CHAPTER 53

# Nutrition in Perioperative & Critical Care

## KEY CONCEPTS

1. The fit, previously well-nourished patient undergoing elective surgery could be fasted for up to a week postoperatively without apparent adverse effect on outcomes, provided that fluid and electrolyte needs are met. On the other hand, it is well established in multiple studies that malnourished patients benefit from nutritional repletion via either enteral or parenteral routes prior to surgery.
2. The indications for total parenteral nutrition (TPN) are narrow, including those patients who cannot absorb enteral solutions (small bowel obstruction, short gut syndrome, etc.); partial parenteral nutrition may be indicated to supplement enteral nutrition (EN), when EN cannot fully provide for nutritional needs.
3. TPN will generally require a venous access line with its catheter tip in the superior vena cava. The line or port through which the TPN solution will be infused should be dedicated to this purpose, if at all possible, and strict aseptic techniques should be employed for insertion and care of the catheter.
4. In the patient with critical illness, discontinuing an EN infusion may require multiple potentially dangerous adjustments in insulin infusions and maintenance of intravenous fluid rates. Meanwhile, the evidence is sparse that EN infusions delivered through an appropriately-sited gastrointestinal feeding tube increases the risk of aspiration pneumonitis.
5. Regardless of whether the TPN infusion is continued, reduced, replaced with 10% dextrose, or stopped, blood glucose monitoring will be needed during all but short, minor surgical procedures.

Issues related to nutrition tend to be far removed from the usual concerns of the surgical anesthesiologist. On the other hand, appropriate nutritional support has been recognized in recent years to be of key importance for favorable outcomes in patients with critical illness, a large fraction of whom will require surgical services. Severe malnutrition causes widespread organ dysfunction and increases perioperative morbidity and mortality rates. Nutritional repletion may improve wound healing, restore immune competence, and reduce morbidity and mortality rates in critically ill patients. This chapter does not provide a complete review of nutrition in the patient undergoing surgery or with critical illness, but rather offers the framework for providing basic nutritional support in such patients. We consider, for example, whether enteral nutrition (EN) or parenteral nutrition (PN) will best meet the needs of an individual patient. This chapter also briefly reviews the conditions under which the ongoing nutritional needs of patients may come into conflict with anesthetic preferences and dogmas, such as the duration that patients must not receive EN before undergoing general anesthesia.

# BASIC NUTRITIONAL NEEDS

Maintenance of normal body mass, composition, structure, and function requires the periodic intake of water, energy substrates, and specific nutrients. Nutrients that cannot be synthesized from other nutrients are characterized as "essential." Remarkably, relatively few essential nutrients are required to form the thousands of compounds that make up the body. Known essential nutrients include 8–10 amino acids, 2 fatty acids, 13 vitamins, and approximately 16 minerals.

Energy is normally derived from dietary or endogenous carbohydrates, fats, and protein. Metabolic breakdown of these substrates yields the adenosine triphosphate required for normal cellular function. Dietary fats and carbohydrates normally supply most of the body's energy requirements. Dietary proteins provide amino acids for protein synthesis; however, when their supply exceeds requirements, amino acids also function as energy substrates. The metabolic pathways of carbohydrate, fat, and amino acid substrates overlap, such that some interconversions can occur through metabolic intermediates (see Figure 32–4). Excess amino acids can therefore be converted to carbohydrate or fatty acid precursors. Excess carbohydrates are stored as glycogen in the liver and skeletal muscle. When glycogen stores are saturated (200–400 g in adults), excess carbohydrate is converted to fatty acids and stored as triglycerides, primarily in fat cells.

During starvation, the protein content of essential tissues is spared. As blood glucose concentration begins to fall during fasting, insulin secretion decreases, and counterregulatory hormones, such as glucagon, increase. Hepatic and, to a lesser extent, renal glycogenolysis and gluconeogenesis are enhanced. As glycogen supplies are depleted (within 24 h), gluconeogenesis (from amino acids) becomes increasingly important. Only neural tissue, renal medullary cells, and erythrocytes continue to utilize glucose—in effect, sparing tissue proteins. Lipolysis is enhanced, and fats become the principal energy source. Glycerol from the triglycerides enters the glycolytic pathway, and fatty acids are broken down to acetylcoenzyme A (acetyl-CoA). Excess acetyl-CoA results in the formation of ketone bodies (ketosis). Some fatty acids can contribute to gluconeogenesis. If starvation is prolonged, the brain, kidneys, and muscle also begin to utilize ketone bodies efficiently.

1 The previously well-nourished patient undergoing elective surgery could be fasted for up to a week postoperatively without apparent adverse effect on outcomes, provided fluid and electrolyte needs are met. The usefulness of nutritional repletion in the immediate postoperative period is not well defined, but likely relates to the degree of malnutrition, number of nutrient deficiencies, and severity of the illness/injury. Moreover, the optimal timing and amount of nutrition support following acute illness remain unknown. On the other hand, malnourished patients may benefit from nutritional repletion prior to surgery.

Modern surgical practice has evolved to an expectation of an accelerated recovery. Accelerated recovery programs generally include early enteral feeding, even in patients undergoing surgery on the gastrointestinal tract, so prolonged periods of postoperative starvation are no longer common practice. All well-nourished patients should receive nutritional support after 5 days of postsurgical starvation, and those with ongoing critical illness or severe malnutrition should be given nutritional support immediately. The malnourished patient presents a different set of issues, and such patients may benefit from both preoperative and early postoperative feeding. Clearly, the healing of wounds requires energy, protein, lipids, electrolytes, trace elements, and vitamins. Depletion of any of these substrates may delay wound healing and predispose to complications, such as infection. Nutrient depletion may also delay optimal muscle functioning, which is important for supporting increased respiratory demands and early mobilization of the patient.

The resting metabolic rate can be measured (but often inaccurately) using indirect calorimetry (known as a metabolic cart) or by estimating energy expenditure using standard nomograms (such as the Harris–Benedict equation), yielding an approximation of daily energy requirements. Alternatively, a simple and practical approach assumes that patients require 25–30 kcal/kg daily. The weight is usually taken as the ideal body weight or adjusted body weight. Even though nutritional requirements can increase greatly above basal levels with certain conditions (eg, burns), the more often relevant reason for determining the daily requirements is to ensure that patients are not unnecessarily overfed. In this regard, obese patients require adjusting the body weight based on the degree of obesity to prevent overfeeding.

## HOW TO FEED THE PATIENT

After total parenteral nutrition (TPN) was established as a feasible approach for feeding patients lacking a functional gut, physicians extended the practice of TPN to many circumstances where "logic" and "clinical experience" suggested that it would be better than EN. For example, one such indication was in the patient with acute pancreatitis, where, in the 1970s, many clinicians thought that a period of TPN would put the gut and pancreas at "rest," allowing for resolution of pain and weight loss. Unfortunately, "logic" and "clinical experience" were incorrect. Now, the worldwide consensus expressed in clinical practice guidelines is that patients with acute pancreatitis (and indeed all others with functioning guts) will have worse outcomes

2 if TPN is provided, rather than EN. Today, the indications for TPN are narrow and include patients who cannot absorb enteral solutions (small bowel obstruction, short gut syndrome, etc.); partial PN may be indicated to supplement EN, in cases in which EN cannot fully provide for nutritional needs. In the latter circumstance, recent evidence suggests that the decision to add supplemental PN should be made only after a week's time in previously well-nourished patients. Earlier initiation of supplementary PN in previously well-nourished patients, as had been supported by 2009 European guidelines, resulted in worse outcomes in a large randomized clinical trial; however, these results are not firmly established, as smaller randomized clinical trials have suggested findings to the contrary. The divergent results from these recent trials may be associated with the type of parenteral formulations being used, types of patients being studied, timing of parenteral nutritional administration, and treatment in the control groups. Thus, further studies are needed to better define patients that may benefit from PN, as well as the optimal timing of nutritional support and formulations for feeding. In short, EN should be the primary mode of nutritional support, and PN should be used when EN is not indicated, not tolerated, or insufficient.

There was a time when nearly every physician who took care of critically ill patients was in the position of frequently ordering TPN for patients. This is no longer the case, given that EN is now so much more widely employed. As a consequence, many hospitals and health systems insist that a nutrition support team take responsibility for those rarer patients who require TPN.

In general, patients with critical illness should undergo whatever initial hemodynamic resuscitation they require before initiation of nutritional support (either EN or PN). Absorption, distribution, and metabolism of nutrients require tissue blood flow, oxygen, and carbon dioxide removal. Adequate tissue blood flow requires an adequately resuscitated patient. Nutrient delivery to ischemic tissues may cause tissue damage by increasing carbon dioxide and oxidant production while consuming energy. Patients with critical illness who require EN will usually require placement of a feeding tube. Feeding tubes may be placed into the stomach in patients with adequate gastric emptying and low risk of aspiration. In patients with delayed gastric emptying or those at high risk of aspiration, feeding tubes are best placed into the small intestine. Ideally, the tip of such tubes will be sited within the small intestine, either by transpyloric placement of a nasoenteral tube or directly into the jejunum during abdominal surgery (via a percutaneous route), reducing the likelihood of gastric distention and regurgitation. Patients who are unable to eat, but require EN over long periods of time, will often undergo percutaneous endoscopic placement of gastrostomy (PEG) tubes (the tips of such tubes can be placed distal to the pylorus). One should confirm that the tips of all feeding tubes are appropriately placed before initiating feeds to reduce the likelihood that EN solutions will be accidentally infused, say, into the tracheobronchial tree or abdominal cavity.

3 TPN will generally require that a venous access line be placed with the catheter tip in the superior vena cava. Peripheral PN can support the nutritional requirements of the patient, but necessitates the use of larger volumes of fluids due

to the requirement for lower osmolarities than used with central PN and increases the risk of phlebitis. The line or port through which the TPN solution will be infused should be dedicated to this purpose, if at all possible, and strict aseptic techniques should be employed for insertion and care of the catheter.

## COMPLICATIONS OF NUTRITIONAL SUPPORT

Diarrhea is a common problem with enteral feedings and may be related to either hyperosmolarity of the solution or lactose intolerance. Gastric distention is another complication that increases the risk of regurgitation and pulmonary aspiration; the use of duodenal or jejunostomy tubes should decrease the likelihood of gastric distention. Complications of TPN are either metabolic or related to central venous access (Table 53–1). Bloodstream infections associated with central and peripheral venous lines remain a major concern, particularly in the patient with critical illness and immunocompromised states.

Overfeeding with excess amounts of glucose can increase energy requirements and production of carbon dioxide; the respiratory quotient can be >1 because of lipogenesis. Overfeeding can lead to reversible cholestatic jaundice. Mild elevations of serum transaminases and alkaline phosphatase may reflect fatty infiltration of the liver as a result of overfeeding.

**TABLE 53–1 Complications of total parenteral nutrition.**

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| **Catheter-related complications** |
| Pneumothorax |
| Hemothorax |
| Chylothorax |
| Hydrothorax |
| Air embolism |
| Cardiac tamponade |
| Thrombosis of central vein |
| Bloodstream infection |
| **Metabolic complications** |
| Azotemia |
| Hepatic dysfunction |
| Cholestasis |
| Hyperglycemia |
| Hyperosmolar coma |
| Diabetic ketoacidosis |
| Excessive $CO_2$ production |
| Hypoglycemia (due to interruption of infusion) |
| Metabolic acidosis or alkalosis |
| Hypernatremia |
| Hyperkalemia |
| Hypokalemia |
| Hypocalcemia |
| Hypophosphatemia |
| Hyperlipidemia |
| Pancreatitis |
| Fat embolism syndrome |
| Anemia |
| Iron |
| Vitamin D, K, or B-12 deficiency |
| Essential fatty acid deficiency |
| Hypervitaminosis A |
| Hypervitaminosis D |

## SPECIFIC NUTRIENTS

Certain nutrients have been associated with improved outcomes. Surgery and anesthesia are well-recognized inducers of inflammation, producing changes in local (near the wound) and plasma concentrations of neurohormones, cytokines, and other mediators. Many investigators have hypothesized that adverse neurohormonal and inflammatory responses to surgery and anesthesia can be ameliorated through specific diets. Several clinical trials (and a recent meta-analysis) suggest that the addition of "immunomodulating" nutrients (specifically arginine and "fish" oil) to EN may reduce the risk of infection and reduce the length of hospital stay in high-risk surgical patients. Similarly, current guidelines for perioperative PN also advocate the inclusion of n-3 fatty acids. There is some evidence that inclusion of long-chain n-3 polyunsaturated fatty acids (n-3 PUFAs), long-chain monounsaturated fatty acids (found in olive oil), or medium-chain fatty acids may be preferable to the use of solutions (such as soy bean-derived lipids) that are rich in longer chain n-6 PUFA. However, such solutions (although widely available outside of the United States) are not approved for use in the United States.

In the past, it was customary to individualize TPN solutions for each patient. Currently, there is little evidence that this is necessary, except in patients who cannot handle a sodium load (eg, those with severe heart failure). Adjustments may also be made in patients requiring renal replacement therapy; however, in most cases, this is not necessary. Similarly, except in patients who are already suffering from hepatic encephalopathy, most patients with liver disease can safely receive standard amino acid solutions. Thus, most patients receiving EN and PN can be safely managed with standardized nutritional formulations. Both EN and PN standardized formulations are available in ready-to-use formats that decrease preparation times and reduce contamination risks during formulation.

## ENTERAL NUTRITION AND *NIL PER OS* RULES PRIOR TO ELECTIVE SURGERY

Long before the recognition by Mendelsohn of the problem posed by aspiration pneumonitis, anesthesiologists were reluctant to anesthetize patients scheduled for elective surgery if they had not been fasted overnight. Over time, the duration of obligatory time of no solid food *per os* has steadily declined, 4 particularly in infants and young children. In the patient with critical illness, discontinuing an EN infusion may require multiple potentially dangerous adjustments in insulin infusions and maintenance of intravenous fluid rates. Meanwhile, the evidence is sparse that EN infusions delivered through an appropriately sited gastrointestinal feeding tube increases the risk of aspiration pneumonitis. It is also relatively easy to empty the stomach immediately prior to anesthesia and surgery using 5–10 minutes of intermittent suction through a nasogastric tube. Therefore, current guidelines and current published evidence support continuing EN infusions (particularly when they are delivered distal to the pylorus) perioperatively and intraoperatively. Similarly, allowing preoperative patients to consume clear liquids, as desired, up to the time of surgery seems to have no influence on the risk of adverse outcomes from aspiration pneumonitis. Moreover, there is abundant evidence that administering a preoperative carbohydrate "load" to nondiabetic patients shortly before surgery will have the salutary metabolic effect of increasing plasma insulin concentrations and decreasing postoperative insulin resistance. Such preoperative carbohydrate loading is not nearly as commonplace as we believe it should be.

## TPN AND SURGERY

Patients who receive TPN often require surgical procedures. Metabolic abnormalities are relatively common, and, ideally, should be corrected preoperatively. For example, hypophosphatemia is a serious and often unrecognized complication that can contribute to postoperative muscle weakness and respiratory failure.

When TPN infusions are suddenly stopped or decreased perioperatively, hypoglycemia may develop. Frequent measurements of blood glucose concentration are therefore required in such instances during general anesthesia. Conversely, if the TPN solution is continued unchanged, excessive hyperglycemia resulting in hyperosmolar nonketotic coma or ketoacidosis (in patients with diabetes) is also possible. The neuroendocrine stress response to surgery frequently aggravates glucose 5 intolerance. Regardless of whether the TPN infusion is continued, reduced, replaced with 10% dextrose, or stopped, blood glucose monitoring will be needed during all but short, minor surgical procedures.

## GUIDELINES

American Dietetic Association. Critical illness evidence-based nutrition practice guideline. Available at: http://www.guidelines.gov/content.aspx?id=12818&search=ada+critical+illness+nutrition.

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## SUGGESTED READING

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