Chapter 15
Medical Nutrition Therapy for Kidney-Related Disorders

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Key Points

- Lifetime risk of chronic kidney disease (CKD) is increasing.
- Diabetes and hypertension are the leading causes of CKD.
- CKD is graded using estimated glomerular filtration rate (eGFR) and urine albumin-to-creatinine ratio (UACR).
- Kidney disease increases the risk for cardiovascular disease. Fluid retention may lead to severe hypertension, pulmonary edema, pericarditis, and heart failure.
- Appropriate nutrition choices can reduce incidence of acidosis, prevent hyperkalemia, improve nutrition biomarkers, and slow the progression of CKD.
- A referral to a dietitian with expertise in CKD should be recommended upon diagnosis of CKD.

Keywords Chronic kidney disease (CKD) • Acute kidney injury (AKI) • End-stage kidney disease (ESRD) • Acidosis • Hemodialysis • Peritoneal dialysis • Kidney stones

Introduction

Chronic kidney disease (CKD) is a global problem with lifetime risks increasing [1–3]. The Centers for Disease Control and Prevention (CDC) estimates that kidney diseases are the ninth leading cause of death in the United States with more that 10% of the adult population being affected [4]. Diabetes and hypertension are the leading causes of kidney disease. CKD is detected and monitored by estimated glomerular filtration rate (eGFR) and urine albumin-to-creatinine ratio (UACR). CKD is a progressive disease and is defined as a reduction of kidney function (eGFR <60 mL/min/1.73 m^3 for >3 months) and/or evidence of kidney damage, including persistent albuminuria (≥30 mg of urine albumin per gram of urine creatinine for >3 months). The classification and relative risk ranked by GFR and albuminuria is reviewed in Fig. 15.1 with colors showing which groups of patients are at

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higher risk for major health outcomes [5, 6]. One of the major goals for CKD is a reduction in new cases of kidney disease and its complications, disability, death, and economic cost [7].

The basic function of the kidney includes the removal of waste products from the blood while regulating body water and electrolytes. As kidney disease progresses, altered nutrition biomarkers are observed which may be related to poor dietary habits [8]. The typical American is high in protein and processed foods which can affect the balance of the body's minerals, including electrolytes, and contributes to the uremic environment of the digestive system. Patients with kidney disease are often prescribed diets that are low in potassium due to hyperkalemia; they are given handouts that focus on limiting fruits and vegetables. Patients become confused and frustrated as this recommendation is at odds with diets widely recommended for the prevention of other diseases, such as diabetes and heart disease (e.g., the Mediterranean and DASH diets); those diets emphasize fruits, vegetables, and whole grains. Evolving evidence of a link between the gut and kidney health [9] suggests a need for emphasis on nutrition for the care of a patient with compromised kidney function.

Patients do not notice any symptoms in the early stages of CKD. The presence of kidney disease increases the risk for cardiovascular disease, including heart attacks and strokes. Fluid retention may lead to edema, severe hypertension, pulmonary edema, pericarditis, and heart failure. Other common health-related consequences in CKD include anemia, metabolic acidosis, hyperkalemia, and bone and mineral disorders [10].

CURRENT CHRONIC KIDNEY DISEASE (CKD) NOMENCLATURE USED BY KDIGO

CKD is defined as abnormalities of kidney structure or function, present for > 3 months, with implications for health and CKD is classified based on cause, GFR category, and albuminuia category (CGA).

Prognosis of CKD by GFR and albuminuria category

Prognosis of CKD by GFR and Albuminuria categories: KDIGO 2012				Persistent albuminuria categories Description and range		
				A1	A2	A3
				Normal to mildy increased	Moderately increased	Severely increased
				<30 mg/g <3 mg/mmal	30-300 mg/g 3-30 mg/mmal	>300 mg/g >30 mg/mmal
GFR categories (ml/min/ 1.73 m²) Description and range	G1	Normal or high	≥90			
	G2	Mildly decreased	60-89			
	G3a	Mildly to moderately decreased	45-59			
	G3b	Moderately to severely decreased	30-44			
	G4	Severely decreased	15-29			
	G5	Kidney failure	<15			

Green: low risk (if no other markers of kidney disease, no CKD): Yellow: moderately increased risk; Orange: high risk; red,very high risk.

Fig. 15.1 Prognosis of CKD by GFR and albuminuria category. Reproduced from: Kidney Disease: Improving Global Outcomes (KDIGO) CKD Working Group. KDIGO 2012, Ref. [6], with permission

Kidney failure or end-stage renal disease (ESRD) refers to the condition, where the kidneys are no longer able to remove waste products. It is typically defined as an eGFR <15 mL/min/1.73 m^2 [4]. Early treatment of CKD with drugs and lifestyle changes can decrease the rate at which CKD worsens and can prevent additional health problems. This helps improve patient outcomes. However, the numerous and sometimes conflicting guidelines for CKD can make providing appropriate care challenging.

Common Disorders in CKD and Their Relationship to Nutrition

Metabolic Acidosis

Accumulating evidence suggests that acidosis is not only a consequence of but a contributor to CKD progression [11]. The kidney maintains the balance of bicarbonate levels so when kidney function is compromised, the ability to neutralize acid is compromised. Acidosis is defined as a serum bicarbonate level <22 mEq/L. Metabolic acidosis can contribute to bone disease, hyperkalemia, and protein catabolism with decreased protein synthesis. The diet consumed by most Americans results in a high dietary acid load because of its high content of animal protein and low content of fruits and vegetables [12]. The findings from studies that investigated dietary acid load and the incidence of CKD suggest a potential avenue for reducing CKD risk through diet [13]. Increasing the intake of fruits and vegetables improves serum bicarbonate levels, much like the use of sodium bicarbonate, and does not induce hyperkalemia. The addition of fruits and vegetables to the diet also demonstrated some preservation of kidney function [14, 15], contrary to the goals presented in much of the aforementioned dietary modification literature provided for CKD patients.

Hyperkalemia

Hyperkalemia is often seen in patients in the later stages of kidney disease. Reduced potassium excretion and metabolic acidosis induce high serum potassium levels. Poorly controlled diabetes is the most common cause of hyperkalemia in advanced CKD. Certain medications (some blood pressure medications, NSAIDS) and severe constipation may also cause hyperkalemia. Other contributors to the dietary potassium load include the use of low-sodium products (such as salt substitutes or low-sodium canned soups which have added potassium chloride in place of sodium chloride), many beverages (energy, electrolyte, coffee, smoothies, and juices), and a high chocolate intake. A high dietary acid load (animal protein and dairy products) is not only high in potassium but also contributes to the metabolic acidosis found in CKD. Patient education intended to reduce potassium levels is often focused on fruits and vegetables that are high in potassium rather than other causes of their hyperkalemia. Recent literature indicates that fruits and vegetables are not necessarily the cause of hyperkalemia; in fact, they can help manage acidosis [14, 15].

The management of hyperkalemia requires a review of medications for any that may cause high potassium levels. It is important to manage diabetes to prevent hyperglycemia. Incidents of hypoglycemia would be better treated with glucose tablets, cranberry juice cocktail, or apple juice which is lower in potassium rather than orange juice. Beverages containing phosphorus additives such as colas or fruit punch are contraindicated to treat hypoglycemia in kidney disease. It is preferable to manage acidosis with diet though sodium bicarbonate is often used. A high-fiber diet which includes fruits and vegetables will also help manage constipation which also may cause hyperkalemia.

Bone and Mineral Disorders

CKD affects calcium and phosphorus balance resulting in a renal bone disease. As CKD progresses, vitamin D levels decline and parathyroid hormone levels rise [16]. High serum phosphorus levels are not usually seen until the later stages of kidney disease, but a diet high in phosphorus may be contributing to the changing bone patterns as CKD progresses. As kidney function decreases, one of the most challenging areas for patients is the control of their phosphorus levels through their choices of food and beverages. Long-term high phosphorus intake contributes to disequilibrium in bone minerals causing increased levels of intact parathyroid hormone (iPTH); this indicates secondary hyperparathyroidism which is common in advancing CKD. A high iPTH level also poses an increased risk for vascular calcification. The control of phosphorus intake and the use of phosphorus binders taken with meals help decrease the absorption of phosphorus. The RD/RDN with expertise in kidney disease is able to recommend the best therapy to help manage secondary hyperparathyroidism. Treatment may include supplementation with vitamin D, especially if vitamin D levels are low.

Evidence shows that a diet high in phosphorus contributes to adverse kidney disease outcomes including vascular calcification, an additional cardiovascular risk in CKD [17]. The source of phosphorus is important to consider when educating patients. Phosphorus occurs naturally in foods which contain protein, but processed foods often have phosphorus added. Patients who frequently eat processed food and fast foods therefore have a high dietary phosphate load. A diet high in animal protein also contributes to the phosphorus load. On the other hand, vegetable proteins are not as bioavailable and have been shown to decrease FGF23 levels, a marker of CKD bone and mineral disorder [18].

Kidney-Gut Connection

Many patients with CKD complain of digestive disorders. Recent literature on how the gut microbiome is influenced by diet has brought about a shift in the focus on dietary management in CKD [9]. Uremia can impair the intestinal barrier structure of the gut due to the accumulation of gut-derived uremic toxins. Changes in the gut microbiome may have a role in systemic inflammation and CVD [19]. Research in the area of microbial modulating therapies, in the form of probiotics, is promising but is often hampered by the unfavorable milieu in the gut of the CKD patient. For probiotic therapy to have a favorable outcome requires an improvement in the gut's biochemical microbiome with the addition of prebiotic nutrients to help the bacteria in the digestive tract to thrive and grow. Prebiotic foods contain certain types of non-digestible carbohydrates (soluble fiber) found in fruits, vegetables, and whole grains which promote the health of the gut. Evidence for gut microbial modulating therapy is preliminary and hopefully in coming years will lead to positive advances in the treatment of CKD.

Medical Nutrition Therapy in Kidney Disease

Sound nutrition is crucial in healthcare models of wellness, health promotion, disease prevention, and disease management [20]. One key aspect of this is medical nutrition therapy (MNT), and it should play an important role in the treatment of CKD. The key practitioners of MNT are registered dietitians (RDs) and registered dietitian nutritionists (RDNs). They use an evidenced-based application of the nutrition-care process including food and/or nutrient delivery, nutrition education, nutrition counseling, and coordination of nutrition care.

Eating patterns are often entrenched as part of a person's lifestyle, and there is no immediate negative response to poor dietary choices. As a result, dietary changes are one of the most challenging obstacles patients face. An RD/RDN with experience in kidney disease is uniquely qualified to coach patients with positive dietary choices that can help preserve their kidney function. Because the nutrition involved with CKD is highly specialized, an RD/RDN who specializes in kidney disease has more training in how foods affect kidney function, bones, and the heart. Unfortunately, MNT provided by an RD/RDN for kidney disease is presently underutilized. With costs of kidney disease rising, it seems prudent to recommend a therapy that has been shown to delay the progression of kidney disease and improve biomarkers [21, 22]. Quality of life is dependent on the ability to make choices, and offering broader dietary choice provides patient empowerment which contributes to greater enjoyment of life with a better nutrition status. MNT has the potential to improve quality of life of patients with kidney disease by improving their nutritional biomarkers, slow the decline in kidney function, and keep them off dialysis longer. MNT by an RD/RDN specializing in kidney disease should be recommended as one of the first therapies as soon as a medical diagnosis of kidney failure or even proteinuria has been made.

Food guides, such as the USDA MyPlate, help guide patients into learning which foods are best and in what amounts. Chapter 28 provides detailed information on food guides as well as for dietary choices in general. The DASH diet (Dietary Approaches to Stop Hypertension) is high in fruits, vegetables, and whole grains with adequate amounts of calcium and protein. Diets that are either vegetarian or consist mainly of plant-based foods have been found to help slow the decline in kidney function, probably due to their lower content of available phosphorus and generous content of phytochemicals that are anti-inflammatory. MNT with an RN/RDN who has renal experience can help guide CKD patients into making better food choices so as to reduce the incidence of acidosis and manage hyperkalemia and the balance of bone minerals.

End-Stage Renal Disease

End-stage renal disease (ESRD) refers to the condition, where the kidneys are functioning minimally or not at all. Dialysis helps keep the body in balance by removing waste products and excess water, maintaining the proper levels of certain chemicals (potassium, sodium, and bicarbonate), and helping to control the blood pressure. Dialysis prolongs life but some patients may choose not to have dialysis and instead follow conservative care. MNT in ESRD focuses on protein, phosphorus, potassium, sodium, and fluid. The diet is individualized based on laboratory levels, the patient's nutrition status and lifestyle, and the modality of dialysis. With patients who choose conservative care rather than dialysis, the focus is on managing the symptoms of uremia. A kidney transplant center will assess if a patient is a suitable candidate for a kidney transplant.

In hemodialysis, the choice is in-center (HD), home hemodialysis (HHD), or nocturnal home dialysis (NHD). The diet for HD and HHD are very similar whereas patients on NHD require fewer restrictions. The time needed for dialysis depends on residual kidney function, how much fluid weight has been gained, and body mass index (BMI). The greatest challenge for nutrition therapy is related to fluid, potassium, and phosphorus. The diet is individualized based on serum levels of potassium and phosphorus, and also weight gain between dialysis sessions. The albumin level, a marker of inflammation, and protein catabolic rate (PCR) are also monitored to ensure that patients have adequate protein intake and status. The focus of MNT in hemodialysis is to ensure the patient is receiving adequate nutrition while maintaining the balance of the body's minerals (potassium, phosphorus, and calcium) and fluid levels. When patients are unable to meet their protein needs, the RD/RDN will recommend nutrition supplements or intra-dialytic amino acid solutions to improve the nutrition status.

There are two choices with peritoneal dialysis (PD), namely, continuous ambulatory peritoneal dialysis (CAPD) or continuous cyclic peritoneal dialysis (CCPD) also known as automated peritoneal dialysis (APD). The basic treatment is the same for each with exchanges of dialysate (usually a dextrose or icodextran solution). CAPD is "continuous," machine-free, and done several times during the day with exchanges done using gravity to drain and then fill the peritoneum in a sanitary environment. With CCPD/APD, a machine (cycler) delivers and then drains the dialysate. The treatment is usually done at night while the patient is sleeping. Patients on peritoneal dialysis require more protein and potassium in their diets. The dextrose used in the dialysate has calories which may contribute to weight gain and thereby aggravate existing diabetes and lipid disorders. If a patient is not able to meet their protein needs, nutrition supplements or dialysate with amino acids may be recommended.

For all types of treatment for ESRD (HD, PD, transplant, or conservative care) the RD/RDN experienced in kidney disease recommends changes to medications so as to manage disorders in serum levels of minerals (such as potassium, phosphorus, and calcium) or iPTH and vitamin D levels. The assessment of nutritional risk factors will allow RD/RDNs to provide customized MNT. The RD/RDN will help patients with nutrition choices to optimize their nutrition status, fluid balance, and assist the patient with their nutritional goals.

Other Kidney Disorders

Kidney Stones

There is much confusion about nutrition and kidney stones. There is no "one size fits all" dietary recommendation for all stone formers; diets low in oxalate is a thing of the past [23]. People form different types of stones and for different reasons. The key to nutrition therapy is to treat the individual problem or problems based on the type of stone, but occasionally there is no nutritional cause (e.g., cystine stones). The major promoters of kidney stones include a low intake of fluid or of fruits and vegetables, a high intake of sodium or acid-promoting foods (animal flesh proteins), and an intake of calcium that is low, suboptimal, or excessive. Other potential factors include alcohol, high sugar intake, certain over-the-counter (OTC) supplements (such as high intake of vitamin C), and excessive energy intake. The first strategy for all stones is to optimize fluid intake and encourage awareness of their hydration status. Urine studies over 24 h are preferred over corrected spot urines because of the individual's variability of excretion rates throughout the day. These 24-h urine samples are helpful in determining individual factors such as urine pH and volume, calcium, sodium, phosphorus, citrate, and uric acid. MNT by an RD/RDN with experience in kidney stones can identify areas in the diet (promoters) and educate the patient on how to minimize these risk factors. This can also serve as an opportunity to increase fruit and vegetable intake.

Gout

Gout is caused by the abnormal metabolism of purines and hyperuricemia (increased levels of uric acid in the blood). This results in deposition of urate crystals which then causes a form of acute arthritis with inflamed joints (usually the knees and feet). Uric acid kidney stones often precede gouty attacks. The disease tends to affect men, especially older men, and is sometimes hereditary. The management

of gout can be challenging given the disease frequently presents in association with comorbid conditions such as obesity, diabetes, renal insufficiency, or hypertension. Drug therapy (anti-inflammatory drugs or antihyperuricemic drugs) is the primary method of treatment for lowering plasma uric acid levels; however, some patients do not respond to medications [24]. Patients should be educated on diet and lifestyle triggers for gout. Food triggers include large servings or animal protein, high-fat foods, alcohol, and foods high in processed sugars. Drastic weight loss measures such as fasting, low-calorie, or high-protein diets can also trigger an attack. A healthy eating pattern which includes adequate fluid intake, fruits, vegetables, and whole grains is encouraged.

Acute Kidney Injury

Acute kidney injury (AKI) is a sudden and usually reversible decline in eGFR. Table 15.1 shows staging for acute kidney injury [6, 25, 26]. There is an elevation of blood urea nitrogen (BUN), creatinine, and other metabolic waste products that are normally excreted by the kidney. The general recommendation for AKI is to determine the cause(s) and treat those that are reversible. Patients should be evaluated within 3 months after acute kidney injury for resolution, new onset, or worsening of preexisting CKD. About 5–10% of patients in intensive care with AKI are treated with continuous renal replacement therapy (CRRT); this is a slow continuous dialysis therapy which is necessary as these patients have hemodynamic instability. These patients are very ill with catabolism and poor nutrition can affect outcomes. The goal of medical nutrition therapy (MNT) in CRRT is to maintain or improve nutrition status, enhance wound healing, support host defense and recovery without exacerbating metabolic derangements. Survivors of acute kidney injury (AKI), if there is residual renal impairment, should be managed according to CKD guidelines.

Nephrotic Syndrome

Nephrotic syndrome is caused by a variety of disorders that damage the kidneys leading to proteinuria. The most common symptoms include proteinuria, edema, foamy appearance of the urine, fluid accumulation, and hyperlipidemia. MNT goals for nephrotic syndrome are similar to CKD with a focus on a healthy eating pattern.

Table 15.1 Staging of AKI

Stage	Serum creatinine	Urine output
1	1.5–1.9 times baseline or ≥0.3 mg/dL (≥26.5 mmol/L) increase	<0.5 mL/kg/h for 6–12 h
2	2.0–2.9 times baseline	<0.5 mL/kg/h for ≥12 h
3	3.0 times baseline or Increase in serum creatinine to ≥4.0 mg/dL (≥354 mmol/L) or Initiation of renal replacement therapy, or, in patients <18 years, decrease in eGFR to <35 mL/min per 1.73 m^2	<0.3 mL/kg/h for ≥24 h or Anuria for ≥12 h

Adapted from KDIGO Clinical Practice Guideline for Acute Kidney Injury, Refs [25, 26]

Summary

MNT facilitated by an RD/RDN who has experience with renal disease should be encouraged when a patient is diagnosed with kidney disease. Improved nutrition awareness can contribute to a slowing in the progression of kidney disease and improving nutritional biomarkers in patients with CKD.

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Suggested Further Reading

GFR Calculator. https://www.kidney.org/professionals/KDOQI/gfr_calculator.
Kidney Health Australia. http://www.kidney.org.au.
National Institute of Diabetes and Digestive and Kidney Diseases. http://www.niddk.nih.gov.
National Kidney Federation, UK. http://www.kidney.org.uk/.
National Kidney Foundation. www.kidney.org.
The Kidney Foundation of Canada. http://www.kidney.ca.