60

Renal Nutrition

Jane M. Greene and Lynn Thomas

Introduction

The kidneys play a vital role in the maintenance of normal blood volume/pressure and regulation of acid-base balance. Approximately one-fourth of the cardiac output is filtered through the kidneys each minute. Urinary excretion is the pathway for removal of the waste products of absorption and metabolism. These include ammonia, urea, creatinine, phosphorus, water, sodium, and potassium. Normal bone health is facilitated by activation of vitamin D and regulation of calcium and phosphorus. The kidney produces the hormone erythropoietin. Deficiency of this hormone results in profound anemia.

A decrease in kidney function greatly affects metabolism and nutritional status. These patients are at risk for protein energy malnutrition. Common manifestations include edema, uremia, hypertension, anemia, and metabolic acidosis. The medical nutrition therapy for kidney failure becomes increasingly complex as the renal disease advances. The diet prescription is matched to the stage of renal failure in order to keep the diet as liberal as possible. Table 60.1[1] defines the terms used in this section.

Nutritional Assessment in the Renal Patient

It is a recommended standard of practice that all renal patients are considered at risk for nutritional compromise. Protein energy malnutrition is a common finding among these patients. Acute and chronic renal failure patients should receive baseline assessments as soon as they are identified or admitted to the hospital. New dialysis patients should receive an assessment within thirty days of the initial treatment. Reassessments should be done at least annually. Short-term updates are required monthly by most dialysis clinics. Any significant changes in weight, laboratory values, or medical status should trigger an in-depth investigation. The goal of the assessment is to develop a diet prescription tailored to the patient's individual needs. The diet should be as liberal as possible and include the patients favorite foods. The patient should be provided with written materials covering

TABLE 60.1

Explanation of Terms Used in this Section

Term	Explanation
Acute renal failure	Sudden onset secondary to shock, trauma, hypertension, exposure to nephrotoxic substances or bacteria; reversible in many cases.
Azotemia	Elevated concentrations of nitrogenous wastes in blood serum.
Chronic renal failure (CRF) or insufficiency (CRI)	Gradual progression terminating with end stage renal disease requiring dialysis or transplant. Causes include obstructive disease of the urinary tract such as congenital birth defects, systemic diseases such as diabetes mellitus or systemic lupus erythematosis, glomerular disease, and overdosing on analgesic medications. Patients follow an increasingly restricted diet as renal failure progresses.
Hemodialysis	Removal from blood of the waste products of metabolism by use of a semipermeable membrane and a dialysis treatment machine. This process takes 3-6 hours three times per week in an outpatient clinic or hospital. Some patients, with appropriate training and assistance, can dialyze at home. Hemodialysis patients follow a diet restricted in sodium, potassium, phosphorus, and fluids.
Nephrotic syndrome	Failure of the glomerular basement membrane to filter waste products appropriately. Large amounts of protein are found in the urine. Patients frequently have edema secondary to hypoalbumenemia.
Peritoneal dialysis	Removal of the waste products of metabolism by perfusion of a sterile dialysate solution throughout the peritoneal cavity. This method of dialysis is done at home. Dialysate exchanges are performed several times per day or continuously at night with the aid of a peritoneal dialysis machine. Peritoneal dialysis patients follow a liberalized diet since dialysis is daily. The diet is normally a low sodium diet with diabetes mellitus restrictions as necessary.
Uremia	A toxic systemic syndrome caused by retention of high levels of urea.

the major points. The diet is modified on a regular basis as indicated. Tables 60.2[2-6] and 60.3[7-9] provide guidelines for various components of the nutrition assessment.

Stages of Renal Failure

The method of treatment and the nutrition recommendations vary as the patient progresses through the various stages of renal failure. The normal kidney removes excess fluid and waste products from the body and maintains acid-base balance. The kidney also regulates blood pressure, stimulates red blood cell production, and regulates the metabolism of calcium and phosphorus. Nephrotic syndrome is a dysfunction of the glomerular capillaries. Symptoms include urine losses of plasma proteins, low serum albumin, edema, and elevated blood lipids. In acute renal failure the nephrons lose function or the glomerular filtration rate (GFR) drops suddenly. Symptoms include increased blood urea nitrogen, catabolism, negative nitrogen balance, elevated electrolytes, acidosis, increased blood pressure, and fluid overload. Nephrotic syndrome and acute renal failure are usually reversible conditions. In chronic renal failure the GFR declines gradually. In early stages, compensation occurs by enlarging the remaining nephrons.

Symptoms similar to those in acute renal failure appear when the kidney is at 75% of normal function. When the GFR is 10% or less of the normal rate the patient is considered to be in end-stage renal disease. Dialysis is started to replace diminished kidney function. Electrolytes, fluids, anemia, and diet are monitored monthly by a registered dietitian. Some patients in end-stage renal failure receive kidney transplants. This restores kidney function and the patient is able to return to a more liberal diet.

TABLE 60.2

Components of the Nutrition Assessment[a]

Component	Approach
Medical history and physical exam	One way to organize findings is to use a review of systems approach. Note any medical problems or surgical procedures that could impact on nutritional status. Look for recent changes in weight and potential drug-nutrient interactions. Measure the patient's height, weight, and other anthropometric measurements. Check for edema and signs of muscle wasting. Activity levels and urine output are helpful in determining energy needs and fluid restriction.
Laboratory values	Look for laboratory values within expected ranges according to the patient's stage of disease. Consider causes for abnormal findings and corrective actions to take.
Food intake assessment	A diet history should be taken using a 24-hour recall and/or food frequency questionnaire. It is important to determine if the recall is typical and if there have been any changes in appetite. Also ask about use of dietary or nutritional supplements. Determine if the patient practices pica (ingestion of nonfood substances such as ice, cornstarch, or clay). Consider if the current intake is adequate and if not, how can the problem be corrected.
Environmental factors	Determine if the patient has an understanding about the necessity for changes in the diet. Investigate psychological and socioeconomic status. Is there someone who helps the patient follow the diet at home? Who does the grocery shopping and cooking? What is the educational level of the patient?

[a] Rating forms for doing a Subjective Global Assessment (SGA) are readily available. This assessment technique looks at weight and weight change, dietary intake, gastrointestinal symptoms, functional capacity, physical examination, and comorbidities. Use of the SGA rating form gives an overall SGA rating that ranges from severely malnourished to well nourished.

TABLE 60.3

Interpretation of Laboratory Results for Hemodialysis and Peritoneal Dialysis Patients

Test	Range in Renal Disease	Reference Range	Comments
Albumin g/L (depends on method of analysis)	35-50	35-55 Infant: 29-55 <3 yrs.: 38-54	Higher values are more desirable; mortality is 50% higher when albumin is <39
Alkaline phosphatase μkat/L	WNL	M 0.317-1.23 F 0.200-1.05 Infant: 1.667-5.50 Child: 1.5-3.83 Teen: 1.667-4.17	High in bone disease
BUN mmol/L	21.43-42.84	1.43-7.85 Infant: 2.86-9.99 Peds: 3.57-7.14	Varies with protein intake and dialysis adequacy
Calcium mmol/L	2.1-2.87	2.1-2.87	Low with insufficient vitamin D; high with excess
Cholesterol mmol/L	<5.52	<5.52	High with nephrotic syndrome, or hereditary disorders of lipid metabolism
HDL-C mmol/L	>1.56	>1.56	
Triglycerides mmol/L	<1.7	<1.7	
Creatinine μmol/L	34.2-256.5	11.97-25.65 Infant: 6.84-20.52 <4 yrs.: 1.71-11.97 4-10 yrs.: 0.34-15.39 10-16 yrs.: 5.13-18.81	Low in extreme muscle wasting
Ferritin mmol/L	2.21-17.7	0.26-6.63 <6 mo.: 0.55-4.42 6 mo.-15 yrs. 0.15-3.09	High in inflammatory states
Glucose mmol/L	3.9-6.1	3.90-6.1	Monthly clinic labs usually are non-fasting

TABLE 60.3 *(Continued)*

Interpretation of Laboratory Results for Hemodialysis and Peritoneal Dialysis Patients

Test	Range in Renal Disease	Reference Range	Comments
Hematocrit	33-36%	M 39-51% F 36-45% Newborn: 40-70% Infant: 30-49% Child: 30-42% Teen: 34-44%	Target for EPO: 30%
Hemogloblin mmol/L	6.84-7.46	7.46-10.57 Newborn: 8.7-14.93 Infant: 6.22-9.33 Child: 6.84-9.95 Teen: 7.46-10.57	
Iron µmol/L	4.48-35.8	10.74-31.32 Infant: 17.9-35.8 4 mo.–2 yrs. 7.2-17.9 Child: 15.2-26.85	Day-to-day variations common
Phosphorus mmol/L	1.48-2.14	0.82-1.55 Newborn: 1.32-2.96 Infant: 1.51-2.20 Child: 1.32-1.97	High serum levels common — binders & low PO4 diet are used for control
Potassium mmol/L	3.5-6.0	3.5-6.0	High serum levels common; low K diet used for control
Sodium mmol/L	WNL	136-145	Varies with fluid status

Acute Renal Failure: Daily Nutrient and Fluid Needs

Table 60.4[10-12] outlines basic nutritional requirements for children who have acute renal failure. Guidelines are adjusted depending on stress level, acute phase, and dialysis treatments. Table 60.5[13-16] outlines basic nutritional requirements for adults who have acute renal failure. Guidelines are adjusted for individuals depending on the stress level, phase of disease, and dialysis treatments.

TABLE 60.4

Daily Nutrient and Fluid Needs for Pediatric Patients with Acute Renal Failure

Age	Energy	Protein
Birth to 1 year	> 100 kcal/kg	1.0-2.0 g/kg
1-3 years	> 100 kcal/kg	1.5-1.8 g/kg
4-10 years	70-90 kcal/kg	1.0-1.5 g/kg
11-18 years	55 kcal/kg	0.8-1.5 g/kg

Nutrient	Recommendations
Sodium	Monitor and adjust as needed
Potassium	Monitor and adjust as needed
Fluids	Individualized
Calcium	Monitor and adjust as needed
Phosphorus	Monitor and adjust as needed
Vitamins and minerals	Follow daily RDA/DRI[45,46] or therapeutic levels depending on needs

Note: Fluids and electrolytes and micronutrients either are unrestricted or individualized by patient rather than age.

TABLE 60.5

Daily Nutrient and Fluid Needs for Adults with Acute Renal Failure

Nutrient	Recommendations
Energy	30-35 kcal/kg
Protein[a]	0.6-0.8 g/kg
Sodium[b]	2 g/day
Potassium[b]	2 g/day
Fluids	Output plus 500 cc
Calcium	Keep serum values within normal limits
Phosphorus	Keep serum values within normal limits
Vitamins and minerals	Follow daily RDA/DRI[45,46] or therapeutic levels (depending on needs)

[a] Increase as renal function improves or if dialysis is started.
[b] Replace in diuretic phase of disease.

TABLE 60.6

Daily Nutrient and Fluid Needs for Pediatric Patients with Chronic Renal Failure

Age	Energy	Protein
Birth-6 months	> 100 kcal/kg	2.2 g/kg
6 months-1 year	~ 100 kcal/kg	1.6 g/kg
1-3 years	~ 100 kcal/kg	1.2 g/kg
4-10 years	70-90 kcal/kg	1.0-1.2 g/kg
11-18 years[a]	> 40-50 kcal/kg	0.9-1.0 g/kg

Nutrient	Recommendations
Sodium	Monitor and adjust with level of renal function
Potassium	Monitor and adjust with level of renal function
Fluids	Individualized
Calcium	Supplement as needed to DRI
Phosphorus	Restrict if high serum levels
Vitamins and minerals	Follow daily RDA/DRI[45,46] or therapeutic levels depending on needs

Note: Fluids, electrolytes, and micronutrients are either unrestricted or individualized by patient rather than age.

[a] Females typically require fewer kcal.

Chronic Renal Failure: Daily Nutrient and Fluid Needs

Table 60.6[10-12] outlines basic nutritional requirements for children who have chronic renal failure. Guidelines are adjusted depending on comorbidity. Table 60.7[13,15,17-20] outlines basic nutritional requirements for adults who have renal insufficiency, but have not yet started dialysis. Guidelines can be adjusted for comorbidities and advanced age.

Post Kidney Transplant: Daily Nutrient and Fluid Needs

Table 60.8[11,12,21] outlines basic nutritional requirements for children who have received renal transplants. Guidelines can be adjusted for comorbidity. Table 60.9[15,18,22-24] outlines basic nutritional requirements for adults who have received kidney transplants. Guidelines can be adjusted for comorbidities and advanced age. As post-transplant patients are at

TABLE 60.7

Daily Nutrient and Fluid Needs for Adults with Chronic Renal Failure

Nutrient	Recommendations
Energy	30-35 kcal/kg
Protein[a]	0.6-0.8 g/kg
Sodium[b]	2-4 g
Potassium[c]	Unrestricted
Fluids	Unrestricted
Calcium	1.0-1.5 g
Phosphorus	10-12 mg/g protein
Vitamins and minerals	Follow daily RDA/DRI[45,46] for B, C, D, iron, & zinc, no supplements for vitamin A or magnesium

[a] 0.8-1.0 g/kg in nephrotic syndrome, do not adjust for urine protein losses.
[b] Possible restriction when gomerular filtration rate <10 ml/minute or when serum values become elevated.
[c] Start restriction when urine output diminishes.

TABLE 60.8

Daily Nutrient and Fluid Needs for Pediatric Patients Post Kidney Transplant

Age	Energy	Protein <3 Months Post Transplant	Protein >3 Months Post Transplant
Birth-5 months	≥ 108 kcal/kg	3.0 g/kg	2.2 g/kg
5 months-1 year	≥ 100 kcal/kg	3.0 g/kg	1.6 g/kg
1-3 years	102 kcal/kg	2.0-3.0 g/kg	1.3 g/kg
4-6 years	90 kcal/kg	2.0-3.0 g/kg	1.2 g/kg
7-10 years	70 kcal/kg	2.0-3.0 g/kg	1.0 g/kg
11-14 years (girls)	47 kcal/kg	1.5-2.0 g/kg	1.0 g/kg
15-18 years (girls)	40 kcal/kg	1.5-2.0 g/kg	0.9 g/kg
11-14 years (boys)	55 kcal/kg	1.5-2.0 g/kg	1.0 g/kg
15-18 years (boys)	45 kcal/kg	1.5-2.0 g/kg	0.9 g/kg

Nutrient	Recommendations
Sodium	1-3 g postoperative, then as tolerated
Potassium	As tolerated
Fluids	Unrestricted
Calcium	Supplement as needed
Phosphorus	Unrestricted
Vitamins and minerals	Supplement as needed

Note: Fluids and electrolytes and micronutrients either are unrestricted or individualized by patient rather than age.

TABLE 60.9

Daily Nutrient and Fluid Needs for Adults Post Kidney Transplant

Nutrient	Recommendations
Energy	25-35 kcal/kg
Protein[a]	1.0-1.5 g/kg
Sodium	2-4 g/day
Potassium	Unrestricted
Fluids	Unrestricted
Calcium	1.0-1.5 g
Phosphorus	Unrestricted
Vitamins and minerals	Follow daily RDA/DRI[45,46]

[a] Higher end for postoperative recovery, 1.0 g/kg for maintenance.

TABLE 60.10

Daily Nutrient and Fluid Needs for Pediatric Patients Undergoing Peritoneal Dialysis

Age	Energy	Protein	Calcium
Birth to 5 months	≥ 108 kcal/kg	2.5-4.0 g/kg	400 mg
5 months — 1 year	≥ 100 kcal/kg	2.0-2.5 g/kg	600 mg
1-3 years	102 kcal/kg	2.0-2.5 g/kg	800 mg
4-6 years	90 kcal/kg	2.0-2.5 g/kg	800 mg
7-10 years	70 kcal/kg	2.0-2.5 g/kg	800 mg
11-14 years (girls)	47 kcal/kg	1.5 g/kg	1200 mg
15-18 years (girls)	40 kcal/kg	1.5 g/kg	1200 mg
11-14 years (boys)	55 kcal/kg	1.5 g/kg	1200 mg
15-18 years (boys)	45 kcal/kg	1.5 g/kg	1200 mg

Nutrient	Recommendations
Sodium	As tolerated
Potassium	As tolerated
Fluids	Usually unrestricted
Phosphorus	As tolerated
Vitamins and minerals	
Infants and toddlers	1 ml multivitamin drops, 1 mg folic acid, vitamin D as needed
Children	1 mg folic acid, 10 mg pyridoxine, 60 mg vitamin C, 5 mg pantothenic acid, 1.0 mg thiamin, 1.2 mg riboflavin, 6 µg B_{12}, 300 µg biotin, 15 mg niacin, vitamin D as needed
Adolescents	1 mg folic acid, 10 mg pyridoxine, 60 mg vitamin C, 10 mg pantothenic acid, 1.5 mg thiamin, 1.7 mg riboflavin, 6 µg B_{12}, 300 µg biotin, 20 mg niacin, vitamin D as needed

Note: Fluids and electrolytes and micronutrients either are unrestricted or individualized by patient rather than age.

increased risk for hyperlipidemia, the diet should incorporate the principles for a Step One Heart Healthy Diet (American Heart Association).

Peritoneal Dialysis: Daily Nutrient and Fluid Needs

Table 60.10[10-12] outlines basic nutritional requirements for children undergoing daily peritoneal dialysis. Guidelines can be adjusted for comorbidity. Table 60.11[15,17,25-27] outlines basic nutritional requirements for adults undergoing daily peritoneal dialysis. Guidelines can be adjusted for comorbidities and advanced age.

Hemodialysis: Daily Nutrient and Fluid Needs

Table 60.12[10-12] outlines basic nutritional assessment parameters for children undergoing hemodialysis at least three times per week. Guidelines can be adjusted for comorbidity. Table 60.13[15,28-30] outlines basic nutritional requirements for adults undergoing hemodialysis three times per week. Guidelines can be adjusted for comorbidities and advanced age.

TABLE 60.11

Daily Nutrient and Fluid Needs for Adults Undergoing Peritoneal Dialysis

Nutrient	Recommendations
Energy[a]	25-35 kcal/kg
Protein	1.2-1.5 g/kg
Sodium	2-4 g
Potassium	3-4 g
Fluids	As tolerated
Calcium	1.0-1.5 g
Phosphorus	12-15 mg/g/protein
Ascorbic acid	60-100 mg
Pyridoxine	5-10 mg
B_{12}	3 μg
Folic acid	0.8-1.0 mg
No A or K	
Zinc	15 mg
Riboflavin	1.8-2.0 mg
Niacin	20 mg
Thiamin	1.5-2.0 mg
Biotin	200-300 μg
Vitamin E	10-15 IU
Pantothenic acid	10 mg
Iron and active vitamin D	Individualized

[a] Includes kcal from dialysate (3.4 kcal/g).

TABLE 60.12

Daily Nutrient and Fluid Needs for Pediatric Patients Undergoing Hemodialysis

Age	Energy	Protein	Calcium
Birth-5 months	≥ 108 kcal/kg	3.3 g/kg	400 mg
5 months-1 year	≥ 100 kcal/kg	2.4 g/kg	600 mg
1-3 years	102 kcal/kg	1.8 g/kg	800 mg
4-6 years	90 kcal/kg	1.8 g/kg	800 mg
7-10 years	70 kcal/kg	1.5 g/kg	800 mg
11-14 years (girls)	47 kcal/kg	1.3-1.5 g/kg	1200 mg
15-18 years (girls)	40 kcal/kg	1.3-1.5 g/kg	1200 mg
11-14 years (boys)	55 kcal/kg	1.3-1.5 g/kg	1200 mg
15-18 years (boys)	45 kcal/kg	1.3-1.5 g/kg	1200 mg

Nutrient	Recommendations
Sodium	As tolerated
Potassium	1-3 mEq/kg
Fluids	Replace urine output and insensible losses
Phosphorus	Supplement PRN
Vitamins and minerals	
Infants & toddlers	1 ml Multivitamin drops, 1 mg folic acid, vitamin D PRN
Children & adolescents	1 mg folic acid, 10 mg pyridoxine, 60 mg vitamin C, 10 mg pantothenic acid, 1.5 mg thiamin, 1.7 mg riboflavin, 6 μg B_{12}, 300 μg biotin, 15 mg niacin, vitamin D PRN

Note: Fluids and electrolytes and micronutrients either are unrestricted or individualized by patient rather than age.

TABLE 60.13

Daily Nutrient and Fluid Needs for Adults Undergoing Hemodialysis

Nutrient	Recommendations
Energy	30-35 kcal/kg
Protein	1.2-1.4 g/kg
Sodium	2-3 g
Potassium	2-3 g
Fluids	Urine output plus 1000 cc
Calcium	1.0-1.5 g
Phosphorus	12-15 mg/g/protein
Ascorbic acid	60-100 mg
Pyridoxine	5-10 mg
B_{12}	3 μg
Folic acid	0.8-1.0 mg
No A or K	
Zinc	15 mg
Riboflavin	1.8-2.0 mg
Niacin	20 mg
Thiamin	1.5-2.0 mg
Biotin	200-300 μg
Vitamin E	10-15 IU
Pantothenic acid	10 mg
Iron and active vitamin D	Individualized

Special Nutrition Focus

According to the 1999 United States Renal Data Systems (USRDS) Renal Data Report, the number of dialysis patients is approaching 200,000. Many practitioners will encounter dialysis patients who have medical nutrition therapy needs beyond the average patient. These patients require intense nutritional management to improve and then maintain good nutritional status either for the short term as in pregnancy, or for the long term as in patients with diabetes or acquired immunodeficiency disease (AIDS).

Pregnant Hemodialysis Patients

The frequency of pregnancy in female dialysis patients is approximately 1.5%. Of these women, 52% will carry to term. Dialysis frequency usually is increased to an average of 24 hours per week. Predialysis BUN is best kept below 60 mg/dl. Table 60.14[31-34] lists the recommendations for nutrients for pregnant women undergoing hemodialysis.

Adult Dialysis Patients with Diabetes Mellitus

Carbohydrate and fat are individualized for diabetic patients with renal disease. New guidelines from the National Cholesterol Education Program state that diabetes is regarded as a cardiovascular disease risk equivalent. Dietary guidelines generally follow the NCEP step II diet. Most sources of fat should be monounsaturated. Plant stanols/sterols can be used in renal patients to enhance LDL lowering. New desirable lipid targets are the same as for the general population; i.e., total cholesterol <5.2 mmol/L, LDL-

TABLE 60.14

Pregnant Hemodialysis Patients

Nutrient	Recommended Amount
Energy	25-45 kcal/kg +250 kcal
Protein	1.0-1.5 g/kg + 10 g
Sodium	Individualize
Potassium	Individualize
Fluids	Individualize
Calcium	1200-1600 mg/day
Phosphorus	Balance of diet/binders
Vitamins and minerals	Consider increased dose of renal vitamins B & C plus zinc, 1,25(OH)2D3 PRN, fat-soluble vitamins A, E, and K are not usually supplemented

TABLE 60.15

Special Nutrition Focus: Adult Patients with Diabetes Mellitus

Nutrient	Recommended Amount		
	Pre-Dialysis	Hemodialysis	Peritoneal Dialysis
Energy	25-35 kcal/kg	30-35 kcal/kg	25-35 kcal/kg[a]
Protein	0.8-1.0 g/kg	1.2-1.4 g/kg	1.5-2.0 g/kg
Sodium	2-4 g	2 g	2-4 g
Potassium	Not restricted	2-3 g	Individualize supplement as needed
Fluids	Not restricted	Urine output plus 1000 cc	Urine output plus 2000 cc
Calcium	1.0-1.5 g	1.0-1.5 g	1.0-1.5 g
Phosphorus	10-12 mg/g/protein	12-15 mg/g/protein	12-15 mg/g/protein
Vitamins & other minerals	Daily RDA/DRI[45,46] for most vitamins and minerals (fat soluble vitamins and magnesium are not supplemented)		

[a] Includes kcal from dialysate (3.4 kcal/g). Many patients will require adjustment of insulin regimens.

cholesterol <2.6 mmol/L, HDL-cholesterol >1.56 mmol/L, triglycerides <1.7 mmol/L. Table 60.15[7,35-39] lists recommendations for nutrients for diabetic patients with renal failure pre-dialysis or undergoing hemo or peritoneal dialysis.

Dialysis Patients with AIDS Nephropathy

Intestinal malabsorption and diarrhea occur in most AIDS patients. It is therefore not uncommon for the patient to be very malnourished when AIDS nephropathy leads to dialysis. Improving and maintaining nutrition status is a special challenge in this population. Table 60.16[40-44] lists the nutrient recommendations for dialysis patients with AIDS.

Medications

Calcium Supplement/Binders

Calcium supplements are used to supplement therapeutic diets that are low in calcium due to the restriction of dairy products and many other foods high in calcium. Calcium products used for supplementation are taken between meals. Calcium products are also used to bind dietary phosphorus in order to change the route of elimination from urine to stool. Products used for phosphate binding are taken within 30 minutes of meals or

TABLE 60.16

Special Nutrition Focus: Dialysis Patients with AIDS Nephropathy

Nutrient	Recommended Amount	
	Hemodialysis	Peritoneal Dialysis
Energy	45-50 kcal/kg	45-50 kcal/kg[a]
Protein	1.4-2.0 g/kg	1.5-2.0 g/kg
Sodium	2-3 g	2-4 g
Potassium	1 meq/kg	Individualize supplement as needed
Fluids	Urine output plus 1000-1200 cc	Urine output plus 2000 cc
Calcium	1.0-1.5 g	1.0-1.5 g
Phosphorus[b]	12-15 mg/g/protein	12-15 mg/g/protein
Vitamins and minerals	Same as non-AIDS patients	

[a] Includes kcal from dialysate (3.4 kcal/g).
[b] Lift restriction if PO intake poor.

TABLE 60.17

List of Products to Provide Suitable Source of Calcium for Patients with Renal Disease[a]

Generic Name	Name Brand	Elemental Ca^{++}	Source
Calcium acetate	PhosLo	169 mg	Braintree Laboratories
	Calphron	169 mg	NephroTech
Calcium carbonate[b]	Calci-chew	500 mg	R&D Laboratories
	Caltrate 600	600 mg	Whitehall Robins Healthcare
	Maalox Quick Dissolve (regular strength)	222 mg	Novartis Consumer Health, Inc.
	Nephro-Calci	600 mg	R&D Laboratories
	Oscal 500	500 mg	SmithKline Beecham
	Rolaids EX	400 mg	Warner Lambert
	TUMS EX	600 mg	SmithKline Beecham
	Viactiv	500 mg	Mead Johnson
Calcium citrate[c]	Citracal	200 mg	Mission Pharmacal

[a] Manufacturer's information.
[b] Efficacy of different brands of calcium carbonate varies due to ability to dissolve. A tablet of calcium carbonate placed in 6 oz. of vinegar at room temperature and stirred frequently should disintegrate within 30 minutes.
[c] Not generally recommended for renal patients secondary to enhanced aluminum absorption.

snacks. Iron supplements should not be taken with calcium supplements. End-stage renal patients do not need to take calcium products with added vitamin D. When vitamin D supplementation is needed it will be prescribed as an activated form. Table 60.17 lists sources of calcium supplementation.

Phosphate Binders (Non-Calcium Based)

Renagel is a polymetric phosphate binder which contains no calcium. Aluminum-containing products are still used to bind dietary phosphorus when calcium supplements are not effective or not medically appropriate. Magnesium binders in combination with calcium acetate are also an alternative in certain situations. The information in Table 60.18 is a sampling of current products.

Vitamin and Mineral Supplements

Vitamin and mineral supplements for renal patients are generally limited to water-soluble vitamins and essential amounts of minerals. Table 60.19 gives recommended supplemen-

TABLE 60.18

Phosphate Binders (Non-Calcium Based)[a]

Active Ingredient	Unit	Aluminum/Unit	Brand Name	Manufacturer
Aluminum Based Binders				
Aluminum carbonate	5 ml	142 mg	Basaljel	Wyeth-Ayerst Laboratories
Aluminum hydroxide	5 ml	208 mg	AlternaGEL suspension	Johnson & Johnson
	5 ml	111 mg	Amphojel suspension	Wyeth-Ayerst Laboratories
	300/600 mg	104/208 mg	Amphojel tablets	Wyeth-Ayerst Laboratories
	1 capsule	134 mg	Dialume	Rhone-Poulenc Rorer
Active Ingredient	**Unit**	**MG/CA^{++} Per Unit**	**Brand Name**	**Manufacturer**
Magnesium/Calcium Based Binders				
Magnesium carbonate/ calcium acetate	1 Tablet	57 mg MG/ 113 mg CA^{++}	MagneBind™ 200	Nephro-Tech
	1 Tablet	85 mg MG/ 76 mg CA^{++}	MagneBind™ 300	Nephro-Tech
Active Ingredient	**Unit**	**Sevelamer Hydrochloride**	**Brand Name**	**Manufacturer**
Polymetric Binder				
Sevelamer hydrochloride	1 Capsule	403 mg/800 mg	Renagel	Genzyme Pharmaceuticals

[a] Manufacturer's information.

TABLE 60.19

Vitamin and Mineral Supplementation

Vitamin	Recommended Amount	Vitamin	Recommended Amount
Vitamin C	40-100 mg	Thiamin(B_1)	1.5 mg
Riboflavin(B_2)	1.7 mg	Niacin	20 mg
Pyroxdine(B_6)	10 mg	Cobalamin (B_{12})	6 µg
Folic acid	0.8-1.0 mg	Pantothenic acid	5-10 mg
Biotin	150-300 µg	Active vitamin D	Oral or IV-based on need

Sample Vitamin/Mineral Supplement Product List

Product	Manufacturer
Vitamins	
Nephro-Vite	R&D Laboratories
Neprho-Vite RX	R&D Laboratories
Nephrocaps	Flemming
Berocca	Roche Laboratories
Albee with C	Whitehall Robins Healthcare
Multivitamin B+C with Zinc	Vitaline Formulas
Vitamins with Iron	
Nephron FA	Nephro-Tech
Nephro-Vite + FE	R&D Laboratories
Active Vitamin D	
Rocaltrol	Roche Laboratories
Calcijex (Calcitriol Injection)	Abbott Laboratories
Zemplar (Paracalcitol Injection)	Abbott Laboratories

TABLE 60.20

Iron Supplements[a]

Source of Iron	Elemental Iron	Brand Name	Form
Ferric gluconate	62.5 mg/5ml	Ferrlecit	IV
Ferrous gluconate	35 mg	Fergon	PO
Ferrous fumarate	66 mg	Chromagen	PO
	106 mg	Hemocyte	PO
	115 mg	Nephro-Fer	PO
Ferrous sulfate	65 mg	Feosol	PO
	50 mg	SlowFe	PO
Iron dextran	50 mg/ml	InFed	IV
	50 mg/ml	Dexferrin	IV
Iron polysaccharide	150 mg	Niferex	PO
	150 mg	Nulron	PO

[a] Manufacturer's information.

tation level for selected vitamins and minerals for adults. Supplements for children need to be individualized depending on requirements for growth. Oral iron supplements are routinely used in conjunction with intravenous Epoetin alfa (EPO) therapy to control anemia in dialysis patients. EPO is an amino acid glycoprotein manufactured by recombinant DNA technology. It has the same biological effects as endogenous erythropoietin in stimulating red blood cell production. Intravenous supplements need to be given as a test dose before actual therapy to access the potential for allergic reaction. Oral supplements can have gastrointestinal side effects such as nausea, vomiting, and constipation. Table 60.20 lists some of the available iron supplements for use with renal patients.

Enteral Nutrition Supplements for the Renal Patient

Nutritional supplements are frequently used to provide nutrients for persons who, even after liberalization of the diet, cannot consume adequate oral nutrition or to supply a complete source of nutrition for patients who are nourished through an enteral feeding tube. There are many products from which to choose that will meet the nutrition requirements for most types of medical nutrition therapy. In addition to a variety of normal nutrition products, there are specialty products available for persons with acute or chronic renal failure including end-stage disease. Table 60.21 offers a partial listing of these products. Choosing the appropriate product can be a challenge since there is such a wide variety from which to choose and since many renal patients are successfully managed with normal supplements, which tend to be less expensive than the specialty formulas. In choosing a formula, the following points should be considered:

1. Goal of therapy: more protein, more kcalories or both
2. How much of the patient's needs are being met by the diet
3. How much of the patient's fluid restriction can be spared for the supplement
4. Which products are affordable and available in the patient's area

For the patient who must be tube fed, the location of the tube must be considered in making the formula selection. The feedings must be timed in order to allow time for dialysis without compromising the nutrition therapy.

TABLE 60.21A

Enteral Nutrition Supplements for Renal Patients[a]

Product	Kcal/cc	CHO g/L	PRO g/L	FAT g/L	K mg/L	PO4 mg/L	%H_2O/L
Novasource renal (Novartis)	2	200	74	100	810	650	70
Magnacal Renal (Mead Johnson)	2	200	75	101	1270	800	71
Nepro (Ross)	2	222	70	95.6	1060	685	70
Suplena (Ross)	2	255	30	95.6	1120	730	71

TABLE 60.21B

Enteral Nutrition Supplements for Renal Patients[a]

Product	Unit	Kcal	CHO	PRO	FAT	K	PO4
EggPro (Nutra/Balance)	1 T (7.5g)	30	0.6 g	6 g	0 g	84 mg	8 mg
ProMod (Ross)	1 scoop (6.6 g)	28	0.67 g	5 g	0.60 g	45 mg	33 mg
Essential ProPlus (NutriSOY International, Inc.)	1 scoop (25 g)	68.5	6.4 g	16.3 g	0.2 g	112.5 mg	187 mg
Re/Neph cookies (Nutra/Balance)	2 oz. cookie	210	29 g	9 g	7 g	125 mg	64 mg
Re/Neph HP/HC (Nutra/Balance)	4 fl. oz.	250	32 g	8 g	10 g	10 mg	24 mg

[a] Manufacturer's information.

Practical Application of the Diet

Food Choices to Control Potassium and Phosphorus

Potassium is widely distributed in foods. As the kidneys primarily excrete this nutrient, dietary intake of potassium is an important aspect of the diet of patients with end-stage renal disease. The diet should initially be individualized for each patient based on food likes and dislikes, and modified if indicated. Although the potassium content of foods varies greatly, most foods can be incorporated into the diet of the hemodialysis patient by limiting quantities and/or by altering method of preparation. Dietary potassium is usually not a problem with peritoneal dialysis, as the patients are dialyzed daily. Some foods very high in potassium are listed in Table 60.22. Phosphorus level is almost impossible to control in end-stage renal disease by diet alone. Phosphate binders are necessary to maintain acceptable blood levels. It is also important that the patient limit the intake of dietary phosphorus. Dietary restrictions should be individualized for each patient depending on food preferences and compliance with binders. Table 60.23 lists some foods very high in phosphorus.

Suggested Meal Plans and Sample Menus

Listed in Table 60.24 are suggested meal plans for four different kcalorie levels of the diet for patients with end-stage renal disease. Additional modifications may be indicated when other disease states are also present. For diabetics, emphasis should be placed on complex carbohydrates. It is difficult to achieve energy and protein goals using complex carbohydrate sources exclusively, due to foods that must be limited due to potassium, phosphorus,

TABLE 60.22

Some Foods Very High in Potassium

Food	Portion	Amount of Potassium
Orange juice, fresh	1 cup	496 mg
Banana	medium	451 mg
Cantaloupe	1 c pieces	494 mg
Honeydew melon	1 c pieces	461 mg
Prunes, dried, cooked	1/2 cup	354 mg
Peanuts, oil roasted	1/2 cup	573 mg
Potato with skin, baked	1 large (202 g)	844 mg
Black-eyed peas, fresh-cooked	1/2 cup	347 mg
Sweet potato, baked	1 medium (114 g)	397 mg
Spinach, cooked from raw	1/2 cup	419 mg

Source: Pennington JAT. *Bowes and Church's Food Values of Portions Commonly Used,* 17th ed, Lippincott Williams and Wilkins, Philadelphia, 1997. With permission.

TABLE 60.23

Some Foods Very High in Phosphorus

Food	Portion	Amount of Phosphorus
Bran cereal, 100%	1/2 cup	344 mg
Milk, 2%	1 cup	232 mg
Whole wheat bread	1 slice	65 mg
Cheese, cheddar	1 oz	145 mg
Black-eyed peas, frozen, boiled	1 cup	208 mg
Peanuts, oil roasted	1 oz	145 mg
Peanut butter, creamy smooth	2 tbsp	103 mg
Lima beans, boiled	1 cup	208 mg
Yogurt, low-fat fruit flavor	8 oz	247 mg
Cocoa, dry unsweetened	2 T	74 mg

Source: Pennington JAT. *Bowes and Church's Food Values of Portions Commonly Used,* 17th ed, Lippincott Williams and Wilkins, Philadelphia, 1997. With permission.

and sodium content. Carbohydrates should be included with meals, rather than as snacks, to help slow absorption. Emphasis should also be placed on consistent meal content, especially of carbohydrate, and timing of meals and snacks to facilitate glycemic control. Fat should be from unsaturated sources, preferably monounsaturated. The percentage of kcalories provided by fat will most likely need to be higher than the recommended 30%. Hyperlipidemia, especially elevated triglycerides, is often present in renal disease. Because of the high risk for cardiovascular disease in renal patients, a diet high in complex carbohydrates and containing less than 30% of kcalories from fat may be appropriate. In view of other restrictions, this may not be a top priority. In order to provide adequate kcalories it may be necessary to provide more than 30% of kcalories from fat. Providing fat kcalories from monounsaturated and polyunsaturated sources can reduce saturated fat and cholesterol.

Emergency Shopping List

End-stage renal disease patients are dependent on dialysis to sustain life. Emergencies such as earthquakes, hurricanes, tornadoes, or floods may limit access to dialysis in a specific area. The patient must then use a diet restricted in fluids, protein, and electrolytes to survive until dialysis is once again available. Table 60.25 lists some guidelines for use in the event of a disaster or emergency.

TABLE 60.24

Sample Menus

1800 kcal[a]	2000 kcal[b]	2200 kcal[c]	2400 kcal[d]
Breakfast			
1/2 cup grits	1/2 cup grits	1 cup grits	1 cup grits
1 piece toast	1 piece toast	1 piece toast	1 piece toast
1/2 c grape juice	1/2 c apple juice	1/2 c apple juice	1/2 c apple juice
1/2 c 2% milk	1/2 c 2% milk	1/2 c 2% milk	1/2 c 2% milk
1 t margarine	1 t margarine	1 t margarine	1 t margarine
Lunch			
1 c rice	1 c rice	1 c rice	1 c rice
1 slice bread	1 slice bread	1 slice bread	1 slice bread
1 c garden salad	1 c garden salad	1 c garden salad	1 c garden salad
	1/2 c pears	1/2 c corn	1/2 c pears
			1/2 c corn
3 oz. skinless chicken breast	3 oz. skinless chicken breast	3 oz. skinless chicken breast	3 oz. skinless chicken breast
1 t margarine	1 t margarine	1 t margarine	1 t margarine
1 T salad dressing	1 T salad dressing	1 T salad dressing	1 T salad dressing
Afternoon Snack			
10 thin pretzels	2 slices bread	6 2 1/2″ graham crackers	6 2 1/2″ graham crackers
	1 oz. lean ham	1/2 c pears	1/2 c pears
1/2 c cottage cheese	1 t mayonnaise	1/2 c cottage cheese	1/2 c cottage cheese
Dinner			
1/2 c mashed potatoes	1/2 c mashed potatoes	1/2 c mashed potatoes	1/2 c mashed potatoes
1 roll	1 roll	1 roll	2 rolls
1 c greens	1 c greens	1 c greens	1 c greens
1/2 c fruit cocktail	1/2 c fruit cocktail	1/2 c fruit cocktail	1/2 c fruit cocktail
3 oz. lean beef	3 oz. lean beef	3 oz. lean beef	3 oz. lean beef
1 t margarine	1 t margarine	1 t margarine	2 t margarine
2 sugar cookies	2 sugar cookies	2 sugar cookies	2 sugar cookies
Bedtime Snack			
3-2 1/2″ square graham crackers	5 vanilla wafers	1 slice bread	2 slices bread
		1 t mayonnaise	1 t mayonnaise
1/2 cup pears	1/2 c pineapple	1 c strawberries	1/2 c peaches
		1 oz. turkey breast	1 oz. turkey breast

[a] 80 g protein, <2000 mg sodium, <2000 mg potassium, <1200 mg phosphorus.
[b] 80 g protein, <2000 mg sodium, <3000 mg potassium, <1200 mg phosphorus.
[c] 90 g protein, <3000 mg sodium, <3000 mg potassium, <1200 mg phosphorus.
[d] 100 g protein, <3000 mg sodium, <3000 mg potassium, <1300 mg phosphorus.

TABLE 60.25

Emergency Shopping List for the Dialysis Patient (Food for 2 to 3 days)

Bottled water: allow 2-3 quarts (~2-3 liters) for hygiene purposes plus usual fluid restriction
Loaf of white bread
Dry cereal: corn flakes, rice krispies, cheerios, puffed wheat and rice, or shredded wheat
Box of vanilla wafers or other plain cookies
Box of graham crackers
Box of unsalted crackers
Small jars of mayonnaise (open one each day)
Small cans of chicken and/or tuna (open, eat, then throw away leftovers; do not try to save without refrigeration)
Can of lemonade or Kool-Aid mix
Granulated sugar
Peanut butter
Lemon candy
Hard candy in different flavors
Powdered milk or boxed milk
Small cans of evaporated milk
Canned fruit: peaches, fruit cocktail, pears, and applesauce
Fresh apples, lemons, carrots, if available
Jelly: apple, grape, strawberry, blueberry, blackberry
Marshmallows
Boxed juices
Plastic dinnerware and utensils
Paper towels and napkins

Note: Food stored in the refrigerator and/or freezer should be used first. Limit fluid intake as much as possible.

Summary

Patients with acute or chronic renal disease are susceptible to the development of profound malnutrition. Protein energy imbalances worsen prognosis regardless of disease stage. A complete nutrition assessment plus frequent monitoring can help identify malnutrition before there is significant depletion in visceral protein stores and weight loss. Important treatment objectives are to communicate with the patient, monitor appropriate laboratory indices, and plan the appropriate nutritional therapy.

References

1. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 25.
2. Blackburn G, Bistrian B, Mainai B, et al. *J Parent Enteral Nutr* 11: 1; 1977.
3. Kopple JD, Massry SG, Eds. *Nutritional Management of Renal Disease* Williams and Wilkins, Baltimore, 1997, pg 203.
4. McCann L, Nelson P, Spinozzi N, Eds. *Pocket Guide to Nutrition Assessment of the Renal Patient*, 2nd ed, National Kidney Foundation, New York, 1997, chap. 1.
5. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 45.
6. Stover J, Ed. *A Clinical Guide to Nutrition Care in End Stage Renal Disease* American Dietetics Association, Chicago, 5: 222; 1994.

7. American Diabetes Association Standards of Medical Care for Patients With Diabetes Mellitus *Clinical Diabetes* January/February, 22, 1997.
8. McCann L, Nelson P, Spinozzi N, Eds. *Pocket Guide to Nutrition Assessment of the Renal Patient*, 2nd ed, National Kidney Foundation, New York, NY, 1997, chap. 2.
9. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 213-236.
10. Kopple JD, Massry SG, Eds. *Nutritional Management of Renal Disease* Williams and Wilkins, Baltimore, 1997, pg 687-712.
11. McCann L, Nelson P, Spinozzi N, Ed. *Pocket Guide to Nutrition Assessment of the Renal Patient*, 2nd ed, National Kidney Foundation, New York, 1997, chap. 11.
12. Stover J, Ed. *A Clinical Guide to Nutrition Care in End-Stage Renal Disease* The American Dietetic Association, Chicago, 1994, pg 79-98.
13. Klahr S, Levey AS, Beck GJ, et al. *N Engl J Med* 330: 877; 1994.
14. Kopple JD, Massry SG, Eds. *Nutritional Management of Renal Disease* Williams and Wilkins, 1997, pg 713-754.
15. McCann L, Nelson P, Spinozzi N, Eds. *Pocket Guide to Nutrition Assessment of the Renal Patient*, 2nd ed, National Kidney Foundation, New York, 1997, chap. 3.
16. Stover J, Ed. *A Clinical Guide to Nutrition Care in End Stage Renal Disease* American Dietetics Association, Chicago, 1994, pg 99-110.
17. Beto J. *J Am Diet Assoc* 95: 898; 1995.
18. Fouque D, Laville M, Boissel et al. *Br Med J* 304: 216; 1992.
19. Kopple JD, Massry SG, Ed. *Nutritional Management of Renal Disease* Williams and Wilkins, 1997, pg 317-340.
20. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 237-252.
21. Mahan L, Escott-Stump S, Eds. *Krause's Food, Nutrition, and Diet Therapy*, 9th ed, Saunders, Philadelphia, 1996, pg 771-804.
22. Kopple JD, Massry SG, Eds. *Nutritional Management of Renal Disease* Williams and Wilkins, 1997, pg 669-686.
23. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 294-315.
24. Pagenkemper JJ, Foulks CJ. *J Renal Nutr* 1: 119; 1991.
25. Kopple JD, Massry SG, Eds. *Nutritional Management of Renal Disease* Williams and Wilkins, Baltimore, 1997, pg 619-668.
26. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 269-293.
27. Stover J, Ed. *A Clinical Guide to Nutrition Care in End Stage Renal Disease* American Dietetics Association, Chicago, 1994, pg 37-56.
28. Kopple JD, Massry SG, Eds. *Nutritional Management of Renal Disease* Williams and Wilkins, Baltimore, 1997, pg 563-600.
29. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 253-268.
30. Stover J, Ed. *A Clinical Guide to Nutrition Care in End Stage Renal Disease* American Dietetics Association, Chicago, 1994, pg 25-36.
31. Grossman SD, Hou S, Moretti M, Saran M. *J Renal Nutr* 3: 5; 1993.
32. Henderson N. *J Renal Nutr* 6: 222; 1996.
33. Hou SH. *Am J Kidney Dis* 23: 60; 1994.
34. Stover J, Ed. *A Clinical Guide to Nutrition Care in End Stage Renal Disease* American Dietetics Association, Chicago, 1994, pg 199-206.
35. Third Report of the National Cholesterol Education Program Expert Panel on Detection, Evaluation and Treatment of High Blood Cholesterol in Adults Executive Summary, May 2001, pg 1-40.
36. Kopple JD, Massry SG, Ed. *Nutritional Management of Renal Disease* Williams and Wilkins, 1997, pg 63-77.

37. McCann L, Nelson P, Spinozzi N, Ed. *Pocket Guide to Nutrition Assessment of the Renal Patient*, 2nd ed, National Kidney Foundation, New York, 1997, chap. 4.
38. Renal Dietetians Dietetic Practice Group, *National Renal Diet: Professional Guide*, American Dietetics Association, 1993.
39. Stover J, Ed. *A Clinical Guide to Nutrition Care in End Stage Renal Disease* American Dietetics Association, Chicago, 1994, pg 69-78.
40. Kopple JD, Massry SG, Ed. *Nutritional Management of Renal Disease* Williams and Wilkins, 1997, pg 257-276.
41. McCann L, Nelson P, Spinozzi N, Eds. *Pocket Guide to Nutrition Assessment of the Renal Patient*, 2nd ed, National Kidney Foundation, New York, NY, 1997.
42. Mitch WE, Klahr S, Eds. *Handbook of Nutrition and the Kidney* Lippincott-Raven, Philadelphia, 1998, pg 45-86.
43. Plourd D. *J Renal Nutr* 5: 182; 1995.
44. Stover J, Ed. *A Clinical Guide to Nutrition Care in End Stage Renal Disease* American Dietetics Association, Chicago, 1994, pg 187-189.
45. *Recommended Dietary Allowances,* 10th ed, National Academy of Sciences, National Academy Press, Washington, DC, 1989.
46. Committee on Dietary Reference Intakes, Dietary Reference Intakes for Calcium, Phosphorus, Magnesium, Vitamin D, and Fluoride, National Academy Press, Washington, DC, 1997.
47. Pennington JAT. *Bowes and Church's Food Values of Portions Commonly Used,* 17th ed, Lippincott Williams and Wilkins, Philadelphia, 1997.