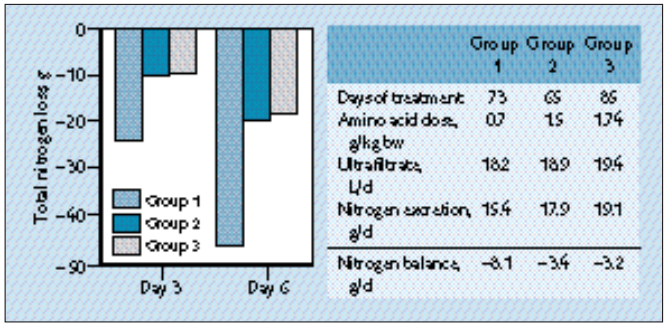
Protein requirements

ESTIMATING THE EXTENT OF PROTEIN CATABOLISM

Urea nitrogen appearance (UNA) (g/d)
= Urinary urea nitrogen (UUN) excretion
+ Change in urea nitrogen pool
= (UUN × V) + (BUN_2 − BUN_1) 0.006 × BW
+ (BW_2 − BW_1) × BUN_2/100
If there are substantial gastrointestinal losses, add urea nitrogen in secretions:
= volume of secretions × BUN_2
Net protein breakdown (g/d) = UNA × 6.25
Muscle loss (g/d) =UNA × 6.25 × 5
V is urine volume; BUN_1 and BUN_2 are BUN in mg/dL on days 1 and 2
BW_1 and BW_2 are body weights in kg on days 1 and 2

FIGURE 18-12
Estimation of protein catabolism and nitrogen balance. The extent of protein catabolism can be assessed by calculating the urea nitrogen appearance rate (UNA), because virtually all nitrogen arising from amino acids liberated during protein degradation is converted to urea. Besides urea in urine (UUN), nitrogen losses in other body fluids (*eg*, gastrointestinal, choledochal) must be added to any change in the urea pool. When the UNA rate is multiplied by 6.25, it can be converted to protein equivalents. With known nitrogen intake from the parenteral or enteral nutrition, nitrogen balance can be estimated from the UNA calculation.



	Group 1	Group 2	Group 3
Days of treatment	73	65	86
Amino acid dose, g/kg bw	0.7	1.5	1.74
Ultrafiltrate, L/d	18.2	18.9	19.4
Nitrogen excretion, g/d	15.4	17.9	19.1
Nitrogen balance, g/d	−8.1	−3.4	−3.2

FIGURE 18-13
Amino acid and protein requirements of patients with acute renal failure (ARF). The optimal intake of protein or amino acids is affected more by the nature of the underlying cause of ARF and the extent of protein catabolism and type and frequency of dialysis than by kidney dysfunction per se. Unfortunately, only a few studies have attempted to define the optimal requirements for protein or amino acids in ARF:

In nonhypercatabolic patients, during the polyuric phase of ARF protein intake of 0.97 g/kg body weight per day was required to achieve a positive nitrogen balance [25]. A similar number (1.03g/kg body weight per day) was derived from a study in which, unfortunately, energy intake was not kept constant [6]. In the polyuric recovery phase in patients with sepsis-induced ARF, a nitrogen intake of 15 g/day (averaging an amino acid intake of 1.3 g/kg body weight per day) as compared to 4.4 g/kg per day (about 0.3 g/kg amino acids) was superior in ameliorating nitrogen balance [26].

Several recent studies have tried to evaluate protein and amino acid requirements of critically ill patients with ARF. Kierdorf and associates found that, in these hypercatabolic patients receiving continuous hemofiltration therapy, the provision of amino acids 1.5 g /kg body weight per day was more effective in reducing nitrogen loss than infusion of 0.7 g (−3.4 versus −8.1 g nitrogen per day) [27]. An increase of amino acid intake to 1. 74 g/kg per day did not further ameliorate nitrogen balance.

Chima and coworkers measured a mean PCR of 1.7 g kg body weight per day in 19 critically ill ARF patients and concluded that protein needs in these patients range between 1.4 and 1.7 g/kg per day [28]. Similarly, Marcias and coworkers have obtained a protein catabolic rate (PCR) of 1.4 g/kg per day and found an inverse relationship between protein and energy provision and PCR and again recommended protein intake of 1.5 to 1.8 g/kg per day [29]. Similar conclusions were drawn by Ikitzler in evaluating ARF patients on intermittent hemodialysis therapy [30]. (*From* Kierdorf *et al*. [27]; with permission.)

Glucose metabolism

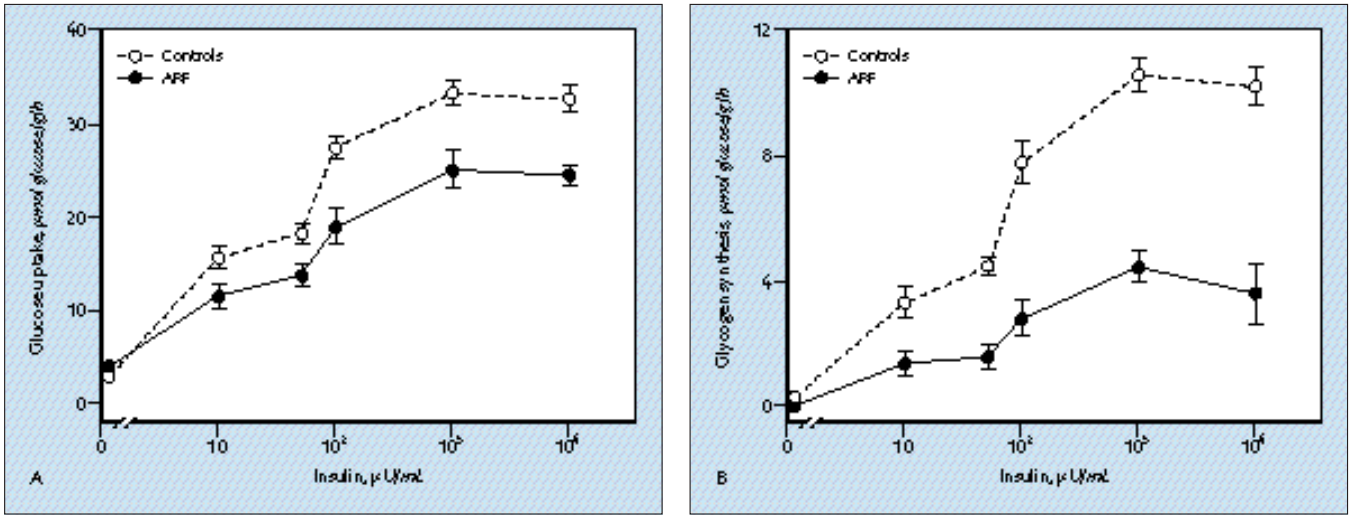


FIGURE 18-14

Glucose metabolism in acute renal failure (ARF): Peripheral insulin resistance. ARF is commonly associated with hyperglycemia. The major cause of elevated blood glucose concentrations is insulin resistance [31]. Plasma insulin concentration is elevated. Maximal insulin-stimulated glucose uptake by skeletal muscle is decreased by 50 %, **A**, and muscular glycogen synthesis is impaired, **B**. However, insulin concentrations that cause half-maximal stimulation of glucose uptake are normal, pointing to a postreceptor defect rather than impaired insulin sensitivity as the cause of defective glucose metabolism. The factors contributing to insulin resistance are more or less identical to those involved in the stimulation of protein breakdown (*see* Fig. 18-8). Results from experimental animals suggest a common defect in protein and glucose metabolism: tyrosine release from muscle (as a measure of protein catabolism) is closely correlated with the ratio of lactate release to glucose uptake [9]. (*From* May *et al.* [31]; with permission.)

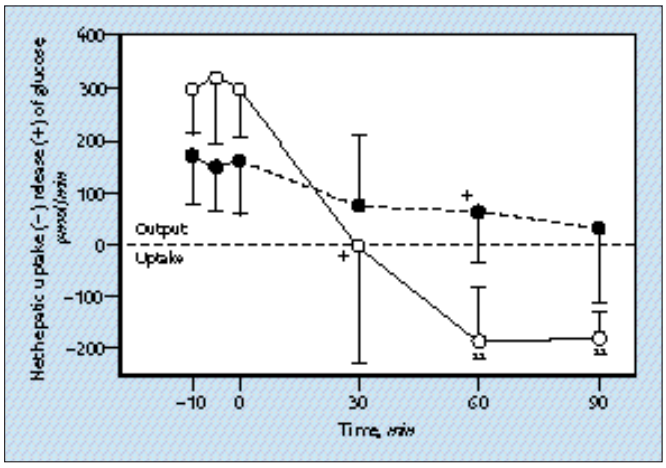


FIGURE 18-15

Glucose metabolism in acute renal failure (ARF): Stimulation of hepatic gluconeogenesis. A second feature of glucose metabolism (and at the same time the dominating mechanism of accelerated protein breakdown) in ARF is accelerated hepatic gluconeogenesis, mainly from conversion of amino acids released during protein catabolism. Hepatic extraction of amino acids, their conversion to glucose, and urea production are all increased in ARF (*see* Fig. 18-7) [12].

In healthy subjects, but also in patients with chronic renal failure, hepatic gluconeogenesis from amino acids is readily and completely suppressed by exogenous glucose infusion. In contrast, in ARF hepatic glucose formation can only be decreased, but not halted, by substrate supply. As can be seen from this experimental study, even during glucose infusion there is persistent gluconeogenesis from amino acids in acutely uremic dogs (•) as compared with controls dogs (o) whose livers switch from glucose release to glucose uptake [32].

These findings have important implications for nutrition support for patients with ARF: 1) It is impossible to achieve positive nitrogen balance; 2) Protein catabolism cannot be suppressed by providing conventional nutritional substrates alone. Thus, for future advances alternative means must be found to effectively suppress protein catabolism and preserve lean body mass. (*From* Cianciaruso *et al.* [32]; with permission.)

Lipid metabolism

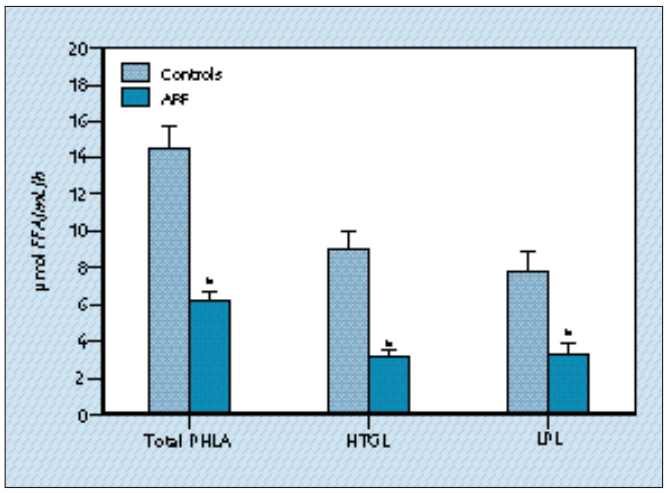


FIGURE 18-16

Lipid metabolism in acute renal failure (ARF). Profound alterations of lipid metabolism occur in patients with ARF. The triglyceride content of plasma lipoproteins, especially very low-density (VLDL) and low-density ones (LDL) is increased, while total cholesterol and in particular high-density lipoprotein (HDL) cholesterol are decreased [33,34]. The major cause of lipid abnormalities in ARF is impairment of lipolysis. The activities of both lipolytic systems, peripheral lipoprotein lipase and hepatic triglyceride lipase are decreased in patients with ARF to less than 50% of normal [35].

Maximal postheparin lipolytic activity (PHLA), hepatic triglyceride lipase (HTGL), and peripheral lipoprotein lipase (LPL) in 10 controls (*open bars*) and eight subjects with ARF (*black bars*). However, in contrast to this impairment of lipolysis, oxidation of fatty acids is not affected by ARF. During infusion of labeled long-chain fatty acids, carbon dioxide production from lipid was comparable between healthy subjects and patients with ARF [36]. FFA—free fatty acids. (*Adapted from* Druml *et al.* [35]; with permission.)

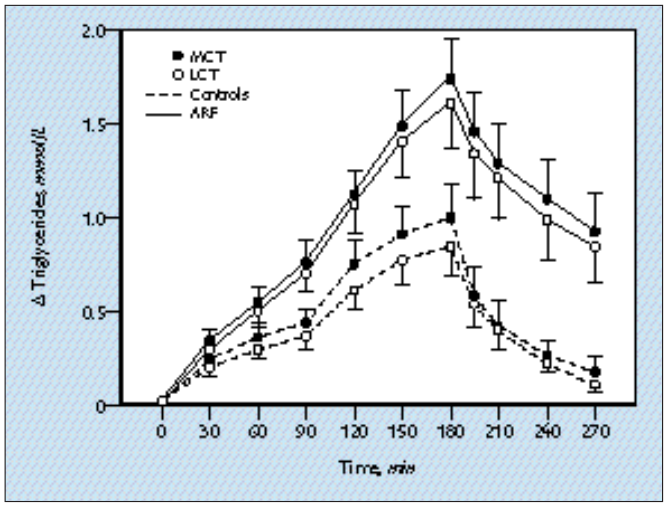


FIGURE 18-17

Impairment of lipolysis and elimination of artificial lipid emulsions in acute renal failure (ARF). Fat particles of artificial fat emulsions for parenteral nutrition are degraded as endogenous very low-density lipoprotein is. Thus, the nutritional consequence of the impaired lipolysis in ARF is delayed elimination of intravenously infused lipid emulsions [33, 34]. The increase in plasma triglycerides during infusion of a lipid emulsion is doubled in patients with ARF (N=7) as compared with healthy subjects (N=6). The clearance of fat emulsions is reduced by more than 50% in ARF. The impairment of lipolysis in ARF cannot be bypassed by using medium-chain triglycerides (MCT); the elimination of fat emulsions containing long chain triglycerides (LCT) or MCT is equally retarded in ARF [34]. Nevertheless, the oxydation of free fatty acid released from triglycerides is not inpaired in patients with ARF [36]. (*From* Druml *et al.* [34]; with permission.)