CHAPTER 22

Surgery and Nutrition Support

KEY CONCEPTS

- Surgical treatment requires added nutrition support for tissue healing and rapid recovery.
- Nutrition problems related to gastrointestinal (GI) surgery require diet modifications because of the surgery's effect on the normal passage of food.
- To ensure optimal nutrition for surgery patients, diet management may involve enteral and parenteral nutrition support.

Malnutrition continues to burden hospitalized patients. A review of the literature from 12 countries indicates that 38.7% of hospitalized elderly patients and 50.5% of elderly patients in rehabilitation facilities have clinical signs of malnutrition, which hinders healing.[1] Effective nutrition support should reverse malnutrition, improve prognosis, and speed recovery in a cost-effective manner. The surgical process also places physiologic and psychologic stress on patients, which causes added nutrition demands and increases the risk for clinical problems.

This chapter looks at the nutrition needs of surgical patients and the enteral and parenteral feeding methods of providing nutrition support. Careful attention to both preoperative and postoperative nutrition support can reduce complications and provide essential resources for healing and health.

NUTRITION NEEDS OF GENERAL SURGERY PATIENTS

A patient who is undergoing surgery often faces significant physical and psychologic stress. As a result, nutrition demands are increased during this period, and deficiencies can develop that lead to malnutrition and clinical complications. Therefore, careful attention must be given to a patient's nutrition status in preparation for surgery as well as to the individual nutrition needs that follow to address wound healing and recovery. A significant amount of research has been dedicated to understanding the association between malnutrition and clinical outcomes. Poor nutrition status and the following clinical problems are well documented[2,3]:

- Impaired wound healing and increased risk of postoperative infection
- Impaired functioning of the GI tract, cardiovascular system, respiratory system, and immune system
- Reduced quality of life and increased mortality rate
- Longer hospital stay and increased medical cost

FOR FURTHER FOCUS

PROTEIN ENERGY MALNUTRITION AFTER SURGERY

Protein energy malnutrition (PEM) compromises quality of life and the ability to recover from surgery and injury. As general health declines with age and the risk for unplanned surgery increases, so does the prevalence of PEM. Actively evaluating the nutritional status of older people in the home, the hospital, or the nursing home may provide valuable information about the preoperative needs of these individuals. Oral supplements or enteral feedings for malnourished elderly patients before surgery is a cost-effective way to improve outcome, reduce hospital stay, and reduce the risk of complications associated with surgery.

Even without a formal nutrition assessment, PEM can be identified by monitoring unplanned weight loss. Unplanned weight loss is indicative of PEM as well as of the inability to deal with physiologic stress. An unplanned weight loss of up to 5% over a 1-month period or of 10% over a 6-month period is considered a significant loss. Unintentional weight loss of more than 5% in 1 month or 10% in 6 months is classified as severe. Identifying and treating those individuals who are at risk for PEM may also prevent poor outcomes in the event of surgery or injury.

The following table provides a quick guide to evaluate weight loss:

	WEIGHT LOSS AND RESULTING WEIGHT (LB)	
Initial Weight (lb)	5%	10%
80	76	72
85	81	77
90	86	81
95	90	86
100	95	90
110	105	99
120	114	108
130	124	117
140	133	126
150	143	135
160	152	144
170	162	153
180	171	162

Preoperative Nutrition Care: Nutrient Reserves

When the surgery is elective (i.e., not necessary or emergent), body nutrient stores can be built up to fortify a patient for the demands of the surgery and the period that immediately follows, when food intake may be limited. Particular needs center on protein, energy, vitamins, and minerals.

Protein

Protein deficiencies among pediatric and adult hospital patients are common.[4] Every patient facing surgery must be equipped with adequate body protein to counteract blood losses that occur during surgery and to prevent tissue **catabolism** during the immediate postoperative period (see the For Further Focus box, "Protein Energy Malnutrition After Surgery"). For example, extensive bone healing may be involved in orthopedic surgery. Protein is essential for establishing healthy bone mineral density, and it is especially relevant with the occurrence of bone fractures among the growing U.S. population of elderly people.[5,6] The adequate dietary consumption of high-quality complete proteins (i.e., those that contain all of the essential amino acids) is associated with the maintenance of lean tissue, bone mineral density, and bone mineral content.[6]

Energy

Sufficient energy must be provided when increased protein is necessary for tissue building. The increased source of kilocalories supports the added energy demands and spares protein for its tissue-building work. For example, carbohydrate intake should be adequate to maintain optimal glycogen stores in the liver as a necessary resource for immediate energy, thereby directing protein to its tissue synthesis task. If a person is underweight, extra energy may be required to increase weight to an ideal maintenance level before surgery. If a person is overweight and the surgery is elective, some weight reduction may help to reduce surgical complications.

Vitamins and Minerals

When increased protein and energy are necessary, the appropriate intake of vitamins and minerals involved

enteral a mode of feeding that makes use of the gastrointestinal tract through oral or tube feedings.

parenteral a mode of feeding that does not involve the gastrointestinal tract but that instead provides nutrition support via the intravenous delivery of nutrient solutions.

catabolism the metabolic process of breaking down large substances to yield the smaller building blocks.

TABLE 22-1 NONRESIDUE DIET*

Food Type	Foods Allowed	Foods Not Allowed
Beverages	Carbonated beverages, coffee, tea	Milk, milk drinks
Bread	Crackers, Melba or Rusk	Whole-grain bread
Cereals	Refined as Cream of Wheat, farina, fine cornmeal, Malt-O-Meal, Pablum, rice, strained oatmeal, cornflakes, or puffed rice	Whole-grain and other cereals
Cheese		None allowed
Desserts	Plain cakes and cookies, gelatin desserts, water ices, angel food cake, arrowroot cookies, tapioca puddings made with fruit juice only	Pastries, all others
Eggs	As desired, preferably hard cooked	Fried eggs
Fats	Butter or substitute, small amount of cream	All others
Fruits	Strained fruit juices	All others
Meat, fish, and poultry	Tender beef, chicken, fish, lamb, liver, veal; crisp bacon	Fried or tough meat, pork
Potatoes or substitutes	Only macaroni, noodles, spaghetti, refined rice	Potatoes, corn, hominy, unrefined rice
Soups	Bouillon and broth only	All others
Sweets†	Hard candy, fondant, gumdrops, jelly, marshmallows, sugar, syrup, honey	Other candy, jam, marmalade
Vegetables	Tomato juice	All others
Miscellaneous	Salt	Pepper

**Presurgery nonresidue diet:* This diet includes only foods that are free from fiber, seeds, and skins and with a minimal amount of residue. Fruits and vegetables are omitted except for strained fruit juices. Milk is omitted. The diet should be adequate in protein and energy, but it is likely to be inadequate in vitamin A, calcium, and riboflavin. If patients are to remain on this diet for a long period, supplementary vitamins and minerals should be administered. *Postsurgery nonresidue diet:* This diet is slightly higher in residue, but it has greater variety and includes potatoes (without skin), white bread products (without bran), processed cheeses, sauces, desserts made with milk (but no fruits or nuts), and cream (2 oz) for coffee, cereal, and gravy. The average daily menu contains slightly more protein, energy, vitamins, and minerals compared with the presurgery nonresidue diet.

†Fruit juice and hard candies may be consumed between meals to increase caloric intake.

in protein and energy metabolism (e.g., B-complex vitamins) must also be supplied. Any specifically identified deficiency states (e.g., iron-deficiency anemia) should be corrected. Electrolyte and water balance are necessary to prevent dehydration.

Immediate Preoperative Period

The usual preparation for surgery calls for nothing to be taken orally for at least 8 hours before the procedure. This protocol is necessary to ensure that the stomach retains no food during surgery, because the presence of food may cause complications such as the aspiration of food particles during anesthesia or during recovery from anesthesia in the event that the patient vomits. In addition, any food present in the stomach may interfere with the surgical procedure or increase the risk for postoperative gastric retention and expansion. Before GI surgery, a nonresidue diet may be followed for several days to clear the surgical site of any food residue (Table 22-1). Commercial nonresidue **elemental formulas** can provide a complete diet in liquid form. These formulas can be administered by tube or made more palatable for oral use with various flavorings.

Emergency Surgery

If the surgery is urgent, no time is available for building up ideal nutrition reserves, which is another reason to maintain good nutrition status through a healthy diet at all times. If optimal nutrition is maintained, then reserves are available to supply needs during times of stress.

Postoperative Nutrition Care: Nutrient Needs for Healing

Adequate nutrition support is necessary to help with recovery from surgery when nutrient losses are great. At the same time, food intake may be diminished or even absent for a period. If a patient is not able to resume

elemental formula a nutrition support formula composed of simple elemental nutrient components that require no further digestive breakdown and are thus readily absorbed (e.g., glucose, amino acids, medium-chain triglycerides).

adequate oral intake within 3 to 5 days, an alternative form of nutrition support such as enteral or parenteral routes must be considered. Several nutrients require particular attention during this time.

Protein

Optimal protein intake during the postoperative recovery period is of primary concern for all patients. Protein is needed to replace losses that occur during surgery and to supply increased demands of the healing process. During the period immediately after surgery, body tissues usually undergo considerable catabolism, which means that the process of tissue breakdown and loss exceeds the process of tissue buildup. Weight loss and malnutrition are common among patients who are experiencing catabolic stress. Although the maintenance of lean body mass improves the survival of catabolic patients, malnutrition or marginal nutritional states are common among hospitalized surgical patients. Some research supports the use of **branched-chain amino acids** in particular to help alleviate the burden of muscle wasting and to improve recovery time during this phase.[7]

In addition to protein losses from tissue breakdown, other losses of protein from the body may occur. These losses include plasma protein loss from hemorrhage, bleeding, and various body fluid losses or **exudates**. The increased loss of plasma protein from extensive tissue destruction, inflammation, infection, and trauma should be monitored. If any degree of prior malnutrition or chronic infection existed, a patient's protein deficiency could easily become severe and cause complications. Several reasons exist for this increased protein demand, and these will be detailed in the following paragraphs.

Building Tissue. The process of wound healing requires building a great deal of new body tissue, which depends on an adequate amount of essential amino acids. Necessary amino acids must come from dietary protein (either oral or tube feedings) or from parenteral nutrition if a patient cannot eat or tolerate enteral feedings for an extended period. Dietary protein recommendations may increase above normal needs to restore lost protein and to build new tissues at the wound site.

Controlling Edema. When serum protein levels are low, **osmotic pressure** is lost, and **edema** develops. Edema is characterized by puffiness or swelling of the tissue from the excess fluid being held there instead of returning to circulation. Generalized edema may adversely affect heart and lung function. Local edema at the wound site also interferes with the closure of the wound, and it hinders the normal healing process.

Controlling Shock. A sufficient supply of plasma protein—mainly albumin—is necessary to maintain blood volume. If the plasma albumin level drops, pressure to keep tissue fluid circulating between the capillaries and cells is insufficient. Without adequate pressure, water leaves the capillaries, and it cannot be drawn back into circulation; this results in edema. Shock symptoms result from a loss of blood volume and the body's efforts to restore it.

Healing Bone. Protein and mineral matter are essential to the foundation of bone tissue for proper formation and healing. Protein provides a matrix for calcium and phosphorus, and these are required for strong bones.

Resisting Infection. Protein tissues are the major components of the body's immune system, and they provide the body's defense against infection. These defense agents include specialized white cells called *lymphocytes* as well as antibodies and various other blood cells, hormones, and enzymes. Tissue strength is a major defense barrier against infection at all times.

Transporting Lipids. Fat is also an important component of tissue structure. It forms the lipid bilayer of cell membranes, and it participates in many other necessary metabolic activities. Protein (e.g., lipoproteins) is necessary for fat transportation via the bloodstream to all tissues and to the liver for metabolism.

Because protein has many important functions during recovery from surgery, protein deficiency at this time can lead to many clinical complications. Such problems include poor wound healing, the rupture of the suture lines (i.e., **dehiscence**), the delayed healing of fractures,

branched-chain amino acids amino acids with branched side chains; three of the essential amino acids are branched-chain amino acids: leucine, isoleucine, and valine.

exudate various materials such as cells, cellular debris, and fluids that have escaped from the blood vessels and that are deposited in or on the surface tissues, usually as a result of inflammation; the protein content of exudate is high.

osmotic pressure hydrostatic pressure across a semipermeable membrane that is necessary to maintain the normal movement of fluid between the capillaries and the surrounding tissue.

edema an unusual accumulation of fluid in the interstitial compartments (i.e., the small structural spaces between tissue parts) of the body.

dehiscence a splitting open; the separation of the layers of a surgical wound that may be partial, superficial, or complete and that involves total disruption and resuturing.

depressed heart and lung function, anemia, the failure of GI **stomas**, a reduced resistance to infection, liver damage, extensive weight loss, muscle wasting, and an increased risk of death.

Water

Surgery induces altered fluid distribution in the patient, which can reduce circulation and hinder recovery.[8] Sufficient fluid intake is necessary to prevent dehydration. Elderly patients, whose thirst mechanisms may be depressed, warrant special attention to total fluid intake and hydration status. During the postoperative period, large water losses may also occur from vomiting, hemorrhage, fever, infection, or **diuresis**. A variety of solutions are available for intravenous administration, depending on the patient's needs. Intravenous fluids after surgery supply some initial hydration needs, but oral intake should begin as soon as possible and be sufficiently maintained.

Energy

As always, when increased protein is demanded for tissue building, enough nonprotein kilocalories must be provided for energy to spare protein for its vital tissue-building function. Therefore, the fuel sources (i.e., carbohydrate and fat) must be sufficient in the total diet. For adults, a minimum of 130 g carbohydrates must be supplied on a daily basis to spare protein from catabolism.[9] In situations of acute metabolic stress (e.g., with extensive surgery or burns), energy needs may increase to as much as 1.2 to 2 kcal/kg body weight/day over basal energy requirements. Energy requirements can be estimated by first calculating the individual's basal energy needs with the Mifflin-St. Jeor equation (see Chapter 6) and then multiplying by an injury factor (1.2 to 2, depending on the patient's status) to meet the added energy needs of stress and sepsis:

$$\text{Male: Basal metabolic rate} = (10 \times \text{Weight in kg}) + (6.25 \times \text{Height in cm}) - (5 \times \text{Age in years}) + 5$$

$$\text{Female: Basal metabolic rate} = (10 \times \text{Weight in kg}) + (6.25 \times \text{Height in cm}) - (5 \times \text{Age in years}) - 161$$

Carbohydrates spare protein for tissue building and help to avoid liver damage by maintaining glycogen reserves in the liver tissue. Excessive fuel storage as body fat should be avoided, because fatty tissue heals poorly and is more susceptible to infection.

Vitamins

Several vitamins require particular attention during wound healing. Vitamin C is vital for building connective tissue and capillary walls during the healing process, but levels are often low in critically ill patients. Studies demonstrate that the parenteral administration of vitamin C protects microvascular functions and improves the risk for morbidity.[10] If extensive tissue building is necessary, as much as 1150 to 3000 mg/day of vitamin C may be beneficial during the postoperative period for patients who are critically ill.[11,12] (Long-term supplementation at this level is not recommended.) As energy and protein intake are increased, the B-complex vitamins that have important coenzyme roles in protein and energy metabolism (e.g., thiamin, riboflavin, niacin) must be increased. Other B-complex vitamins (e.g., folate, B_{12}, pyridoxine, and pantothenic acid) play important roles in building hemoglobin and thus must meet the demands of an increased blood supply and general metabolic stress. Vitamin K, which is essential for blood clotting, is usually present in a sufficient amount because it is synthesized by intestinal bacteria. However, patients who are treated with antibiotics may have decreased gut flora and vitamin K synthesis.

Minerals

Attention to any mineral deficiencies is essential. Tissue catabolism results in cell potassium and phosphorus loss. Electrolyte imbalances of sodium and chloride also result from fluid imbalances. Iron-deficiency anemia may develop from blood loss or inadequate iron absorption (see the Drug-Nutrient Interaction box, "Aspirin and Iron Absorption"). Another mineral that is important in wound healing is zinc. Adequate protein-rich food consumption usually meets this need, because most dietary zinc is found in protein foods of animal origin such as beef, crab, lobster, and oysters. However, even if patients have adequate dietary intake of zinc, surgical trauma and infection may lead to reduced serum zinc status. Studies that have evaluated zinc supplementation in wound healing indicate that oral zinc supplementation (17 mg/day) and topical zinc therapy may help to facilitate the healing process, particularly among patients with low zinc levels.[13,14]

stoma the opening that is established in the abdominal wall that connects with the ileum or the colon for the elimination of intestinal wastes after the surgical removal of diseased portions of the intestines.

diuresis the increased excretion of urine.

DRUG-NUTRIENT INTERACTION

ASPIRIN AND IRON ABSORPTION

Aspirin is one of the most common analgesics used in the United States today. Its use is implicated in the presence of other conditions as well, such as transient ischemic attacks (i.e., mini strokes), myocardial infarctions, arthritis and other inflammatory diseases, blood-clotting disorders, and insomnia.

Long-term aspirin use may lead to poor iron absorption. The acetylsalicylic acid found in aspirin can irritate the stomach lining and prevent or slow the normal excretion of gastric acid. Gastric acid is needed to keep iron in its Fe^{3+} state until absorption can occur in the duodenum. When gastric acid levels are low, iron-deficiency anemia may result.

For the greatest absorption, aspirin should be taken on an empty stomach with a large glass of water. This dilutes the acetylsalicylic acid, thereby reducing the erosion of the stomach lining. Aspirin may be taken with other liquids but never with alcohol; it increases the bioavailability of alcohol and thus increases the risk for adverse side effects.

Sara Harcourt

GENERAL DIETARY MANAGEMENT

Initial Intravenous Fluid and Electrolytes

Routine intravenous fluids are used to supply hydration needs and electrolytes and not to sustain energy and nutrients. For example, a 5% dextrose solution with normal saline (i.e., 0.9% sodium chloride solution) contains only 5 g dextrose/dL or approximately 170 kcal/L (dextrose provides 3.4 kcal/g), although the patient's total energy need is more than 10 times that amount. A return to regular eating should be encouraged and maintained as soon as tolerated.

Methods of Feeding

The method of feeding used in the nutrition care plan depends on the patient's condition. Many patients are both energy and protein undernourished during hospital stays.[15] The appropriate and timely administration of nutrition support is an important predictor of overall health outcomes and quality of life.[16] The physician, the dietitian, and the nurse work together to manage the diet by using oral, enteral, or parenteral feeding as necessary:

- *Oral:* nourishment through the regular GI route by oral feedings; may include a variety of diet plans, textures, and meal replacement liquid supplements
- *Enteral:* technically refers to nourishment through the regular GI route either by regular oral feedings or tube feedings; however, in medical nutrition therapy, enteral feedings imply tube feedings
- *Parenteral:* nourishment through the veins (either small peripheral veins or a large central vein)

When a patient is capable of meeting his or her nutrient needs by oral feedings and when feedings are well tolerated, then that is the feeding method of choice. Table 22-2 lists conditions that often require nutrition support by tube feeding or parenteral nutrition. General criteria for selecting the most appropriate nutrition support method are listed in Box 22-1.

Oral Feedings

When the GI tract can be used, it is the preferred route of feeding: orally if possible and by feeding tube if not. Most general surgical patients can and should receive oral feedings as soon as feasible to provide adequate nutrition. Oral feedings provide needed nutrients and help to stimulate the normal action of the GI tract. Feedings within 24 hours after surgery are associated with reduced complications and earlier hospital discharge.[17] When oral feedings begin, the patient may begin with clear or full liquids and then progress to a soft or regular diet as indicated. Individual tolerance and needs are always the guide, but encouragement and help should be supplied as part of the general care of postsurgery patients to facilitate eating as soon as possible. If inadequate caloric intake is a concern, the energy value of foods in the regular diet may also be increased with added sauces, dried protein powder, and dressings. Alternatively, a general food supplement formula such as Boost or Ensure may be added orally with or between meals. More frequent, less bulky, and concentrated small meals may be helpful to make every bite count.

Routine House Diets. A schedule of routine "house" diets that is based on a cyclic menu is typically followed in most hospitals. The basic modification is in texture, and this ranges from clear liquid (no milk) to full liquid (including milk) and soft food to a full regular diet. Mechanically altered soft diets are designed for patients

TABLE 22-2 CONDITIONS THAT OFTEN REQUIRE NUTRITION SUPPORT

Recommended Route of Feeding	Condition	Typical Disorders
Enteral nutrition	Impaired nutrient ingestion	Neurologic disorders HIV/AIDS Facial trauma Oral or esophageal trauma Congenital anomalies Respiratory failure Cystic fibrosis Traumatic brain injury Anorexia and wasting with severe eating disorders
	Inability to consume adequate nutrition orally	Hyperemesis gravidarum Hypermetabolic states (e.g., burns) Comatose states Anorexia with congestive heart failure, cancer, chronic obstructive pulmonary disease, and eating disorders Congenital heart disease Impaired intake after orofacial surgery or injury Spinal cord injury
	Impaired digestion, absorption, and metabolism	Severe gastroparesis Inborn errors of metabolism Crohn's disease Short-bowel syndrome with minimal resection
	Severe wasting or depressed growth	Cystic fibrosis Failure to thrive Cancer Sepsis Cerebral palsy Myasthenia gravis
Parenteral nutrition	Gastrointestinal incompetence	Short-bowel syndrome or major resection Severe acute pancreatitis Severe inflammatory bowel disease Small-bowel ischemia Intestinal atresia Severe liver failure Major gastrointestinal surgery
	Critical illness with poor enteral tolerance or accessibility	Multiorgan system failure Major trauma or burns Bone marrow transplantation Acute respiratory failure with ventilator dependency and gastrointestinal malfunction Severe wasting with renal failure and dialysis Small-bowel transplantation, immediately after surgery

Adapted from Mahan LK, Escott-Stump S. *Krause's food & nutrition therapy*. 12th ed. St. Louis: Saunders; 2008.

with chewing or swallowing problems. Small amounts of liquid may be added to regular foods to achieve an appropriate consistency when pureed. These diets may be further modified, depending on the patient's needs. For example, low-sodium, low-fat, or high-protein requirements can still be met with mechanically altered diets. Therapeutic soft diets are used to transition between liquid and regular diets. Whole foods that are low in fiber and limited seasonings are included as tolerated. Table 22-3 summarizes the details of routine hospital diets.

Assisted Oral Feeding. In accordance with the patient's condition, assistance with eating may be needed. Patients usually like to maintain independence as much as possible and should be encouraged to do so with whatever degree of assistance that is necessary. Plate guards or special utensils to facilitate independence are usually welcomed by both the patient and the staff. The staff should try to learn each patient's needs and limitations so that little things (e.g., having the meat precut or the bread buttered before bringing the tray to the bedside) can be

BOX 22-1 CRITERIA FOR SELECTING A NUTRITION SUPPORT METHOD

The physician will make a decision about the most appropriate method of medical nutrition therapy for the patient with the use of the following criteria. Either the pharmacist or the registered dietitian will make the calculations for the formula or total parenteral nutrition solution that will be used.

Enteral nutrition support is indicated for patients with the following characteristics:

- They have functional gastrointestinal tracts.
- They have adequate digestive and absorptive capacity in their gastrointestinal tracts, but they cannot or will not eat enough to meet their needs. Examples: mechanical (e.g., neurologic disorder of swallowing, obstruction in the upper gastrointestinal tract, malabsorption or maldigestion that requires elemental formulas) or psychologic problems (e.g., eating disorders); unconsciousness; prematurity without suck reflex
- They are at risk for malnutrition without nutrition support. Examples: patients whose nutrient needs are elevated to the point that they are not capable of orally consuming enough energy (e.g., with severe trauma or burns)

Parenteral nutrition support is indicated for patients with the following characteristics:

- They do not have sufficient gastrointestinal tract function and they need nutrition support for more than 5 to 7 days. Examples: short-bowel syndrome, intestinal infarction, obstruction in the lower gastrointestinal tract, severe prolonged diarrhea, nothing by mouth before surgery for more than 7 days
- There is a need for bowel rest (e.g., enteral fistulas, acute inflammatory bowel disease).
- They do not have access for feeding tube placement and need nutrition support.
- They repeatedly pull out their feeding tubes.

Peripheral Parenteral Nutrition

- Length of therapy of less than 5 to 7 days
- Not hypermetabolic
- No fluid restriction

Central Parenteral Nutrition

- Length of therapy of more than 5 to 7 days
- Hypermetabolic
- Fluid restriction
- Poor peripheral access or central access already in place

BOX 22-2 ASSISTED ORAL FEEDING GUIDELINES

- Have the tray securely placed within the patient's sight.
- Sit down beside the bed if this is more comfortable, and make simple conversation or remain silent as the patient's condition indicates. Do not carry on a conversation with another patient or coworker or on the phone; this will exclude the patient whom you are helping.
- Offer small amounts, and do not rush the feeding.
- Allow ample time for a patient to chew and swallow or to rest between mouthfuls.
- Offer liquids between the solids, with a drinking straw if necessary.
- Wipe the patient's mouth with a napkin during and after each meal.
- Let the patient hold his or her bread if desired and if he or she is able to do so.
- When feeding a patient who is blind or who has eye dressings, describe the food on the tray so that a mental image helps create a desire to eat. Sometimes the analogy of the face of a clock helps a patient to visualize the position of certain foods on the plate (e.g., indicate that the meat is at 12 o'clock, the potatoes are at 3 o'clock, and so on).
- Warn the patient that soup feels particularly hot when it is taken through a straw.
- Identify each food that is being served beforehand.

done without making the patient feel inadequate. Box 22-2 provides guidelines for the times that complete assistance is needed.

Assisted feeding times provide a special opportunity for nutrition counseling and support. Important observations can be made during this time. The assistant can closely observe the patient's physical appearance and responses to the foods served, the patient's appetite and tolerance for certain foods, and the meaning of food to the person. These observations help the nurse and the dietitian to adapt the patient's diet to meet any particular individual needs. Helping patients learn more about their nutrition needs is an important part of personal care. People who understand the role of good food in health (e.g., that it helps them to regain strength and recover from illness) are more likely to accept the diet prescription. Patients also feel more encouraged to maintain sound eating habits after discharge from the hospital as well as to improve their eating habits in general.

Enteral Feedings

When a patient cannot eat orally but the remaining portions of the GI tract can be used, an alternate form of enteral feeding by tube provides nutrition support. Enteral tube feedings preserve gut function, they are noninvasive, and they are less expensive than parenteral nutrition. The most common route is the nasogastric tube, which is inserted through the patient's nasal cavity and down to the stomach. For patients who are at risk for aspiration,

TABLE 22-3 ROUTINE HOSPITAL DIETS

Food	Clear Liquid*	Full Liquid	Mechanical Soft†	Regular House Diet
Soup	Clear, fat-free broth; bouillon	Same as clear, plus strained or blended cream soups	Same as clear and full, plus all cream soups	All
Cereal	Not included	Cooked refined cereal	Cooked cereal, corn flakes, rice, noodles, macaroni, and spaghetti	All
Bread	Not included	Not included	White bread, crackers, Melba toast, and Zwieback	All
Protein foods	Not included	Milk, cream, milk drinks, and yogurt	Same as full, plus eggs (not fried), mild cheeses, cottage and cream cheeses, fowl, fish, tender beef, veal, lamb, liver, and bacon	All
Vegetables	Not included	Vegetable juices or pureed vegetables	Potatoes: baked, mashed, creamed, steamed, or scalloped; tender, cooked, whole, bland vegetables; fresh lettuce, and tomatoes	All
Fruit and fruit juices	Strained fruit juices as tolerated and flavored fruit drinks	Fruit juices	Same as clear and full, plus cooked fruit: peaches, pears, apple sauce, peeled apricots, and white cherries; ripe peaches, pears, and bananas; orange and grapefruit sections without membrane	All
Desserts and gelatin	Fruit-flavored gelatin, fruit ices, and popsicles	Same as clear, plus sherbet, ice cream, puddings, custard, and frozen yogurt	Same as clear and full, plus plain sponge cakes, plain cookies, plain cake, puddings, and pies made with allowed foods	All
Miscellaneous	Soft drinks as tolerated, coffee, tea, decaffeinated coffee and tea, cereal beverages such as Postum, sugar, honey, salt, hard candy, Polycose (Abbott Nutrition, Columbus, Ohio), and residue-free supplements	Same as clear, plus margarine and all supplements	Same as clear and full, plus mild salad dressings	All

*Seldom used.
†Mechanically altered diets can vary depending on the condition of the patient. This may include pureed foods, mechanically soft foods, or mechanically advanced diets that focus on foods with high moisture.

reflux, or continuous vomiting, a nasoduodenal or nasojejunal tube may be more appropriate (Figure 22-1, *A*). In both cases, a tube is first inserted through the nose and into the stomach. It is then passed through the stomach and into the appropriate portion of the small intestine by peristaltic activity or endoscopic or fluoroscopic guidance. Correct placement of the tube is verified by radiography, **auscultation**, or gastric content aspiration. Modern small-bore nasoenteric feeding tubes are made of soft and flexible polyurethane and silicone materials. These feeding tubes are relatively comfortable for the patient, and they easily carry the variety of nutrient materials that are available in enteral nutrition support formulas.

Alternative Routes. The patient's disease state, GI anatomy, function, motility, and estimated length of enteral therapy are all important aspects to consider when determining the most appropriate access point for enteral feedings. The nasoenteric route is indicated for short-term therapy of 4 weeks or less in many clinical situations. For long-term feedings, however, an enterostomy (i.e., the

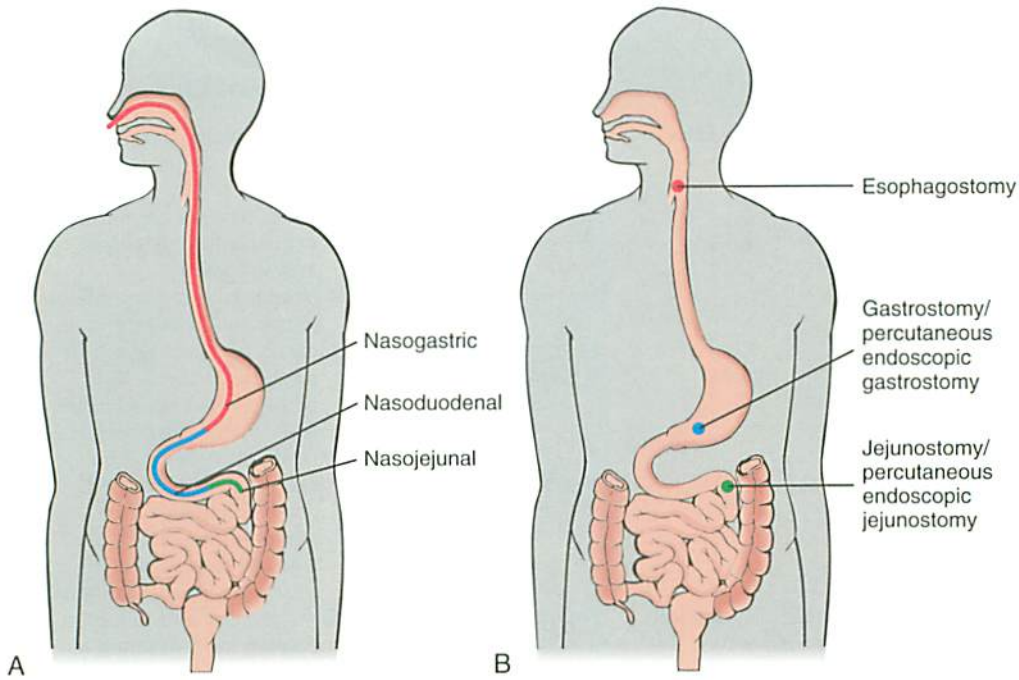

Figure 22-1 Types of enteral feeding. **A,** Nonsurgical routes accessed through the nasal cavity. **B,** Surgically placed feeding routes. (Copyright Rolin Graphics.)

surgical placement of the tube at progressive points along the GI tract) provides a more comfortable route, as follows (see Figure 22-1, *B*):

- *Esophagostomy:* A cervical esophagostomy is placed at the level of the cervical spine to the side of the neck after head and neck surgeries for cancer or traumatic injury. This placement removes the discomfort of the nasal route and enables the entry point to be easily concealed under clothing.
- *Percutaneous endoscopic gastrostomy:* A gastrostomy tube may be surgically placed through the abdominal wall into the stomach if the patient is not at risk for aspiration.
- *Percutaneous endoscopic jejunostomy:* A jejunostomy tube is surgically placed through the abdominal wall and passed through the duodenum into the jejunum. This procedure is indicated for patients with gastroparesis, gastric obstructions, or a history of reflux or aspiration or for those who otherwise cannot tolerate gastric feedings.

Formula. The tube-feeding formula is generally prescribed by the physician and the clinical dietitian in accordance with the patient's nutrition needs and tolerance. In addition to the immediate needs of the patient, other considerations include preexisting conditions, comorbidities, food allergies, food intolerances, and other aspects of nutrient needs that are specific to the patient. Several varieties of commercial formulas are available and designed to meet particular needs. These products may be made from intact nutrients for use with a fully functioning GI system that is capable of digestion and absorption. Others may be made from predigested elemental or semi-elemental nutrients that are readily absorbed with only minimal residue. Still others may be formulated for special problems or single-nutrient modules of protein, carbohydrate, and fat mixed together as calculated by the dietitian or the pharmacist to meet a patient's specific needs.

With the development of improved formulas and feeding equipment, the question of using blender-mixed formulas of regular foods seldom arises. The use of pureed table food for tube feedings may present the following problems:

- *Physical form:* Foods that are broken down and mixed in a blender yield a sticky, larger-particle mixture that does not go through the small feeding tubes easily and thus requires the use of the more uncomfortable large-bore tubing.
- *Safety:* Blender-mixed formulas carry problems of bacterial growth and infection as well as

TABLE 22-4 EXAMPLES OF ENTERAL FORMULAS AND MACRONUTRIENT COMPONENTS*

Brand Name	Manufacturer	MACRONUTRIENT SOURCES		
		Carbohydrate	Protein	Fat
Standard Complete Diets: Intact Macronutrients				
Ensure	Ross Products (Columbus, Ohio)	Sucrose	Casein	Soy oil and canola oil
Osmolite	Ross Products	Corn syrup	Casein and soy protein isolate	Canola oil, corn oil, and MCT
Jevity (1 Cal)	Ross Products	Maltodextrin and corn syrup	Casein	Canola oil, corn oil, and MCT
Standard Complete Diets: Semi-Elemental and Elemental				
Vital HN	Ross Products	Maltodextrin and sucrose	Whey protein concentrate	Safflower oil and MCT
Optimental	Ross Products	Maltodextrin and sucrose	Whey protein hydrolysate	Structured lipids (i.e., marine oil and MCT)

In addition to the standard formula examples provided, there are also specialty formulas that are intended to meet the needs of patients with unique requirements. Specialty diet formulas are available for trauma, cancer, HIV, renal conditions, and pediatric conditions.
*All formulas are enriched with essential vitamins and minerals as needed. There are many more formulas available; only a few examples are provided here.
MCT, Medium-chain triglycerides.

inconsistent nutrient composition because the solid components settle out.

- *Digestion and absorption:* Pureed food requires a fully functioning GI system to digest the food and absorb its released nutrients. Many patients have GI deficits that require nutrients with varying degrees of predigestion (i.e., hydrolysis) or smaller molecular structure.

For comparison, note that commercial formulas provide a sterile, homogenized solution that is suitable for small-bore feeding tubes and that ensures a fixed profile of nutrients in intact or elemental form. Formulas are available in varying caloric densities (e.g., 1 kcal/mL, 1.5 kcal/mL, 2 kcal/mL) to meet a patient's need for calories in a given volume of fluid. Some examples are given in Table 22-4. No matter what type of feeding tube or formula is used to meet a patient's physiologic needs, this feeding method may contribute to a patient's psychologic stress. Support for a patient's quality of life is an important part of the planning of patient care.

Rate. For any form of tube feeding, the amount of formula and the rate at which it is given must be regulated. See the Clinical Applications box entitled "Calculating a Tube Feeding," for details about setting the rate of administration for a tube feeding. Adults who are receiving **bolus** or gravity-controlled feedings that are introduced into the stomach generally tolerate full-strength formulas from the beginning if they are provided as three to eight feedings per day. The amount given is increased by 60 to 120 mL every 8 to 12 hours until the goal volume for nutrient needs is met. Pump-assisted feedings are used for small-bowel feedings and for critically ill patients to allow for the slower administration of **continuous feedings**. Critically ill patients or those who have not been fed enterally for some time will not be able to tolerate large feedings at initiation and should start with slow rates (10 to 40 mL/hr), with gradual increases to the goal rate (e.g., increase by 10 to 20 mL/hr every 8 to 12 hours).[17]

Monitoring for Complications. Tube-fed patients require continuous monitoring for appropriate feeding schedules, tolerance, and potential complications. For patients who are fed by tube, diarrhea is the most frequently reported GI complication. Although a number of factors may contribute to diarrhea in tube-fed patients, the addition of fiber-rich formulas may improve bowel function and help to reduce the incidence of diarrhea.[18] However, fiber-supplemented formulas are contraindicated for patients with impaired gastric emptying.

auscultation listening to the sounds of the gastrointestinal tract with a stethoscope.

bolus feeding a volume of feeding from 250 mL to 500 mL over a short period of time (usually 10 to 15 minutes) that is given via several feedings per day.

continuous feeding an enteral feeding schedule with which the formula is infused via a pump over a 24-hour period.

CLINICAL APPLICATIONS

CALCULATING A TUBE FEEDING

To calculate the nutrient needs of a patient, the following information is required:

1. Ideal body weight in kilograms (lb/2.2)
   - Female: 100 lb ± 5 lb for every inch above or below 5 feet
   - Male: 106 lb ± 6 lb for every inch above or below 5 feet
2. Energy needs
   - Basal metabolic rate* × Injury factor (which depends on the condition of the patient)
3. Total formula needed (Energy need [kcal/day] ÷ Formula [kcal/mL])
4. Feeding schedule (Total formula ÷ Number of feedings)

Sample Calculation†

How many milliliters of formula does the following patient need at each feeding?

- She is a 37-year-old woman who is 5 feet and 7 inches tall.
- She is under considerable catabolic stress, with an injury factor of 1.8.
- Energy value of formula: 1.5 kcal/mL
- Schedule: 6 feedings per day

1. Ideal body weight: 100 lb + (7 in × 5 lb) = 135 lb/2.2 = 61.4 kg
2. Basal metabolic rate: (10 × 61.4 kg) + (6.25 × 170.2 cm) − (5 × 37) − 161 = 1332 kcal/day

   1332 kcal/day × 1.8 (injury factor) = 2398 kcal/day

3. Formula: 2398 kcal/day ÷ 1.5 kcal/mL = 1599 mL/day
4. Feeding schedule: 1599 mL/day ÷ 6 feedings/day = 266.5 mL/feeding

*As calculated by the Mifflin-St. Jeor equation: Female basal metabolic rate = (10 × Weight) + (6.25 × Height) − (5 × Age) − 161; male basal metabolic rate = (10 × Weight) + (6.25 × Height) − (5 × Age) + 5.
†These equations require the weight in kilograms, the height in centimeters, and the age in years.

Medications and *Clostridium difficile* enterocolitis are common culprits that cause diarrhea and should be ruled out before further changes are made to the enteral formula.[19]

Box 22-3 provides guidelines for an ideal monitoring schedule, and Table 22-5 gives problem-solving suggestions for common issues that may be encountered with tube feeding.

Parenteral Feedings

If a patient cannot tolerate food or formula moving through the GI tract, alternative methods of nutrition support are necessary. The term *parenteral nutrition* refers to any feeding method other than one that involves the normal GI route. In current medical terminology, parenteral nutrition specifically refers to the feeding of nutrients directly into the blood circulation through certain veins (i.e., a peripheral vein in the arm or the subclavian vein) when the GI tract cannot be used. Compared with enteral feeding, parenteral feedings are more invasive and expensive, and they introduce more risk. However, for patients in whom part or all of the GI tract or the accessory organs (e.g., liver, pancreas) are not functioning, it is necessary. Table 22-2 outlines indications for parenteral feedings. Depending on the nutrition support necessary, the following two routes are available:

- Peripheral parenteral nutrition is used when a solution of no more than 800 to 900 mOsm/L is sufficient to provide nutrient needs and when feeding is necessary for only a brief period of 5 to 7 days or less or as a supplement to enteral feedings. The osmolality (i.e., mOsm/L) of a solution depends on the concentration of its total particles, including dextrose, protein, and electrolytes. Small peripheral veins, usually in the arm, are used to deliver the less-concentrated solutions (Figure 22-2). Some catheters allow for an extended feeding period in a peripheral vein for individuals with large veins who can tolerate the extended dwell catheter.
- Total parenteral nutrition (TPN) is used when the energy and nutrient requirement is large or when full nutrition support is needed for longer periods. A large central vein (usually the subclavian vein that leads directly into the rapid flow of the superior vena cava to the heart) is used for the surgical placement of the catheter. The catheter may access the superior vena cava by direct access (Figure 22-3, *A*); a peripherally inserted central catheter (Figure 22-3, *B*); or a tunneled catheter (Figure 22-3, *C*). Nutrition support solutions of much higher osmolality are tolerated by the central veins.

TPN is used in cases of major surgery or complications, especially those that involve the GI tract or when the patient is unable to obtain sufficient nourishment enterally. TPN provides crucial nutrition support from solutions that contain glucose, amino acids, electrolytes,

BOX 22-3 MONITORING THE PATIENT WHO IS RECEIVING ENTERAL NUTRITION

Anthropometrics
- Weight (daily for 3 to 4 days until stable and then at least three times per week)
- Length or height in pediatric patients (monthly)

Physical Assessment
- Signs and symptoms of edema (daily)
- Fluid balance (daily)
- Adequacy of enteral intake (at least two times per week)
- GI motility (every 2-4 hours during initiation of feedings, every 8 hours when stable)
  - Abdominal distention and discomfort
  - Nausea and vomiting; risk for aspiration
  - Gastric residuals
  - Stool output and consistency
- Tube placement: make sure that the tube is in the desired location (daily for the short term or as needed if there are indications of migration)

Biochemical Measures
- Glucose (three times daily until stable, then two to three times per week)
- Serum electrolytes (daily until stable, then two to three times per week)
- Blood urea nitrogen (one to two times per week)
- Serum calcium, magnesium, and phosphorus (one to two times per week)
- Complete blood count and transferrin or prealbumin (once a week)

Adapted from Moore MC. *Nutrition assessment and care.* 6th ed. St Louis: Mosby; 2009; and Bankhead R, Boullata J, Brantley S, et al; A.S.P.E.N. Board of Directors. Enteral nutrition practice recommendations. *JPEN J Parenter Enteral Nutr.* 2009;33(2):122-167.

minerals, and vitamins. Fat in the form of lipid emulsions is also used to supply needed energy and the essential fatty acids. A basic TPN solution may contain between 3.5% and 15% crystalline amino acids and 5% to 70% dextrose, with additional micronutrients that are specific to patient needs. Each constituent of the parenteral solution contributes to the overall osmolality. Because the peripheral access point has a limited capacity for high osmolality, this must be considered when choosing an appropriate site for access.

A team of specialists including physicians, dietitians, pharmacists, and nurses works closely together during the administration of TPN. The physician and the clinical dietitian on the nutrition support team determine the individual formula that is needed on the basis of a detailed individual nutrition assessment and concurrent medication use (see the Drug-Nutrient Interaction box, "Propofol and Lipids in Nutrition Support"). The pharmacist

TABLE 22-5 PROBLEM-SOLVING TIPS FOR PATIENTS WHO ARE RECEIVING ENTERAL NUTRITION

Problem	Suggested Solutions
Thirst and oral dryness	Lubricate the lips Chew sugarless gum Brush the teeth Rinse the mouth frequently
Tube discomfort	Gargle with a mixture of warm water and mouthwash Gently blow the nose Clean the tube regularly with water or a water-soluble lubricant If persistent, gently pull out the tube, clean it, and reinsert it Request a smaller tube
Tension and fullness	Relax and breathe deeply after each feeding
Reflux or aspiration	Lift the head of the bed to 30 to 45 degrees
Constipation	Use a fiber-containing formula Assess for adequate fluid intake
Diarrhea	Take antidiarrheal medications if bacterial infections have been ruled out Avoid excess sorbitol and hypertonic solutions Use continuous feedings instead of bolus feedings Evaluate for lactose intolerance and intestinal mucosal atrophy
Gustatory Distress*	
General dissatisfaction with feeding	Warm or chill feedings *Caution:* Feedings that are too cold may cause diarrhea Serve favorite foods that have been liquefied
Persistent hunger	Chew gum Suck hard candy
Inability to drink	Rinse the mouth frequently with water and other liquids

*This refers to the frustration that is experienced when the sense of taste is not satisfied.

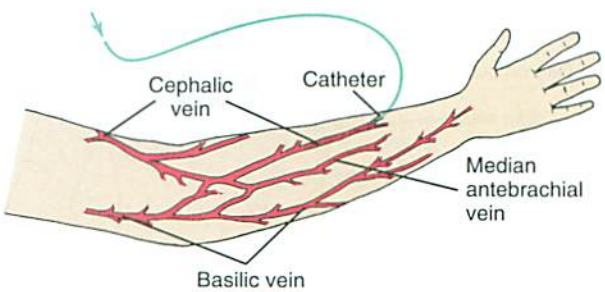

Figure 22-2 Peripheral parenteral nutrition feeding into the small veins of the arm.

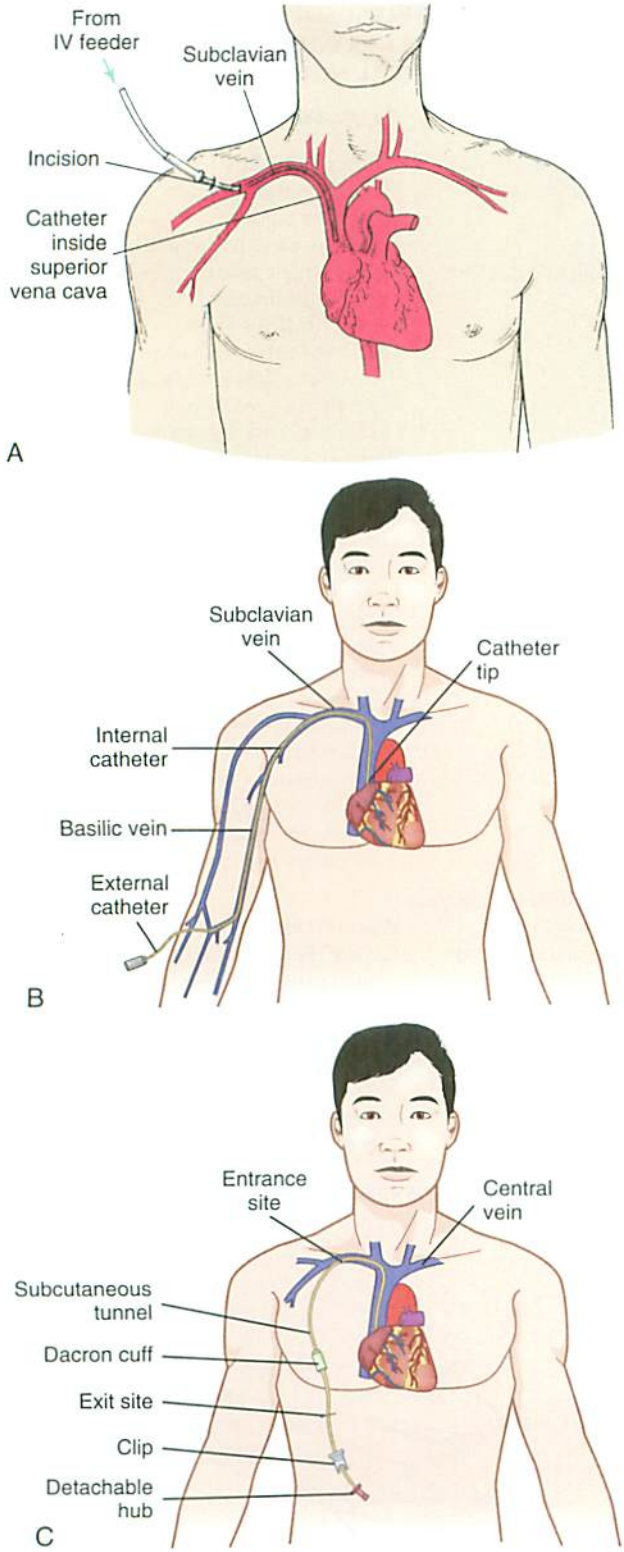

Figure 22-3 Catheter placement for total parenteral nutrition. **A,** A direct line via the subclavian vein to the superior vena cava. **B,** A peripherally inserted central catheter line. **C,** A tunneled catheter.

BOX 22-4 THE ADMINISTRATION OF TOTAL PARENTERAL NUTRITION FORMULAS

The careful administration of total parenteral nutrition formulas is essential. The physician will make the decision regarding the most appropriate access point for total parenteral nutrition for the patient. Specific protocols vary somewhat but include the following points:

- *Ensure proper access.* Make sure that the proper route for access is in place and has been verified.
- *Start slowly.* Allow time for the patient to adapt to the increased glucose concentration and osmolality of the solution.
- *Schedule carefully.* During the first 24 hours, 1 to 2 L is administered by continuous drip, with the slow rate usually regulated by an infusion pump.
- *Monitor closely.* Note the metabolic effects of glucose and electrolytes. The blood glucose level is not to exceed 200 mg/dL.
- *Increase volume gradually.* After the first day, increase the volume by a maximum of approximately 1 L/day to reach the desired daily volume.
- *Make changes cautiously.* Watch for the effect of all changes, and proceed slowly.
- *Maintain a constant rate.* Keep the correct hourly infusion rate, with no "catch up" or "slow down" efforts made to meet the original volume order.
- *Discontinue slowly.* Take the patient off of the total parenteral nutrition feeding gradually by reducing the rate and daily volume by approximately 1 L/day. Patients are given dextrose 10% to help them adjust to lower glucose levels.

on the nutrition support team mixes the solutions in accordance with the prescription. The administration of the solution is an important nursing responsibility (Box 22-4).

The use of either TPN or enteral feedings via tube must first be discussed with the patient or the patient's family. The use of assisted medical technology in feeding is not always welcome and may be against the will of the patient for ethnic, cultural, religious, or personal reasons. See the Cultural Considerations box entitled "Cultural Differences in Advanced Care Planning" for more information.

SPECIAL NUTRITION NEEDS AFTER GASTROINTESTINAL SURGERY

Because the GI system is uniquely designed to handle food, a surgical procedure on any part of this system requires special dietary attention and modification.

DRUG-NUTRIENT INTERACTION

PROPOFOL AND LIPIDS IN NUTRITION SUPPORT

Propofol is a drug that is often used for sedation and anesthesia during surgery or to maintain sedation in mechanically ventilated patients in the intensive care unit. The drug is fat soluble, and it is emulsified in an oil and water solution for intravenous administration. During long-term sedation, patients often receive nutrition support in the form of enteral or total parenteral nutrition. One important consideration for the nutrition support team is the concurrent administration of propofol. The lipid emulsion contributes 1.1 kcal per mL; therefore, enteral or total parenteral nutrition solutions must provide reduced calories from fat to compensate for those that are provided with the propofol.

Propofol and other intravenous lipid emulsions are designed like chylomicrons. They are cleared from the bloodstream by the same enzyme: lipoprotein lipase. Elevated serum triglycerides may result if the infusion rate of propofol exceeds the clearance rate. This is more likely to occur with long-term use of propofol, when other risk factors are present (e.g. advanced age, previous diagnosis of cardiovascular disease, renal failure) or when the overall amount of lipid provided exceeds the patient's needs.[1] Serum triglycerides should be monitored during propofol infusion to prevent hypertriglyceridemia.

Kelli Boi

1. Mirtallo JM, Dasta JF, Kleinschmidt KC, Varon J. State of the art review: intravenous fat emulsions: current applications, safety profile, and clinical implications. *Ann Pharmacother.* 2010;44(4):688-700.

CULTURAL CONSIDERATIONS

CULTURAL DIFFERENCES IN ADVANCED CARE PLANNING

Advanced care planning is the process by which future treatment of a patient is determined before it is needed. Advanced directives and living wills are examples of documents that are recognized in the United States by all health care institutions. The Patient Self-Determination Act of 1991 was intended to promote the use of advanced care procedures and to strengthen the rights of patients during end-of-life medical procedures. Such documents are the only way that the treatment preferences of the patient can be ensured during times of unconsciousness or when there is otherwise an inability to communicate.

Some consider medical nutrition therapy in the form of enteral and parenteral nutrition to be a life-sustaining intervention. Several recent studies have compared the cultural discrepancies with regard to attitudes toward advanced care planning.[1-3] Researchers suggest that significant differences exist among various racial and ethnic patients and their caregivers with regard to advanced care planning and end-of-life decisions. When demographic values are examined, several factors are related to the completion of a living will, a do-not-resuscitate order, or orders that address the removal of life support. These values include the following:

- *Gender:* Females are more likely than males to complete advance directives.
- *Education:* Most individuals who complete advance directives have at least a high school education.
- *Religion:* Some religions (e.g., Catholicism, Judaism) encourage the completion of advance directives, whereas others promote the use of life-saving technology, even when the individual will not recover.
- *Age:* Individuals who have completed advance directives are more likely to be 85 years old or older.[3]
- *Ethnicity:* Researchers have also found African-American patients to be more likely than Caucasians to request life-supportive treatments.[1-3]

By recognizing such cultural differences in desired treatment and knowing the likelihood of patients having advanced care planning, health care professionals can assist the patient with greater awareness and sensitivity and provide more culturally appropriate education to patients and their families about advanced directives, living wills, and all methods of life support that may be available. Even if the patient has verbally expressed his or her wishes to the family, sometimes family members find it difficult to follow through with the patients wishes. Advanced care planning can alleviate the burden on the family and ensure that the patient's wishes are granted.

Jennifer E. Schmidt

1. Johnson RW, Newby LK, Granger CB, et al. Differences in level of care at the end of life according to race. *Am J Crit Care.* 2010;19(4):335-343; Quiz 344.
2. Sharma RK, Dy SM. Documentation of information and care planning for patients with advanced cancer: associations with patient characteristics and utilization of hospital care. *Am J Hosp Palliat Care.* 2011;28(8):543-549.
3. Alano GJ, Pekmezaris R, Tai JY, et al. Factors influencing older adults to complete advance directives. *Palliat Support Care.* 2010;8(3):267-275.

Mouth, Throat, and Neck Surgery

Surgery that involves the mouth, jaw, throat, or neck requires modification with regard to the mode of eating. These patients usually cannot chew or swallow normally, so accommodations must be made to address individual limitations.

Oral Liquid Feedings

Concentrated liquid feedings should be planned to ensure that adequate nutrition is supplied in a smaller amount of food. An enriched commercial formula can be used several times a day to supply needed nourishment.

Mechanical Soft Diets

Mechanical soft diets are used to transition between liquid and regular diets. Whole foods that are easy to chew and swallow are included as tolerated (see Table 22-3). Because high-fiber foods (e.g., vegetables) are often omitted as part of the mechanical soft diet, the overall fiber intake may be substantially lower than recommendations.

Enteral Feedings

For cases that involve radical neck or facial surgery or when a patient is severely debilitated, tube feedings may be indicated. For long-term needs, improved equipment and standardized commercial formulas have made continued home tube feeding possible for many patients. A nasogastric tube is often used, but the obstruction of the esophagus and other complications require the surgeon to make a gastrostomy at the time of surgery.

Gastric Surgery

Nutrition Problems

Because the stomach is the first major food reservoir in the GI tract, gastric surgery poses special problems for the maintenance of adequate nutrition. Some of these problems may develop immediately after the surgery, depending on the type of surgical procedure and the individual patient's response. Other physical or malabsorption complications may occur later, when the person begins to eat a regular diet.

Gastrectomy

Serious nutritional deficits may occur immediately after gastric surgery, especially after a total gastrectomy. Increased gastric fullness and distention may result if the gastric resection also involved a **vagotomy**. Because it lacks the normal nerve stimulus, the stomach becomes **atonic** and empties poorly. Food fermentation occurs, and this produces discomfort, gas, and diarrhea. Weight loss is common after extensive gastric surgery.

To cover the immediate postoperative nutrition needs after a gastrectomy procedure, surgeons usually prepare a jejunostomy through which the patient can be fed an elemental formula. Frequent small oral feedings are resumed in accordance with the patient's tolerance. A typical pattern of simple dietary progression may cover approximately 2 weeks. The basic principles of such general diet therapy for the immediate postgastrectomy period involve both the size of the meals (which should be small and frequent) and the nature of the meals (which are generally simple, easily digested, bland, and low in bulk).

Dumping Syndrome

Dumping syndrome is a frequently encountered complication subsequent to extensive gastric resection. After the initial recovery from surgery, when the patient begins to feel better and eats a regular diet in greater volume and variety, discomfort may occur beginning 10 to 30 minutes after meals. A cramping and full feeling develops, the pulse becomes rapid, and a wave of weakness, cold sweating, and dizziness may follow. Nausea, vomiting, or diarrhea typically terminates the event.

This complex of symptoms constitutes a shock syndrome that results when a meal that contains a large proportion of readily soluble carbohydrates rapidly enters or "dumps" into the small intestine. When the stomach is bypassed, food quickly passes from the esophagus into the small intestine. This rapidly entering food mass is a concentrated solution with a higher osmolality compared with the surrounding circulation of blood. To achieve osmotic balance (i.e., a state of equal concentrations of fluids within the small intestine and the surrounding blood circulation), water is drawn from the circulatory system into the intestine. This water shift rapidly shrinks the vascular fluid volume, thereby causing shock. Blood pressure drops, and signs of rapid heart rate to rebuild the blood volume appear; these include a rapid pulse, sweating, weakness, and tremors.

If the meal consisted of simple carbohydrates, late dumping may occur approximately 2 hours after eating. The initial concentrated solution of simple carbohydrate has been rapidly absorbed, which results in a rapid rise in blood glucose and stimulates an overproduction of insulin. Blood sugar eventually drops below normal, with

vagotomy the cutting of the vagus nerve, which supplies a major stimulus for gastric secretions.

atonic without normal muscle tone.

CLINICAL APPLICATIONS

CASE STUDY: JOHN HAS A GASTRECTOMY

After a long experience with persistent peptic ulcer disease that involved more and more gastric tissue, John and his physician decided that surgery was needed. John then entered the hospital for a total gastrectomy. John weathered the surgery well and received some initial nutrition support from an elemental formula fed through a tube that the surgeon had placed into his jejunum. After a few days, the tube was removed. Over the next 2-week period, John was gradually able to take a soft diet in small oral feedings. He soon recovered enough to go home, and he gradually felt his strength returning. He was relieved to be free of his former ulcer pain, and he began to resume more and more of his usual activities, including eating a regular diet of increasing volume and variety.

However, as time went by, John began having more discomfort after meals. He felt a cramping sensation, an increased heartbeat, and then a wave of weakness with sweating and dizziness. John would often become nauseated and have diarrhea. As his anxiety increased, he began to eat less and less, and his weight began to drop. He was soon in a state of general malnutrition.

John finally returned to seek medical help. The physician and the clinical dietitian outlined a change in his eating habits, and a special food plan was developed for him. Although the diet seemed strange to him, John followed it faithfully because he had felt so ill. To his surprise, he soon found that his previous symptoms after eating had almost completely disappeared. Because he felt so much better on the new diet plan, he formed new eating habits around it. His weight gradually returned to normal, and his state of nutrition markedly improved. John found that he always fared better if he would nibble on food items throughout the day rather than consume large meals as he used to do.

Questions for Analysis

1. What were John's nutrition needs immediately after surgery and for the next 2 weeks? Why did his feedings need to be resumed cautiously?
2. Why is emphasis given to postsurgical protein sources? How should this nutrient be provided?
3. Why is fluid therapy important after surgery?
4. After John began to feel better and resumed eating, why did he become ill? Describe why his symptoms developed.
5. Using the principles of the special diet that the dietitian provided to relieve John's symptoms, plan a day's meal and snack pattern for John that includes basic instructions and suggestions that you would discuss with him.

symptoms of hypoglycemia (e.g., weakness, shaky, sweating, confusion). These distressing reactions to food increase anxiety. As a result, less and less food is eaten. Weight loss and general malnutrition follow (see the Clinical Applications box, "Case Study: John Has a Gastrectomy").

Bariatric Surgery

Special considerations must be made after bariatric surgery, because patients typically have deficiencies in several micronutrients for an extended period (see the For Further Focus box, "Nutrient Deficiencies after Bariatric Surgery"). After gastric bypass, patients progress slowly from a clear liquid diet to a regular diet at approximately 6 weeks postsurgery, but they are limited to approximately 1 cup of food per meal from that point forward, and they are subject to dumping syndrome. Patients should avoid using a straw to reduce air swallowing, which can cause discomfort. Table 22-6 provides a general guideline for dietary advancement after bariatric surgery. The combination of severely reduced intake coupled with dumping syndrome dramatically reduces nutrient availability.[20]

Careful adherence to the postoperative diet allows dramatic relief from these distressing symptoms as well as the gradual stabilization of weight. The careful reintroduction of milk in small amounts may later be used to test tolerance. Patients may also find that eating slowly, eliminating fluids during meals, and lying down for 15 to 30 minutes after eating help to decrease the rate of gastric emptying.

Gallbladder Surgery

For patients with acute gallbladder inflammation (i.e., **cholecystitis**) or gallstones (i.e., **cholelithiasis**) (Figure 22-4), the treatment is usually the removal of the gallbladder (i.e., **cholecystectomy**). The modern procedure for this removal, called *laparoscopic cholecystectomy,* requires only minimal surgery that involves small skin punctures;

cholecystitis acute gallbladder inflammation.

cholelithiasis gallstones.

cholecystectomy the removal of the gallbladder.

TABLE 22-6 DIET STAGES AFTER BARIATRIC SURGERY*

Diet State	Postoperative Period	Fluids And Foods	Comments
1	1 to 2 days	Clear liquids†	Sugar-free, caffeine-free, noncarbonated
2	2 to 3 days	Clear and full liquids	Full liquids should have 15 g of sugar or less and 3 g of fat or less per serving. Examples: 1% or skim milk mixed with whey or soy protein powder (with a limit of 20 g of protein per serving) Lactaid milk or soymilk mixed with soy protein powder Light or plain yogurt Begin supplementation: chewable multivitamin with mineral supplementation, chewable or liquid calcium citrate, vitamin D, and vitamin B_{12}‡
3	10 to 14 days	Clear liquids; replace full liquids with pureed, diced, soft, and moist protein sources	Examples of protein sources: eggs; ground meat; poultry; fish; cooked beans; cottage cheese; low-fat yogurt Nonfat gravy or light mayonnaise can be added to moisten food. Continue to drink 48 to 64 oz of fluid per day at least 30 minutes before or after food intake.
	4 weeks§	Add well-cooked soft vegetables and soft, peeled fruit	Protein should be consumed first to ensure adequate protein intake before satiety. Continue to drink 48 to 64 oz of fluid per day at least 30 minutes before or after food intake.
	5 weeks§	Add crackers with protein	Continue to consume protein with some fruit or vegetable at every meal. Avoid pasta, rice, and bread. Continue to drink 48 to 64 oz of fluid per day at least 30 minutes before or after food intake.
4	6 weeks§	Healthy solid foods	Consume mixed meals of protein, fruits, vegetables, and whole-grain carbohydrates. Eat from small plates with small utensils for portion control. Continue to drink 48 to 64 oz of fluid per day at least 30 minutes before or after food intake.

*These diet stages are not standardized. The timing of diet advancement should be modified on the basis of the individual's tolerance for the previous diet stage.
†For procedures other than laparoscopic adjustable gastric banding, the diet can be started after a Gastrografin swallow test is performed to assess for leaks.
‡For biliopancreatic diversion with duodenal switch, at least 350 to 500 μg of oral vitamin B_{12} daily is recommended; this may need to be administered intramuscularly.
§This is usually longer for biliopancreatic diversion with duodenal switch.

the previous surgery required a transverse right upper quadrant incision. Through these small openings, the surgeon can insert needed instruments and a laparoscope fitted with a miniature camera and bright fiber-optic lighting.

Because the function of the gallbladder is to concentrate and store bile, which helps with the digestion and absorption of fat, some moderation in dietary fat intake is usually indicated. After surgery, the control of fat in the diet (e.g., less than 30% of total energy intake as fat) facilitates wound healing and comfort, because the hormonal stimulus for bile secretion still functions in the surgical area, thereby causing pain with the high intake of fatty foods. The body also needs a period to adjust to the more dilute supply of bile that is available to assist with fat digestion and absorption directly from the liver. Depending on individual tolerance and response, a low-fat diet may be needed; see the guide given for gallbladder disease in Table 18-7.

Intestinal Surgery

Intestinal disease that involves tumors, lesions, or obstructions may require the surgical resection of the affected intestinal area. For complicated cases that require the removal of large sections of the small intestine, the use of enteral nutrition support may be difficult at first. In such cases, TPN is used for nutrition support, with a

FOR FURTHER FOCUS

NUTRIENT DEFICIENCIES AFTER BARIATRIC SURGERY

Bariatric surgery for obese patients (i.e., those with a body mass index of 30 kg/m^2 or more) is becoming more common around the world. Although surgery is currently the most effective means of long-term weight loss and maintenance, it is not without drawbacks. Restrictive eating patterns, dumping syndrome, and nutrient deficiencies from malabsorption are common complications after surgery. The quality-of-life cost-benefit ratio of surgery is difficult to assess: obesity increases the mortality rate, but the complications of surgery can introduce a new set of risks.

The Roux-en-Y gastric bypass (see Chapter 15), in which the amount of bowel that is capable of absorbing nutrients is reduced, is the surgery of choice for obesity in the United States. Obese patients are at risk for complications during surgery from comorbid conditions such as diseases of the cardiovascular, endocrine, renal, pulmonary, gastrointestinal, and musculoskeletal systems.[1] Therefore, special care must be taken to prepare the patient for surgery.

Bariatric surgery that induces malabsorption (e.g., gastric bypass, biliopancreatic diversion) presents particular nutritional problems. Protein energy malnutrition is a significant risk for many patients, and it results in hospitalization and the necessity of parenteral nutrition support in severe cases. Patients who have undergone bariatric procedures should be screened every 6 to 12 months for protein energy malnutrition.[2] In addition, significant micronutrient deficiencies warrant mineral and multivitamin supplementation postoperatively. There are also specific nutrients to be aware of and that should be supplemented for life[3]:

- Vitamins: A, B_1, B_{12}, C, D, K, and folate
- Minerals: copper, iron, selenium, and zinc

1. Eisenberg D, Duffy AJ, Bell RL. Update on obesity surgery. *World J Gastroenterol.* 2006;12(20):3196-3203.
2. Strohmayer E, Via MA, Yanagisawa R. Metabolic management following bariatric surgery. *Mt Sinai J Med.* 2010;77(5):431-445.
3. Shankar P, Boylan M, Sriram K. Micronutrient deficiencies after bariatric surgery. *Nutrition.* 2010;26(11-12):1031-1037.

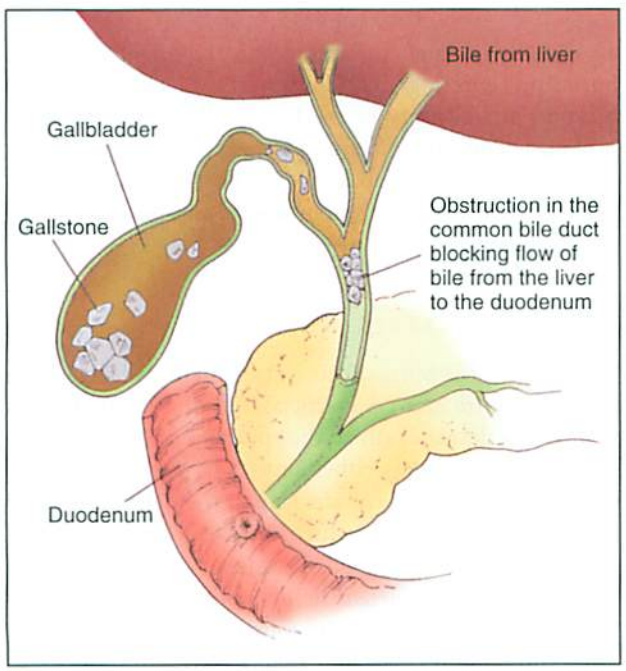

Figure 22-4 Gallbladder with stones (i.e., cholelithiasis).

small allowance of oral feeding for personal food desires when tolerated. After general resection for less severe cases, a diet that is relatively low in dietary fiber may be beneficial in the beginning to allow for healing and comfort.

Intestinal surgery sometimes requires making an opening in the abdominal wall to the intestine, called a *stoma*, for the elimination of fecal waste. If the opening is in the area of the ileum, which is the last section of the small intestine, it is called an *ileostomy* (Figure 22-5, *A*). The food mass is still fairly liquid at this point in the GI tract, and more problems are encountered with management. If the opening is farther along in the large intestine, it is called a *colostomy* (Figure 22-5, *B*). In the large intestine, the water is predominantly reabsorbed and the remaining feces are more solid, thereby making management easier. Patients with an ostomy begin a clear liquid diet during the immediate postoperative period. Patients progress toward small, frequent feedings of meals that are relatively low in dietary fiber, as tolerated. Encouraging patients to drink plenty of fluids between meals may help to reduce diarrhea. Lactose intolerance and fat malabsorption are common complications in patients with ileostomies and should be monitored, with dietary adjustments made as indicated.[21]

Patients need support and practical help to learning about self-care with an ostomy. Eliminating gas-producing foods, odor-causing foods, and foods that may cause an obstruction will help to facilitate maintenance. A relatively low-fiber diet is helpful at first, but the goal is to advance to an individualized diet that is acceptable to the patient as soon as tolerated. Progression to a regular diet is important for nutritional value and emotional support. Regular food provides psychologic comfort, and

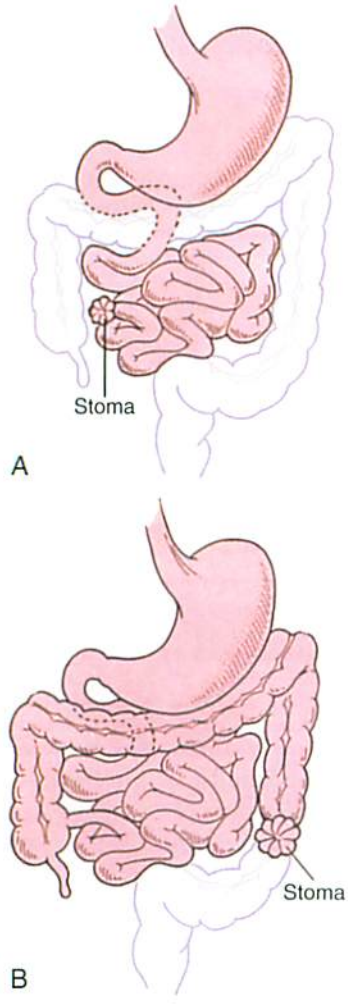

Figure 22-5 **A,** Ileostomy. **B,** Colostomy.

dietary adjustments to individual preferences for specific foods can be made.

Rectal Surgery

For a brief period after rectal surgery or hemorrhoidectomy, a clear fluid or nonresidue diet (see Table 22-1) may be indicated to reduce painful elimination and to allow for healing. In some cases, a nonresidue commercial elemental formula may be used to delay bowel movements until the surgical area has healed. Return to a regular diet is usually rapid.

SPECIAL NUTRITION NEEDS FOR PATIENTS WITH BURNS

In the United States, there are approximately 450,000 visits to emergency departments and 3500 deaths per year

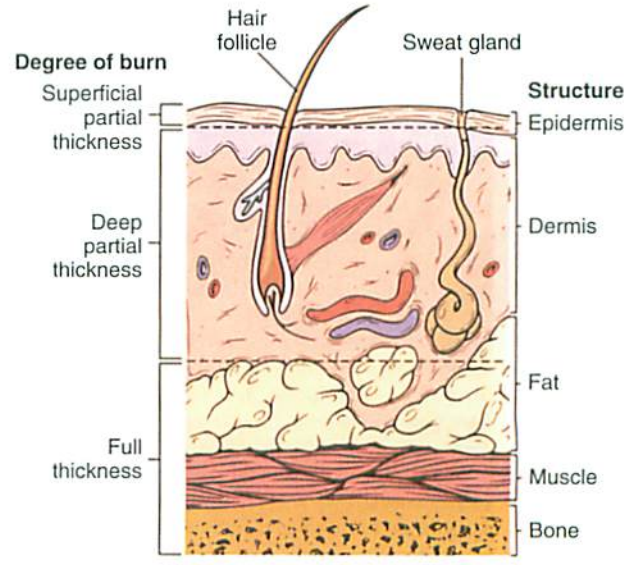

Figure 22-6 Depth of skin area involved in burns. (Reprinted from Lewis SM, Heitkemper MM, Dirksen SR. *Medical-surgical nursing: assessment and management of clinical problems.* 7th ed. St Louis: Mosby; 2007.)

as a result of burn injuries.[22] The treatment of severe burns presents a tremendous nutrition challenge. The location and severity of the burn will greatly affect the prognosis and plan of care of the patient. Comorbidities and other injuries complicate care, but they must be considered when deciding when, where, and how to initiate nutrition support.

Type and Extent of Burns

The depth of the burn affects its treatment and its healing process (Figure 22-6). Superficial (i.e., first-degree) burns involve cell damage only to the epidermis. Second-degree burns are classified as either superficial partial-thickness burns, which involve cell damage to the dermis, or deep partial-thickness burns, which involve both the first and second layers of skin. Full-thickness (i.e., third-degree) burns result in complete skin loss, including the underlying fat layer. Subdermal (i.e. fourth-degree) burns leave bone and tendon exposed. Patients with burn injuries of more than 10% of the total body surface area (TBSA) are referred to a regional burn unit facility for specialized burn team care that includes nutrition support.

Stages of Nutrition Care

The nutrition care of patients with massive burns presents a great challenge and must be constantly adjusted to

individual needs and responses. At each stage, critical attention is given to amino acid requirements for tissue rebuilding, fluid and electrolyte balance, and energy support. Energy expenditure in burned patients can be very high, and it will fluctuate depending on the stage of healing.

Burn Shock or Ebb Phase

From the first hours until approximately the second day after a burn, massive flooding edema occurs at the burn site. The destruction of protective skin leads to immediate losses of heat, water, electrolytes (mainly sodium), and protein. As water is drawn from surrounding blood to replace the losses, general loss continues, blood volume and pressure drop, and urine output decreases. Cell dehydration follows as intracellular water is drawn out to balance the loss of tissue fluid. Cell potassium is also withdrawn, and circulating serum potassium levels rise.

Immediate intravenous fluid therapy with a salt solution (e.g., 6% hetastarch in saline, balanced salt solution) or **lactated Ringer's solution** replaces water and electrolytes and helps to prevent shock. After approximately 12 hours, when vascular permeability returns to normal and losses begin to decrease at the burn site, albumin solutions or plasma can be used to help restore blood volume. Medical nutrition therapy is not the priority during the ebb phase. The stability of the patient and his or her resuscitation needs are greater during this phase and must be established before nutrition efforts are considered.

Acute or Flow Phase

After approximately 48 to 72 hours, tissue fluids and electrolytes are gradually reabsorbed, and the pattern of massive tissue loss is stabilized. A sudden diuresis occurs, and this indicates successful initial therapy. Constant attention to fluid intake and output with evaluation for any signs of dehydration or overhydration are essential. This state of hypermetabolism may last weeks to months. Toward the end of the first week after the burn, adequate bowel function returns, and a rigorous medical nutrition therapy program must begin. The following three major reasons exist for these increased nutrient and energy demands:

1. Tissue destruction brings large losses of protein and electrolytes that must be replaced.
2. Tissue catabolism follows the injury and involves a further loss of lean body mass and nitrogen.
3. Increased metabolism brings added nutrition needs to cover the energy costs of infection, fever, and the increased protein metabolism of tissue replacement and skin grafting.

lactated Ringer's solution a sterile solution of calcium chloride, potassium chloride, sodium chloride, and sodium lactate in water that is given to replenish fluid and electrolytes; this solution was developed by the English physiologist Sidney Ringer (1835-1910).

Medical Nutrition Therapy

Most patients with burns of less than 20% of the TBSA are able to consume an oral meal plan that is adequate in nutrient needs, unless the burn site hinders eating. Successful nutrition therapy during this critical feeding period is based on vigorous protein and energy intake as follows[21]:

- *High protein:* The aggressive supplementation of protein is crucial to promote early wound healing and to support immune function. Depending on the extent of the burn and the associated catabolic losses, individual protein needs vary from 1.5 to 2 g/kg/day. This level of protein will equal 20% to 25% of energy intake. For obese individuals or patients with burns that cover less than 10% of the TBSA, protein intake is calculated at 1.2 g/kg.
- *High energy:* Energy needs are commonly between 25 to 30 kcal/kg. However, individual energy needs will vary greatly among patients and should be calculated with the most precise method available. Energy needs are calculated by using either the Harris-Benedict equation with a stress factor of 1.5; the Curreri equations on the basis of the amount of TBSA burned; or indirect calorimetry with an injury factor of 20% to 30%. The Harris-Benedict and indirect calorimetry methods were covered in Chapter 6. The Curreri equation is as follows: 25 kcal/kg body weight + (40 × Percentage of TBSA burned), with a maximum of 50% TBSA used. Beyond 50% of the TBSA being burned, little increase in total energy needs occurs.
  - Overfeeding increases metabolic stress and should be avoided. Such high energy needs are necessary to spare the protein that is essential for tissue rebuilding and to supply the greatly increased metabolic demands that are essential for healing. A liberal portion of the total kilocalories should come from carbohydrate, with a moderate amount of fat supplying the remaining needs. The frequent recalculation of energy needs may be necessary if the patient is gaining or losing weight. One goal of medical nutrition therapy is for patients to not lose more than of 10% of their body weight from the point of admission.

- *High vitamin, high mineral:* Increased vitamin C (500 mg/day) may be needed as a partner with amino acids for tissue rebuilding. Vitamin A (10,000 IU/day) and zinc are specifically important for optimal immune function, and they are often supplemented. Increased thiamin, riboflavin, and niacin are necessary for increased energy and protein metabolism. Special attention to electrolyte imbalances and to calcium and phosphorus ratios in the blood are warranted during this period. Patients are given a daily multivitamin supplement.

Dietary Management. With any method, a careful dietary intake record must be maintained to measure progress toward the increased nutrition goals. Oral feedings are preferred if they are well tolerated and if they allow nutrition needs to be met. Concentrated liquids with added protein or amino acids and commercial formulas such as Ensure may be used as added interval nourishment. Solid foods given on the basis of individual preferences are usually tolerated by the second week. However, hypermetabolic states and poor appetite make oral feedings difficult for patients with major burns.

Either enteral or parenteral methods of feeding may be used to meet crucial nutrient demands when oral intake is inadequate, which is defined as less than 75% of goal intake for more than 3 days. When enteral feedings are impossible because of associated injuries or complications, parenteral feeding can provide essential nutrition support. Studies evaluating early (i.e., within 24 hours) versus delayed (i.e., after 48 hours) enteral nutrition support indicate that initiating nutrition support soon after the burn injury may stimulate protein retention and reduce the hypermetabolic response, but this has not been associated with an improved recovery rate and thus remains inconclusive.[23]

Follow-Up Reconstruction. Continued nutrition support is essential to maintain tissue strength for successful skin grafting or reconstructive plastic surgery. Patients need the physical rebuilding of body resources that surgery requires as well as personal support to rebuild their will and spirit, because disfigurement and disability are quite possible. Optimal physical stamina that is gained through persistent and supportive medical, nutrition, and nursing care helps patients to rebuild the personal resources that they need to cope.

SUMMARY

- Before surgery, the tasks are to correct any existing deficiencies and to build nutrition reserves to meet surgical demands. After surgery, the tasks are to replace losses and to support recovery. The additional task of encouraging eating is often necessary during this period of healing.
- Postsurgical feedings are given in a variety of ways, and the oral route is always preferred. However, the inability to eat or damage to the intestinal tract may require enteral tube feedings or parenteral feedings. Special formulas are used for such alternate means of nourishment, and these are designed to meet individual needs.
- For patients who are undergoing surgery of the GI tract, special diets are modified in accordance with the surgical procedure being performed.
- For patients with massive burns, increased nutrition support is necessary in successive stages in response to the burn injury and to the continuing requirements of tissue rebuilding.

CRITICAL THINKING QUESTIONS

1. Describe the consequences of nutrient imbalances (specifically with protein, energy, vitamins, minerals, and fluid) on the preoperative, immediate postoperative, and long-term postoperative periods.
2. Describe appropriate medical nutrition therapy for patients who are undergoing gastric resection, cholecystectomy, and rectal surgery.
3. How do an ileostomy and a colostomy differ? What are the dietary needs for each?
4. Outline the nutrition care of a burn patient from treatment for immediate shock through recovery and tissue reconstruction.

CHAPTER CHALLENGE QUESTIONS

True-False

Write the correct statement for each statement that is false.

1. *True or False:* Nothing is given by mouth for at least 8 hours before surgery to avoid food aspiration during anesthesia.
2. *True or False:* The most common nutrient deficiency related to surgery is protein.
3. *True or False:* Vitamin C is essential for wound healing, because it is involved in building strong connective tissue.
4. *True or False:* Regardless of the type, oral liquid feedings usually provide little nourishment.
5. *True or False:* Tube feedings can only be successfully prepared from complete commercial preparations.
6. *True or False:* After gastrectomy, a patient can return to regular eating habits within a few days.
7. *True or False:* After a diseased gallbladder is surgically removed, a patient can freely tolerate any foods that contain high amounts of fat.
8. *True or False:* A careful diet record of the total food and liquid intake is important for a burn patient to ensure that increased nutrient and energy demands are met.

Multiple Choice

1. Postsurgical edema develops at the wound site as a result of
   - **a.** decreased plasma protein levels.
   - **b.** excess water intake.
   - **c.** excess sodium intake.
   - **d.** a lack of early ambulation and physical exercise.
2. In a postoperative orthopedic patient's diet, protein is essential to
   - **a.** provide the extra energy that is needed to regain strength.
   - **b.** provide a matrix to anchor mineral matter and to form bone.
   - **c.** control the basal metabolic rate.
   - **d.** give more taste to the diet, thereby increasing appetite.
3. Complete high-quality protein is essential to wound healing, because it
   - **a.** supplies the essential amino acids that are needed for tissue synthesis.
   - **b.** is used to meet the body's increased energy demands.
   - **c.** is a source of glucose for the body.
   - **d.** provides the most concentrated source of kilocalories.
4. A diet for postgastrectomy dumping syndrome should include which of the following? *(Circle all that apply.)*
   - **a.** Small, frequent meals
   - **b.** No liquid with meals
   - **c.** No milk, sugar, sweets, or desserts
   - **d.** A high protein content
5. For a burn patient, a diet that is high in protein and energy is essential to do which of the following? *(Circle all that apply.)*
   - **a.** To replace the extensive loss of tissue protein at burn sites
   - **b.** To provide essential amino acids for extensive tissue healing
   - **c.** To counteract the negative nitrogen balance from a loss of lean body mass
   - **d.** To meet the added metabolic demands of infection or fever

Evolve **Please refer to the Students' Resource section of this text's Evolve Web site for additional study resources.**

REFERENCES

1. Kaiser MJ, Bauer JM, Rämsch C, et al. Frequency of malnutrition in older adults: a multinational perspective using the mini nutritional assessment. *J Am Geriatr Soc.* 2010;58(9): 1734-1738.
2. Corish CA. Pre-operative nutritional assessment. *Proc Nutr Soc.* 1999;58(4):821-829.
3. Sullivan DH, Bopp MM, Roberson PK. Protein-energy undernutrition and life-threatening complications among the hospitalized elderly. *J Gen Intern Med.* 2001;17(12): 923-932.
4. Joosten KF, Hulst JM. Prevalence of malnutrition in pediatric hospital patients. *Curr Opin Pediatr.* 2008;20(5): 590-596.
5. Thorpe MP, Evans EM. Dietary protein and bone health: harmonizing conflicting theories. *Nutr Rev.* 2011;69(4): 215-230.
6. Loenneke JP, Balapur A, Thrower AD, et al. Short report: relationship between quality protein, lean mass and bone health. *Ann Nutr Metab.* 2010;57(3-4):219-220.
7. Sun LC, Shih YL, Lu CY, et al. Randomized, controlled study of branched chain amino acid-enriched total parenteral nutrition in malnourished patients with gastrointestinal cancer undergoing surgery. *Am Surg.* 2008;74(3): 237-242.

8. Grocott MP, Mythen MG, Gan TJ. Perioperative fluid management and clinical outcomes in adults. *Anesth Analg.* 2005;100(4):1093-1106.
9. Food and Nutrition Board, Institute of Medicine. *Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids.* Washington, DC: National Academies Press; 2002.
10. Wilson JX. Mechanism of action of vitamin C in sepsis: ascorbate modulates redox signaling in endothelium. *Biofactors.* 2009;35(1):5-13.
11. Long CL, Maull KI, Krishnan RS, et al. Ascorbic acid dynamics in the seriously ill and injured. *J Surg Res.* 2003;109(2):144-148.
12. Rümelin A, Humbert T, Lühker O, et al. Metabolic clearance of the antioxidant ascorbic acid in surgical patients. *J Surg Res.* 2005;129(1):46-51.
13. Ellinger S, Stehle P. Efficacy of vitamin supplementation in situations with wound healing disorders: results from clinical intervention studies. *Curr Opin Clin Nutr Metab Care.* 2009;12(6):588-595.
14. Lansdown AB, Mirastschijski U, Stubbs N, et al. Zinc in wound healing: theoretical, experimental, and clinical aspects. *Wound Repair Regen.* 2007;15(1):2-16.
15. Leistra E, Willeboordse F, van Bokhorst-de van der Schueren MA, et al. Predictors for achieving protein and energy requirements in undernourished hospital patients. *Clin Nutr.* 2011;30(4):484-489.
16. Ha L, Hauge T, Spenning AB, Iversen PO. Individual, nutritional support prevents undernutrition, increases muscle strength and improves QoL among elderly at nutritional risk hospitalized for acute stroke: a randomized, controlled trial. *Clin Nutr.* 2010;29(5):567-573.
17. Bankhead R, Boullata J, Brantley S, et al; A.S.P.E.N. Board of Directors. Enteral nutrition practice recommendations. *JPEN J Parenter Enteral Nutr.* 2009;33(2):122-167.
18. Whelan K, Schneider SM. Mechanisms, prevention, and management of diarrhea in enteral nutrition. *Current Opin Gastroenterol.* 2011;27(2):152-159.
19. O'Keefe SJ. Tube feeding, the microbiota, and *Clostridium difficile* infection. *World J Gastroenterol.* 2010;16(2):139-142.
20. Strohmayer E, Via MA, Yanagisawa R. Metabolic management following bariatric surgery. *Mt Sinai J Med.* 2010;77(5):431-445.
21. American Dietetic Association. *ADA nutrition care manual.* American Dietetic Association; 2010.
22. American Burn Association. Burn incidence and treatment in the United States: 2011 fact sheet (website): www.ameriburn.org/resources_factsheet.php?PHPSESSID=4b52270c210bae604542f5b77e9827c6. Accessed November 16. 2011.
23. Wasiak J, Cleland H, Jeffery R. Early versus late enteral nutritional support in adults with burn injury: a systematic review. *J Hum Nutr Diet.* 2007;20(2):75-83.

FURTHER READING AND RESOURCES

American Burn Association. www.ameriburn.org

American Society for Parenteral and Enteral Nutrition. www.nutritioncare.org

Burn Foundation. www.burnfoundation.org

Ferreira LG, Anastacio LR, Correia MI. The impact of nutrition on cirrhotic patients awaiting liver transplantation. *Curr Opin Clin Nutr Metab Care.* 2010;13(5):554-561.

Koch TR, Finelli FC. Postoperative metabolic and nutritional complications of bariatric surgery. *Gastroenterol Clin North Am.* 2010;39(1):109-124.