Enteral and parenteral nutrition
- Enteral nutrition, if possible, should always be the preferred route of nutrient administration. Enteral feeding maintains the integrity of absorptive villi of the gastrointestinal tract, and decreases translocation of pathological organisms across the gastrointestinal mucosa and into the bloodstream. Patients on enteral feeding have decreased infectious complications, and fewer ventilator and intensive care unit days.
- Intravenous feeding (total parenteral nutrition, or TPN) is required when the gastrointestinal tract is not functional.

Assessment of nutritional status
Nutritional status can be evaluated by body weight, subjective global assessment (SGA), and certain biochemical markers.

Body weight
Malnutrition may be present when there is weight loss of 10% to 20% over a short time, or weight is less than 90% of ideal body weight, or BMI is less than 18.5. Nutritional assessments in critically ill patients by body weight are often inaccurate due to significant amount of fluid shift in the disease state.

Subjective global assessment (SGA)
The SGA is a clinical method to evaluate the nutritional status of a patient. See Table 64.1 for detailed components of SGA.

Biochemical markers of malnutrition and metabolic stress
- Pre-albumin: level decreases acutely. Half-life 2 days.
Transferrin: level decreases at later stage of malnutrition. Half-life 8–10 days.

- Albumin: poor marker for nutritional status, may be affected by many other pathological status. Half-life 20 days.
- C-reactive protein: acute phase reactant. Level decreases in malnutrition. Half-life 19 hours.

**Initiation of TPN**

**Indication**
TPN is initiated if patient cannot tolerate enteral nutrition and if duration of nutritional support is anticipated to be >7 days.

**Route of TPN administration**
- Peripheral access: use only if central access is not available and lipid concentration <20% and glucose concentration <10%.
- Central access: for long-term use.
  - location: tip of catheter needs to be confirmed in the vena cava before administration of TPN
  - insertion site: internal jugular vein or subclavian vein (short-term access), PICC (peripherally inserted central catheter, mid-term access), or tunneled catheters (long-term access); femoral vein is not preferred due to higher risk of infection
  - a dedicated port is required for TPN infusion, to decrease risk of infection.

**Contraindications to TPN**
Severe hyperglycemia (serum glucose >250 mg/dl); lipid nephrosis; egg allergy; acute pancreatitis, bacteremia or fungemia (relative contraindications).

**Nutrient composition of the TPN mixture**
The base solution is commonly 500 ml of 10% amino acids and 500 ml of 50% dextrose.
Additives: electrolytes, vitamins, minerals, trace elements, insulin, H₂ blockers, etc. The following steps are used to determine the composition of the TPN mixture:

1. Determine total volume.
   - Holliday–Segar method: the total daily fluid needs can be estimated as follows:
     - 100 ml/kg for the first 10 kg
     - 50 ml/kg for the second 10 kg
     - 20 ml/kg for each additional kg
   - The final volume is usually 2 to 2.5 l/day for an average adult patient.

2. Determine caloric and protein needs.
   - Total caloric needs = 25 (kcal/kg) × body weight (kg).
   - Total protein needs = (0.8–1.0) (g/day) × body weight (kg).
   - For patients on renal replacement therapy, 1.5 to 2.5 g/kg/day of protein is required to maintain a positive nitrogen balance.

3. Determine volume of lipid.
   - Calories provided by lipid: 20% to 30% of total caloric intake.
   - Volume of lipid: 1.1 kcal/ml of 10% lipid emulsions or 2 kcal/ml of 20% lipid emulsions.

4. Goal rate: initiate with 1 liter on day one, advancing 20–50 ml/h.

5. Determine additives.
   - Sodium and potassium are added as chlorides or acetates, with the ratio of acetates to chlorides increased in patients with hyperchloremia or acidosis. Sodium bicarbonate is incompatible with the nutrient solution; therefore acetate is used.

**Metabolic monitoring**

**Daily weight**
Persistent weight loss with fluid balance taken account of indicates additional calories (500–1,000 kcal/day) are needed to maintain lean body mass.

**Nitrogen balance**

\[ N_{\text{in}} - N_{\text{out}} = \frac{[\text{protein (g)}]}{6.25} - [24 \text{ h UNN (urine urea nitrogen, g)} + 4] \]
- Positive nitrogen balance: indicative of anabolism. Desired to maintain lean body mass.
- Negative nitrogen balance: indicative of catabolism.

**Respiratory quotient (RQ)**
Ratio of CO₂ production and O₂ consumption. Can be measured using indirect calorimetry in a closed ventilator system.
- RQ ≥1: excessive calorie intake; indicating need to decrease glucose or lipids.
- RQ <0.82: inadequate calorie intake.

**Complications of TPN**
- Complications related to central venous access: pneumothorax, thrombosis, infection, etc. The most
common organism of infection is staphylococcus, followed by enterococcus.

- Metabolic complications:
  - hyperglycemia: monitor glucose at least every 2 h
  - fatty liver
  - increased CO₂ production, acidosis, and respiratory failure.
- Refeeding syndrome: rapid refeeding causes an insulin surge, which increases intracellular uptake of potassium and phosphate from the extracellular space.
  - decreased serum concentration of potassium, phosphorus, and magnesium
  - respiratory failure: decreased vital capacity, tidal volume, respiratory rate; difficult to wean from mechanical ventilation; increased CO₂ production, respiratory acidosis
  - cardiac failure: increased fluid retention, increased cardiac workload and oxygen consumption.
- To prevent refeeding syndrome, gradually increase the calories per day, and closely monitor serum electrolytes level as well as patient’s fluid status.

**Perioperative management of TPN**

- TPN should always be continued in the perioperative period, to minimize risk of hypoglycemia and maximize the nutritional benefit.

- When TPN is discontinued, to prevent hypoglycemia: place patient on dextrose 10% infusion at the same rate the TPN was infused. Monitor glucose frequently.

**Question**

1. Potential complications associated with TPN include all of the following except which?
   a. ketoacidosis
   b. hyperglycemia
   c. hypoglycemia
   d. hypophosphatemia
   e. increased work of breathing

**Answers**

1. a. Acidosis in patients receiving TPN is hyperchloremic nonketone acidosis, resulting from formation of HCl during metabolism of amino acids. Other electrolyte abnormalities include hypomagnesemia and hypocalcemia.

**Further reading**

