Nutrition in Chronic Kidney Disease: Literature Review

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Significance and Prevalence

Chronic Kidney disease (CKD) is defined as impaired kidney function (1). It is associated with malnutrition (2), and it imposes substantial mortality and morbidity burden (3). In the United States, CKD affects about 15% of the population or 30 million adults with about 22% of these cases resulting in dialysis or transplantation (4). In the Western world, the prevalence is 150 to 400 per million population (pmp) compared to 50 pmp in poor countries (1). Research suggests that CKD is very diverse, and it is more than twice as prevalent in the United States at 13.1% compared to Poland at 5.8% (1). The literature emphasizes that adults with CKD ages 65 and older have a 2-fold prevalence of cardiovascular disease resulting from complications with CKD (5). The highest prevalence of CKD is in older women. (1) Furthermore, 417.0 million females compared to 335.7 million males had CKD worldwide in 2016 (3). At most,10 elderly adults out of 24 have a reduced glomerular filtration rate (GFR), which determines kidney function of < 60/ mL/min/ 1.73m ^{2} (stage 3 or more progressed), and 10 out of 22 have albuminuria in addition to a reduced GFR (1). The Western diet is associated with an increased risk of CKD with increased levels of albumin and/or a fast decline in GFR (> or = 3 mL/min/ 1.73m^2) (4).

However, literature has found that diet is significant in the management and prevention of CKD. At every stage of CKD, dietitians provide medical nutrition therapy (MNT) to delay the onset of dialysis, maintain patients in normal nutrition status (6), and slow the progression and onset of symptoms (7). Specifically, MNT helps prevent and treat protein-energy wasting, electrolyte imbalances, and bone abnormalities (6). Additionally, the diet recommendations are restrictive (6). Malnutrition in CKD is often undiagnosed in patients, but it occurs in 30-40% of patients (2), and nutrition screening and management should take place to improve quality of care and patient outcomes (6).

Known Risk Factors of CKD

Unhealthy lifestyle behaviors associated with CKD are physical inactivity, late-night dinner, and bedtime snacking in middle-aged and older adults (8). According to data from the Midlife in the United States Study, higher economic status was associated with a reduced probability of being at high risk for risk factors related to kidney function rather than at low risk (OR [95% CI] = 0.82 [0.71-0.95]) (9). As part of a cross-sectional cohort study, a multivariate regression analysis showed patients who were smoking or physically inactive but received nutrition education had better estimated glomerular filtration rate (eGFR) (OR [95% CI] =3.67 [2.04-5.29]) compared to patients without nutrition education, which suggests that nutrition education can slow kidney function decline (8). However, this same study showed that smoking was not associated with kidney function (8). In contrast, a different study found that current smokers significantly increased the odds ratio of developing CKD compared to non-smokers (OR [95% CI] = 2.18 1.57-3.03) (10). Physical activity duration, increased by an hour, was negatively associated with eGFR (OR [95% CI] = -0.71 [-1.08 to -0.35]) in type 2 diabetic patients (8). 70% of all cases of renal failure are accounted by diabetes and hypertension in the United States (4). Obesity, hypercholesterolemia, and elevated inflammation also increase the risk of CKD (9). Compared to men, women with diabetes experience a greater burden of diabetic kidney disease risk factors (11). CKD risk factors and other diseases are fueled by following a calorie-dense diet, the Western Diet, which is high in saturated fats, carbohydrates, sodium, and animal protein and is low fruit, vegetable, and/ or fiber intake (4). According to the literature reviewed by Kramer, more than 90% of two major causes of CKD, hypertension and diabetes, could be prevented if all adults in the United States followed healthy dietary and lifestyle habits (4). Additionally, diet was strongly associated with body mass index (BMI) in the Framingham Offspring Study; a high BMI increased the odds of developing CKD by 23% per standard deviation unit (12).

CKD genetics requires more research; however, the literature highlights that African Americans develop CKD at higher rates than Caucasians and Mexican Americans (12, 13). Genome-wide and candidate gene studies suggest that common genetic variants in the myosin, heavy chain 9, non-muscle (MYH9) gene are associated with CKD (13). In contrast, National Health and Nutrition Examination Surveys and collected biospecimens for DNA extraction taken by the Centers for Disease Control were accessed to evaluate the associations between kidney-related traits and end-stage renal disease-associated genetic variants across racial/ethnic groups (13). It was found that none of the MYH9 variants tested were associated with disease traits in African Americans (13). However, more CKD cases were identified among 55.6% of African Americans (1555/2796) compared to 29.2% of Caucasians (1734/5940) and 27.3% of Mexican Americans (922/3378) (13).

Nutrition Management

An effective strategy in managing and preventing the progression of CKD is to make dietary and lifestyle modifications. Various research suggests that dietary patterns low in processed and red meats and high in fruits and vegetables, such as Dietary Approaches to Stop Hypertension (DASH), can help stop the decline of eGFR (5, 14, 15). Conversely, the Western Diet likely causes increased levels of albumin excretion and a rapid decline in eGFR (5). People with CKD can modify the DASH diet to achieve a protein intake of 0.6-0.8 g/kg, 0.8-1.0 g/d of phosphorus, and 2-4 g/d of potassium (4). High protein diets should be avoided by people with CKD who are not on dialysis(4). Lower dietary acid loads, for example, meats and cheeses and more fruits and vegetables, have been found to prevent CKD progression in clinical studies (16-18). Regarding water intake, a prospective cohort study also found that the relation between plain water intake and progression of CKD is U-shaped, meaning that both low and high-water intake may not be beneficial in those with CKD (19). Coupled with adequate nutrition, exercise can help prevent the loss of lean body mass in CKD patients (20). Research suggests that resistance training seems to be effective and protective in CKD patients on a low-protein diet by improving protein utilization, muscle fiber generation, and function and body composition (20, 21). According to D'Alessandro et al., in CKD patients who are on a low-protein diet, like the DASH diet, the extra energy needs related to exercise can be obtained by increasing the intake if protein-free foods, which provide more of other macronutrients and are almost free of protein, phosphorus, potassium, and sodium (22). According to a review, physical activity can positively affect the nutritional status of CKD patients and may facilitate the anabolic effects of dietary interventions (20).

A second strategy for managing CKD, which is supported by research, is MNT by a dietitian, specifically having to do with reducing protein, potassium, sodium, and phosphorus to meet the Academy of Nutrition and Dietetics Guidelines. A retrospective cohort study found that an MNT group had less decline in eGFR than a non-MNT group (0.3 vs. 9.9 mL/min/173m^2, respectively) with a mean difference of 9.6, and after adjusting for each stage of CKD, the mean difference was greater at 11.4. (23) Sodium, protein, potassium, and phosphorus are nutrients that need to be modified and monitored in patients with CKD (15). Lower dietary protein targets may be challenging to achieve, and it may be reasonable for clinicians to aim for the lower end of the protein recommendation of 0.6-0.8 g/kg/d (7). This is because low-protein trials show that actual protein intake tended to be above 0.8g/kg/d despite the low-protein dietary prescription (15, 24-28). The Academy of Nutrition and Dietetics rated the evidence from research supporting protein restriction in CKD patients not on dialysis and without diabetes as strong; however, it is also strongly rated that there is insufficient evidence to recommend a particular protein type (plant vs. animal) (6, 15). A low protein diet with adequate energy can help minimized hyperphosphatemia in non-dialysis patients, and those on dialysis are at risk of hyperphosphatemia and should be monitored (21). The Academy of Nutrition and Dietetics rated the evidence from research supporting normal phosphorus levels in CKD patients as strong (6). Managing phosphorus can help prevent CKD mineral and bone disorder (15). Calcium is essential in patients with CKD; a cross-over study found that total elemental calcium should be within 800-1200 mg/day to prevent calcium deficiency and calcium loading (29). Research shows that patients placed on potassium-losing diuretics may need supplementation due to elevated urinary excretion of potassium (15). In addition, research shows that potassium-containing salt substitutes should be avoided (14). However, according to Beto et al., potassium restriction can be difficult because it mostly cannot be tasted, and foods that contain potassium often do not have nutrition labels (14). However, sodium can often be tasted, and according to Munson et al., sodium restriction in patients with CKD can help reduce blood pressure and proteinuria (15). The Academy of Nutrition and Dietetics rated the evidence from research supporting sodium limitation to $<$ 2.3g/d to lower blood pressure and improve volume control in CKD patients as strong (6). A study using 24-hour urine collections for a urine analysis showed at baseline a urine volume of more than 2 L/d and estimated sodium and protein intake within targets in 51.6% and 40.3% of cases, which improved during follow-up for protein only to 45.9%, suggesting that this is a reliable tool to monitor salt and protein in CKD patients (30). Education on restrictions will be appropriate for nearly all patients with CKD (15). A controlled clinical trial established the effectiveness of education intervention in kidney function improvement in an intervention group compared to a controlled group (31). The mean change in GFR was 7.5 +/- 8.9 mL/min/1.73 m2 after the education intervention (31).

Nutrition Prevention

A strategy to prevent CKD is managing the major causes of CKD. Most CKD cases are largely preventable, and it is estimated that > 24% of CKD cases in industrialized countries are related to nutritional factors (4). According to Kramer, >90% of type 2 diabetes cases and 65% of hypertension cases are the two major causes of CKD (4). The World Health Organizations' plans for the prevention related to nutrition in CKD are a 30% relative reduction in mean population intake of sodium, a 25% relative reduction in hypertension, and halting the rise in diabetes and managing it (32). Furthermore, an estimated 70% of dietary salt from a Western diet comes from bread and processed foods, and the restriction of these foods will reduce dietary salt, saturated fat, and carbohydrate intake (32). According to Beto et al., glycemic (if diabetic) and blood pressure control should be individualized and monitored (14).

A second strategy for CKD prevention is awareness and screening (33, 34). The assessment of a registered dietitian during screening can help evaluate these factors (14). However, screening tests for kidney function can be affected by dehydration status, diet composition, and extreme exercise variables (14). Additionally, screening for CKD in people with diabetes and hypertension is generally recommended (32). Awareness is also essential in preventing CKD progression since it often is a silent disease that can remain asymptomatic until it reaches an advanced stage (33, 34). Among the 1.7 million adults with CKD, 1.5 million are unaware that they have the disease (34). Awareness of early and advanced CKD is low, with less than 20% in industrialized nations (33). The Academy of Nutrition and Dietetics recommends that medical and health history be assessed for the presence of comorbidities that may contribute to CKD and CKD progression (14).

Best Standard of Practice and Justifications

The best standard of practice for CKD is to intervene with MNT to develop a management plan to reinforce diet adherence and prevention of nutrition complications and CKD progression with education and counseling (35). The dietitian also needs to conduct routine nutrition assessment and review monthly laboratory test results related to nutrition (35). Communication with the healthcare team is essential regarding laboratory indicators relating to bone and mineral disorders, anemia, and dialysis outcomes (35).

As mentioned earlier, patients who received MNT had less decline in eGFR compared to non- MNT patients (23). MNT is recommended by the National Kidney Foundation and the Academy of Nutrition and Dietetics in every stage of CKD (5, 23, 36). The Academy of Nutrition and Dietetics describes MNT to manage CKD as one of the most critical interventions for slowing CKD progression (5).

Counseling and education are justified; Campbell et al. studied counseling on a prescription of 0.75 g/ kg/day protein and 145 kJ/kg/d energy compared with written education material for three months (37). The intervention group had a lower reduction in body cell mass and improved in adherence to prescription intake (37). According to the literature reviewed, dietary protein requirements in CKD are calculated to maintain lean body mass, positive nitrogen balance, and normal serum albumin(38-41). Research indicates that before dialysis, protein should be reduced to 0.6 g/kg body weight/d (42-44). Reduction to this level resulted in a 32% reduction in renal deaths (OR [95% CI = [0.55-0.8]]) (44), which emphasizes the importance of CKD management. In a randomized controlled trial, Sullivan found that counseling on reducing phosphates in foods compared to usual intake significantly reduced serum phosphate levels by 0.6 mg/dL and improved food label reading (45). Nutrition interventions can improve glucose and blood pressure control, slow CKD progression, improve laboratory indicators, and delay dialysis need (23, 36, 46-50). Considering cultural beliefs when presenting educational material may improve adherence by providing practicality and personalized examples (51-53).

Justifications for assessing laboratory values, body weight, and/or self-reported dietary intake records are that it is essential to monitor food intake, prescribe a diet, and check for compliance to the prescribed diet (14, 54, 55). A 2-year retrospective cohort study found a significant reduction in malnutrition from 14% to 3% in serum phosphate and maintained serum albumin in patients who received a 6-month dietetic review with intensive follow-up (56). Higher mortality and morbidity have been reported in patients who do not meet the goals made with the help of healthcare professionals (57), which justifies the importance of communicating laboratory values indicating complications.

Conclusion

Overall, CKD or impaired kidney function is a health concern in the United States and the rest of the world (1-4). The elderly are at the most risk of CKD and its complications because of a decline in kidney function with age (5). Women and women with diabetes are especially at risk compared to men (3, 11). The western diet contributes to the risk of CKD because of its high sodium levels (4). However, an adequate diet and MNT by a dietitian is essential in managing and preventing CKD (2, 6, 7). Controlling hypertension and diabetes is critical because they are two of the major causes of CKD (4, 14). African Americans are at a higher risk of developing CKD (12, 13). Research suggests that the DASH diet can help stop CKD decline (5, 14, 15). Additionally, the primary nutrients needing to be modified in patients with CKD are sodium, protein, and phosphorus, and the Academy of Nutrition and Dietetics supports this approach (6, 15). Exercise can help prevent muscle loss and support anabolism in CKD patients on low protein diets (20-22). Fluid intake should be adequate to prevent CKD progression (19), and 24-hour urine collections can be used to monitor salt in protein in CKD patients (30). CKD is largely preventable by reducing processed foods, which will reduce sodium intake (32). Because of the silent onset of CKD, making the public aware of CKD is essential (33, 34). The best standard of practice includes MNT with the components of the Nutrition Care Process (35).

Limitations of the literature reviewed are that many of the studies were often limited in sample size. In fact, in one study sample size was due to low levels of health literacy (29). More randomized controlled trials are needed to examine clinical outcomes from nutritional interventions in CKD and to prevent CKD progression (21). All the literature provided in this literature review may have failed to include relevant studies and one or more relevant factors associated with CKD, such as obesity (32). Additionally, few studies have looked at MNT use, and existing studies suggest that only 10% of patients with CKD receive any MNT before dialysis (5).

Further studies are needed in this area as studies on e-learning (31) because most US patients with CKD are not meeting with RDNs until they develop kidney failure (5). Future studies can use larger sample sizes, especially in this with stages 1 and 2 CKD (31). Future studies could also examine better biomarkers to predict CKD risk and progression, to improve awareness and patient success, and to help limit renal death in people with CKD (58). Studies focusing on the impact of lifestyle measures on renal outcomes and examining optimal methods to improve the diets of those with CKD are needed (4). More research is also needed to explore the impact of specific diets, such as the vegetarian diet, on CKD outcomes (4). Future trials could examine whether intermittent protein restriction slows CKD progression (4). Furthermore, adequate nutrition coupled with exercise needs to be researched further in all CKD stages (20).

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