Table 34-1	Indications for Parenteral Nutrition
ACUTE	
Prematurity	
Trauma	
Burns	
Bowel surgery	
Multiorgan system failure	
Bone marrow transplantation	
Malignancy	
CHRONIC	
Short bowel	
Intractable diarrhea syndromes	
Intestinal pseudo-obstruction	
Inflammatory bowel disease	
Immunodeficiency	

risk of aspiration pneumonia. **Short bowel syndrome** is the most common indication for long-term PN; it may be caused by a congenital gastrointestinal anomaly or acquired after necrotizing enterocolitis (see Chapter 63). Some patients with a chronic indication for PN eventually may be transitioned to partial or full enteral feedings.

ACCESS FOR PARENTERAL NUTRITION

PN can be given via either a peripheral intravenous (IV) line or a central venous line. Long-term PN should be given via a central venous line (CVL). Acute PN may be given peripherally, although a temporary CVL often is used. Most children with cancer or receiving a bone marrow transplant have a CVL. A **peripherally inserted central catheter** is an excellent source of central access for acute PN because of the lower risk for complications than with a standard CVL.

A peripheral IV line has two major limitations. First, it frequently fails, necessitating interruption of PN and potentially painful placement of a new line. Second, high-osmolality solutions cause **phlebitis** of peripheral veins; this limits the dextrose and amino acid content of peripheral PN. The dextrose content of peripheral PN cannot be greater than 12%, with a lower limit if the amino acid concentration is high. Lipid emulsion has a low osmolality; therefore, it can be administered peripherally via the same IV line as the dextrose and amino acid solution. Patients can receive adequate nutrition via a peripheral IV line, but the volume of PN needs to be higher than is necessary when central access is available because of the limitations on dextrose and amino acid concentration. This situation may be problematic in patients who cannot tolerate larger fluid volumes.

COMPOSITION OF PARENTERAL NUTRITION

PN can provide calories, amino acids, electrolytes, minerals, essential fatty acids, vitamins, iron, and trace elements. The **calories** in PN are from dextrose and fat. The amino acids in PN are a potential source of calories, but they should be used predominantly for protein synthesis. PN is given as two separate solutions: a dextrose plus amino acid solution and a 20% lipid emulsion. The dextrose solution has all of the other components of PN except for fat.

The dextrose concentration of peripheral PN is typically 10% to 12%, whereas central PN has a concentration of about 20%, although it may be increased to 25% to 30% in patients who are fluid restricted. To avoid hyperglycemia, the dextrose delivery is increased gradually when starting PN. Protein delivery in PN is via amino acids in the dextrose solution. The goal is 0.8 to 2 g protein/kg/24 hr for older children, 1.5 to 3 g/kg/24 hr for full-term and older infants, and 2.5 to 3.5 g/kg/24 hr for preterm infants.

The electrolyte and mineral composition of PN depends on the age and the underlying illness. The 20% lipid emulsion provides essential fatty acids and calories. The lipid emulsion is started at a rate of 0.5 to 1 g/kg/24 hr, gradually increasing the rate so that the patient receives adequate calories; this typically requires 2.5 to 3.5 g/kg/24 hr. The lipid emulsion usually provides 30% to 40% of the required calories; it should not exceed 60%. The serum triglyceride concentration is monitored as the rate of lipid emulsion is increased, with reduction of the lipid emulsion rate if significant hypertriglyceridemia develops.

COMPLICATIONS

There are many potential complications of PN. CVLs are associated with complications during insertion (pneumothorax or bleeding) and long-term issues (thrombosis). **Catheter-related sepsis,** most commonly due to coagulase-negative staphylococci, is common and, on occasion, necessitates catheter removal. Other potential pathogens are *Staphylococcus aureus,* gram-negative bacilli, and fungi. Electrolyte abnormalities, nutritional deficiencies, hyperglycemia, and complications from excessive protein intake (azotemia or hyperammonemia) can be detected with careful monitoring.

The most concerning complication of long-term PN is **cholestatic liver disease,** which can lead to cirrhosis and liver failure. Current PN decreases the risk of liver disease by including reduced amounts of hepatotoxic amino acids. The best preventive strategy is early use of the gastrointestinal tract, even if only trophic feeds are tolerated.

Chapter 35

SODIUM DISORDERS

The kidney regulates sodium balance and is the principal site of sodium excretion. Sodium is unique among electrolytes because **water balance,** not sodium balance, usually determines its concentration. When the sodium concentration increases, the resultant higher plasma osmolality causes increased thirst and increased secretion of antidiuretic hormone (ADH), which leads to renal conservation of water. Both of these mechanisms increase the water content of the body, and the sodium concentration returns to normal. During hyponatremia, the fall in plasma osmolality decreases ADH secretion, and consequent renal water excretion leads to an