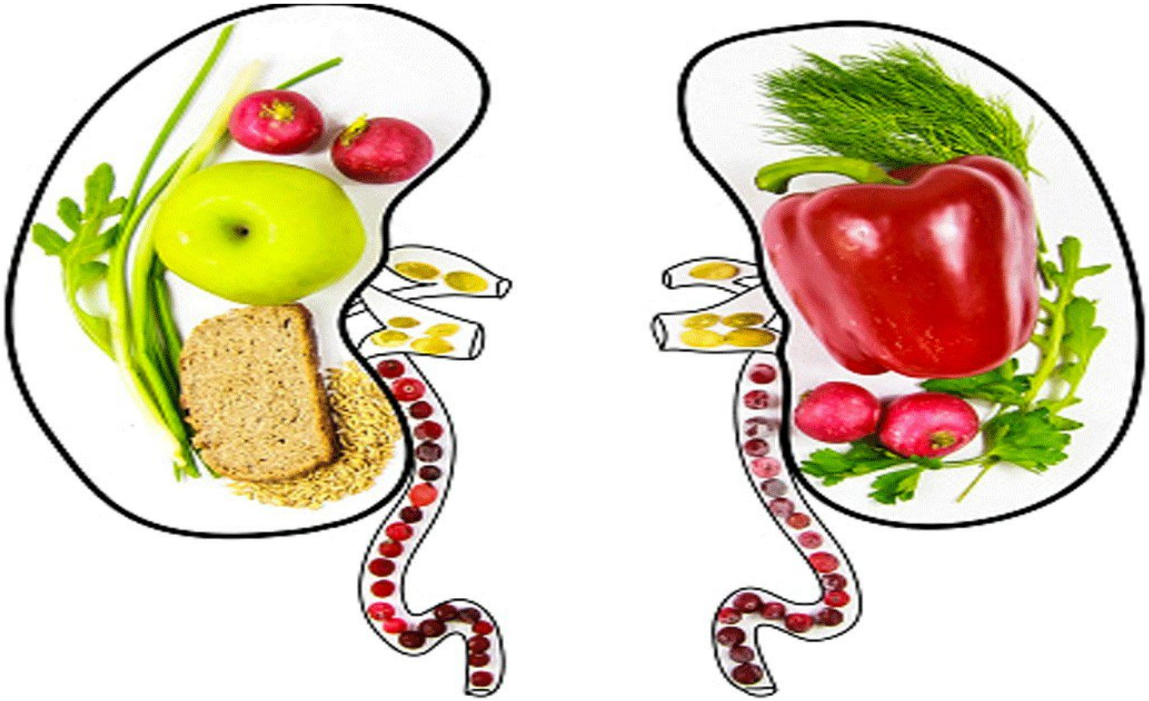
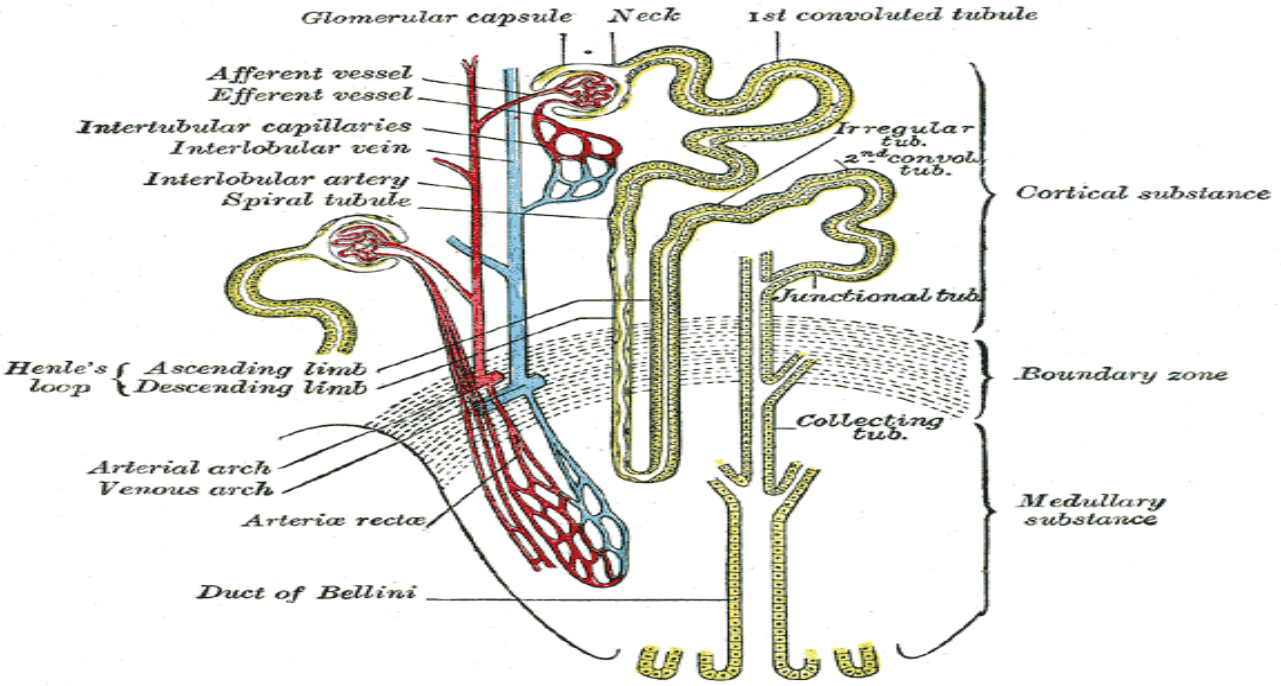


DIET FOR RENAL DISEASES

INTRODUCTION TO KIDNEY



ANATOMY

The kidneys are two retroperitoneal organs the size of a fist. The right kidney is usually found to be slightly lower than the left kidney. Each kidney is 11–12 cm long, 5–7.5 cm wide, and 2.5–3 cm thick. The average weight of a kidney in adults is 125–170 grams in men and 115–155 grams in women.

The kidney is made up of a complex capillary network and an array of tubules that perform regulatory and metabolic functions that are vital to life.The functioning unit of the kidney is called the nephron. Each kidney consists of approximately 1.2 million nephrons. Each nephron is made up of a glomerulus, which is a capillary tuft located between two arterioles (the afferent and the efferent), and a network of tubules lined by epithelial cells.

ANATOMY

The afferent arteriole carries blood to the glomerulus, and the efferent arteriole carries blood away from it. The nephron extends through three sections of the kidney called the cortex, outer medulla, and inner medulla. Tubules are divided into several sections that differ by the type of epithelial cells that they contain, including the proximal convoluted tubule, the loop of Henle, the distal convoluted tubule and the collecting duct.The cortex contains the glomeruli and the proximal and distal convoluted tubules.

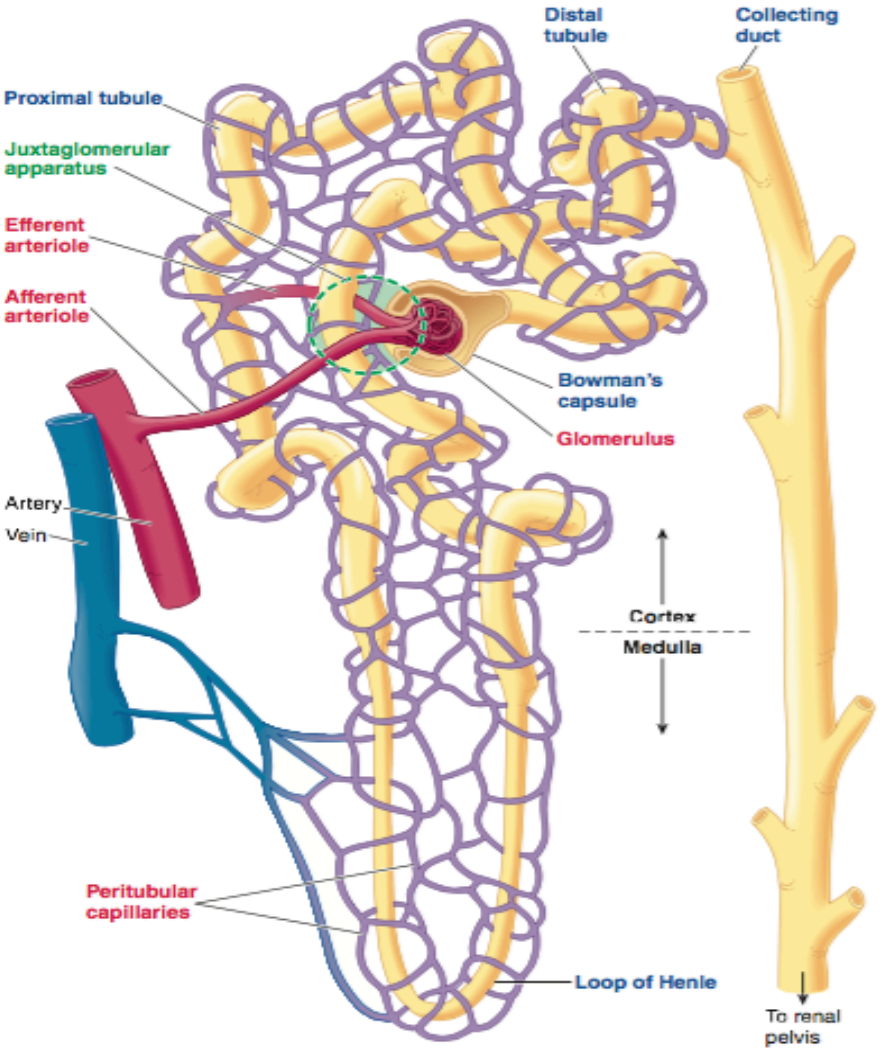
PHYSIOLOGY

The primary functions of the kidney include maintenance of homeostasis through control of fluid, pH, and electrolyte balance and blood pressure; excretion of metabolic endproducts and foreign substances; and the production of enzymes and hormones. By understanding this normal physiology, you will be able to understand how the direct consequences of the loss of renal function result within various disease states.

Urine formation is a crucial component in the maintenance of homeostasis. As systemic blood filters through the glomerulus, which filters large proteins and blood cells, the first step in urine formation occurs

Ultrafiltrate is modified as it passes through the network of tubules, either by reabsorption of amino acids, glucose, selective minerals, and water or by secretion of solutes and water.

Sodium is regulated by the kidneys, under the control of aldosterone. If serum sodium levels are elevated, sodium is exchanged with potassium so that homeostasis is restored. The kidney additionally plays a significant role in blood pressure control. Cardiac output and blood pressure are dependent on plasma volume. The formation of urine also serves as the route for excretion of waste products, including the byproducts of metabolism such as uric acid, creatinine, and urea. Other wastes excreted are drugs and environmental toxins.The kidney's role in controlling both hydrogen and bicarbonate ions is a critical component of the maintenance of pH.



Overview of Functions of Parts of a Nephron

Vascular component

- Afferent arteriole—carries blood to the glomerulus
- Glomerulus—a tuft of capillaries that filters a protein-free plasma into the tubular component
- Efferent arteriole—carries blood from the glomerulus
- Peritubular capillaries—supply the renal tissue; involved in exchanges with the fluid in the tubular lumen

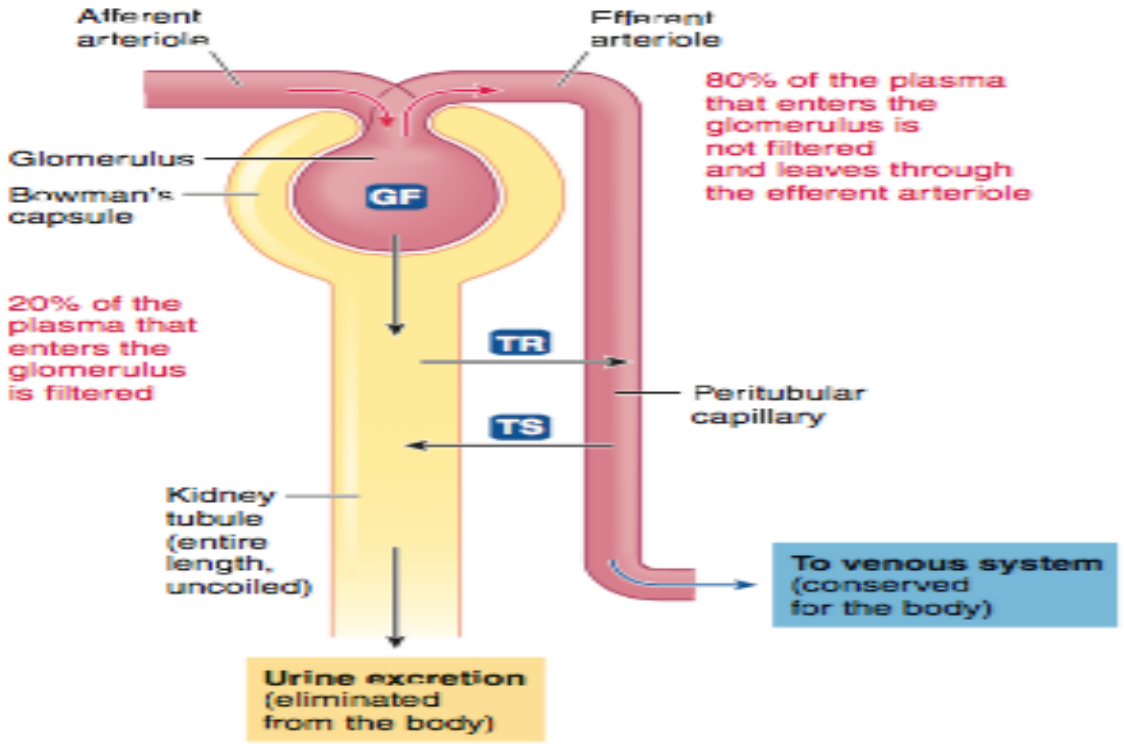
Tubular component

- Bowman's capsule—collects the glomerular filtrate
- Proximal tubule—uncontrolled reabsorption and secretion of selected substances occur here
- Loop of Henle—establishes an osmotic gradient in the renal medulla that is important in the kidney's ability to produce urine of varying concentration
- Distal tubule and collecting duct variable, controlled reabsorption of Na^+ and H_2O and secretion of K^+ and H^+ occur here; fluid leaving the collecting duct is urine, which enters the renal pelvis

Combined vascular/tubular component

- Juxtaglomerular apparatus—produces substances involved in the control of kidney function

Figure 18.3 Filtration Processes along the Renal Tubules



GF = **Glomerular filtration**—nondiscriminant filtration of a protein-free plasma from the glomerulus into Bowman's capsule

TR = **Tubular reabsorption**—selective movement of filtered substances from the tubular lumen into the peritubular capillaries

TS = **Tubular secretion**—selective movement of nonfiltered substances from the peritubular capillaries into the tubular lumen

CHRONIC KIDNEY DISEASE

DEFINITION AND DIAGNOSIS

- Chronic kidney disease (CKD) is a syndrome of progressive and irreversible loss of the excretory, endocrine, and metabolic functions of the kidney secondary to kidney damage. CKD progresses slowly over time, and there may be intervals during which kidney functions remain stable.
- The National Kidney Disease Education Program (NKDEP) has defined CKD as having a GFR of less than 60 mL/min/ 1.73 m2 for three months or longer and/or albuminuria of more than 30 mg of urinary albumin per gram of urinary creatinine.

THE NATIONAL KIDNEY FOUNDATION DESCRIBES FIVE STAGES OF CHRONIC KIDNEY DISEASE

Table 18.1 Stages of Chronic Kidney Disease

Stage	Description	GFR (mL/min/1.73 m^2)	Action*
	At increased risk	≥60 (with CKD risk factors)	Screening CKD risk reduction
1	Kidney damage with normal or increased GFR	≥90	Diagnosis and treatment Treatment of comorbid conditions Slowing progression CVD risk reduction
2	Kidney damage with mild decrease in GFR	60–89	Estimating progression
3	Moderate decrease in GFR	30–59	Evaluating and treating complications
4	Severe decrease in GFR	15–29	Preparation for kidney replacement therapy
5	Kidney failure	<15 (or dialysis)	Replacement (if uremia present)

Chronic kidney disease is defined as either kidney damage or GFR <60 mL/min/1.73 m^2 for 3 months or longer. Kidney damage is defined as pathologic abnormalities or markers of damage, including abnormalities in blood or urine tests or imaging studies.

EPIDEMIOLOGY & ETIOLOGY

- Nearly one in every nine adults has CKD and millions more are at risk for developing the condition. The incidence of CKD is even higher among patients with diabetes mellitus, cardiovascular disease, and hypertension.
- Diabetes, hypertension, and glomerulonephritis are the leading causes of kidney failure; however, there are the following additional causes and risk factors associated with the disease:
- Ethnicity—African-Americans are nearly four times as likely to develop kidney failure as white Americans; Native Americans are nearly two times as likely, and Hispanic Americans have nearly twice the risk of non-Hispanic whites
- Family history—CKD runs in families, so one's risk is greater if a family member has kidney failure
- Hereditary factors such as polycystic kidney disease (PKD)
- A direct and forceful blow to the kidneys
- Prolonged consumption of over-the-counter painkillers that combine aspirin, acetaminophen, and other medicines such as ibuprofen

HOW DOES DIABETES LEAD TO CKD?

Diabetic nephropathy is the most common cause of CKD in the United States. People with either type 1 or type 2 diabetes are at increased risk. The risk is greater if blood sugars are not controlled. The earliest detectable change in the course of diabetic nephropathy is a thickening in the glomerulus, perhaps caused by hyperglycemia and a change in the basement membrane of the tissue. Since the glomerulus is responsible for filtering the blood and the fluid that eventually forms urine, as these glomeruler changes occur, the kidney may start allowing more protein (albumin) than normal to be excreted in the urine. As diabetic nephropathy progresses, increasing numbers of glomeruli are destroyed and increasing amounts of albumin are excreted, which can be detected by a urinalysis. As the number of functioning nephrons declines, each remaining nephron must clear an increasing solute load. Eventually, the limit to the amount of solute that can be cleared is achieved and the concentration in body fluids increases, leading to azotemia and uremia. Because the progression is slow (microalbuminuria can continue up to 5–10 years before other symptoms develop), the body can partially adapt to the changes. At this point, a kidney biopsy clearly shows diabetic nephropathy.

TREATMENT

The goal of medical and nutritional management of kidney disease is to treat the underlying renal pathophysiology in order to delay the progression of the disease. Medical and nutritional care correlates with the level of kidney dysfunction. For example, those individuals with stage 1 or 2 CKD may initially only require EPO replacement and supplementation of vitamin D. Progression of the disease is highly individualized, and many patients may remain at these initial stages for months to years. However, when CKD progresses to end stage of renal disease (ESRD or CKD stage 5) and harmful wastes build up in the blood, blood pressure rises, and excess fluid is retained, more extensive treatment is needed to replace the work of the kidneys. Treatment options include hemodialysis, peritoneal dialysis, and kidney transplantation.

MEDICAL NUTRITION THERAPY IN CKD

As kidney function deteriorates, the ability of the kidney to excrete metabolic products of protein, regulate acid/base balance, produce adequate amounts of erythropoietin, activate vitamin D, and regulate calcium, phosphorus, potassium, sodium, and fluid excretion diminishes. Therefore, nutrients that are usually affected by CKD include protein, energy, sodium, potassium, phosphorus, calcium, vitamins, minerals, and fluid. As a result modifications in these nutrients are frequently necessary.

PROTEIN

In CKD, as the GFR and excretion of nitrogenous wastes decline, it is necessary to control the level of protein intake while continuing to maintain a positive nitrogen balance. Protein restriction can minimize the symptoms of uremic toxicity by reducing the production of nitrogenous wastes in the blood. Some evidence also suggests that protein restriction early in the course of CKD due to glomerular damage may slow the progression of the disease and delay the need to initiate dialysis therapy. The generally accepted level of protein restriction for patients with CKD stages 1 to 3 is 0.75g/kg per day, which is approximately what the DRIs recommend for normal healthy adults. This is actually a restriction for most individuals, as the American diet is generally much greater in protein content. For stages 4 and 5 (GFR <25 mL/ minute), 0.6 g/kg per day (using an adjusted body weight if the patient is obese) is suggested, only if feasible to meet overall nutritional needs.

PROTEIN

Approximately 50 percent of high biological value protein (HBV) is usually encouraged to ensure that essential amino acid requirements are met. The biological value of a dietary protein is determined by its constituent amino acids, with the highest value given to proteins that contain all essential amino acids, such as eggs, meats, and other animal proteins. It has also been shown, however, that carefully planned low-protein vegetarian diets containing soy and plant-based protein may reduce proteinuria, improve serum protein levels, and retard the progression of CKD as compared to animal proteins. Additional increased protein needs due to catabolism from use of glucocorticoid (steroid) therapy or recent surgery as well as acute illness with decreased oral intakes may contraindicate limiting dietary protein.

ENERGY

The recommendations for adequate energy intake for individuals with CKD not yet on dialysis are generally 35 kcal/kg per day to maintain body weight and allow for effective protein utilization. It has been recommended that 30 kcal/kg per day be used for those older than 60 years of age due to a more sedentary lifestyle. Calories from complex and simple carbohydrates must be included in the diet to provide adequate energy to prevent weight loss. Low protein food products are available and can improve overall caloric intake while minimizing protein content, but the expense, taste, and availability must be considered.

LIPIDS

Additional fat, in the form of monounsaturated and polyunsaturated fats, may also be recommended to provide adequate calories for patients with CKD. Since dyslipidemia is prevalent in patients with CKD, lipid levels should be monitored, and an effort made to keep total cholesterol, LDL-C, HDL-C, and triglyceride levels within normal limits. Pharmacologic therapy may be needed to manage lipid levels, as some studies utilizing statins have shown cardiovascular risk reduction for patients with CKD stages 2 to 3.

SODIUM

As renal failure progresses to a GFR of about 10 percent of normal, renal sodium excretion subsequently falls. Sodium intake may have to be limited to prevent sodium retention, generalized edema, hypertension, and/or congestive heart failure, especially in the advanced stages of CKD when excretion diminishes. The NKF/KDOQI Clinical Practice Guidelines on Hypertension and Antihypertensives recommend a sodium intake of less than 2.4g/day unless a sodium wasting disease is present or medications causing sodium loss are prescribed.

Measuring urinary sodium in a 24-hour urine collection may be helpful in determining how much sodium is being excreted. Urinary sodium is reported in milliequivalents (mEq), making it necessary to convert from milligrams to milliequivalents to determine how many milliequivalents of sodium are associated with any given diet.

Conversion of milligrams of sodium to milliequivalents

To convert milligrams of sodium to milliequivalents, divide the number of milligrams by the molecular weight of sodium (23 mg Na = 1 mEq Na). For example, assuming that a low-sodium diet is limited to 2000 mg/day, it contains 87 mEq of sodium (Table 10-3).

Table 10-3 Foods With High Sodium Content

Bacon	Ham	Scrapple
Barbecue sauce	Hotdogs	Smoked meats or fish
Bouillon cubes*	Meat tenderizers	Soy sauce
Canned seafood*	Nuts, salted*	Steak sauce
Cheeses, processed	Olives	Soups, canned* & dried mixes
Chinese food	Packaged or prepared	Tomato juice*
Cold cuts	casserole dishes	Tomato sauce
Corned beef	Popcorn	Vegetable juice*
Corn chips	Pickles	Worcestershire sauce
Crackers*	Potato chips, pretzels*	
Dried beef	Relish	
"Fast Foods"	Salt pork	
Frozen dinners (unless of a healthy variety).	Sauerkraut	
Gravy, canned or packaged	Sausages	

POTASSIUM

The kidney usually handles potassium efficiently until the GFR is significantly reduced (<10 mL/ min). Thus, a dietary potassium restriction may be necessary only during the latter stages of CKD. Exceptions include renal diseases such as diabetic nephropathy, in which aldosterone deficiency develops and potassium excretion declines. Use of an angiotensin-converting enzyme (ACE) inhibitor to control blood pressure in some individuals may also require a mild-to-moderate potassium restriction, even with good urine output. ACE inhibitors suppress the renin-angiotensin system, resulting in decreased aldosterone levels and subsequent elevations in serum potassium levels. Angiotensin receptor antagonists used to control hypertension can also cause hyperkalemia, though the likelihood is probably lower than with ACE inhibitors. When serum potassium levels are consistently greater than 5.0 mEq/L, a potassium-restricted diet of 2 to 3 g/day (51 to 77 mEq/ day) should be initiated

High-Potassium Vegetables

Artichokes
Beans (navy, lentil, kidney, pinto)
Broccoli
Brussels sprouts
Carrots, raw
French fries,
Greens
Lima beans
Parsnips
Potato, baked and chips
Pumpkin
Spinach
Sweet potato
Tomato
Winter squash (butternut, acorn)
Tomato juice
Vegetable juices

High-Potassium Fruits and Juices

Apricots
Avocados
Bananas
Cantaloupes
Dates
Figs
Honeydew melons
Mangos
Nectarines
Oranges, orange juice
Papayas
Prunes
Raisins
Rhubarb
Watermelon (if more than one cup chunks)
Apricot nectar
Prune juice

Other high-potassium foods

Milk (more than 4 to 8 ounces/day)
Chocolate
Nuts
Bran cereal

Salt substitutes (containing KCL)
Molasses
Potato chips

Other high-potassium foods

Milk (more than 4 to 8 ounces/day)
Chocolate
Nuts
Bran cereal
Salt substitutes (containing KCL)
Molasses
Potato chips

Low-to-medium potassium vegetables*

Asparagus
Beets
Cabbage
Carrots, cooked
Cauliflower
Celery
Corn
Cucumber
Eggplant
Green beans
Green peppers
Kale
Lettuce
Okra
Onions
Peas
Potato (only when double-boiled)
Radishes
Wax beans
Zucchini

Low-to-medium potassium fruits and juices*

Apples, apple juice
Applesauce
Blueberries
Cherries
Cranberries, cranberry juice
Fruit cocktail
Grapefruits, grapefruit juice (only 4 ounces/day)
Grapes, grape juice
Lemons
Limes
Peaches, fresh (small)
Pears, fresh (small), pear nectar
Pineapples, pineapple juice (only 4 ounces/day)
Plums
Raspberries (1 cup)
Strawberries (1 cup)
Tangerines

CALCIUM, PHOSPHORUS, PARATHYROID HORMONE AND VITAMIN D

Mineral-Bone-Disorder (MBD) describes the clinical syndrome resulting from abnormal mineral bone metabolism which occurs with CKD. Renal osteodystrophy refers to only the complex bone lesions present in the majority of patients with CKD, and includes osteitis fibrosa and osteomalacia, which are associated with this disorder. Restriction of dietary phosphorus has been shown to prevent the development of secondary hyperparathyroidism, which is frequently seen in patients with CKD. Also, in the past decade increased vascular and soft tissue calcifications have been seen in this population, believed to be related to calcium/phosphorus metabolism and treatment to maintain proper balance of these minerals. As a result, the NKF/KDOQI Clinical Practice Guidelines for Bone Metabolism and Disease recommend a phosphorus restriction of 800 to 1000 mg/day for individuals with CKD stages 3 and 4 when the serum phosphorus level is greater than 4.6 mg/dL. With a protein-restricted diet, this is usually feasible, as animal protein-based foodsare also high in phosphorus content. If dairy products are avoided in a vegetable-based low-protein diet utilizing soy products, this level of phosphorus restriction is also feasible.

PHOSPHORUS CONTENT OF SELECTED FOODS

Foods	Portion Size	Phosphorus Content (mg)
Dairy		
Cheese, cheddar	1 ounces	145
Cheese, cream	1 Tbsp.	15
Frozen yogurt	½ cup	95–100
Half-and-half	½ cup	110
Ice cream	½ cup	70–100
Milk (whole, low-fat, skim)	8 ounces	220–230
Pudding (vanilla/chocolate dry mix regular made with 2% milk)	½ cup	115–135
Pudding (chocolate dry mix instant made with 2% milk)	½ cup	350
Pudding, (vanilla/chocolate/ tapioca/ rice-ready-to-eat)	½ cup	45–75
Yogurt (all kinds)	8 ounces	215–350

Foods	Portion Size	Phosphorus Content (mg)
Protein foods		
Beef, cooked	3 ounces	150–200
Eggs, whole	1 large	95
Liver, Beef (panfried)	3 ounces	410
Peanut butter	1 Tbsp.	55
Sardines, Atlantic, canned in oil	3 ounces	415
Tuna	3 ounces	140–265
Vegetables		
Baked beans and pork and beans	½ cup	95–150
Dried beans	½ cup	130
Chickpeas	½ cup	110–140
Lentils, boiled	½ cup	180
Soybeans, green boiled	½ cup	140
Soybeans, mature boiled	½ cup	210
Bread and cereals		
Barley, pearled cooked	1 cup	85
Bread, white	1 slice	25
Breads whole grain	1 slice	60
Cornbread (from mix)	1 piece	225
Raisin Bran	1 cup	225
Miscellaneous		
Chocolate	1 ounce	70
Nuts, mixed, dry	1 ounce	125
Peanuts, dry roasted	1 ounce	100
Beverages		
Beer	12 ounces	50
Coffee, brewed	6 ounces	5
Colas	12 ounces	60

MEDICATIONS

- A “phosphate binder”, which may be prescribed with meals, interferes with the absorption of phosphate in the small intestine while maintaining serum phosphate levels within normal range
- Calcium acetate, sevelamer hydrochloride or sevelamer carbonate (non-absorbed phosphate- binding polymers without calcium or aluminum), and lanthanum carbonate have also been utilized
- Serum calcium levels may not decrease until the GFR is less than 30 mL/ minute, thus initially eliminating any need for specific calcium supplementation until later stages of CKD
- Since foods rich in calcium (primarily dairy products) are also high in phosphorus content and must be restricted; calcium carbonate and calcium acetate may be used between meals to increase serum calcium levels.

Medication	Dose	Ca^{2+} (mg) (elemental)	Al (mg)	Manufacturer
Calcium carbonate*				
Calcium carbonate, 1250 mg	1 tab	500	0	Roxane Labs
Oscal 500	1 tab	500	0	GlaxoSmithKline
Tums—Regular	1 tab	200	0	GlaxoSmithKline
Extra-strength	1 tab	300	0	GlaxoSmithKline
Ultra	1 tab	400	0	GlaxoSmithKline
500	1 tab	500	0	GlaxoSmithKline
Calcium acetate				
PhosLo	1 tab	169	0	Fresenius Medical Care_
Calphron	1 tab	169	0	Nephro-Tech,
Calcium Acetate	1 tab	169	0	Hillestad Pharmaceuticals
Phoslyra	5 ml	169	0	Fresenius Medical Care
Sevelamer HCL				
Renagel, 800 mg	1 tab	0	0	Sanofi Aventis
Renagel, 400 mg	1 tab	0	0	Sanofi Aventis
Sevelamer carbonate				
Renvela, 800 mg	1 tab	0	0	Sanofi Aventis
Renvela powder, 0.8 g	1 pkt	0	0	Sanofi Aventis
Renvela powder, 2.4 g	1 pkt	0	0	Sanofi Aventis
Lanthanum carbonate				
Fosrenol, 1000 mg	1 tab	0	0	Shire
750 mg	1 tab	0	0	Shire
500 mg	1 tab	0	0	Shire

MEDICATIONS

Water Balance and Fluid Restriction

Fluid intake for individuals with CKD should be balanced by their ability to eliminate fluid. As long as urine output essentially equals the daily fluid intake, fluid balance is maintained. If edema becomes apparent, prescribing loop diuretics often increases sodium and water excretion sufficiently to maintain balance. In the latter stages of CKD, a fluid limit equal to the volume of urine output plus 500mL/day for insensible fluid losses may be necessary to prevent edema and hyponatremia.

Nutrient Recommendations for CKD

	Acute	CKD	Nephrotic Syndrome	HD	PD
Protein g/kg[1]	0.6–0.8 based on renal function/treatment	0.60–0.75 g/kg ≥50% HBV	0.8–1.0 Replacing urine loss is controversial	≥1.2 ≥50% HBV	≥1.2–1.3 ≥50% HBV
Energy kcal/kg[1]	35–50 based on stress/ nutrition status	30–35 >60 yrs 35 <60 yrs	35 unless obese; complex CHO; ↓ cholesterol; <30% fat	30–35 >60 yrs; 35 <60 yrs	30–35 >60 yrs; 35 <60 yrs including dialysate
Na^+ g/day[2]	1–2 based on BP, edema; replace losses in diuretic phase	Varies from 1–3 to no added salt	1–2	2	2; monitor fluid balance
K^+ g/day	Maintain serum <5 mEq/L; replace losses in diuretic phase	Usually unrestricted unless serum level is high	Usually unrestricted	2–3 adjust to serum levels	3–4 adjust to serum levels
Phosphorus mg/g pro or mg/day	Maintain serum P WNL	800–1000 mg/d 10–12 mg/g pro Maintain serum P and PTH WNL	Maintain serum P WNL	800–1000 mg/d adjust to meet pro needs; 10–12 mg/g pro	800–1000 mg/d adjust to meet pro needs; 10–12 mg/g pro
Calcium g/day	Maintain serum WNL	DRI; maintain serum levels WNL	Same as predialysis	<2.0 g including binder load; maintain serum levels WNL	<2.0 g including binder load; maintain serum levels WNL
Fluid cc/d	Output plus 500 cc	Usually unlimited	Maintain balance	Output + 1000 cc Limit ID wt gain	Maintain balance
Vitamins/ Minerals (Daily)	DRI: adjust to degree of catabolism; TPN may require MVT and minerals	DRI: B-complex & C; ensure adequate nutritional vitamin D; give 1,25 vitamin D as needed to control PTH; individualize iron, zinc	Same as CKD	C 60–100 mg; B_6 2 mg; folate 1–5 mg; B_{12} 3 μg/d; RDA others; vit E 15 IU/d; zinc 15 mg/d; individualize iron and vit D; replete nutritional D	Same as HD but may need 1.5 to 2 mg of B_1 due to dialysis loss; replete nutritional vitamin D; individualize 1,25 vitamin D as needed for control of SHPT
Fiber	N/A	20–30 g	N/A	20–25 g	20–25 g

CKD Stage 4 = GFR 15–29 mL/min /1.73 m^2

[1]Based on standard or adjusted body weight.

DIALYSIS

DEFINITION

Dialysis is a renal replacement procedure that removes excessive and toxic by-products of metabolism from the blood, thus replacing the filtering function of healthy kidneys. It can maintain life once CKD progresses to the end stage, even though endocrine and metabolic functions of the kidney are not totally replaced.

WHEN TO START DIALYSIS?

The decision to initiate dialysis depends on the severity of symptoms. Unnecessary delay should be avoided in order to prevent medical complications of advanced uremia and subsequent patient debilitation and deterioration. Symptoms considered to be definite indications for dialysis therapy include pericarditis, uncontrollable fluid overload, pulmonary edema, uncontrollable and repeated hyperkalemia, coma, and lethargy. Less severe symptoms such as azotemia, nausea, and vomiting require a subjective determination that takes into consideration the patient's quality of life.

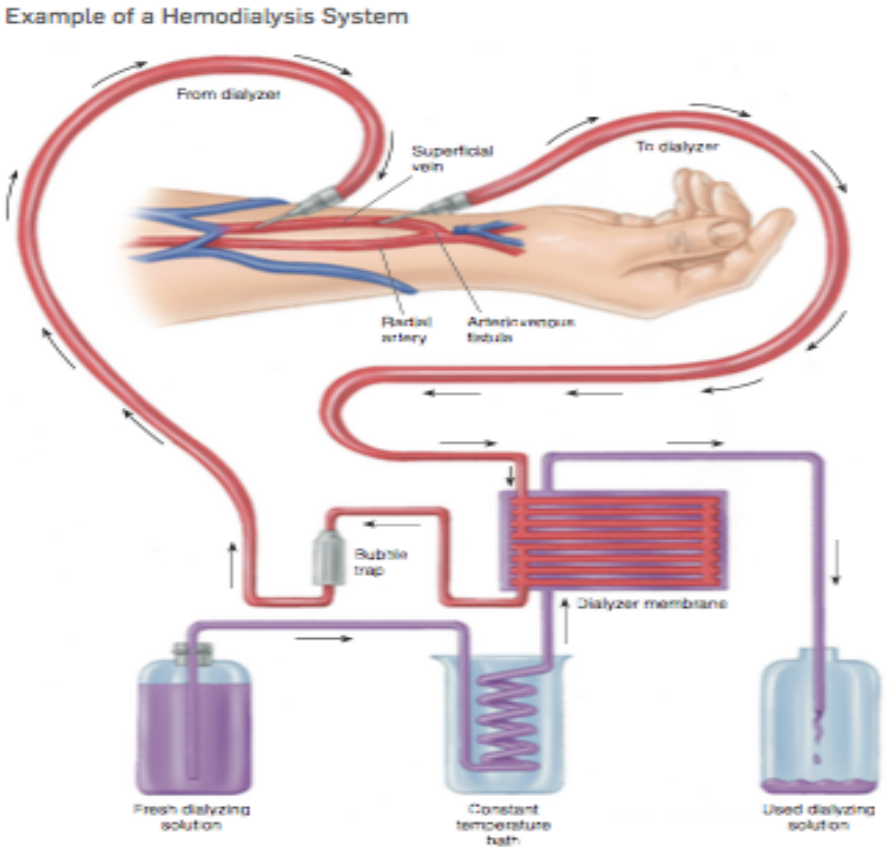
TYPES OF DIALYSIS

Currently two major types of renal replacement therapy are used for patients with CKD Stage 5: hemodialysis (HD) and peritoneal dialysis (PD). The most common method is hemodialysis. Patients and their nephrologist (a physician specializing in kidney disease) choose the type of dialysis based on several factors, including underlying kidney disease and other comorbid factors such as cardiovascular disease, age, family support, and proximity to a dialysis center.

DIALYSIS PROCESS

- Regardless of the modality, both methods require a selective, semipermeable membrane that allows passage of water and small to middle-molecular weight molecules and ions but excludes large molecular weight molecules such as proteins. Waste products and excess fluids are removed from the body by the actions of diffusion, ultrafiltration, and osmosis. During the removal of unwanted solutes, fluid and electrolyte balance must be maintained. This is accomplished by passing blood across the semipermeable membrane that is exposed to some rinsing fluid (dialysate). Dialysates have varying ion and mineral compositions.

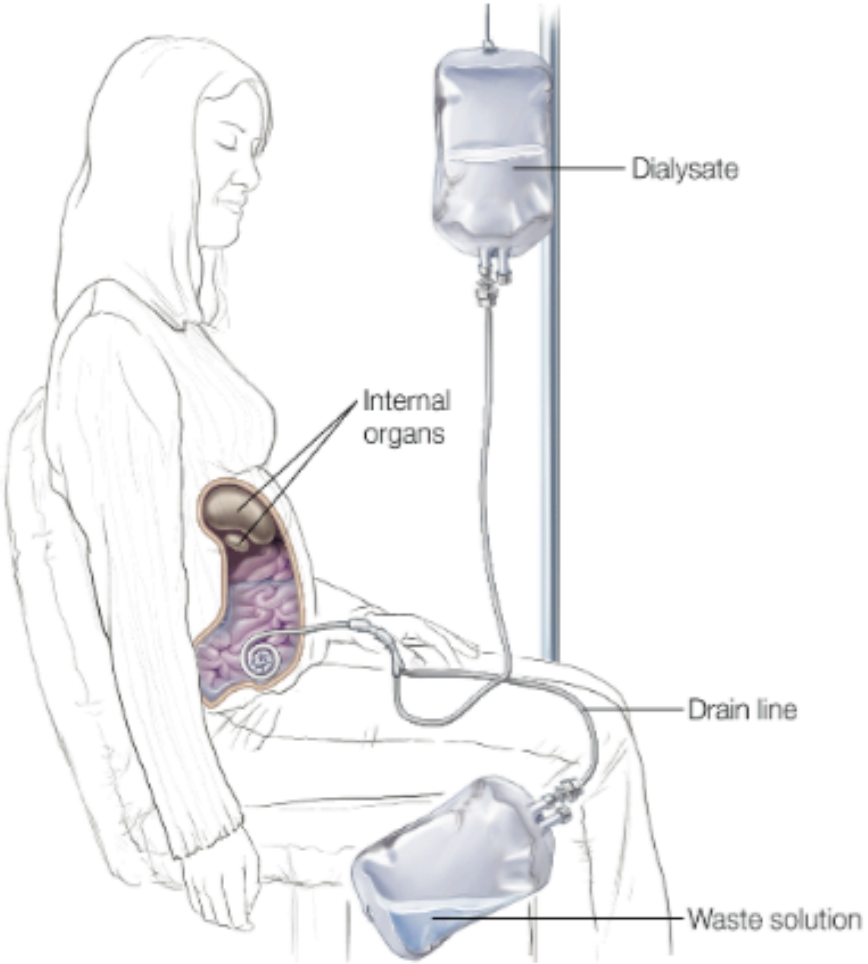
HEMODIALYSIS: Since dialysis therapy requires access to the circulatory system, patients receiving hemodialysis first need to undergo a procedure that allows continual access to the blood-stream. In hemodialysis, the selective membrane is a man-made dialyzer sometimes referred to as an artificial kidney. The most common types are the hollow fiber and parallel-plate dialyzers.

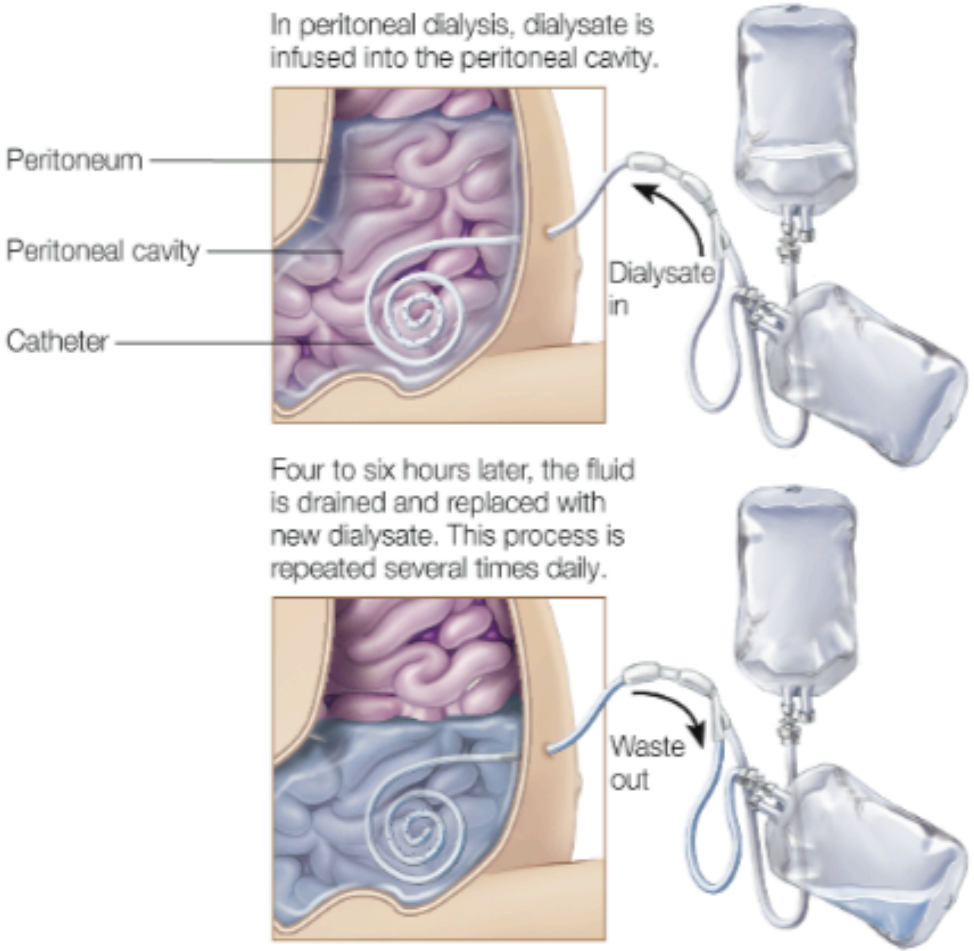


DIALYSIS PROCESS

PERITONEAL DIALYSIS: In peritoneal dialysis, the lining of the patient's peritoneal wall serves as the selective membrane. Dialysate is introduced into the peritoneum through the peritoneal catheter. Solutes from the plasma circulating in the vessels and capillaries perfusing the peritoneal wall pass across the peritoneal membrane into the dialysate which is subsequently removed and exerted.

Figure Peritoneal Dialysis





MEDICAL NUTRITION THERAPY IN DIALYSIS

The goals of medical nutrition therapy for patients on dialysis are to maintain:

- Protein equilibrium to prevent a negative nitrogen balance;
- Serum potassium and sodium concentrations within an acceptable range and maintain total body sodium as close to normal as possible;
- fluid homeostasis by preventing fluid overload or volume depletion;
- serum calcium, phosphorus, and PTH levels within an acceptable range to prevent renal osteodystrophy and metastatic calcification; and
- adequate levels of vitamins and other minerals.

PROTEIN

Protein intake for patients undergoing maintenance dialysis must at least equal minimum dietary protein requirements but not worsen the uremic syndrome by causing retention of urea, electrolytes, and various minerals. The loss of amino acids, the catabolic stress of dialysis, and the level of protein intake in the predialysis period may all contribute to poor protein status in the chronic dialysis patient. A protein allowance of 1.2 g/kg per day for incenter HD patients and 1.2 to 1.3 g/ kg per day for HHD and PD patients will often minimize the accumulation of excessive nitrogenous wastes, maintain a positive nitrogen balance, and replace the amino acids lost during dialysis. During episodes of peritonitis, patients receiving PD have increased dietary protein needs due to greater losses of protein across an inflamed peritoneum. Many patients on both HD and PD periodically require supplemental commercial or homemade nutritional drinks, bars, or protein powders in order to achieve adequate protein intake.

ENERGY

The caloric intake for patients undergoing maintenance dialysis should be adequate to maintain or achieve ideal body weight. Unless the diet provides sufficient calories from carbohydrate and fat, endogenous protein is used for energy production, and the patient develops a negative nitrogen balance and loses significant muscle mass. With PD, calories gained from glucose absorbed from the dialysate must be considered when determining total caloric needs to prevent excess weight gain and obesity. Patients on both HD and PD, however, may also require nutritional supplements to meet caloric as well as protein intake goals.

LIPID

Lipid abnormalities are frequently prevalent in patients with kidney disease. Commonly, patients undergoing HD present with normal or high total cholesterol, LDL-C, and triglyceride levels. Patients on PD frequently have high total cholesterol, LDL-C, and triglyceride levels, and low HDL-C levels. Medical nutrition therapy is aimed at normalizing cholesterol and triglyceride levels without adversely affecting protein and overall caloric intakes in dialysis patients. Pharmacologic therapy for dyslipidemia is often initiated in order to avoid further restrictions to an already complex diet regime. It is recommended that both PD and HD patients adhere to the nutrient composition guidelines of the therapeutic lifestyle changes (TLC) diet.

Therapeutic Lifestyle Changes for Patients with CKD

Nutrient	Recommended Intake
Saturated Fat	7% of total kcal
Polyunsaturated Fat	Up to 10% of total kcal
Monounsaturated Fat	Up to 20% of total kcal
Total Fat	25–35% of total kcal
Carbohydrates	50–60% of total kcal
Protein	Approximately 15% of total kcal
Cholesterol	<200 mg/day
Total kcal	Balance energy intake and expenditure to maintain desirable body weight/prevent weight gain
Fiber	20–30 g/day with 5–10 grams soluble fiber

FLUID AND SODIUM

- Fluid and sodium allowances are highly individualized and based primarily on residual urine out-put and dialysis modality. Other considerations include blood pressure control, interdialytic weight gains in HD patients, presence of edema, and congestive heart failure.
- The interdialytic weight gain goal in HD patients should not exceed 5% of body weight. Higher fluid gains can lead to sudden changes in blood volume and hypotension during the hemodialysis treatment. Since most patients become oliguric or anuric within the first 12 months of hemodialysis, it is prudent to recommend a 2 gram sodium diet with a fluid allowance of not more than 1 L (1000 mL) daily. If urine output is greater than 1 L per day, the sodium and fluid allowance can be liberalized to approximately 2 to 4 g sodium per day and 2 L (2000 mL) of fluid per day.

- Fluid and sodium requirements for patients on PD therapy are highly individualized and largely based on ultrafiltration. Ultrafiltration can remove 2 to 2.5 kg of fluid per day. If a patient on PD gains too much fluid, higher dextrose concentrations must be used, which leads to greater fluid removal but can also lead to weight gain, higher triglyceride levels, and insulin resistance. Therefore, the use of these higher dextrose concentrations should be minimized. Typical fluid and sodium restriction for the PD patient includes a fluid allowance of 2 L per day and a sodium allowance between 2 and 4 g per day. Symptoms of fluid overload can include shortness of breath, hypertension, congestive heart failure, and edema. Fluid intake is best controlled by limiting dietary sodium intake.

Table 18.8 Tips to Control Fluid Intake

- Limit high-salt foods so you will have less thirst.
- Take your pills with your mealtime liquids, applesauce, or pureed fruits, as allowed.
- Drink from small glasses and cups.
- Drink only when you are thirsty. Reach for very cold beverages. Beverages that are less sweet will quench your thirst.
- Weigh yourself daily. You should not gain more than the prescribed number of pounds each day.
- Use sour candy or sugar-free gum to moisten your mouth. Try special thirst-quencher gums.
- Add some lemon juice to water or ice. The sour taste will help to quench your thirst.
- Try swishing your mouth with very cold water or low-alcohol mouthwash when you are thirsty. *Do not swallow it!*
- Brush teeth often—good mouth hygiene is essential.
- Keep lips moist with lip balm or moisturized lipstick.
- Use ice cubes instead of liquids. One cup of ice is equal to ½ cup of water/juice and will last longer.
- Freeze grapes and eat throughout the day as one of your fruit servings (serving is ½ cup).
- Try frozen blueberries and pineapple tidbits, fruit cocktail, and other recommended fruits.
- Remember that some foods should also be counted as fluids. These include soups, Popsicles®, sherbet, ice cream, yogurt, custard, and gelatin.

POTASSIUM

Potassium intake must be individualized to maintain normal serum potassium levels. Patients on maintenance HD usually can maintain serum potassium levels between 3.5 and 5.5mEq/L with diets containing 2 to 3g/day (50 to 75mEq/day). When serum potassium levels are persistently high, despite dietary counseling, the dialysate potassium content may be lowered or a sodium exchange resin added to the medication regime. When serum potassium levels are consistently low (hypokalemia), the dietary intake may be liberalized and/or dialysate potassium content increased. This is especially important for patients receiving digoxin therapy, as hypokalemia can cause arrhythmias. Patients on maintenance PD usually maintain a normal serum potassium level without restricting potassium intake. If serum potassium levels fall below normal, dietary potassium is increased, and if unsuccessful, potassium supplements may be required. For those on HHD, the diet may be more liberal in potassium as well, depending upon frequency of and amount of dialysis performed

How do I get some of the potassium out of my favorite high-potassium vegetables?

The process of leaching will help pull potassium out of some high-potassium vegetables. It is important to remember that leaching will not pull all of the potassium out of the vegetable. You must still limit the amount of leached high-potassium vegetables you eat. Ask your dietitian about the amount of leached vegetables that you can safely have in your diet.

How to Leach Vegetables

For potatoes, sweet potatoes, carrots, beets, and rutabagas:

1. Peel and place the vegetables in cold water so they won't darken.
2. Slice vegetable ⅛ inch thick.
3. Rinse in warm water for a few seconds.
4. Soak for a minimum of two hours in warm water. Use ten times the amount of water to the amount of vegetables. If soaking longer, change the water every four hours.
5. Rinse under warm water again for a few seconds.
6. Cook vegetable with five times the amount of water as the amount of vegetable.

For squash, mushrooms, cauliflower, and frozen greens:

1. Allow frozen vegetable to thaw to room temperature and drain.
2. Rinse fresh or frozen vegetables in warm water for a few seconds.
3. Soak for a minimum of two hours in warm water. Use ten times the amount of water to the amount of vegetables. If soaking longer, change the water every four hours.
4. Rinse under warm water again for a few seconds.
5. Cook the usual way, but with five times the amount of water as the amount of vegetable.

Sources: Bowes & Church Food Values of Portions Commonly Used, 17th ed., Pennington JA, Lippincott, 1998. Diet Guide for Patients with Kidney Disease, Renal Interest Group-Kansas City Dietetic Association, 1990.