TABLE 98e-5 PARENTERAL TRACE METAL SUPPLEMENTATION FOR ADULTS[a]

Trace Mineral	Intake
Zinc[b]	2.5–4 mg/d; an additional 10–15 mg/d per L of stool or ileostomy output
Copper	0.5–1.5 mg/d; possibility of retention in biliary tract obstruction
Manganese	0.1–0.3 mg/d; possibility of retention in biliary tract obstruction
Chromium	10–15 μg/d
Selenium	20–100 μg/d; necessary for long-term PN, optional for short term
Molybdenum	20–120 μg/d; necessary for long-term PN, optional for short term
Iodine	75–150 μg/d; necessary for long-term PN, optional for short term

[a]Commercial products are available with the first four, the first five, and all seven of these metals in recommended amounts. [b]The basal IV zinc requirement is approximately one-third of the oral requirement, because only approximately one-third of orally ingested zinc is absorbed.

Abbreviation: PN, parenteral nutrition.

PARENTERAL NUTRITION

INFUSION TECHNIQUE AND PATIENT MONITORING

Parenteral feeding through a peripheral vein is limited by osmolarity and volume constraints. Solutions with an osmolarity >900 mOsm/L (e.g., those which contain >3% amino acids and 5% glucose [290 kcal/L]) are poorly tolerated peripherally. Parenteral lipid emulsions (20%) can be given to increase the calories delivered. The total volume required for a marginal amino acid provision rate of 60 g (equivalent to 50 g of protein) and a total of 1680 kcal is 2.5 L. Moreover, the risk of significant morbidity and mortality from incompatibilities of calcium and phosphate salts is greatest in these low-osmolarity, low-glucose regimens. For short-term infusions, calcium may be temporarily limited or even omitted from the mixture. Parenteral feeding via a peripheral vein is generally intended as a supplement to oral feeding; it is not suitable for the critically ill. Peripheral PN may be enhanced by small amounts of heparin (1000 U/L) and co-infusion with parenteral fat to reduce osmolarity, but volume constraints still limit the value of this therapy, especially in critical illness.

PICCs may be used to infuse solutions of 20–25% dextrose and 4–7% amino acids, thus avoiding the traumatic complications of percutaneous central vein catheter placement. With PICC lines, however, flow can be position-related, and the lines cannot be exchanged over a wire for infection monitoring. It is important to withdraw blood samples carefully and appropriately from a dual-port PICC because intermixing of the blood sample with even tiny volumes of nutrient infusate will falsely indicate hyperglycemia and hyperkalemia. For all these reasons, centrally placed catheters are preferred in critical illness. The subclavian approach is best tolerated by the patient and is the easiest to dress. The jugular approach is less likely to cause a pneumothorax. Femoral vein catheterization is strongly discouraged because of the risk of catheter infection. For long-term feeding at home, tunneled catheters and implanted ports are used to reduce infection risk and are more acceptable to patients. Tunneled catheters require placement in the operating room.

Catheters are made of Silastic®, polyurethane, or polyvinyl chloride. Silastic catheters are less thrombogenic and are best for tunneled catheters. Polyurethane is best for temporary catheters. To avoid infection, dressing changes with dry gauze should be performed at regular intervals by nurses skilled in catheter care. Chlorhexidine solution is more effective than alcohol or iodine compounds. Appropriate monitoring for patients receiving PN is summarized in Table 98e-6.

TABLE 98e-6 MONITORING THE PATIENT RECEIVING PARENTERAL NUTRITION[a]

Clinical Data	
General sense of well-being	
Strength, as evidenced by getting out of bed, walking, and resistance exercise as appropriate	
Vital signs, including temperature, blood pressure, pulse, and respiratory rate	
Fluid balance: weight (recorded at least several times weekly); fluid intake (parenteral and enteral) vs. fluid output (urine, stool, gastric drainage, wound, ostomy)	
Parenteral nutrition delivery equipment: tubing, pump, filter, catheter, dressing	
Nutrient solution composition	
Laboratory Data	
Finger-stick glucose	Three times daily until stable
Blood glucose, Na, K, Cl, HCO_3, BUN	Daily until stable and fully advanced; then twice weekly
Serum creatinine, albumin, PO_4, Ca, Mg, Hb/Hct, WBC count	Baseline; then twice weekly
INR	Baseline; then weekly
Micronutrient tests	As indicated

[a]Parameters are assessed daily unless otherwise specified.

Abbreviations: BUN, blood urea nitrogen; Hb, hemoglobin; Hct, hematocrit; INR, international normalized ratio; WBC, white blood cell.

Source: Adapted from the chapter on this topic in *Harrison's Principles of Internal Medicine*, 16e, by Lyn Howard, MD.

STANDARD VERSUS INDIVIDUALIZED NUTRIENT PROVISION

Even though premixed solutions of crystalline amino acids and dextrose are in common use, the future of evidence-based PN lies in computer-controlled sterile compounders that rapidly and inexpensively generate personalized solutions that meet the specific protein and calorie goals for different patients in different clinical situations. For example, 1 L of a standard mixture of 5% amino acids/25% dextrose solution provides 50 g of amino acids (41.5 g of protein substrate) and 1000 kcal; the use of this solution to meet the 1.5–to 2.0-g/kg protein requirement of an acutely ill 70-kg patient requires the infusion of 2.5–3.4 L of fluid and a potentially excessively high energy dose of 2500-3300 kcal. When the body fat store is adequate, clinical evidence increasingly supports the greater safety and efficacy of high-protein, moderately hypocaloric SNS in such patients. A sterile compounder can accurately generate an appropriate recipe for such a patient. For example, 1 L of a solution including 600 mL of 15% amino acids, 300 mL of 50% dextrose, and 100 mL of electrolyte/micronutrient mix contains 75 g of protein substrate and 800 kcal; thus it is feasible to meet the patient's protein requirement with only 1.4–1.9 L of solution and a more appropriate 1100–1520 kcal; any mild gap in energy provision is easily filled by use of intravenous lipid.

COMPLICATIONS

Mechanical The insertion of a central venous catheter should be performed by trained and experienced personnel using aseptic techniques to limit the major common complications of pneumothorax and inadvertent arterial puncture or injury. The catheter's position should be radiographically confirmed to be in the superior vena cava distal to the junction with the jugular or subclavian vein and not directly against the vessel wall. Thrombosis related to the catheter may occur at the site of entry into the vein and extend to encase the catheter. Catheter infection predisposes to thrombosis, as does the SRI. The addition of 6000 U of heparin to the daily parenteral formula for hospitalized patients with temporary catheters reduces the risk of fibrin sheath formation and catheter infection. Temporary catheters that develop a thrombus should be removed and, according to clinical findings, treated with anticoagulants. Thrombolytic therapy can be considered for patients with permanent catheters, depending on the ease of replacement and the presence of alternative, reasonably acceptable venous access sites. Low-dose warfarin therapy (1 mg/d) reduces the risk of thrombosis in permanent catheters used for at-home parenteral SNS, but full anticoagulation may be required for patients who have recurrent thrombosis related to permanent catheters. A recent U.S. Food and Drug Administration mandate to reformulate parenteral multivitamins to include vitamin K at a dose of 150 μg/d may affect