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Evaluation of nutritional status and prognostic impact assessed by the prognostic nutritional index in children with chronic kidney disease

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Abstract

To evaluate the nutritional status of children with chronic kidney disease (CKD) before dialysis via a series of indexes, and investigate the prognostic impact of nutritional status in these patients assessed by the Prognostic Nutritional Index (PNI).

Fifty-four children with CKD before dialysis were enrolled in this study. The nutritional status was evaluated by different indexes, including dietary intake, anthropometry data and biochemical parameters. Additionally, PNI is calculated as 10 × serum albumin (g/dL) + 0.005 × lymphocyte count (/mm^3). Glomerular filtration rate (GFR) of patients with different PNI scores was followed up.

Thirty-four patients (63.0%) experienced unreasonable dietary intake, and the patients with CKD stage 4 were characterized by lower energy intake. The height was the most affected anthropometry parameter. Additionally, 46 patients (85.2%) suffered from anemia. The serum albumin of 42 patients (77.8%) was <35 g/L, while 34 cases (63.0%) had increased cholesterol and triglyceride. According to the PNI scores, the patients were divided into 3 groups: high-PNI (PNI ≥ 38), middle-PNI (35 ≤ PNI < 38), and low-PNI (PNI < 35). Of the 54 patients, the PNI was <35 in 29 (53.7%) and ≥38 in 13 (24.1%). The patients with CKD stage 4 were belonged to the low-PNI group. At follow-up, GFR decreased significantly in patients with low-PNI scores compared with the high-PNI group ($P < .05$).

Malnutrition, as a common complication of CKD, has a prognostic impact in children with CKD before dialysis, as assessed by the PNI score.

Abbreviations: ALB = albumin, BMI = body mass index, CKD = chronic kidney disease, Cr = serum creatinine, GFR = glomerular filtration rate, Hb = hemoglobin, PNI = Prognostic Nutritional Index, RDA = recommended dietary allowance, SDS = standard deviation score, TC = total cholesterol, TG = triglyceride, TP = total protein.

Keywords: children, chronic kidney disease, nutritional status, prognosis, prognostic nutritional index

1. Introduction

Nutritional status, as a predictable factor in chronic kidney disease (CKD), is particularly important for children, owing to its influence on growth and development.[1] Quality of life is better in children with adequate nutritional status when they have reached end-stage renal failure.[2] One major challenge for pediatricians is balancing the nutritional requirements of these patients so as to promote normal growth and development. Thus, the provision of adequate nutrition and regular evaluation of nutritional status are key points in the management of children with CKD.[3]

Factually, the deterioration of renal function can cause progressive effects on nutritional status, usually leading to malnutrition, a common and serious complication of CKD in children.[4,5] Because of the many different diagnostic tools, the prevalence of malnutrition widely varies among different studies, ranging from 20% to 50% at different stages of CKD.[6] Contributing factors to malnutrition include low residual renal function, hormonal factors, inflammation, metabolic acidosis, dietary restrictions and lifestyle practices.[2,7] These factors result in serious nutritional complications for the patients during the course of pre-dialysis, which eventually affect the prognosis of the disease.[7]

Although the importance of nutritional status has been underlined in many clinical guidelines on the management of children with CKD,[8–11] few data are available for the nutritional evaluation of those pediatric patients before dialysis. In addition, it is noteworthy that nutritional status is even more difficult to define, because it is a complex concept that cannot be summarized by merely one measurement.[12] Multiple indexes are required to make an accurate and complete description of nutritional status, consisting of dietary intake, anthropometry data, biochemical parameters and so on.[13] Furthermore, a useful methodology to predict adverse outcomes of patients remains need to be established. The Prognostic Nutritional Index

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(PNI) is calculated as follows: 10 × serum albumin (g/dL) + 0.005 × lymphocyte count (/mm^3). PNI, easy to calculate, has been used to evaluate the nutritional status of patients with many diseases, such as heart failure, gastric cancer, colorectal cancer and so on, as it only based upon the serum albumin level and lymphocyte count.[14,15] The prognostic value of the PNI score used in CKD remains unclear. Therefore, this study aimed to evaluate the comprehensive nutritional status of children with CKD before dialysis via a series of indexes, and investigate the prognostic impact of nutritional status in these patients assessed by PNI.

2. Methods

2.1. Subjects

A total of 54 children with CKD stages 2 to 4 were enrolled in this study from July 2013 to January 2018. According to the stage of CKD, all the patients were divided into 3 groups: 12 ones with CKD stage 2, 22 with stage 3 and 20 with stage 4. CKD stages were defined according to Schwartz formula.[16,17] Exclusion criteria:

1. patients with severe edema, severe infection, dyspnea, cardiac failure and other systemic diseases;
2. patients having receiving renal replacement therapy, including hemodialysis and peritoneal dialysis;
3. patients on tube feeding or parenteral nutrition.

Mean follow-up was at least 3 months since the first time of data collection. Informed consents were obtained from all children and their parents.

2.2. Clinical manifestations

Children with advanced stages of CKD, who may be prepared for the possible need of renal replacement therapy, may complain of gastrointestinal symptoms, including anorexia, nausea, vomiting, and constipation. These symptoms occurring in children were usually different from the adult counterpart. Other clinical signs included fatigue, nocturia, and so on. At these stages, other complications could probably occur, such as recurrent infections.

2.3. Dietary interview

Dietary intake was obtained by a questionnaire consisting of 7 parts: general characteristics, frequency of meal, regularity of meal time, frequency of overeating, frequency of snack intake, offending and favorable food, detailed food intake for every meal, and snacks.[18,19] Dietary data was collected by consecutive 3-day food record.[13] Children and their parents were carefully instructed how to record the items and amounts of all foods, snacks, and beverages. Dietary assessment was based on self-reported data without dietary intervention. All the food records were analyzed to calculate the energy and nutrient components, compared with recommended dietary allowance (RDA) in guidelines for CKD patients.[2,13,20]

2.4. Anthropometry data

Anthropometric data were obtained by the standard methods and the same rater. The mean value of three measurements was used for data analysis.

(1) Body weight and height were measured after the patients had been instructed to wear light clothes and not to wear shoes.
(2) Body mass index (BMI) was calculated according to the following formula: BMI = weight (kg) / height^2 (m^2).

Anthropometric data were expressed in standard deviation score (SDS). Values for weight, height, and BMI were compared with the normative values of Chinese population for the same age and gender, according to *Height and weight standardized growth charts for Chinese children and adolescents aged 0 to 18 years*.

2.5. Biochemical parameters

Fasting values for hemoglobin (Hb) (anemia described as Hb < 110 g/L for younger than 6 years and <120 g/L for older than 6 years), lymphocyte count, total protein (TP), albumin (ALB), total cholesterol (TC), triglyceride (TG), urea, serum creatinine (Cr) were measured. GFR was calculated using the equation before and after follow-up.[21]

2.6. The prognostic nutritional index (PNI)

The PNI score was calculated according to the following formula: 10 × serum albumin (g/dL) + 0.005 × lymphocyte count (/μL). Based on this index, the patients could be divided into three groups: high-PNI (PNI ≥ 38), middle-PNI (35 ≤ PNI < 38), and low-PNI (PNI < 35) groups.

2.7. Statistical analysis

Results were expressed as median, mean, standard deviation, range, percentage, minimum, and maximum. Statistical analyses were done with Microsoft Excel and SPSS software (version 18.0, SPSS). The measured parameters between 2 groups were compared by χ^2 –test for categorical data. All reported P value < .05 was considered statistical significant.

3. Results

3.1. Patients' characteristics

Clinical characteristics of patients with different CKD stages, such as age, gender, duration of disease, underlying renal disease, nutrients intake, and other clinical conditions, were presented in Table 1.

3.2. Dietary intake

Energy and nutrients intake of patients with different CKD stages was showed in Table 1. It is noteworthy that patients with CKD stage 4 were characterized by lower energy intake than the recommended level ($P < .05$), as well as carbohydrate, total protein and fat.

Further investigation of the dietary interview revealed that 34 patients (63.0%) experienced unreasonable diet, 12 (22.2%) of whom received insufficient carbohydrate from the diet; while 16 (29.6%) cases received insufficient total protein, including animal and plant proteins. Moreover, the food source of proteins was not reasonable for those patients and the animal protein shares in total protein in most patients. Additionally, 18 patients (33.3%) had a decreased or increased fat intake. Minerals and vitamins intakes in the majority of patients were lower than the recommendations or on the recommended level, except for vitamin C consumption. Other nutrients and energy values of diet, in comparison with the recommendation, were presented in Table 2.

Table 1

Clinical characteristic of children with different CKD stages.

	CKD stage 2 n=12	*CKD stage 3 n=22*	*CKD stage 4 n=20*
Age (years)	8.7±2.7	8.9±2.5	9.5±3.4
Male/female	7 / 5	10 / 12	9 / 11
Duration of disease (years)	1.2±0.4	2.1±0.9	3.7±1.3
Underlying renal disease			
Primary glomerulonephritis	6 (50.0%)	9 (40.9%)	2 (10.0%)
Secondary glomerulonephritis	4 (33.3%)	4 (18.2%)	2 (10.0%)
Pyelonephritis	0	1 (4.5%)	1 (5.0%)
Others and unknown	2 (16.7%)	8 (36.4%)	15 (75.0%)
Patients with fatigue	4 (33.3%)	17 (77.3%)	20 (100.0%)
Patients with gastrointestinal symptoms	5 (41.7%)	15 (68.2%)	16 (80.0%)
Patients with recurrent infection	6 (50.0%)	13 (59.1%)	11 (55.0%)
biochemical parameters			
Hemoglobin (g/L)	119±18	98±15	84±17
Total protein (g/L)	54.5±6.2	50.7±5.6	49.2±7.1
Albumin (g/L)	35.7±4.7	29.4±5.2	24.5±4.1
Total cholesterol (mmol/L)	5.1±1.3	7.6±2.9	8.5±2.3
Triglyceride (mmol/L)	1.6±0.9	2.1±1.1	2.4±1.3
Urea (mmol/L)	12.5±2.9	21.4±5.2	29.7±4.6
Creatinine (μmol/L)	97.0±11.0	212.0±57.0	337.0±124.0
GFR (ml/min/1.73 m^2)	79.8±15.3	48.1±11.5	23.7±6.1
Energy and nutrients intake/Constituted ratio (% of energy)			
Energy (kcal)	1582.3±498.3	1532.7±383.9	1375.8±505.2*
	100%	100%	100%
Carbohydrate (g)	239.1±78.7	235.1±56.0	201.2±60.8*
	60.4%	61.4%	58.5%
Total protein (g)	35.2±9.2	31.3±11.4	30.7±12.1*
	8.9%	8.2%	8.9%
Fat (g)	53.9±16.3	51.9±12.7	49.8±18.4*
	30.7%	30.4%	32.6%
The PNI score	37.6±5.7	33.7±4.9	29.3±3.8

GFR = glomerular filtration rate, PNI = prognostic nutritional index.
* Energy intake, carbohydrate, total protein and fat of patients with CKD stage 4 were lower than the recommended level ($P < .05$).

3.3. Anthropometric measurements

The height was the most affected anthropometric parameter, as 72% of the patients were short (height SDS below −3, mean −4.2±2.3). The body weight was less affected than the height, as body weight SDS in 38% of the patients was less than −3 SDS (mean −2.84±2.38). In addition, the BMI in 19% of the patients was <3rd percentile, while only 4% of the patients >97th percentile (ranged from 17.1 to 23.8). Moreover, the mean values of heights and body weights deteriorated as GFR decreased. A significant decrease of the height in the patients with CKD stage 4 was compared with those with CKD stages 2 and 3 ($P < .05$).

Table 2

Nutrients and energy value of diet in analyzed patients, compared with recommendations.

N=54	*Below recommended level*	*On recommended level*	*Above recommended level*
Energy	16 (29.6%)	37 (68.5%)	1 (1.9%)
Carbohydrate	12 (22.2%)	40 (74.1%)	2 (3.7%)
Total protein	16 (29.6%)	38 (70.4%)	0
Fat	14 (25.9%)	36 (66.7%)	4 (7.4%)
Fiber	28 (51.9%)	26 (48.1%)	0
Vitamin A	24 (44.4%)	30 (45.6%)	0
Vitamin B1	15 (27.8%)	39 (72.2%)	0
Vitamin B2	12 (22.2%)	42 (77.8%)	0
Vitamin C	10 (18.5%)	39 (72.2%)	5 (9.3%)
Calcium	19 (35.2%)	35 (64.8%)	0
Iron	17 (31.5%)	37 (68.5%)	0
Zinc	21 (38.9%)	33 (61.1%)	0

3.4. Biochemical parameters

The results showed that 46 patients (85.2%) suffered from varied degrees of anemia. In children with CKD stage 4, the incidence of anemia is even higher, up to 100%, and severe anemia was the most characteristic. The serum albumin of 42 patients (77.8%) was <3.5 g/L, while 34 patients (63.0%) had increased cholesterol and triglyceride. The biochemical parameters of patients with different CKD stages were showed in Table 1.

3.5. The PNI score

Based on the formula, the patients could be divided into 3 groups: high-PNI (PNI ≥ 38), middle-PNI (35 ≤ PNI < 38), and low-PNI (PNI < 35) groups.

Of the 54 patients who were enrolled in the study, the PNI was <35 in 29 (53.7%) and ≥38 in 13 (24.1%). The median (range) PNI was 33.9. All of the patients with CKD stage 4 were belonged to the low-PNI group.

Table 3

The follow-up of GFR in patients with different PNI scores.

GFR change[*]	*High-PNI n = 13*	*Middle-PNI n = 12*	*Low-PNI n = 29*
Decrease	2 (15.4%)	4 (33.3%)	11 (37.9%)[†]
No improvement	8 (61.5%)	6 (50.0%)	18 (62.1%)
Increase	3 (23.1%)	1 (16.7%)	0

[*] Initial value ± 10%.

[†] GFR significantly decreased in patients with low-PNI scores compared with the subjects with high-PNI scores ($P < .05$).

3.6. The follow-up of patients

After at least 3 months since the first time of data collection, the GFR was measured again and compared with the previous values (Table 3). The alterations of GFR of patients with high-PNI, middle-PNI, and low-PNI scores were investigated respectively. The result showed that GFR significantly decreased in patients with low-PNI scores compared with the subjects with high-PNI scores ($P < .05$).

4. Discussion

The main goals in the management of CKD in predialysis patients are alleviation of uremic symptoms, delaying the kidney replacement therapy and improvement of life quality, which may be achieved by a reasonable and appropriate diet, applied with other elements of treatment.[22] In fact, the children with CKD had poor appetite and dietary restriction. Moreover, it is possible that after diagnosis some patients are unable to limit the quality and quantity of nutrients, such as protein, fat, minerals, and vitamins, even without nutritional training and dietary intervention associated with CKD, so that not all of them are able to reach the healthy dietary goal. It is noteworthy that the nutrition is a critical aspect in the treatment of CKD before starting kidney replacement therapy.[23] However, malnutrition is a major problem among children with CKD. In our study, of the total 54 patient, more than half of participants had different degrees of malnutrition. Because of the many different diagnostic tools used among different studies, the prevalence of malnutrition varies widely, ranging from 20% to 50% at different stages of CKD.[6] In a word, malnutrition is highly prevalent in children with CKD, especially in those with advanced stages. Recently, overnutrition, unbalanced dietary and lifestyle practice are of increasing concern to the pediatric CKD population. For this reason, it is essential to recognize this problem as early as possible, and establish the correct nutritional status in children with CKD in order to improve the life quality.

In CKD, many factors other than inadequate nutrient intake (such as hormonal imbalance, acidosis, etc) contribute to malnutrition, which is ultimately characterized by the loss of body weight, low serum albumin levels, and increased metabolic rate.[24] However, the best method used to evaluate nutritional status in children with CKD has not been established, because nutritional status is a so complex concept that it is difficult to define. Adequate nutritional status can perhaps be described as the normal body composition by consumption of appropriate types and amounts of food, as well as maintenance of a normal pattern of growth and development. Although severe malnutrition is easily recognized, the distinction between adequate nutrition and mild-to-moderate malnutrition is not clear, because no single measurement can comprehensively reflect nutritional status.[25] Moreover, it is important to recognize that each method has limitations. For example, dietary assessment may be limited by incomplete or inaccurate data, which depend on whether day-to-day dietary variability is captured.[26] Serum albumin remains another important marker of the general evaluation for children with CKD, but its limitations must be recognized. As pointed out in the K/DOQI guidelines, serum albumin may be insensitive to acute changes in nutritional status owing to its long half-life. Additionally, serum albumin is depressed both in the setting of volume-overload states and systemic inflammation.[27,28] In our study, we recommended another screening index for evaluation of nutritional status of children with CKD by the PNI scores. In the present studies, the PNI score, which is a simple tool to evaluate malnutrition, was found to predict long-term prognosis, including all-cause death. The independent relationship between hypoalbuminemia and a lower lymphocyte count, due to immunity response or inflammatory activity, has also been reported.[29] In the absence of other suitable tools, the PNI score, which based on the albumin level and the lymphocyte count, seems to be the most fitting for rapidly evaluating the nutritional status, even had a prognostic impact on CKD patients.

Moreover, nutritional status is a critical prognostic factor in children with CKD, and is associated with adverse events of the disease, such as increased rates of hospitalization, increased mortality and decreased quality of life in these patients.[2,17] In our study, the result of follow-up showed that renal function deteriorated significantly in patients with low-PNI scores ($P < .05$), especially in patients with CKD stages 4. 12 patients (22.2%) had received regular hemodialysis at follow-up. Malnutrition, as assessed using the PNI score, affects the prognosis of patients with CKD. Thus, the evaluation of malnutrition plays an important prognostic role in such patients.

5. Conclusion

Malnutrition, as a common complication of CKD, has a prognostic impact in children with CKD before dialysis, as assessed by the PNI score. PNI, easy to calculate, has been used to evaluate the nutritional status in patients with various diseases, which is an independent predictor of outcomes in patients with CKD, especially for subjects with advanced CKD stages.

Author contributions

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