Dietetic-nutritional management strategies for patients with chronic kidney disease

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Abstract. Diet management is the key to nutritional intervention for CKD patients, the most restrictive diet among all chronic diseases, so the dietetic-nutritional management of CKD patients becomes an important element in clinical work. According to the clinical practice guidelines for the nutritional therapy of chronic kidney disease, this paper describes the diet management of patients from the perspective of seven nutrients, aiming to provide reference for clinical work.

Keywords: Chronic kidney disease, dietetic-nutritional therapy, management strategies.

1. Introduction

Dietetic-nutritional management of CKD patients is thought to have a beneficial effect on renal dysfunction, low protein diet is a key component of clinical intervention [1]. Patients with CKD are the main participants in diet management, requiring close collaboration between multidisciplinary professionals (nephropathic dietitians, physicians, nurses, etc.), while also encouraging the active participation of caregivers [2, 3]. For patients with CKD, regardless of the stage, individualized dietetic- nutritional plan should be tailored according to the patient's personal needs, nutritional status, medication, morbidities, complications, biochemical indicator, etc. The basic dietary principle is that the amount of food consumed should be in accordance with the recommended dietary intake, and generally speaking, it should be necessary to reduce protein intake, ensure adequate caloric intake, reduce and monitor sodium, phosphorus, potassium intake, adequate dietary fiber, and adequate intake of all vitamins and other minerals [2-4].

2. Protein

For a long time, low protein diet has been widely used in clinical practice, with the purpose to reduce the high metabolic load of residual renal function and proteinuria, reduce the risk of cardiovascular disease, and improve the symptoms of metabolic acidosis and uremia [1, 5-7]. Under the premise that the body's energy intake is adequate and essential amino acid requirements are met, appropriate protein-restricted diet is safe in the short or long term [2, 4]. Regardless of the stage of CKD, high-protein diet (>1.3 g·kg-1·d-1)should be avoided, and 50%-70% of dietary protein should be of high quality [8]. Additionally, it has been considered that red meat proteins and processed meats are strongly associated with the development and progression of CKD, and the risk of end-stage renal disease (ESRD) was not associated with protein from poultry, fish, eggs or dairy products, and low-fat dairy products would reduce the risk and slow down CKD progression [1, 9-12]. However, protein restriction should start from CKD stage 3 onwards, especially in patients with hypertension, edema, high levels of potassium, nitrogen and phosphorus; and those with diabetic kidney disease (DKD), which may need to be more stringent[3,4].Since CKD patients need to restrict protein intake, conventional rice and noodle diets do not help patients control protein intake very well. In recent years, free (low) protein products are gradually appearing on the market, which provide enough calories but contain almost no protein, phosphorus, sodium and potassium, and can be a substitute for staple foods for CKD patients [2, 3].

3. Carbohydrates and lipids

In CKD patients, while adopting a low protein diet, the proportion of carbohydrates and fats should be increased accordingly to give the body sufficient energy [13] which not only increases the utilization of protein, but also reduces the accumulation of nitrogenous metabolites in the kidney and protects the residual kidney function [14]. It is recommended that the carbohydrate energy supply ratio for CKD patients is 55% to 65%, and those with abnormal sugar metabolism should limit refined sugar intake, and consume high-fiber foods, such as mixed grain cereals, oatmeal, whole wheat bread, mixed fruits and vegetables to provide heat, which can regulate intestinal flora and have a laxative effect; fat energy supply ratio is 25%-35%, of which saturated fatty acids should not exceed 10% and trans fatty acids should not exceed 1%, n-3 fatty acids and monounsaturated fatty acids intake can be increased appropriately, and vegetable oils such as flaxseed oil, tea seed oil or olive oil are recommended to replace butter (animal fats) because animal fats aggravate atherosclerosis and inhibit hematopoiesis; there is no evidence that low-fat diet can improve prognosis of the kidney, and those with lipid metabolism disorders should have a low-fat diet with cholesterol intake <300 mg/d and the maximum daily vegetable oil dosage is about 60 g [8, 13, 15-17]. Individualized recommended energy intake for CKD patients can be developed based on the patient's age, gender, physical activity level, target weight, fat-free body weight, body composition, inflammation level, CKD stage, and co-morbidities to maintain a normal nutritional status [4, 8].

4. Minerals

4.1. Sodium

Excessive salt (sodium) intake is detrimental to blood pressure control, cardiovascular and renal health [1, 18]. In patients with CKD, dietary sodium restriction is strongly recommended to reduce fluid retention, control blood pressure, and reduce cardiovascular risk, and reduce proteinuria in conjunction with pharmacotherapy to improve prognosis [1, 19-21]. Previous studies have shown that each 1g reduction in sodium intake is associated with a 15% reduction in the risk of cardiovascular complications, a 15% reduction in the risk of ESRD in patients with DKD, and a 10% reduction in the risk of ESRD in patients with non-diabetic CKD [22-24]. It is estimated that if potassium salt substitution were used nationwide it would provide considerable benefits, prevent about 1/9 of the population from dying from cardiovascular disease and reduce the number of deaths in CKD patients, so potassium salt can be used instead of sodium salt to reduce sodium intake, but it is not recommended for CKD patients at risk of hyperkalemia [14]. However, it is important to note that elevated and/or decreased serum sodium levels are independently associated with mortality in non-dialysis CKD patients, regardless of the presence of congestive heart failure, and therefore sodium intake below 1.5 g/d is not recommended for CKD patients [1, 25]. Usually, the sodium content of food consumed throughout the day is around 1000mg, and the salt intake can be increased by about 3.3g on top of this to reach a sodium intake of 2.3g/d [14].

4.2. Phosphorus

Phosphorus is an essential nutrient for many physiological functions, but excessive phosphorus intake has adverse effects on the skeletal, renal and cardiovascular systems, especially in patients with CKD who are more susceptible to high phosphorus intake [26, 27]. Although dietary phosphorus intake is not a key determinant of blood phosphorus concentration and is not strongly associated with the occurrence of ESRD and all-cause mortality in patients with CKD [1, 28]. However, higher phosphorus is consumed in food, the more it is absorbed by the body. Normally 80% of phosphorus in the body is excreted through the kidneys, so it may increase the risk of high blood phosphorus in CKD patients, so a phosphorus-restricted diet is still important for the prevention and treatment of hyperphosphatemia [29-31].

Phosphorus is found in protein-rich foods, of which inorganic phosphorus is most easily absorbed by the body (absorption rate of 90%-100%), mainly in processed foods containing phosphorus additives and preservatives, such as processed red meat products, canned fish, fast food, baked food, colas and other beverages [32]. Inorganic phosphorus is often overused as it can add an additional 100mg of phosphorus load per 100g of processed food, which is 2-2.5 times more than non-processed foods [16]. Organic phosphorus absorption rate is low, which presenting in plant foods and animal protein, animal protein organic phosphorus absorption rate of 40%-60%, while plant-derived organic phosphorus (absorption rate of 20%-50%) is more difficult to be absorbed [33-36].

Since each 1g of protein contains 12-14 mg of phosphorus on average, the intake of essential protein also increases phosphorus intake, i.e. high protein intake in the diet is often closely related to high phosphorus intake [14, 32], but low phosphorus diet is not equal to low protein diet, it is recommended to restrict phosphorus intake without restricting protein intake, otherwise excessive phosphorus restriction may lead to insufficient protein intake and affect the nutritional status of patients bringing adverse prognosis and increase the risk of death in CKD patients [29, 32, 37]. Therefore, it is important to achieve a balanced intake of protein and phosphorus. It is recommended that CKD patients limit processed foods containing phosphorus additives and preservatives, choose fresh foods without food additives, low phosphorus/protein ratio (<12mg/g is considered low phosphorus food), and foods with low absorption rate of organic phosphorus, and should not consume fast food/cooked food products for convenience [26, 37-39].

4.3. Potassium

The main route of potassium excretion in healthy adults is urine (80%-90%), and the intake of potassium-rich foods usually does not cause hyperkalemia, but patients with CKD are prone to hyperkalemia due to decreased kidney function, with an incidence of 22.89%, commonly seen in patients with advanced CKD [40-42]. The more symptoms caused by CKD in patients with concomitant hyperkalemia, the more health-related quality of life is significantly reduced, and the risk of hospitalization and overall health care costs increase [43, 44]. The incidence of adverse cardiovascular events is increased by approximately 90% and the rate of death is increased by 65% compared to CKD patients with normal potassium [41, 46]. In addition to renal function and diet, medicines, acid-base balance, glycemic control, and gastrointestinal problems can also increase the risk of hyperkalemia in CKD patients [1, 27]. Current medical evidence is insufficient to demonstrate that dietary potassium intake is associated with CKD progression [21, 46] and there is a lack of recommendations for optimal dietary potassium intake to delay and influence CKD progression [47]. Therefore, the management of hyperkalemia in CKD patients is based on prevention. For CKD patients with blood potassium >5.0 mmol/L, education on low-potassium diet is provided, intake of high-potassium foods is restricted, special table salts such as low-sodium salt and balanced salt are banned, condiments such as soy sauce are used sparingly, and vegetables with high potassium should be soaked and blanched before cooking [41, 43]. However, a potassium-rich plant-based diet is alkaline and can lower blood pressure, reduce the risk of stroke and kidney stones, improve metabolic acidosis, protect bone health, and have a role in cardiovascular protection [46, 48-50]. Hypokalemia is associated with muscle weakness and hypertension in patients with CKD, and dietary over-restriction of potassium intake also predisposes to constipation, potentially increasing the risk of cardiovascular events and all-cause mortality, as well as uremic toxin accumulation in patients with CKD, but CKD patients should not blindly restrict dietary potassium intake to avoid hyperkalemia [1, 41, 46, 51].

4.4. Calcium

Calcium is essential for promoting bone growth and development in the body, and calcium balance has an impact in maintaining normal pumping function of the heart, as well as on muscle function. The kidneys play an important role in calcium reabsorption, so as CKD progresses, blood calcium levels decrease [1, 52], leading to secondary hyperparathyroidism (SHPT) and disorders of bone

metabolism, while hypercalcemia increases the risk of cardiovascular events and death in patients [8, 50]. Calcium-rich foods often also contain phosphorus, protein, and fat, which are more slowly absorbed than inorganic calcium supplements and may reduce hypercalcemia and cardiovascular risk [34, 53]. In patients with CKD, maintaining blood calcium balance requires consideration of several factors, including renal function, bone metabolism, use of vitamin D analogs and calcium, whether or not to dialyze and the type of dialysate they use [1]. Although the recommended intake of dietary calcium is not clear, patients with CKD should consume appropriate dietary calcium to maintain calcium homeostasis [1].

5. Vitamin D

Vitamin D deficiency is closely related to osteoporosis and reduced skeletal muscle strength. Although active vitamin D has been widely used in clinical treatment, nutritional vitamin D supplementation is equally valuable, which facilitates the increase of 1, 25 (OH)2D concentration and protects the kidney by correcting abnormal calcium and phosphorus metabolism, preventing SHPT, improving renal anemia and insulin resistance, It also reduces the risk of fractures and falls, reduces the risk of cardiovascular disease, and improves patient prognosis [54-57]. 90% of the body's vitamin D is synthesized through ultra-violet light exposure to the skin, with only a small portion coming from the diet, mainly referring to vitamin D2 and vitamin D3, the former from plant foods and the latter from animal food s [58-60]. Therefore, although there are no guidelines for safe doses of vitamin D supplementation, patients with CKD may be appropriately supplemented with dietary nutritional vitamin D and have serum calcium, phosphorus, and 25 (OH) D levels measured regularly, especially in patients taking calcium-phosphate-containing conjugates and/or active vitamin D analogs [1, 8, 13].

6. Water

Increased fluid intake in CKD population is a potentially important therapeutic approach, and increasing daily urine output (i.e., urine volume $\geqq$ 3000 ml/d) may be beneficial in slowing the decline of renal function in patients with CKD, especially in patients with recurrent renal stones and autosomal polycystic kidney (ADPKD) progressing to CKD in the early stages of CKD [14]. It is well known that daily fluid intake is closely related to urine volume and edema in CKD patients, and monitoring fluid intake and output is an important part of dietary management for dialysis patients. When blood pressure is normal, there is no edema and serum sodium level and other indicators are within normal range, urine volume can be used as an important reference to guide water intake, and fluid intake in dialysis patients is also related to factors such as dialysis mode and residual urine volume [27]. As for pre-dialysis CKD patients, when there is no edema, hypertension and normal urine output, fluid restriction can be left alone; if mild edema is present, appropriate restriction of water intake is sufficient [8]. If CKD patients have severe edema, oliguria (urine volume <400ml/d) or combined with severe cardiovascular disease, fluid intake should be strictly limited [13], and generally the daily fluid intake is limited to 1000ml. However, attention should be paid to avoid hyponatremia caused by combined diuretics and acute exacerbation of CKD [14].

7. Dietary fiber

Dietary fiber is an essential nutrient for maintaining human health and is mainly derived from plant-based diets. Studies have shown that there is a negative correlation between dietary fiber intake and the risk of CKD, with an increase of 5 g of fiber per day reducing the risk of CKD by 11%, suggesting that a high intake of dietary fiber may reduce the incidence of CKD [61]. For CKD patients, high dietary fiber intake can also promote health, including regulating weight, improving blood lipids, and reducing hunger in obese CKD patients; promoting intestinal motility and defecation, regulating

intestinal flora composition and metabolism, repairing gastrointestinal dysfunction, and promoting excretion of urinary toxins and potassium [19, 50, 62, 63]; slowing the decline in glomerular filtration rate(GFR), reducing the risk of cardiovascular disease in CKD patients, and even avoiding or delaying entry into dialysis [63-65]; It helps to treat DKD or reduce the risk of type 2 diabetes [65]; it also reduces the mortality rate of CKD patients [63, 66]. The monitoring of serum potassium and phosphate levels, high fiber diet is safe and beneficial [66].

The importance of dietetic-nutritional in the prevention and treatment of CKD has been widely accepted, therefore, this article summarizes the latest information on the diet management for CKD patients, aiming to provide a reference for clinical work, so as to CKD patients can obtain the optimal benefits from dietetic-nutritional therapy.

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