REVIEW

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CME CREDIT

Perioperative nutrition support: Who and how

ABSTRACT

Perioperative nutrition support can reduce postoperative complications in some malnourished patients, but there are risks, such as a greater risk of infection. The decision to use nutrition support—either total parenteral nutrition or enteral feedings—before and after surgery depends on how severely the patient is malnourished, the type of surgical procedure, and whether the surgery is elective.

KEY POINTS

Malnourished patients are at greater risk for perioperative and postoperative morbidity and mortality compared with well-nourished patients.

Preoperative nutrition support for 7 to 10 days is beneficial in severely malnourished patients whose surgery can be delayed this long.

Nutrition support should be considered in postoperative patients who cannot eat within 7 to 10 days after surgery.

Whenever possible, enteral nutrition is preferred over parenteral nutrition, as it is safer and more cost-effective.

Immune-enhancing enteral formulas are intended to bolster the function of the immune system in stressed patients.

NUTRITION SUPPORT—total parenteral nutrition (TPN) and enteral nutrition (tube feedings)—is not for everybody undergoing surgery. Although giving nutrition support before and after surgery can decrease postoperative morbidity and mortality, several well-designed studies showed that certain subsets of surgical patients suffer worse outcomes with TPN than with standard care.[1–4] Therefore, it is imperative to carefully choose which patients should receive nutrition support and by what route.

In this article we briefly review the literature on this controversial topic and describe methods for assessing nutritional status and determining which patients should receive perioperative nutrition support. We also discuss how to supply nutrition to patients who require perioperative nutrition support.

MALNUTRITION POSES RISK

Malnutrition is associated with adverse outcomes in surgical patients. Although it is difficult to establish a causal relationship, it is known that malnutrition can impair wound healing and immunocompetence and decrease cardiac and respiratory muscle function. Furthermore, malnourished patients undergoing surgery have higher rates of morbidity and mortality as well as longer hospital stays compared with adequately nourished patients.[5–10]

STUDIES OF PREOPERATIVE TPN

Although more than 20 studies have examined the effects of preoperative TPN, most of them were small, the quality varied, and the results differed. One large study, however, has provided valuable information (see below).

The Veterans Affairs Total Parenteral Nutrition Cooperative Study[2] included 395 malnourished patients who required nonemergency laparotomies or thoracotomies, but not vascular or cardiac procedures. Patients were randomly assigned to receive either TPN for 7 to 15 days before surgery and 3 days after surgery or no perioperative TPN.

At 90 days, there were more infectious complications in the TPN group than in the control group (14.1% vs 6.4%; $P = .01$), but more noninfectious complications in the control group (22.2% vs 16.7%; $P = .2$). The most common infectious complications were pneumonia and bacteremia, and the most common noninfectious complications were cardiovascular events and respiratory failure.

A possible explanation for the greater number of infectious complications in the TPN group may be that these patients received a high-calorie regimen—nearly 45 kcal/kg/day, which led in some cases to hyperglycemia, a known risk factor for infections. Furthermore, the excess of infections in the TPN group was all in the subgroups with either borderline or mild malnutrition. In contrast, severely malnourished patients receiving TPN had fewer noninfectious complications than controls (5% vs 43%; $P = .03$) and no increase in infectious complications. The severely malnourished subgroup also had fewer overall major complications with TPN than the subgroup without (21% vs 47%; $P = .12$).

Well-nourished patients may do worse with TPN

Heyland et al[11] did a meta-analysis of 27 randomized studies of perioperative TPN and concluded that TPN had no effect on mortality but was associated with fewer major complications.

Subgroup analysis showed a trend toward fewer deaths and complications in TPN patients in studies published before 1988 (the halfway point of the analysis) but not later. Although the reason for the difference in results before and after this time was not entirely evident to the authors, they speculated that it was because the later studies were of higher quality.

Klein et al[12] analyzed 22 studies and found that malnourished patients receiving TPN for 7 to 10 days before surgery had a 10% absolute reduction in postoperative complications.

Koretz et al[13] reached contrary conclusions in a meta-analysis for the American Gastroenterological Association Position Paper on TPN, finding that preoperative TPN did not have any effect on perioperative complications.

Comment. The reason for the differing findings among the three meta-analyses is that Koretz et al combined studies using TPN with studies using only "protein-sparing therapy" (< 10 kcal/kg/day of nonprotein energy). Furthermore, despite using similar inclusion criteria, Koretz et al included 23 studies in their analysis that the other meta-analyses did not. Some of these 23 studies were not randomized controlled trials, and others were repeat presentations of the same data.

These meta-analyses, moreover, point out an inherent weakness and limitation of all meta-analyses: differences among the studies in patient populations and treatments. Only Heyland et al[11] attempted to account for such heterogeneity in their subgroup analyses (ie, by grouping studies containing only malnourished patients and comparing these trials with other trials). These investigators also developed a scoring system to assess the methodologic quality of the individual studies, and used it to adjust the results in their analysis.

STUDIES OF PREOPERATIVE ENTERAL NUTRITION

Few studies examined enteral nutrition in preoperative patients.

Lim et al[14] found lower morbidity and mortality rates in patients receiving TPN vs enteral nutrition, but the differences were not statistically significant.

Sako et al[15] found no differences in rates of postoperative complications and mortality in patients who received preoperative TPN vs those who received enteral nutrition.

STUDIES OF POSTOPERATIVE TPN

Numerous small studies examined the effects of postoperative TPN.

Yamada et al[16] found that cancer patients receiving postoperative TPN vs oral intake had fewer postoperative complications, a

higher survival rate, and higher body weights, serum albumin levels, and total lymphocyte counts. The likely reason for the better survival rate was that TPN allowed the patients to tolerate more chemotherapy.

Collins et al[17] found that postoperative patients had faster wound-healing rates and a lower incidence of postoperative sepsis with TPN vs an amino acid solution or oral intake.

However, both of these studies, while statistically significant, were quite small (23 and 30 patients, respectively).

Preshaw et al,[18] on the other hand, found no reduction in the rate of colonic fistulas after colonic anastomosis with 6 days of postoperative TPN vs oral intake alone.

Woolfson and Smith[19] found no difference in morbidity and mortality rates after major thoracoabdominal procedures in patients treated with 7 days of postoperative TPN vs controls who received the standard postoperative fluid regimen.

Unlike the Veterans Affairs Group, which stratified patients on the basis of nutritional status, these latter two studies looked at patients who were well-nourished or whose nutritional status was unspecified.

Torosian[20] reviewed eight prospective randomized trials of postoperative TPN. Pooled analysis showed an overall 10% greater incidence of complications in patients receiving TPN.

Klein et al,[12] in another meta-analysis, also found a 10% greater incidence of complications in patients receiving routine postoperative TPN.

STUDIES OF POSTOPERATIVE ENTERAL NUTRITION

Few studies examined the use of postoperative enteral nutrition. Some found that it improved wound healing, reduced septic complications, reduced length of stay, and reduced the hypermetabolic response—energy requirements that exceed the patient's usual basal energy expenditure.[21–26]

However, a review of five studies that prospectively compared postoperative enteral and parenteral nutrition head-to-head reported similar rates of morbidity and mortality.[27]

WHO SHOULD RECEIVE NUTRITION SUPPORT?

Nutrition support is indicated in patients who are unable or unwilling to consume, digest, and assimilate adequate nutrients orally. However, not all patients who cannot eat for a few days are candidates—only those in whom the benefits outweigh the risks.

How long a patient can go without adequate nutritional intake without increasing surgical risk is unknown. Most well-nourished patients recover well without nutrition for several days after surgery while receiving standard intravenous fluids and then slowly reintroducing an oral diet. Moreover, some surgical patients do worse with TPN than with standard care.[2,3] This is likely because nutrition support carries inherent risks such as catheter sepsis, hyperglycemia, electrolyte abnormalities, and liver dysfunction.

Who should receive preoperative nutrition support?

There are three main criteria in determining if a patient should receive preoperative nutrition support:

- The patient must be severely malnourished.[28]
- The procedure should be one in which nutrition support has been shown to improve clinical outcome, eg, a major thoracoabdominal procedure
- The surgery should be elective and safe to delay for 7 to 10 days—the length of time that preoperative nutrition support should be given.

Overfeeding may be worse than malnutrition

Enteral or parenteral? Nutrition support should preferably be given through the enteral route if reliable access to the gastrointestinal tract can be obtained and formula tolerance is demonstrated. If this is not possible, TPN is the preferred route of feeding.

Who should receive postoperative nutrition support?

Candidates for postoperative nutrition support are not always obvious at the time of surgery. Often, the patient's postoperative recovery needs to be monitored for several days before the need for nutrition support becomes apparent.

TABLE 1

Degree of malnutrition: Current vs usual and ideal body weight

DEGREE OF MALNUTRITION	% OF IDEAL BODY WEIGHT*	% OF USUAL BODY WEIGHT
Mild	80%–90%	90%–95%
Moderate	70%–79%	80%–89%
Severe	< 70%	< 80%

*Ideal body weight can be determined by a variety of formulas. While all of the formulas have their shortcomings, the method proposed by Hamwi[32] is the most common:
Men: 106 pounds for the first 5 feet of height plus 6 pounds for each additional inch
Women: 100 pounds for the first 5 feet of height plus 5 pounds for each additional inch

ADAPTED FROM GRANT JP. NUTRITION ASSESSMENT BY BODY COMPARTMENT ANALYSIS. IN: GRANT JP. HANDBOOK OF TOTAL PARENTERAL NUTRITION. PHILADELPHIA: WB SAUNDERS COMPANY, 1992: 20.

As a general rule, postoperative nutrition support should be started only if the patient cannot tolerate an oral diet 7 to 10 days after surgery if mildly malnourished, or 5 to 7 days after surgery if severely malnourished.[20]

On the other hand, postoperative nutrition support should be considered sooner if you believe that the patient will not be able to resume oral intake within 7 to 10 days after surgery.[29]

Whenever possible, enteral nutrition is preferred over parenteral nutrition, as it is associated with equal or better outcomes and is safer and more cost-effective.

To avoid the refeeding syndrome, start at 1/2 the energy requirement for 3 to 5 days

HOW TO ASSESS NUTRITIONAL STATUS

A comprehensive nutrition assessment is essential before surgery, since it helps in estimating surgical risk and in determining whether a patient is a candidate for nutrition support. It should determine whether the patient is malnourished and, if so, to what degree. Generally, the severity of malnutrition is proportional to the level of surgical risk.[7,8,30]

Since no single test can accurately determine nutritional status, clinicians must look at several markers. Laboratory tests such as serum albumin and anthropometric measurements such as weight have been traditionally used to assess nutritional status. Unfortunately, these markers can be influenced by nonnutritional factors such as liver dysfunction, edema, or ascites.

The Prognostic Nutrition Index[30] was developed to prospectively predict the risk of postoperative complications in surgical patients on the basis of nutritional parameters alone. It uses a combination of nutritional markers: serum albumin, serum transferrin, triceps skinfold measurement, and skin tests for delayed hypersensitivity. It was originally validated in studies of gastrointestinal surgery patients and has since been shown to be of use in many other surgical populations. However, it is not widely used in clinical practice.

History and physical examination. Equations such as the Prognostic Nutrition Index should not replace a thorough history and physical examination. In fact, a careful patient history and physical examination alone may be a more valuable assessment of nutritional status than objective markers.

Subjective global assessment, a clinical technique based on the history and physical examination alone, has been developed and validated. This technique categorizes patients as well nourished, malnourished, or severely malnourished.[7,8,31] The most significant determinants of this scoring system are muscle wasting, loss of subcutaneous tissue, and weight loss.

Baker et al[7] demonstrated that patients categorized as severely malnourished by subjective global assessment had significantly higher rates of infection and antibiotic use and longer hospitalizations than well-nourished and mildly malnourished patients.

Anthropometric measurements such as weight are useful in assessing nutritional status in combination with a patient history and physical examination.

How much weight has been lost in what time? Loss of more than 10% of usual body weight within 6 months is considered severe and is associated with increased morbidity and mortality, as is 7.5% in 3 months, 5% in 1 month, or 2% in 1 week.[9]

What is the patient's current weight as a percent of his or her ideal body weight[32] *or usual weight?* Patients weighing less than 70% of their ideal weight or less than 80% of their usual weight are considered severely malnourished (**TABLE 1**).[33]

Laboratory tests such as visceral protein status testing can also help determine the

degree of malnutrition.

Serum albumin is helpful in assessing malnutrition, and low levels are associated with increased morbidity and mortality in surgical patients.[5,10,34]

Serum transferrin levels, with a shorter half-life than albumin, are more sensitive to the short-term response of a patient to nutrition support as long as any underlying injury or insult is resolved.

We use serum transferrin levels, although some clinicians prefer prealbumin as a marker of short-term changes in nutrition status. Each has its inherent advantages and disadvantages but they have important characteristics in common. All visceral protein levels decrease with the physiologic stress of an injury response, and this decrease correlates with the morbidity and mortality of the patient's illness. In addition, the magnitude of depletion roughly corresponds to the degree of malnutrition (TABLE 2) These markers can be used to help identify candidates for nutrition support and to follow patients' responses to nutrition support as long as the underlying illness has been treated or resolved.

However, it is important to be aware of nonnutritional factors such as fluid status and liver function that can influence visceral protein levels, and not to use visceral protein status as the sole criterion for assessing nutritional depletion.

TABLE 2

Determining degree of malnutrition using visceral protein levels

	ALBUMIN (G/DL)	TRANSFERRIN (MG/DL)
Normal	3.5–5.0	200–400
Mild malnutrition	2.8–3.4	150–199
Moderate malnutrition	2.1–2.7	100–149
Severe malnutrition	< 2.1	< 100

ADAPTED FROM RUSSELL MK, MCADAMS MP. LABORATORY MONITORING OF NUTRITIONAL STATUS. IN: MATARESE LE, GOTTSCHLICH MM, EDITORS: CONTEMPORARY NUTRITION SUPPORT. PHILADELPHIA: W.B. SAUNDERS, 1998: 47–63.

HOW MUCH NUTRITION SUPPORT TO GIVE?

If perioperative nutrition support is deemed necessary, how much does the patient need? There are several ways to calculate this.

Calories. Up to 25 to 35 kcal/kg/day or 1.5 to 1.75 times the basal energy expenditure. The basal energy expenditure is calculated by the Harris-Benedict equation:

Men 66.47 + 13.75W + 5H – 6.76A;

Women 655.1 + 9.56W + 1.85 H – 4.68A;

where W = weight in kg, H = height in cm, and A = age in years.

- **Protein:** 1.5 to 2 g/kg/day.

Use adjusted body weight if the patient is overweight

In calculating how much nutritional support to give, if the patient is at or below his or her ideal body weight, one should use the patient's current weight. But if the patient is overweight (> 120% of ideal body weight), one should use the *adjusted body weight*.

The concept of adjusted body weight assumes that one fourth of the excess weight is composed of lean tissue and that a patient should receive nutrition support only for his or her ideal body weight plus the excess lean tissue. Thus: adjusted body weight = ideal body weight + 0.25 (current body weight – ideal body weight).

Do not overfeed

Care must be taken not to "overfeed" patients (ie, give them more calories than they need) or to induce a refeeding syndrome.

Surgical patients have increased energy requirements that need to be met but should not be exceeded. Overfeeding with more than 35 kcal/kg/day has been shown to cause increased septic and metabolic complications, is clearly inferior to optimal nutrition, and may be as detrimental as the patient's underlying malnutrition.[20]

Refeeding syndrome occurs when severely malnourished patients are abruptly given their full energy requirements, whether by enteral feedings or TPN. Signs and symptoms include fatigue, lethargy, muscle weakness, edema, cardiac arrhythmias, respiratory failure, and hemolysis. The cause is a rapid shift of potassium, phosphorous, and magnesium from the extracellular to the intracellular space when glucose is first given to such patients.

Therefore, when beginning nutrition

Whenever feasible, enteral feeding is preferable to TPN

TABLE 3

Typical indications for perioperative nutrition support

Indications for enteral nutrition support
- Severe dysphagia or esophageal obstruction
- Neurologic and muscular diseases (Guillain-Barré syndrome, myasthenia gravis, amyotrophic lateral sclerosis, severe multiple sclerosis)
- Major burns or trauma
- Mild pancreatitis

Indications for total parenteral nutrition
- Diffuse peritonitis
- Intestinal obstruction
- Intractable vomiting or diarrhea
- Paralytic ileus
- Severe acute pancreatitis
- High-output enterocutaneous fistula
- Bowel ischemia
- Short bowel syndrome
- Complete malignant bowel obstruction

support in a severely malnourished patient, we advise giving one half of his or her energy requirement for 3 to 5 days while keeping electrolyte concentrations and fluid balance in the normal range before advancing to full requirements.[35]

Immune-enhancing formulas are promising but far from routine

ENTERAL OR PARENTERAL NUTRITION?

There is continued debate on *how* to provide nutritional support: enterally or parenterally.

Most experts agree that enteral nutrition is better than parenteral since it is safer and more cost-effective. Most comparative studies of enteral nutrition and parenteral nutrition, however, show that outcomes are comparable with either route.[14,15,21,22,27,36,37]

Keep in mind that most of the studies of perioperative feeding used parenteral nutrition in the treatment group and an ad lib oral diet in the control group. Few studies used a similar design to compare enteral nutrition in the treatment group against an ad lib oral diet in the control group.

With this in mind, tube feedings are indicated in patients with adequate digestive and absorptive capacity of the gastrointestinal tract but who cannot or will not consume adequate nutrients orally. Specific indications for tube feedings and TPN are listed in TABLE 3.

Immediately after surgery, tube feedings may not be an option due to paralysis of the bowel, but they should be considered once function begins to return. Tube feedings can often be started even in the absence of bowel sounds or the passage of flatus. In cases in which the return of normal gastric emptying is delayed, enteral feeding into the jejunum is an option through nasoenteric, gastrojejunostomal, and jejunostomal feeding tubes.

IMMUNONUTRITION: A NEW TYPE OF NUTRITIONAL SUPPORT

Immune-enhancing formulas are intended to bolster the function of the immune system in stressed patients. These are usually enteral formulas that contain supplemental arginine, RNA, and omega-3 fatty acids. This is a relatively new area of research, having only emerged in the last 10 years.

There are now numerous studies dealing with the use of these formulas in perioperative patients.

Daly et al[38] studied such a formula in patients undergoing elective surgery for gastrointestinal malignancies and found fewer infectious and wound complications in the group that received the formula (11% vs 37%; $P = .02$).

Braga et al (1998)[39] concluded that enhanced enteral formulas can lead to a shorter length of stay and less-severe infections in surgical patients.

Heyland et al,[40] in a meta-analysis, suggested that immune-enhancing formulas may have a favorable impact on the rate of postoperative infectious complications and on length of stay.

Braga et al (2002)[41] demonstrated reduced complications and hospital length of stay in patients given immunonutrition as compared to standard enteral nutrition.

The Summit on Immune-Enhancing Enteral Therapy[42] recommended these formulas for specific groups of patients, including malnourished patients undergoing elective gastrointestinal surgery. However, the recommendations of this meeting are not officially endorsed by the American Society for Parenteral and Enteral Nutrition.

Although these formulas are promising,

their use is far from routine and should not be attempted without a clear understanding of a specific formula's content and proposed indications.

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