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The role of food and nutrition in the prevention and pathogenesis of chronic kidney disease

Sylwia Uniejewska[1]

[1]Wydział Lekarski i Nauk o Zdrowiu UJK w Kielcach [The Faculty of Medicine and Health Sciences at Jan Kochanowski University of Kielce]
https://orcid.org/0000-0002-3107-0592
swu72@gazeta.pl

Summary: The incidence of chronic kidney disease increases with the aging of the population. The occurrence of this disease in our part of the world increases rapidly, which results in increased costs of treatment. Cardiac or renal replacement therapy in the final stages of the disease is very expensive. Keeping patients with CKD (chronic kidney disease) on a proper diet allows for significant improvement of their quality of lives and may extend the moment of introduction of dialysis or the need for a kidney transplant.

Key words: chronic kidney disease, diet, complications of CKD

Introduction

Chronic kidney disease (CKD), formerly called chronic renal failure, is a civilization disease associated with aging. Its development is closely related to the development and the course of other civilization diseases, such as hypertension, diabetes, obesity or heart failure. CKD develops slowly,

deceitfully, initially without any symptoms. Its incidence in the population of Poland is estimated at 16% [1].

Chronic kidney disease is defined as a multi-symptom syndrome resulting from permanent damage or a reduction in the number of active nephrons that are destroyed by various disease processes affecting the renal parenchyma.

CKD classification

In clinical practice, five stages of disease are distinguished as shown in the table below [2].

Stadium	Description	eGFR
I	Damage to kidneys with normal or reduced GFR	below 90
II	Damage to kidneys with a mild GFR reduction	60 - 89
III	Kidney damage with moderate GFR reduction	30 - 59
IV	Kidney damage with severe GFR reduction	15 - 29
V	End-stage renal failure, uremia	Below 15 or dialysis

Epidemiology

The deterioration of renal function may occur following the majority of chronic nephropathies, excluding only a small number of chronic tubulopathies. Precise epidemiological data on the incidence of CKD are regularly collected only for patients in the final stage of CKD treated with renal replacement therapy. Thus, among the causes of end-stage of CKD, diabetic nephropathy dominates, chronic glomerulonephritis is in the second place, and the frequency of hypertensive nephropathy increases considerably [3, 4]. It is also worth noting that in the next place there are unknown or imprecise reasons. Indirectly, this confirms the diagnosis of CKD too late in many cases - just before the implementation of renal replacement therapy, i.e. when the range of diagnostic tests and procedures is largely limited. The epidemiological situation of all remaining CKD stages, apart from the end stage, is much more difficult to determine due to the lack of complete data. Estimating the number of people in whom CKD can be expected, it turns out that the disease is indeed a social one and can affect a large percentage of people both in the world and in our country [5-7]. To sum up the epidemiological situation, it should be stressed that CKD is a much more frequent problem than previously thought.

The most common causes of chronic renal failure include:

• diabetic nephropathy,

• glomerulonephritis,

• hypertensive nephropathy,

• polycystic kidney degeneration,

• bacterial interstitial nephritis,

• non-bacterial interstitial nephritis - nephrolithiasis,

• neoplastic diseases of the urinary tract,

• multiple myeloma,

• amyloidosis.

Energy demand in CKP

In the case of chronic kidney disease, the patient's energy demand changes depending on the stage of the disease.

In the first two stages, weight reduction is recommended for patients with obesity, which translates into better control of lipids and glycaemia. Such a procedure allows for slowing down the progression of renal failure [8].

The energy demand of patients at these stages of the disease is close to the needs of healthy people. Therefore, people with normal body weight, in order to maintain it [weight], are recommended to consume 35 kcal/kg bw/day [9]. However, in overweight and obese people, to obtain a moderate weight reduction, the individual energy requirements should be calculated based on the formula: basal metabolic rate (BMR) × physical activity coefficient, where BMR for men = 11.6 × body weight (kg) + 879 kcal, for women = 8.7 × body weight (kg) + 826 kcal, and the physical activity coefficient for people leading a sedentary lifestyle is 1.3, for the people average active - 1.5, and with regular physical activity - 1.7 [10]. From the metabolic rate calculated in this way 1000 kcal should be subtracted, receiving a diet with moderate caloric deficit, which will influence the body weight reduction by about 1 kg per week.

At further stages, attention should be paid to calculating this amount of energy in the diet to prevent malnutrition. At the stages of the disease, when the GFR is 15 - 59, the energy demand usually decreases, but there is a tendency to increase the caloric deficit. At these stages, one should still aim at normalization the patient's body weight, for example by using a moderate caloric deficit. The control of the caloric deficit should be carried out in such a way as to prevent a drop in a fat free mass. According to the recommendations of the National Kidney Foundation, people with a normal body weight below the age of 60 should continue to consume about 35 kcal/kg bw/day. In contrast, in people over 60 years of age, due to the tendency for a decrease in a fat free mass (and development

of sarcopenia) and the reduced physical activity, an acceptable energy supply is 30-35 kcal/kg bw/day [10].

In advanced renal insufficiency, mortality increases with the lack of nitrogen balance adjustment. In the end stage of chronic kidney disease, it is recommended to consume 30-35 kcal/kg bw/day and modify the nutrition according to current needs, as well as regular monitoring of the nutritional status, taking into account the glucose caloricity in the dialysis fluid in patients undergoing dialysis.

In patients qualified for renal transplant the body weight should be reduced, whereas it has been reported that slight obesity may paradoxically prolong the life of patients undergoing dialysis [11].

Supply of macronutrients in CKD

Protein - a low-protein diet is used in chronic kidney disease. The amount of protein in the diet is modified depending on the stage of the disease. A low-protein diet also reduces the intake of phosphorus and sodium. The use of low-protein diet is mainly justified in chronic renal failure caused by diabetes [12]. In this group, the supply of protein should be correlated closely with the patient's condition. It is generally recommended that the supply of protein should be 0.6g/kg bw/day, which should contain 50% of full-value protein of the animal origin (contains all amino acids).

In patients in the 5^{th} stage of CKD (GFR <15 ml/min / /1.73 m2), including those treated with renal replacement therapy, protein and energy malnutrition is a significant clinical problem. It is estimated that it occurs in 26-76% of patients with hemodialysis and 18-50% undergoing peritoneal dialysis. The average protein intake in this group of patients is 0.94-1.0 g/kg bw/day, but nearly half of the patients examined take smaller amounts. In contrast, the necessary protein intake ensuring a neutral or positive nitrogen balance, preventing the occurrence of protein-energy malnutrition in patients undergoing dialysis, is approximately 1.2g/kg bw/day. It has also been observed that the lower intake of protein by these patients is associated with a decrease in the serum of albumin and increased morbidity and mortality [16]. For this reason, the supply of protein in dialyzed patients should amount to about 1.2g/kg bw/day, of which at least 50% should be animal proteins containing all essential amino acids [13, 14, 15, 16].

In the states of nephrotic proteinuria it is recommended a supply of the protein at the level of 0.8 - 1g/kg bw/ day and, as before, at least 50% of the protein should be of animal origin.

Fats - in patients with CKD, there often appears the lipid metabolism dysfunction which leads to faster development of atherosclerosis. Cardiovascular disease is the main cause of death in group of people with chronic kidney disease. Fats in patients with renal failure are the second, after carbohydrates, source of energy taking into account the limitation of protein intake. They should cover approx. 30% of energy demand.

The main sources of both saturated fatty acids and cholesterol are: fatty meat and cured meats, offal (liver, heart, kidneys), bacon, lard, fat milk, butter, cheeses and processed cheeses and egg yolk. Therefore, the consumption of these products should be reduced to a minimum. The monounsaturated fatty acids should be up to 20% of the daily energy value of the diet (olive oil, sesame oil and rapeseed oil), and up to 10% - polyunsaturated fatty acids (omega-3, omega-6). The sources of omega-3 fatty acids are fatty sea fish: mackerel, herring, Atlantic salmon, halibut, as well as soybean, linseed and rapeseed oils. In turn, omega-6 acids are found in sunflower and corn oils. A good source of polyunsaturated fatty acids are also high quality margarines [17].

Carbohydrates - should cover half of the energy demand of a CKD patient. These should mainly be complex carbohydrates, while the intake of simple carbohydrates and refined starch should be limited. This limits the production of triglycerides and improves glucose tolerance.
For this reason, the patient should first of all consume whole-grain bread, brown rice, whole-meal pasta, potatoes, groats and oatmeal as well as vegetables [17]. The recommended intake of dietary fiber should be 20-30g/day. In the case of extreme renal failure, the supply of vegetables containing high amounts of potassium and fruits with high fructose content should be limited.

Nutritional recommendations in patients with chronic kidney disease [18]

	Stadium 1	Stadium 2	Stadium 3	Stadium 4	Stadium 5
Energy demand in kcal/day	No recommendation	No recommendation	No recommendation	35 (above 60 years of age 30 - 35)	35 (above 60 years of age 30 - 35)
Protein g/kg bw /day	0.6 - 0.75 including about 50% of complete proteins	0.6 - 0.75 including about 50% of complete proteins	0.6 - 0.75 including about 50% of complete proteins	0.6 - 0.75 including about 50% of complete proteins	1 – 1.2
Fats - % of total energy demand	25 - 35	25 - 35	25 - 35	25 - 35	25 - 35
Carbohydrates -% of total energy demand	about 50	about 50	about 50	about 50	about 50

Mineral ingredients

Sodium

In chronic renal failure, the ability to excrete sodium decreases.

Excess sodium in the body leads to increased thirst, water retention, edema, hypertension.

One should eliminate all products with the addition of table salt from the diet, like: canned food, marinades, cured meat, meat products, smoked products, smoked salted fish, cheeses, pickles, cereal products - cornflakes, food concentrates with the addition of sodium glutamate (stock cubes, powdered soups and sauces, "vegeta").

Meals should not be salted [17]. Hyponatremia may also indicate overhydration.

Such stringent sodium restrictions are not necessary when using diuretics. For flavor reasons, salt and spice mixtures can be replaced with vegetable spices, such as green parsley, dill, celery, onion, garlic, cumin, basil, lemon balm, mint, tarragon, coriander, thyme, marjoram, sweet pepper, cinnamon, vanilla, lemon juice [21].

Phosphorus

In kidney failure, the excretion of phosphorus is impaired.

An excess of phosphorus reduces the concentration of calcium in the blood by precipitation of calcium and phosphorus salts deposited in the form of deposits in the heart, muscles, blood vessels.

High concentrations of phosphorus lead to decalcification and osteoporosis. The clinical symptoms of excess of phosphorus in the blood are negligible, while the consequences of this condition, appearing after months or years, are dramatic.

Excess phosphorus in the body is not felt immediately after the consumption of phosphorous-rich products, but it will appear in a few months with bone and joint pain! After many years, there will also be an advanced, secondary hyperparathyroidism and acceleration of calcification of the blood vessel walls, resulting from a high calcium-phosphate product (Ca x P) [22]. A rich calcium diet, however, is difficult to apply, because calcium-rich products contain large amounts of harmful phosphorus at the same time.

To limit the consumption of phosphorus, one should give up products, such as offal, veal, fish, cereal, whole-wheat bread, dry legume seeds, carbonated beverages.

On the other hand, one should not exclude from the diet milk and its products, such as kefir, yogurt, quark cheese. These products, although they contain large amounts of phosphorus, are also a rich source of easily accessible calcium and therefore should be included in the diet. Instead, cheeses and processed cheeses should be given up [17,18].

In patients with renal insufficiency, in order to maintain the proper level of calcium and phosphate metabolism, supplementation of the active form of vitamin D and calcium preparations is recommended.

Potassium

In kidney failure in the first stage of the disease (latent kidney disease) and the second stage (compensated kidney failure), the majority of patients should use a high-potassium diet due to the loss of potassium caused by increased urine output.

With worsening kidney function (not compensated and end-stage renal failure), at an elevated level of potassium, the consumption of this element should be reduced by limiting products, such as chocolate and chocolate products, cocoa, nuts, dry legume seeds, groats (especially buckwheat), dried plums, figs, bananas, citrus fruits, avocados, mushrooms, potatoes, carrots, tomatoes (especially ketchup and tomato concentrate), leafy vegetables and some spices, such as dried parsley, basil, tarragon, pepper powder.

To limit the content of potassium and sodium in the diet, one should use the so-called double cooking without salt.

Peeled and finely chopped vegetables should be poured with a large amount of boiling water and soaked for half an hour, then rinsed several times and boiled until tender [17].

Low-potassium diet, unfortunately, contains small amounts of vitamins from the B, B1, B2, B6 group, folic acid and vitamin C, therefore, they should be supplemented.

Iron

Because iron is absorbed worse in patients with renal insufficiency than in healthy people, it is recommended to eat foods containing iron in the form of heme (red meat - beef, veal, poultry meat and fish), whose iron is absorbed more easily. Non-heme iron contained in products, such as eggs, vegetables or fruit is less well absorbed. An important factor increasing the intake of iron in the intestines is vitamin C. It should be paid attention to its proper supply [21].

Nutritional recommendations in patients with CKD, minerals [18]

	Stadium 1	Stadium 2	Stadium 3	Stadium 4	Stadium 5 – hemodialyzed patients	Stadium 5 – patients with peritoneal dialysis
Sodium – mg/d	1000 - 3000	1000 - 3000	1000 - 3000	1000 - 3000	750 - 2000	750 - 2000
Potasssium – mmol/d	No recommendation	No recommendation	No recommendation	No recommendation	50 - 75	50 - 75
Calcium - mg/d	No recommendation	No recommendation	No recommendation	No recommendation	1200 - 1600	1200 - 1600
Phosphorus - m/kg bw/d	No recommendation	No recommendation	8 - 10	5 - 10	10 - 17	10 - 17
Magnesium - mg/d	No recommendation	No recommendation	No recommendation	200 - 300	200 - 300	200 - 300
Iron - mg/d	No recommendation	No recommendation	No recommendation	8 for men, 8 – 12 for women	Depending on the demand and dose of the erythropoiesis stimulant	Depending on the demand and dose of the erythropoiesis stimulant
Zinc – mg/d	No recommendation	No recommendation	No recommendation	10 - 15	10 - 15	10 - 15

Other disturbances in the levels of minerals in CKD include excessive accumulation of magnesium and a decrease in the level of zinc. A patient with chronic kidney disease should consume a maximum of 200 - 300mg of magnesium per day. To this one should limit the magnesium rich products, such as

corn, poppy seeds, beets, linseed, oats, cocoa, nuts, soybeans, beans, peas, chocolate, tomatoes and tomato concentrate, parsley (parsley root and top).

The recommended intake of zinc is on average around 12mg per day. Supplementation of this element should be carried out only in the case of deficiency symptoms, such as decreased libido, taste and smell disorders, delay in wound healing or lack of appetite [19].

Micronutrients - vitamins

As the disease progresses, the chances of vitamin deficiencies increase. This is due, inter alia, to reduced appetite, dietary restrictions, taste disorders and increasing nausea. Also, the absorption of some vitamins in CKD patients is impaired. The problem of vitamin deficiency may also be caused by the loss of water-soluble vitamins during dialysis.

The most common is a deficiency of vitamin D3 in the mechanism of impaired synthesis of its active forms. The deficiency of vitamin D3 leads to hyperparathyroidism and ultimately contributes to the development of renal osteoporosis. Vitamin D3 should be supplemented at every stage of chronic kidney disease.

Usually, there is no need to administer vitamins A, E and K.

Among water-soluble vitamins deficiencies are associated with vitamins C, B6 and folic acid.

The doses of vitamin supplementation in the course of CKD are presented in the table below [20].

Vitamin	Recommended daily supplementation
Vitamin B1 (thiamine)	1.1 – 1.2mg
Vitamin B2 (riboflavin)	1.1 – 1.3mg
Vitamin B5 (pantothenic acid)	5mg
Vitamin B6 (pyridoxine)	10mg
Vitamin B12 (cobalamin)	2.4 ug
Vitamin C (ascorbic acid)	75 – 90mg
Vitamin PP (Niacin)	14 – 16mg
Vitamin H (biotin)	30ug
Folic acid	1mg
Vitamin A (retinol)	Do not supplement
Vitamin E (alpha-tocopherol)	Do not supplement
Vitamin D - active form	0.25 – 1ug
Vitamin K	Do not supplement

In the course of chronic kidney disease, dietary treatment is a very important component of the therapeutic process. The diet should take into account the demand for ingredients at various stages of the disease and should also be accepted by the patient. Dietary counseling for CKD patients should be individualized, taking into account the stage and dynamics of the disease course. In teams dealing with chronic kidney disease a qualified dietitian should be employed.

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