Magnesium (Mg) is the second most abundant intracellular cation and the fourth most abundant cation of the human body. Magnesium plays an essential role as a cofactor for a variety of enzymes, including those involved in several key steps of intermediary metabolism and phosphorylation. In addition, Mg is required for protein and nucleic acid synthesis, the cell cycle progression, cytoskeletal and mitochondrial integrity, and the binding of substances to the plasma membrane. Disorders of Mg homeostasis may lead to profound changes in the function and well being of the organism. Serum Mg concentration is normal in patients with early renal failure, but hypermagnesemia usually occurs in the advanced stage of renal failure due to the reduced urinary Mg excretion. Following the introduction of chronic hemodialysis or continuous ambulatory peritoneal dialysis (CAPD) treatment, the major factor to determine Mg balance is Mg levels in the dialysate. Patients with end-stage renal disease (ESRD) who are receiving dialysis may develop various complications including hypertension, atherosclerosis, dyslipidemia, and renal osteodystrophy. The disturbance of Mg balance in those patients maintained on dialysis may affect the development of these complications.

Serum Magnesium Level

The total body Mg content is approximately 2000 mEq or 25 g. Like calcium (Ca), only a small fraction (about 1%–2%) of whole-body Mg store exists in the extracellular fluid compartment. Approximately 60% and 20% of total body Mg are found in bone and muscle, respectively. Circulating level of Mg is tightly controlled within narrow ranges between 1.7 to 2.6 mg/dL in healthy individuals. Although no single mechanism has been demonstrated for Mg homeostasis, the cellular availability of Mg is closely regulated by the kidney, gastrointestinal tract, and bone. On a normal dietary intake of Mg, urinary Mg excretion averages 100 to 150 mg/day. The kidney is able to respond rapidly to changes in Mg level in the extracellular fluid by modulating tubular Mg re-absorption. In patients receiving Mg-containing antacids, urinary Mg
Magnesium in Hemodialysis Patients

Excretion can increase to 500 to 600 mg/day or more. Conversely, when dietary intake of Mg is restricted, urinary Mg excretion decreases to as low as 10 to 12 mg/day, indicating kidney as the major organ to maintain Mg homeostasis. Taken collectively, Mg disturbance may occur more easily as renal dysfunction progresses. However, the derangement of Mg homeostasis in chronic kidney disease has received less attention than that of Ca or phosphorus. Serum Mg level is usually normal in patients with early stages of renal failure, but hypermagnesemia becomes common in patients with progression of renal impairment (Figure 26.1). Hypermagnesemia becomes apparent when the glomerular filtration rate falls below 30 mL/min. Hypermagnesemia of chronic renal failure is usually asymptomatic, probably due to the gradual increase of serum Mg, although abrupt increase of serum Mg may occur when ESRD patients take Mg-containing antacids or laxatives.

Metabolic balance studies indicate that 25% to 60% of dietary Mg is absorbed. The preferential site of Mg absorption in the intestine may be different depending on the animal species studied. In humans, the temporal pattern of the appearance of radiolabeled Mg into the plasma following ingestion suggests that most of Mg absorption occurs in the small intestine. Although Mg shares with Ca the common pathways for intestinal absorption, most of the evidence suggests that Mg is absorbed mainly by ionic diffusion and solvent drag resulting from the bulk flow of water, in contrast to the fact that most of Ca absorption occurs by vitamin D–induced active transport at the gastrointestinal tract. The data available are not consistent with regard to whether the intestine is capable of modifying Mg absorption according to the Mg content of the diet. Although a few studies suggested that vitamin D and parathyroid hormone (PTH) may increase the intestinal absorption of Mg, other studies found no

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**FIGURE 26.1.** Serum magnesium concentration in patients with maintained on hemodialysis (n = 714). In 714 patients of our unit dialyzed with a standard dialysate Mg (1.0 mEq/L) the mean serum Mg concentration was 2.5 mg/dL, and moreover 35% of subjects had hypermagnesemia.