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Xuemei Zhang[1], Shaomin Huang[1], Lian Lin[1], Xiaohua Wang[1], Xiuqing Zhang[2], Yan Lei[1]

[1]Department of Nephrology, Center of Nephrology and Urology, The Seventh Affiliated Hospital, Sun Yat-sen University, Shenzhen, China, 518017
[2]Department of Obstetrics and Gynecology, Dongguan People's Hospital, Dongguan, China, 523000

Corresponding author:
Yan Lei, MD, PhD
Department of Nephrology,
Center of Nephrology and Urology,
The Seventh Affiliated Hospital,
Sun Yat-sen University
628 New Lake Street,
Guangming New District,
Shenzhen, China, 518017
Email: yanleisysu@gmail.com
Tel: (86)-13416191205

ABSTRACT

Objective: To evaluate the effect of individualized nutritional support on protein-energy malnutrition in patients with maintenance hemodialysis.

Design: Retrospective study

Setting: Department of Nephrology, the Seventh Affiliated Hospital of Sun Yat-sen University

Subjects: Maintenance hemodialysis patients

Interventions: Patients with regular nutritional support received routine nursing and nutritional guidance, while patients with individualized nutritional support had personalized nursing plan with particular emphasis on proper protein intake and restrictions on sodium, potassium, calcium, and phosphorus intake.

Main Outcome Measures: Patients' dietary behavior management scores, electrolyte levels, and nutritional status indicators at 3 months post-nursing were compared.

Results: After nursing, the scores of self-care, liquid control, low-salt diet, low-potassium diet, and adherence in times of particular difficulty in patients with individualized nutritional support were significantly higher than those with regular nutritional support ($p<0.001$). Moreover, compared to patients with regular nursing, patients with individualized nutritional support had lower levels of serum calcium, phosphorus, and potassium ($p<0.001$), and their nutrition status indicators, including triceps skinfold thickness, upper arm circumference, levels of albumin and hemoglobin, were significantly improved ($p<0.001$).

Conclusion: These data demonstrate that individualized nutritional intervention can effectively regulate diet behaviors of patients, correct the water-electrolyte disorder, and ameliorate protein-energy wasting in patients with maintenance hemodialysis. Further clinical trials addressing long-term impacts of individualized nutrition intervention on patients with maintenance hemodialysis are warranted.

KEY WORDS: Maintenance hemodialysis, Individualized nutrition intervention, Chronic kidney disease (CKD), Care, Protein-energy wasting

INTRODUCTION

Chronic kidney disease (CKD) remains a global health and economic burden and is associated with a decline in quality of life and shortened life expectancy. According to the latest report, 697.5 million people worldwide were diagnosed with CKD in 2017, of which 1.2 million died and 3.1 million were on dialysis.[1] Maintenance hemodialysis is a blood purification therapy used to treat uremia in patients with end-stage kidney disease (ESKD), the final stage of CKD.[2] While maintenance hemodialysis could effectively remove uremic toxins from the blood and control disease progression,[3, 4] the mortality rate among hemodialysis patients remains high due to various etiologies including the protein-energy wasting (PEW).[4-6] According to The International Society of Renal Nutrition and Metabolism (ISRNM), PEW refers to the decreased body protein mass and energy reserves caused by multiple factors, such as anemia, volume overload, nutrient loss during dialysis, and production of inflammatory cytokines.[7, 8] Despite advances in CKD management, PEW frequently occurs in maintenance hemodialysis patients, with a reported incidence ranging from 28% to 52%,[6, 9-11] and is associated with significant increases in morbidity and mortality as reported by many centers.[12-17] Therefore, there is an unmet need to explore strategies for the prevention or treatment of PEW

in patients with maintenance hemodialysis.

It has been reported that dietary patterns and behaviors may affect the nutritional status as evaluated by the Subjective Global Assessment (SGA) and are related to all-cause mortality in dialysis patients.[5, 18] Indeed, patients on maintenance dialysis frequently suffer from loss of appetite, anorexia, and inflammation, which can lead to reduced dietary intake and increased nutrient loss. The consensus in the field of dietetic-nutritional therapy (DNT) recommends that the diet of CKD patients should include modulation of protein and caloric intake, control of sodium and potassium intake, and reduction of phosphorus intake.[19] However, the success and safety of dietetic-nutritional management of CKD patients often rely on patient adherence, education, interdisciplinary cooperation, and follow-up.[19]

Individualized nutritional intervention is a new nutritional nursing model based on an individualized nursing concept. Several reports support that the intensive individualized nutrition intervention increases nutritional intakes, prevents therapy-associated weight loss, and improves long-term prognosis in cancer patients.[20, 21] However, it remains unclear whether the individualized nutrition intervention could improve the dietetic-nutritional management and ameliorate PEW in CKD patients.

This study aimed to evaluate the effect of individualized nutrition intervention on patients with maintenance hemodialysis. We compared the clinical characteristics of 50 CKD patients on maintenance hemodialysis with regular nursing and nutritional guidance or with individualized nutritional support in our center. We hypothesized that individualized nutrition intervention could help improve the dietary behaviors of patients and prevent PEW during maintenance hemodialysis.

SUBJECTS AND METHODS

Subjects

Fifty patients who received maintenance hemodialysis from January 2019 to April 2020 in the Department of Nephrology at The Seventh Affiliated Hospital, Sun Yat-sen University were included. The inclusion criteria were as follows: (1) diagnosed with chronic renal failure; (2) receiving maintenance hemodialysis therapy for at least 3 months; (3) clear in consciousness to cooperate with the completion of the study; and (4) signing the informed consent. The exclusion criteria were as follows: (1) having mental disorders; (2) complicated with the malignant tumor or hematological diseases; and (3) loss of follow-up and dropping out of the study. Among these patients, 25 patients received regular nutritional support and 25 patients received individualized nutritional support. Their main characteristics including age, gender, weight, primary diseases, blood pressure, and education levels were listed in Table 1.

This study was reviewed and approved by the Ethics Committee of The Seventh Affiliated Hospital, Sun Yat-sen University. All patients provided informed consent prior to the study. This study was conducted in accordance with the 1964 Helsinki Declaration.

Study design

For patients with regular nursing and nutritional support, we conducted routine health education, informed patients and their families of notices during maintenance hemodialysis therapy, comforted patients, emphasized the importance of maintenance hemodialysis, carefully monitored patient’s vital signs, and made

good records every time the hemodialysis was performed.

The individualized nutrition support was based on routine nursing care plus additional personalized nutritional plan. More specifically, the individualized nutrition intervention group, formed by renal physicians, the chief nurses, nurses, and dietitians, would develop an individualized nutritional intervention plan for patients according to each patient's condition and characteristics of maintenance hemodialysis therapy. The group emphasized the importance of nutrition intervention to the patients first, and then implemented the nutrition intervention regimens as listed below. (A) Liquid restrictions: during the period of maintenance hemodialysis therapy, the daily weight gain of patients should be controlled within 5% as far as possible. Too much water intake can lead to edema and weight gain, so daily drinking water should be strictly limited. Educating the patients about the water content of foods and reducing the proportion of foods that are rich in water. When feeling thirsty, the patients can contain a little water in the mouth or chew gum. (B) Dietary sodium salt restrictions: daily sodium salt intake should be strictly controlled. Patients or their families should reduce the addition of salt, soy sauce, and other condiments when cooking dishes, and avoid eating preserved foods as far as possible. (C) Dietary potassium restrictions: explain the dangers of excessive potassium intake to patients and tabulate the potassium content of various foods. Avoiding eating high potassium food in the daily diet, especially fungus mushroom, orange, red jujube, and other foods with high potassium. When cooking, take the appropriate measures to remove potassium, such as cooking after soaking the vegetable root and stem slices or blanching vegetables briefly. (D) Dietary phosphorus restrictions: explain the dangers of excessive phosphorus intake to patients and tabulate the phosphorus content of various foods. Paying attention to seafood, animal viscera, egg yolk and other foods with high phosphorus, which should be prohibited. (E) Adequate protein intake: assure at least 1.2g/kg of protein intake every day and increase the proportion of high-protein food in their daily diet, like lean meat and milk.

Study measurements

We collected and compared the data of dietary behavior management score, electrolyte levels (serum calcium, phosphorus, and potassium), and nutritional status index (triceps skinfold thickness, upper arm circumference, albumin, and hemoglobin) of the two groups at 3 months post-nursing.

The dietary behavior management score system was modified from literature [22]. The dietary compliance scale for kidney diseases was used for evaluation, which included five areas: self-care, liquid control, low-salt diet, low-potassium diet, and adherence in times of particular difficulty. The maximum score for each area was 100, and the score was proportional to dietary behavior compliance.

Statistical analysis

All statistical analyses were performed using the SPSS 26.0 software. Counting data were analyzed using a χ^2 test and measurement data were analyzed using the *t*-test. The p-value of less than 0.05 was considered statistically significant.

RESULTS

Baseline patient characteristics

As shown in Table 1, baseline patient characteristics, such as age, gender, primary disease, blood pressure, and education level, were comparable between patients with regular nursing and patients with individualized nutritional support. In particular, the majority of the participants were about 60 years old with primary diseases including chronic glomerulonephritis and diabetic nephropathy.

Individualized nutritional support enhances patient's dietary adherence and behavior

To determine the effect of individualized nutrition support on patient's dietary adherence and behavior, data on dietary behavior management scoring tests based on the report by *Rushe et al.* were compared pre and post-nursing among patients in the control group and the intervention group.[22] As shown in Table 2, before nursing, the two groups showed no significant difference in dietary behavior management scores on the items including self-care, liquid control, low-salt diet, low-potassium diet, and adherence in times of particular difficulty ($p>0.05$). However, after nursing, the scores of various dietary behavior management items in the individualized nutritional support group were significantly higher than those before nursing, and the scores were higher than those of the regular nursing group ($p<0.001$). These results indicate that individualized nutrition support has a positive impact on patients' dietary adherence and behavior.

Individualized nutritional support improves patients' electrolyte balance

Electrolytes and fluid managements are critical for patients with maintenance hemodialysis.[23] We then compared the levels of serum electrolytes including calcium, phosphorus, and potassium between the two groups (Table 3). Before nursing, the two groups showed no significant difference in the electrolyte levels ($p>0.05$). However, after nursing, the levels of serum calcium, phosphorus, and potassium in patients with individualized nutritional support were significantly lower than those before nursing, and the levels of serum calcium, phosphorus, and potassium were all lower than those in patients with regular nutritional support ($p<0.001$).

Individualized nutritional support ameliorates the nutrition status, low albumin, and anemia of patients

Before nursing, there were no significant differences in triceps skinfold thickness, upper arm circumference, and the levels of albumin and hemoglobin between the two groups ($p>0.05$). After nursing, the triceps skinfold thickness, upper arm circumference, of patients with individualized nutritional support were significantly higher than those in patients with regular nutritional support or before nursing, $p<0.001$ (Table 4). Moreover, the levels of albumin and hemoglobin of the intervention group were higher than those in patients with regular nutritional support ($p<0.001$). These results suggest that individualized nutritional support improve the nutrition status and anemia of patients with maintenance dialysis.

DISCUSSION

This retrospective study yielded several findings. First, after nursing, the scores of dietary behavior management (including self-care, liquid control, low-salt diet, and low-potassium diet) had been improved in patients with individualized nutritional support, suggesting the benefit of individualized nutritional support on patient's compliance of dietary behaviors. Moreover, after nursing, the electrolyte imbalance, low albumin levels, muscle mass, and anemia in patients with individualized nutritional support were also improved, suggesting that individualized nutritional intervention can improve the nutritional status of patients, correct the water-electrolyte imbalance, and reduce the risk of malnutrition.

Uremia frequently occurs in patients with ESKD and is associated with a high risk of death.[24] Maintenance hemodialysis, by utilizing technologies such as adsorption and filtration for blood purification, can effectively remove toxin molecules, correct acid-base balance, and reduce renal inflammation.[25] However, during treatment, patients often suffer from loss of appetite, irregular eating behaviors, and malnutrition, which would dampen the efficacy of the dialysis efficacy and promote disease progression.[26] Therefore, nursing with high quality is critically needed for improving life quality and the success of dialysis in CKD patients. This demand gives rise to the individualized nutritional intervention in the clinic.

At present, the routine nursing measure for CKD patients during the maintenance hemodialysis could be too general and lack of specificity. These nursing measures are often unsatisfied for CKD patients, especially for the patient with risks of malnutrition. How to reduce the risk of malnutrition in CKD patients has been a critical nursing problem that needs to be solved. Given that malnutrition is often associated with dietary nutrition, individualized nutritional intervention could be a highly targeted specialized nursing model for reducing the risk of malnutrition.

It has been demonstrated that compared with routine nursing, nutritional intervention is more effective and specialized. Individualized nutritional intervention integrates with individualized nursing concepts and gives full consideration to the patients' differences and the actual demands while making a nursing plan. During the implementation of nursing measures, the actual nutritional needs of patients can be satisfied, which fully demonstrates the personalized and humanized nursing spirit.[27] In this study, patients with individualized nutritional support received personalized nutritional guidance in addition to routine nursing measures and imposed dietary restrictions on dietary liquid, sodium, potassium, and phosphorus intake based on the characteristics of the maintenance hemodialysis therapy. At the same time, we adjusted dietary proportion to ensure that the daily protein intake can meet the nutritional needs of the patients.

It should be noted that including the albumin level as a nutritional status maker has been controversial as the albumin level could increase in various scenarios including inflammation and infection.[28, 29] However, there is also compelling evidence showing that low albumin frequently is frequently seen in CKD patients with PEW.[8, 30] In this study, we observed that post-individual nutritional support, the levels of albumin in patients with maintenance dialysis significantly increased, along with increased levels of hemoglobin,[31] suggesting that the nutrition status could be ameliorated in these patients.

We acknowledge that several limitations should be noted in this study. First, the sample size in this study is relatively small; a multi-center study with a larger sample size may strengthen the power of the study. Second, the relatively short follow-up time (3 months) makes it difficult to determine the effect of individualized

nutritional support on critical outcomes of the CKD patients, such as infection, cardiovascular events, and mortality. Despite these limitations, this study strongly supports that individualized nutritional support could be beneficial for preventing PEW in patients with maintenance hemodialysis.

CONCLUSION

In summary, individualized nutritional support used in maintenance hemodialysis therapy can effectively regulate diet behaviors of patients, correct the water-electrolyte disorder, ameliorate PEW, and reduce the risk of malnutrition. Clinical trials are warranted to confirm its effect on long-term outcomes of patients with maintenance hemodialysis at risk of malnutrition.

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Authors' contributions: X.Z. and Y.L. designed and directed the project; all authors collected the data; X.Z., X.W., X.Z., and Y.L. analyzed the data; X.Z., S.H., and L.L. wrote the first manuscript; all authors revised the manuscript.

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Table 1: Baseline characteristics of patients with regular nutritional support or with individualized nutritional support

Parameters	**Regular (n=25)**	**Individualized (n=25)**	**P-value**
Age (year)	60.48±12.37	60.93±12.41	0.898
Gender (Male/Female)	15/10	14/11	0.774
Primary diseases			
Chronic glomerulonephritis	17	16	0.765
Diabetic nephropathy	8	9	
Weight (kg)	57.21±7.35	57.48±7.20	0.896
Amount of dehydration (kg)	1.94±0.30	1.92±0.31	0.818
Systolic pressure (mmHg)	113.27±3.51	113.40±3.58	0.897
Diastolic pressure (mmHg)	84.36±2.37	84.29±2.40	0.918
Educational levels			
Primary school	9	8	0.637
Middle school	8	9	
High school or technical secondary school	5	4	
Undergraduate or junior college	3	4	

Table 2: The dietary behavior management scores of patients with regular nutritional support or with individualized nutritional support

Parameters	Timing	Regular (n=25)	Individualized (n=25)	P-value
Self-care	Pre-nursing	77.54±5.46	77.83±5.52	0.853
	Post-nursing	78.21±6.35	85.30±7.09	<0.05
	P-value	0.691	<0.001	
Liquid control	Pre-nursing	78.19±6.02	78.32±6.14	0.940
	Post-nursing	78.93±6.75	86.07±6.83	<0.05
	P-value	0.684	<0.001	
Low-salt diet	Pre-nursing	77.62±5.91	77.90±5.98	0.868
	Post-nursing	78.35±6.43	86.12±6.76	<0.001
	P-value	0.678	<0.001	
Low-potassium diet	Pre-nursing	76.38±5.48	76.47±5.56	0.954
	Post-nursing	77.24±6.30	85.09±6.45	<0.001
	P-value	0.609	<0.001	
Adherence in times of particular difficulty	Pre-nursing	77.46±5.13	77.68±5.27	0.882
	Post-nursing	77.90±6.29	85.78±6.92	<0.001
	P-value	0.788	<0.001	

Table 3: The electrolyte levels of patients with regular nutritional support or with individualized nutritional support

Parameters	Timing	Regular (n=25)	Individualized (n=25)	P-value
Serum calcium	Pre-nursing	2.58±0.72	2.53±0.75	0.811
	Post-nursing	2.45±0.69	1.87±0.43	<0.05
	P-value	0.518	<0.001	
Serum phosphorus	Pre-nursing	2.34±0.24	2.30±0.26	0.575
	Post-nursing	2.28±0.25	1.81±0.27	<0.001
	P-value	0.391	<0.001	
Serum potassium	Pre-nursing	6.17±0.94	6.14±0.95	0.911
	Post-nursing	6.02±0.91	4.78±0.64	<0.001
	P-value	0.569	<0.001	

Table 4: The nutritional status indicators of patients with regular nutritional support or with individualized nutritional support

Parameters	Timing	Regular (n=25)	Individualized (n=25)	P-value
Triceps skinfold thickness (mm)	Pre-nursing	6.67±1.20	6.70±1.23	0.931
	Post-nursing	6.80±1.45	8.39±1.57	<0.05
	P-value	0.731	<0.001	
Upper arm circumference (cm)	Pre-nursing	14.17±1.85	14.27±1.96	0.854
	Post-nursing	14.39±2.01	16.95±2.48	<0.001
	P-value	0.689	<0.001	
Albumin (g/L)	Pre-nursing	35.66±1.80	35.83±1.85	0.743
	Post-nursing	36.02±2.31	39.45±2.74	<0.001
	P-value	0.542	<0.001	
Hemoglobin (g/L)	Pre-nursing	104.15±1.72	104.31±1.76	0.747
	Post-nursing	104.52±2.39	108.74±3.50	<0.001
	P-value	0.533	<0.001	