cardiovascular disease risk factors (e.g., tobacco cessation); use of medications that block the RAAS pathway; diet modifications; avoidance of nephrotoxins; and identification of reversible causes of acute kidney injury in the setting of CKD.

Management of Hypertension and Diabetes

Several controlled trials have demonstrated that treatment of hypertension attenuates the rate of progression of kidney disease. The present recommendation is to target blood pressure to lower than 140/90 mm Hg in patients with diabetes or kidney disease. However, the evidence supporting this recommendation in CKD is limited, and there is debate as to whether a higher target may be acceptable. Medications that block the production or effect of angiotensin II further prevent progression of CKD, beyond control of hypertension, in patients with proteinuria. Dihydropyridine calcium channel blockers have not been shown to be as beneficial as ACE inhibitors or ARBs in slowing CKD progression.

For patients with diabetes mellitus, adequate glycemic control also slows progression of CKD. The recommended goal is to maintain glycosylated hemoglobin (hemoglobin A_{1c}) values less than 7%, irrespective of a concurrent diagnosis of CKD, although this level of glycemic control warrants caution due to hypoglycemic risk (see Chapter 66). ACE inhibitors and ARBs may be considered, in patients with diabetes and proteinuria who do not have hypertension, to slow CKD progression.

Diet

Dietary protein restriction is advocated to slow progression of CKD. Several meta-analyses have indicated that reduced-protein diets are modestly beneficial to slow CKD progression, but the largest clinical trial, the MDRD study, did not show a significant benefit. The recommended dietary protein intake in advanced CKD is 0.60 g/kg/day with at least 50% of the protein being of high biologic value. The present consensus is that aggressive dietary management in patients with CKD, including proper restriction of sodium, potassium, phosphorus, and protein intake under the supervision of a dietician, may reduce progression of CKD, albeit to a small extent.

Avoidance of Toxic Drug Effects

Many drugs that are excreted by the kidney should be avoided, or their doses should be reduced, as shown in Table 32-2. Drugs may injure the kidney in many ways, including direct toxicity leading to acute tubular necrosis, induction of interstitial nephritis, and development of urinary crystals that obstruct the kidney. Common classes of medications that injure the kidney include antibiotics, specifically aminoglycosides; nonsteroidal anti-inflammatory drugs, including cyclooxygenase 2 (COX2) inhibitors; and antiretroviral medications. Certain over-the-counter herbal medications, including aristolochic acids, can cause CKD. Others, such as St. John's wort, may interact with kidney transplant medications and should be avoided.

Iodinated radiocontrast agents can cause acute worsening of kidney function, especially in patients with CKD. Iso-osmolar contrast agents are less toxic than high-osmolar agents. Patients who are at high risk for contrast-induced kidney injury should receive adequate hydration, and the volume of the contrast agent should be minimized. The magnetic resonance imaging contrast agent gadolinium has been associated with the severe fibrotic skin condition of nephrogenic systemic fibrosis in patients with advanced CKD.

TABLE 32-2 DRUG DOSAGE ADJUSTMENTS IN CHRONIC KIDNEY DISEASE

MAJOR DOSAGE REDUCTION	MINOR OR NO REDUCTION	AVOID USE
ANTIBIOTICS		
Aminoglycosides	Erythromycin	Nitrofurantoin
Penicillin	Nafcillin	Nalidixic acid
Cephalosporins	Clindamycin	Tetracycline
Sulfonamides	Chloramphenicol	
Vancomycin	Isoniazid, rifampin	
Quinolones	Amphotericin B	
Fluconazole	Aztreonam, tazobactam	
Acyclovir, ganciclovir	Doxycycline	
Foscarnet		
Imipenem		
OTHERS		
Digoxin	Antihypertensives	Aspirin
Procainamide	Benzodiazepines	Sulfonylureas
H_2 antagonists	Quinidine	Lithium carbonate
Meperidine	Lidocaine	Acetazolamide
Codeine	Spironolactone	NSAIDs
Propoxyphene	Triamterene	Phosphate-containing bowel-preparation agents

NSAIDs, Nonsteroidal anti-inflammatory drugs.

Reversible Causes of Acute Deterioration in Kidney Function

The rate of decline in GFR for individual patients is generally log-linear over time. Accordingly, a plot of the reciprocal of the plasma creatinine concentration against time usually predicts the rate at which a specific patient will reach ESRD (E-Fig. 32-5). When such a patient suddenly shows acute worsening of kidney function, the differential diagnosis should be considered and investigated, as described in Chapter 31 (Acute Kidney Injury).

Care for the Patient with End-Stage Renal Disease

As CKD progresses to kidney failure, preparation is needed for RRT. Patients with moderate CKD should be referred to a nephrologist for comanagement, including evaluation of risk for CKD progression, estimation of timing until kidney failure, and education related to RRT. Late referral (<3 months before ESRD) is associated with a higher risk for death after initiation of RRT.

Renal Replacement Therapies

For those progressing to ESRD, discussions about available RRT options should occur early and should be paired with an assessment of the expectations and values of the patient and other family members. Options include kidney transplantation, dialysis, and medical management without dialysis, sometimes referred to as conservative care. In medically eligible patients, kidney transplantation is encouraged because it allows a better