regularly updated computerized records. Baseline demographic and clinical data, including gender, age, body mass index (BMI), primary kidney disease, blood pressure (BP), and comorbid conditions were collected. The Charlson comorbidity index (CCI) was calculated according to presence of each comorbidity [33].

Anthropometric measurements

BMI, Triceps skinfold thickness (TSF) and Mid-arm circumference (MAC) were picked up as three anthropometric markers to compose the CNSS. BMI was calculated as weight in kilogram divided by the square of height in meter. TSF was measured with a skinfold caliper by anthropometrists. MAC was measured with a plastic measuring tape. Anthropometric norms for dialysis patients were previously reported [34, 35].

Laboratory measurements

The collected laboratory data included baseline serum albumin (ALB), triglycerides (TG), total cholesterol (TC), high-density lipoprotein cholesterol (HDL-C), low-density lipoprotein cholesterol (LDL-C), very-low-density lipoprotein cholesterol (VLDL-C), uric acid (UA), phosphates (P), calcium (Ca), alkaline phosphatase (ALP), potassium (K), C-reactive protein (CRP), hemoglobin (HB), and parathyroid hormone (PTH). All the biochemical parameters were assessed in the center laboratory of our hospital.

Subjective global assessment (SGA)

Subjective global assessment was calculated according to dietary intake, weight loss, gastrointestinal symptom and subcutaneous fat loss with a maximum score of 7 in each item and 28 in total. Using SGA, a score of 24–28 indicates normal nutritional status of the patient (Grade A); a score of 15–23 indicates moderate nutritional risk (Grade B), and a score of <22 indicates an unsatisfactory nutritional status of patients (Grade C).

Comprehensive Nutritional Scoring System (CNSS)

With the purpose of developing a scoring system integrating subjective and objective assessments, we created the Comprehensive Nutritional Scoring System (CNSS) by combining SGA grade with three anthropometric measurements (BMI, MAC and TSF) and two laboratory markers (serum albumin and total cholesterol). The CNSS, therefore, was composed of six components. Each of them is categorized into three categories marking from 1 to 3 (Table 1).

Note that ALB and MAC are independent protective factor of all-cause mortality ($P < 0.05$), we give them greater weight while calculating total CNSS score (CNSS score = SGA score + BMI score + 2*ALB score + TC score + 2*MAC score + TSF score), corresponding to their profound effect on all-cause mortality of peritoneal dialysis patients.

To distinguish moderate and severe malnourished patients from well-nourished ones, we divide all them into three grades. A CNSS score of 28–32 indicates normal nutritional status (CNSS Grade 1); a score of 23–27 indicates moderate nutritional risk (CNSS Grade 2), and a score of <22 indicates an unsatisfactory nutritional status of PD patients (CNSS Grade 3).

Outcome Event

The primary outcome of interest was all-cause mortality and cardiovascular (CV) mortality, infection-related mortality was considered as the secondary outcome of interest. Survival status was censored on December 31, 2015, for the patients who were still on PD therapy in our center.

Statistical analysis

Continuous variables are presented as the means and the standard deviations or the medians with the interquartile ranges, and categorical variables are presented as frequencies with percentages. Differences between different CNSS grades were examined with one-way ANOVA, Kruskal-Wallis, or chi-square tests as appropriate. Survival analyses were performed using the Kaplan-Meier Survival Curve, and the groups were compared using a log-rank test. The censored events included kidney transplantation, transfer to

Table 1. Components of Comprehensive Nutritional Scoring System(CNSS). Six components are respectively scored as 1, 2 and 3. Multivariate Cox regression analysis including all the six components reveals that ALB and MAC are independent protective factor of all-cause mortality (P<0.05)

Components	Score	1	2	3	P
SGA Grade		C	B	A	0.500
BMI(kg/m ²)	Male	< 16.5	≥16.5 and <19	≥19	0.910
	Female	< 17	≥17 and <20	≥20	
MAC(cm)	Male	< 20	≥20 and <25	≥25	0.003
	Female	< 19	≥19 and <23	≥23	
TSF(mm)	Male	< 10	≥10 and <13	≥13	0.739
	Female	< 13	≥13 and <16.5	≥16.5	
ALB (g/L)		< 30	≥30 and <35	≥35	0.282
TC(mmol/L)		< 3.14	≥3.14 and ≤5.86	> 5.86	0.014

hemodialysis therapy, a move to another dialysis center, and loss to follow-up. The Cox proportional hazards regression model was used to assess the relationship between the CNSS scores or grades and all-cause, cardiovascular and infection-related mortalities after adjusting for several groups of covariates. Covariates with P-value < 0.2 in univariate models or for importance of clinical concern were selected for multivariate Cox regression models. The results are expressed as the hazard ratio (HR) and the 95% confidence interval (95% CI). All statistical tests were two-sided, with a value for P < 0.05 defined as significant. All statistical analyses were performed using SPSS software, version 22.0 for Windows 10.

Results

Patient Characteristics

A total of 1964 patients initiated peritoneal dialysis at our center during the study period; 1040 patients were excluded, and the remaining 924 patients were included in the final analysis (Fig. 1). The mean age of the cohort was 49.97±14.14 years, 55.09% of the patients were male. The primary cause of end-stage renal disease is chronic glomerulonephritis among 64.83% patients, followed by diabetic nephropathy (11.47%) and hypertensive nephropathy (4.98%). The baseline characteristics of the patients categorized by CNSS Grade are summarized in Table 2. The systolic pressure, serum creatinine (Cr), serum calcium (Ca), triglyceride (TG), very low-density lipoprotein (VLDL) and hemoglobin (HB) varied from three CNSS grades (P<0.05). No significant differences were observed between there grades in terms of gender, age, diastolic pressure, primary kidney disease, proportion of diabetes, Charlson Comorbidity Score, serum uric acid (UA), phosphate (P), high density lipoprotein(HDL), low density lipoprotein (LDL), alkaline phosphatase (ALP), serum potassium (K), fasting blood glucose (FBG), C-reactive protein (CRP) or parathyroid hormone (PTH) level (P>0.05).

Fig. 1. Flow chart of the participants in the study cohort. PD, peritoneal dialysis.

Table 2. Baseline Demographics and Biochemical Characteristics Categorized by CNSS Grades. Values are expressed as mean $\pm$ SD, median and range (for non-normally distributed variables) or percentage. P-values are shown here for comparison, despite P above 0.05

	All patients (n=924)	Grade 1(8-15) (n=83)	Grade 2 (16-19) (n=347)	Grade 3 (20-24) (n=494)	P
Age	49.97 $\pm$ 14.14	49.55 $\pm$ 17.08	50.74 $\pm$ 15.31	49.50 $\pm$ 12.68	0.438
Male, n (%)	509(55.09)	45(54.22)	192(55.33)	272(55.06)	0.983
Systolic Pressure	144.98 $\pm$ 22.83	149.884 $\pm$ 24.63	147.42 $\pm$ 23.71	142.44 $\pm$ 21.58	0.001
Diastolic Pressure	89.23 $\pm$ 15.48	88.87 $\pm$ 15.36	89.90 $\pm$ 14.15	89.41 $\pm$ 15.55	0.072
Primary kidney disease, n (%)					0.847
Chronic					
Glomerulonephritis	599(64.83)	51(61.45)	224(54.55)	324(65.59)	
Diabetic Nephropathy	106(11.47)	9(10.84)	47(13.54)	50(10.12)	
Hypertensive	46(4.98)	3(3.61)	15(4.32)	28(5.67)	
Nephropathy					
Obstructive	14(1.52)	2(2.41)	4(1.15)	8(1.62)	
Nephropathy					
Polycystic Kidney	21(2.27)	2(2.41)	7(2.02)	12(2.43)	
Others or Unknown	138(14.94)	16(19.28)	50(14.41)	72(14.57)	
Charlson Score	2.52 $\pm$ 0.92	2.64 $\pm$ 0.90	2.58 $\pm$ 0.94	2.45 $\pm$ 0.91	0.064
Diabetes Mellitus, n (%)	116(12.55)	10(12.05)	50(14.41)	56(11.34)	0.412
Laboratory Tests					
Cr	761.94 $\pm$ 286.69	665.13 $\pm$ 140.33	790.37 $\pm$ 292.19	758.24 $\pm$ 277.42	0.001
UA	525.63 $\pm$ 136.44	503.19 $\pm$ 128.25	522.68 $\pm$ 130.30	531.48 $\pm$ 139.785	0.191
Ca	2.10 $\pm$ 0.26	2.11 $\pm$ 0.25	2.05 $\pm$ 0.31	2.09 $\pm$ 0.28	<0.001
P	1.86 $\pm$ 0.50	1.77 $\pm$ 0.58	1.88 $\pm$ 0.54	1.86 $\pm$ 0.46	0.229
TG	1.54 $\pm$ 1.01	1.30 $\pm$ 0.73	1.36 $\pm$ 0.81	1.71 $\pm$ 1.15	<0.001
HDL	1.09 $\pm$ 0.34	1.12 $\pm$ 0.35	1.12 $\pm$ 0.36	1.07 $\pm$ 0.33	0.056
LDL	2.34 $\pm$ 0.80	2.30 $\pm$ 0.87	2.32 $\pm$ 0.88	2.36 $\pm$ 0.73	0.682
VLDL	0.86 $\pm$ 0.49	0.81 $\pm$ 0.52	0.83 $\pm$ 0.46	0.90 $\pm$ 0.50	0.047
ALP	79.34 $\pm$ 53.12	91.72 $\pm$ 101.05	76.57 $\pm$ 37.98	79.21 $\pm$ 47.55	0.065
K	4.54 $\pm$ 0.76	4.38 $\pm$ 0.99	4.52 $\pm$ 0.82	4.58 $\pm$ 0.67	0.081
FBG	4.81 $\pm$ 1.45	4.62 $\pm$ 1.03	4.90 $\pm$ 1.92	4.77 $\pm$ 1.08	0.196
HB	82.74 $\pm$ 16.89	77.22 $\pm$ 13.48	80.58 $\pm$ 16.15	85.19 $\pm$ 17.50	<0.001
CRP	6.96 $\pm$ 20.13	8.30 $\pm$ 15.93	6.01 $\pm$ 22.62	7.40 $\pm$ 18.87	0.503
PTH	367.29 $\pm$ 326.49	368.29 $\pm$ 416.68	357.13 $\pm$ 308.51	374.26 $\pm$ 322.13	0.755

Table 3. Relationships between CNSS Grade and Outcomes of CAPD Patients. Abbreviations: CV, cardiovascular; HD, hemodialysis

Outcomes	All patients (n=924)	Grade 1 (8-15) (n=83)	Grade 2 (16-19) (n=347)	Grade 3 (20-24) (n=494)	P
All-cause mortality, n (%)	83(8.98)	16(19.28)	35(10.09)	32(6.48)	0.001
CV Mortality	38(4.11)	5(6.02)	17(4.90)	16(3.24)	0.321
Infection-related Mortality	7(0.76)	2(2.41)	2(0.58)	3(0.61)	0.191
Transfer to HD, n (%)	92(9.96)	8(9.64)	38(10.95)	46(9.31)	0.733
Renal Transplantation, n (%)	137(14.83)	6(7.23)	46(13.26)	85(17.21)	0.035
Frequency of hospitalization	1.33±0.80	1.41±0.81	1.36±0.86	1.30±0.74	0.308
Hospitalization days (d)	15.82±13.76	19.88±19.28	16.93±15.36	14.36±11.00	0.001

Associations of the CNSS Grades with outcomes of CAPD patients

The median follow-up period was 25.4 months (range from 3.0 to 178.4 months). During the study period, 83 (8.98%) patients died while 92 transferred to hemodialysis and 137 (14.83%) received renal transplantation. The rate of loss to follow-up is 13 out of 924 (1.9%).

Among the 83 deaths, 16 (19.28%) deaths occurred in the CNSS Grade 1, whereas 35 (10.09%) and 32 (6.48%) deaths occurred in Grade 2 and Grade 3, respectively. Chi-squared test revealed significant difference of the all-cause mortality among three grades ($P=0.001$). Proportion of patients receiving renal transplantation decreased

while hospitalization days increased across worsening CNSS categories ($P = 0.035$ and $P = 0.001$, respectively). There was a tendency of increases in CV mortality and hospitalization frequency across improvement of CNSS grades but the difference is not statistically significant ($P = 0.321$ and $P = 0.308$, respectively) (Table 3).

The Kaplan-Meier survival curves for all-cause mortality for the patients with the different CNSS Grades are illustrated in Fig. 2. All-cause varies significantly between the three grades (long-rank test $P < 0.001$). The patients in better CNSS Grade exhibited higher

Fig. 2. Kaplan-Meier survival analysis for the surviving patients comparing subgroups of CNSS grade in the study population. There is a significant difference in survival status comparing three subgroups of patients divided by CNSS ($P < 0.001$ by log-rank test).

Table 4. Relationships between CNSS Grades and all-cause, CV and infection-related mortalities. Abbreviations: HR, hazard ratio; CI, confidence interval; CV, cardiovascular. Model 1: Adjusted for age and gender. Model 2: Adjusted for model 1 covariates and blood pressure, diabetes, Charlson comorbidity score. Model 3: Adjusted for model 2 covariates and serum creatinine, triglyceride, calcium, hemoglobin, C-reactive protein

Cox Model	All-cause Mortality		CV Mortality		Infection-related Mortality	
	HR (95% CI)	P Value	HR (95% CI)	P Value	HR (95% CI)	P Value
Univariate	0.53(0.39–0.72)	<0.001	0.65(0.41–1.02)	0.062	0.49(0.17–1.42)	0.189
Multivariate						
Model 1	0.56(0.41–0.77)	<0.001	0.69(0.43–1.10)	0.121	0.52(0.17–1.54)	0.236
Model 2	0.58(0.42–0.78)	<0.001	0.71(0.44–1.13)	0.145	0.55(0.19–1.61)	0.277
Model 3	0.56(0.41–0.78)	0.001	0.77(0.47–1.27)	0.308	0.63(0.19–2.08)	0.448

Table 5. Relationships between CNSS score and all-cause, CV and infection-related mortalities. Abbreviations: HR, hazard ratio; CI, confidence interval; CV, cardiovascular. Model 1: Adjusted for age and gender. Model 2: Adjusted for model 1 covariates and blood pressure, diabetes, Charlson comorbidity score. Model 3: Adjusted for model 2 covariates and serum creatinine, triglyceride, calcium, hemoglobin, C-reactive protein

Cox Model	All-cause Mortality		CV Mortality		Infection-related Mortality	
	HR (95% CI)	P Value	HR (95% CI)	P Value	HR (95% CI)	P Value
Univariate	0.85(0.79–0.92)	<0.001	0.87(0.78–0.98)	0.021	0.92(0.69–1.22)	0.579
Multivariate						
Model 1	0.87(0.80–0.94)	<0.001	0.89(0.79–0.99)	0.046	0.94(0.71–1.25)	0.678
Model 2	0.86(0.80–0.93)	<0.001	0.89(0.79–1.00)	0.057	0.98(0.74–1.30)	0.876
Model 3	0.87(0.80–0.94)	<0.001	0.91(0.80–1.03)	0.121	1.00(0.75–1.34)	0.985

cumulative survival rates. One-year cumulative survival rate was 90.4%, 96.0%, 97.0%, respectively, in CNSS Grade 1, 2 and 3. Two-year cumulative survival rate was 81.7%, 91.2%, 94.5% while three-year cumulative survival rate was 75.1%, 83.6%, 92.3% respectively.

Table 4 displays the hazard ratios (HRs) of all-cause, CV and infection-related mortality that were associated with the different CNSS grades while considering CNSS Grade 1 as the reference. According to the multivariable Cox proportional hazards model analysis, the high CNSS grade was associated with significantly lower all-cause (Model 1: HR, 0.56, 95% CI, 0.41 to 0.77, $P < 0.001$; Model 2: HR, 0.58, 95% CI, 0.42 to 0.78, $P < 0.001$; Model 3: HR, 0.56, 95% CI, 0.41 to 0.78, $P = 0.001$) even after adjusting for potential confounding factors.

Associations of the CNSS score with All-cause, CV and Infection-related Mortalities

Using the CNSS score as a continuous variable, the HRs for all-cause mortalities associated with a one-point increase in the CNSS score were 0.85 (95% CI, 0.79 to 0.92, $P < 0.001$) in univariate Cox model. Multivariate Cox model further revealed the CNSS score is an independent protective factor of all-cause mortality (Model 3: HR, 0.87, 95% CI, 0.80 to 0.94, $P < 0.001$) (Table 5).

Discussion

The prevalence of ESRD is rising sharply worldwide, with maintenance dialysis being the most common renal replacement treatment(RRT) [36]. In china, the number of ESRD patients receiving PD therapy is rapidly growing in recent years [37]. Patients on long-term dialysis have a significantly increased risk of mortality, and cardiovascular disease (CVD) and infection are most common causes of death in dialysis patients [38, 39]. Many researchers

have shown a variety of risk factors that predict the outcomes of dialysis patients, including age [40], sex [41], RRF [42], blood pressure [43, 44], comorbidity [45], BMI [46-49], serum ALB [50, 51], pre-ALB [52-54], TC [55-58], TG [59, 60], VLDL [61], HB [62], Ca, P [63], PTH, ALP [64], UA [65, 66], K, CRP [67], dialysis adequacy [68, 69], incident peritonitis [70, 71] and so on. Much effort has been done to maintain stable blood pressure, correct anemia and electrolyte disturbance as well as ensure dialysis adequacy and prevent peritonitis, in order to improve the long-term outcomes of dialysis patients. The importance of assessing and monitoring protein-energy wasting (PEW), however, has been underestimated. Therefore, our group performed this longitudinal cohort study focusing on the association between nutritional status and outcomes among PD patients in our center.

The CNSS proposed in our study contains serum biochemical indicators (TC, ALB), body mass (BMI), and muscle mass parameters (MAC, TSF), consistent with the diagnostic criteria recommended by ISRNM, as at least three out of the four categories satisfied for diagnosing PEW [1]. Former studies reported the etiology and pathogenesis of the PEW mainly involved inflammation [72-74], inadequate nutritional intake [75, 76], loss of nutrients into dialysate [5, 77-79], loss of residual renal function [6, 80-82], hypercatabolic state [83] and so on. Other researches revealed that insulin resistance increased muscle consumption in home peritoneal dialysis patients [84-86] and combining diabetes, infection, cardiovascular disease and acidosis status may aggravate the decomposition [87]. Therefore, the present study performed multivariate Cox proportional hazards model analysis to adjust their co-effects. Statistical analysis revealed that both CNSS grade and CNSS score are independent protective factors for all-cause mortality among incident PD patients even after adjusting for potential confounding factors including age, gender, blood pressure, diabetes, Charlson comorbidity score, serum creatinine, triglyceride, calcium, hemoglobin and C-reactive protein.

The incidence rate of PEW, defined as CNSS Grade 1 and Grade 2, is 46.54% in this study, corresponding to the range of 18%-56% from the previous reports [1-5]. Moreover, compared to SGA, the most classic subjective nutritional assessment system, the CNSS quantitatively evaluates the nutritional status, and better distinguishes the malnutritional degree of PD patients. Using SGA system, the number of patients belonging to Grade C, who were considered as severe malnourished is merely 7 out of 924 PD patients and controversially, no death or cardiovascular event has ever happened in the very few SGA Grade C patients, raising doubts about the predicting value of SGA for mortality. The CNSS, on the contrary, distinguished 83 out of 924 patients who are at high malnutritional risk and predicted highest all-cause mortality in this group. In consideration of MIS scoring system, it is comparatively complicated and requires a great number of data including medical history, physical examination, laboratory examination and dietary intake, which makes it less clinically practical. By contrast, the CNSS selects the most common markers and indicators of PD patients during the follow-up examination. The simplified procedure of CNSS saves both time and money expenditure and could be a potentially promising indicator for assessing PEW in the further.

Among the variety of indicators covered in this study, ALB and MAC were found to be independent protective factors for all-cause mortality, which is consistent with former research results [46, 47]. However, Our study showed that TSF has no independent correlation with all-cause mortality, which is similar to some other researches [34, 35]. This may be due to the short-term impact of the indicator on mortality, as reported to be associated only with the early stage (< 6 months) outcomes in peritoneal dialysis patients [46].

Previous studies have found that BMI [46-49] and TC [55-58] are protective factors for all-cause mortality in patients with ESRD and dialysis, contrary to the general population and considered as examples of obesity paradox. In 2004, Liu Y et al [88] divided dialysis patients into inflammation - malnutrition and non-inflammatory - malnutrition groups according to BMI and CRP. Interestingly, the subgroup analysis found that in the non-inflammation-malnutrition group, the TC level was related with all-cause and cardiovascular

mortality, consistent with the normal population group, while TC was negatively associated with all-cause and cardiovascular mortality in inflammation-malnutrition. In our study, BMI and TC are neither risk nor protective factor, which may result from the regional and ethnic difference and the diverse distribution of malnutritional individuals among different studies.

Several limitations need to be taken into consideration in our study. Firstly, due to the nature of a single-center retrospective study, the selection of patients may have a deviation and the integrity and homogeneity of the data cannot be guaranteed. Secondly, compared with the diagnostic criteria of PEW proposed by ISRNM in 2008, nutritional assessment in this study is still deficient for the lack of dietary parameters such as daily energy intake (DEI) and daily protein intake (DPI). Moreover, depression, fatigue [89] and cognitive impairment [90] is prevalent in about 27% patients with end-stage renal disease. The CNSS still included subjective assessment, which is difficult to perform on these patients. Besides, the nutritional status changes with the process of peritoneal dialysis. Our study, however, failed to explore time-related change of CNSS and its influence on the long-term prognosis of PD patients owing to unavailability of nutritional data in a proportion of patients during the follow-up period. Lastly, the limited set of variables does not allow us to take all potential confounding factors under control and might bias the results.

Conclusion

The CNSS, integrating the subjective and objective nutritional markers and indicators, quantitatively and comprehensively evaluates the nutritional status in CAPD patients. The categorized CNSS grade and continuous CNSS score independently predict all-cause mortality in chronic PD patients. The CNSS grade identifies malnourished patients from the whole cohort and differentiates varying degrees of PEW. It provides an alternative nutritional scoring system and has potential to guide clinical intervention and treatment, thereby improves survival rate and life quality of CAPD patients.

Disclosure Statement

The authors of this manuscript state that they do not have any Disclosure Statements and nothing to disclose.

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