

Nutritional Support of Trauma Patients

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- nutritional immunomodulation
- conditionally essential nutrients

The metabolic alterations associated with trauma can quickly lead to malnutrition and its attendant complications. Although physicians once starved wounded soldiers to limit inflammation, nutritional support is now known to modulate immune function, to positively impact gastrointestinal function, and to minimize malnutrition-associated complications in critically ill patients.

NUTRITIONAL ALTERATIONS IN TRAUMA PATIENTS

The pathophysiologic changes that occur in the trauma patient influence nutritional status and impact the provision of nutritional support.¹ The neurohormonal milieu in trauma patients causes hypermetabolism and hypercatabolism, both of which contribute to malnutrition. Protein turnover is increased due to an increase in protein breakdown; the by-products (i.e., the amino acids) are then used for wound healing, production of acute phase reactant proteins, and gluconeogenesis. Although this process is important in the face of injury, it also results in loss of lean body mass, increased production of urea, and increased urinary nitrogen losses. Numerous studies have shown that it is difficult, if not impossible, to reverse the trauma patient's obligate nitrogen losses in the early postinjury phase.²

Trauma also is associated with alterations in the metabolism of fat, carbohydrates, and micronutrients. Fat mobilization from body stores and clearance of triglycerides from the circulation are suppressed. Hyperglycemia secondary to insulin resistance also is characteristic of trauma patients and is sometimes called "diabetes of illness." Both of these can affect a patient's tolerance of nutritional support. Finally, there

is increased urinary excretion of potassium, magnesium, phosphorus, and other micronutrients, which predisposes the trauma patient to multiple deficiencies.

Changes to the gastrointestinal system also occur in the critically ill patient, and these changes both predispose the patient to malnutrition and can make it difficult to provide nutritional support. Decreased perfusion of the intestine reduces absorptive capacity and also increases intestinal permeability, thus increasing the risk of bacterial translocation. Ileus is common in trauma patients; it reduces the passage rate of enteral nutrition and increases the risk for pulmonary aspiration. In humans, ileus is usually limited to the stomach and colon; thus duodenal and jejunal feedings usually are well tolerated.³

These metabolic and gastrointestinal alterations all predispose the trauma patient to malnutrition. Malnutrition is detrimental to the patient because it causes muscle weakness, impairs wound healing, depresses immune function, increases infectious complications, and is an independent risk factor for morbidity and mortality.¹ Therefore preventing or minimizing malnutrition is critical for the successful recovery of trauma patients.

GOALS OF NUTRITIONAL SUPPORT

Based on the metabolic alterations present, the goals of nutritional support in trauma patients are:

- To prevent or minimize the development of malnutrition
- To minimize wasting of lean body mass
- To support immune function
- To facilitate tissue repair and wound healing
- To optimize gut barrier function

These goals can be achieved only by appropriate case selection and by providing an optimal diet via the optimal route.

PATIENT SELECTION

Nutritional assessment can be difficult in the trauma patient. Fluid shifts and intensive fluid therapy during the resuscitation stage make many standard indicators of nutritional status such as body weight and serum albumin useless. However, because most trauma patients have a good premorbid state of health, the goals of nutritional support in these patients are slightly different from those in patients with many other acute and chronic diseases. The major goal of nutritional support in most trauma patients is to *prevent* malnutri-

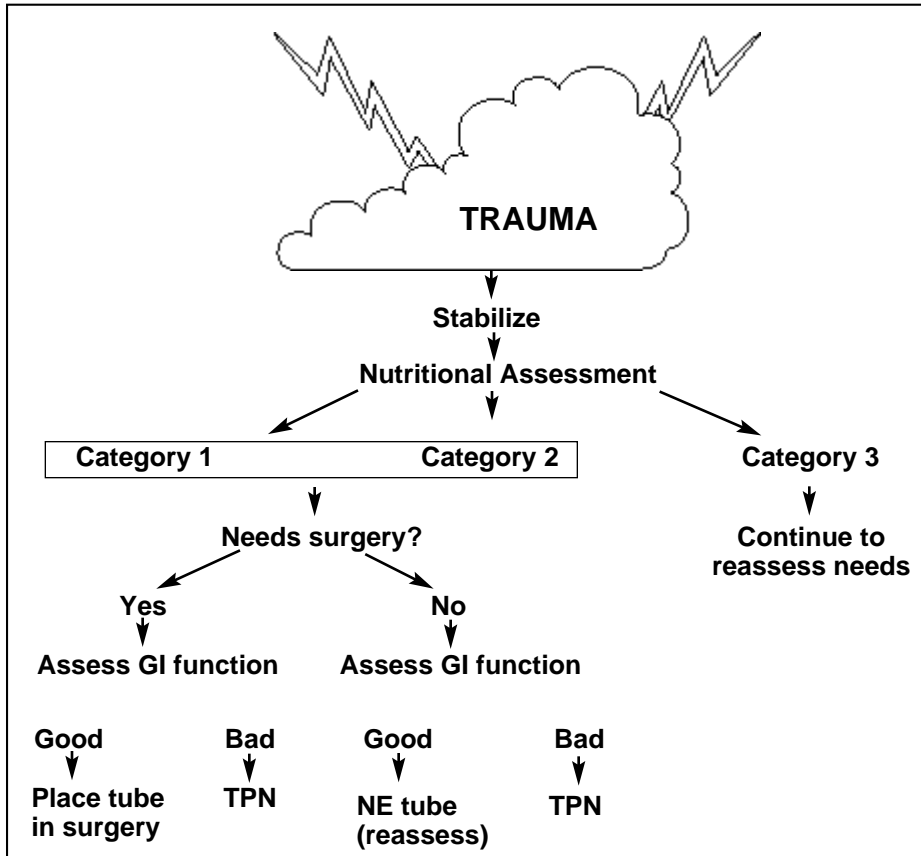


Figure 1. Decision pathway for selecting the appropriate route of nutritional support in trauma patients. Category 1 patients are those with historical, clinical, or laboratory signs of preexisting malnutrition or debilitation. Category 2 patients are previously well nourished but for which a prolonged recovery is anticipated and sufficient voluntary oral intake is not expected to occur within several days. Patients in Category 3 are previously well nourished and are expected to recover and voluntarily eat sufficient amounts within 3 to 4 days. GI = gastrointestinal system; NE = nasoesophageal.

tion and losses of lean body mass rather than to replenish such losses. Thus the clinician's most important assessment is that of anticipated magnitude and duration of the recovery phase. For practical purposes, the trauma patient can be classified into three nutritional categories:

- Category 1—Patients with historical, clinical, or laboratory signs of preexisting malnutrition or debilitation. The minority of patients fit into this category since most trauma patients are previously healthy animals.
- Category 2—Previously well-nourished patients in which a prolonged recovery is anticipated and sufficient voluntary oral intake is not expected to occur within several days.
- Category 3—Previously well-nourished patients that are expected to recover and voluntarily eat sufficient amounts within 3 to 4 days.

Nutritional support for patients in Categories 1 and 2

should be instituted as early as possible once the patient has been hemodynamically stabilized. Patients in Category 3 may not benefit from specialized nutritional support; if, however, recovery does not progress as planned or voluntary oral intake does not take place within 3 to 4 days of injury, nutritional support should be instituted at that time.

TIMING

A number of studies of human trauma patients have demonstrated that early enteral feeding (within 24 to 48 hours of admission) reduces the incidence of sepsis and total cost.³ Nonetheless, neither enteral nor parenteral feedings should be initiated in a hemodynamically unstable patient; acid-base and major electrolyte abnormalities also should be corrected first.

ENTERAL VERSUS PARENTERAL

There is a great deal of evidence supporting the importance of the gastrointestinal tract in the trauma patient, not only for the digestion and absorption of nutrients but also as a host defense against intestinal bacteria and their products,⁴ which can trigger the systemic inflammatory response. There also is ample evidence that lack of nutrients and their trophic factors in the gut impairs intestinal mucosal structure and function and can contribute to the loss of intestinal mucosal integrity. Enteral nutrition promotes enterocyte growth and development, improves enzymatic production and gut immune function, and maintains the enterocyte barrier function. Therefore providing enteral nutrition can help prevent bacterial translocation.

These findings were demonstrated in a study by Kudsk and associates in which the mortality rate after a septic challenge was significantly lower in rats receiving a total parenteral nutrition (TPN) solution enterally than in rats receiving the same solution parenterally.⁵ Prospective randomized human trials also have shown that patients receiving enteral nutrition have reduced incidence of sepsis compared to those receiving TPN.⁶ Enteral nutrition also has fewer complications than parenteral nutrition and is less expen-

sive. Based on this evidence, nutritional support should be provided by the enteral route if at all possible. Even if full energy requirements are not tolerated enterally, as little as 30% to 40% of requirements can maintain gastrointestinal structure and function.

In situations where the animal is vomiting or is too obtunded to guard its airway, however, parenteral nutrition is recommended. Patients with head trauma, for example, are a population in which enteral nutrition should be used with caution. The majority of human head trauma patients, have dysfunction of the lower esophageal sphincter, which contributes to a high risk of aspiration with gastric feeding.⁷ Therefore most human trauma patients are fed into the jejunum (either by nasojejunal tubes or jejunostomy tubes). This may represent a good option for veterinary trauma patients as well. Figure 1 shows one protocol for a decision-making process for route of nutritional support in trauma patients.

SPECIFIC NUTRIENTS

Energy

It is critical to provide adequate energy so that body reserves are not used and catabolism can be minimized. However, it also is important to avoid overfeeding energy to avoid metabolic complications (i.e., hyperglycemia, hyperammonemia, hypertriglyceridemia), excess CO₂ production, and hepatic steatitis. Illness energy requirements (IERs) of humans with acute major trauma have been measured to be between 1.0 and 1.75 times resting energy requirements (RERs), depending on the severity of illness and whether the patient is paralyzed.^{8,9} In the past, recommendations for energy requirements of veterinary patients were extrapolated from human data and dogs or cats with major trauma were often fed calories to provide 1.5 to 2.0 times RER. Now there are a small number of studies demonstrating that the apparent RER of critically ill dogs is not significantly different than that of healthy dogs.¹⁰ Although it still is important to take into account the fact that pain, fever, treatments (i.e., bandage changes), and severity of illness will increase the IER, estimates of energy requirements for critically ill dogs and cats are now much more conservative. Current recommendations of IER for trauma patients are:

$$\text{IER} = 1.0 \text{ to } 1.5^a \times \text{RER}$$

where RER = 70 × body weight in kilograms^{0.75}

Protein

Because of the catabolic process that takes place in trauma patients, it is important to provide adequate

^aThe illness factor should be increased with an increased severity of illness.

protein. However, it is difficult (or even impossible) to eliminate the negative nitrogen balance and lean body mass loss. It is a much more realistic goal to *minimize* protein loss in trauma patients. Current recommendations are to provide 4 to 5 g/100 kcal in dogs and 6 g/100 kcal in cats.

Carbohydrate

Carbohydrate often is the major source of calories for the critically ill patient. Because of the altered insulin/glucagon ratio and insulin resistance, however, hyperglycemia can occur. If it does, it is usually transient and can be managed with insulin. With parenteral nutrition, a maximum of 4 mg/kg/min should be administered. By avoiding excessive glucose, the percentage of patients that become hyperglycemic while receiving nutritional support can be minimized.

Fat

Because of its high-nutrient density, fat is used to provide calories and essential fatty acids to the trauma patient. High-fat enteral solutions can be difficult for some trauma patients to absorb because of the gastrointestinal changes that occur. For parenteral solutions, a maximum lipid infusion rate of 2 g/kg/day will help to avoid metabolic complications such as hyperlipidemia and suppression of the reticuloendothelial system.

Micronutrients

The specific requirements of critically ill dogs and cats are unknown. In human trauma patients, however, many authors recommend an increased intake of vitamins A, C, and E, as well as zinc, selenium, and magnesium.¹¹ For example, low pretreatment zinc concentrations have been shown to improve wound healing in human patients (a relatively common finding). Further research is necessary to determine safe and effective levels of these nutrients in the critically ill animal.

Conditionally Essential Nutrients

A number of nutrients that are not required in the diet of healthy dogs and cats might become necessary in critically ill patients; these are termed "conditionally essential nutrients."

Glutamine is the most abundant amino acid in the body and is important for acid-base balance, as a precursor for nucleotide synthesis, and as a primary fuel source for enterocytes, lymphocytes, and macrophages. Glutamine also is a precursor for glutathione, an important antioxidant. It is thought that glutamine requirements in critically ill patients may exceed their

capacity to synthesize it, thus making glutamine conditionally essential. Although there is a great deal of evidence in rodent models for improved protein synthesis, improved intestinal function, and reduced bacterial translocation with glutamine supplementation, the data from human and veterinary patients are less clear. A number of human and veterinary enteral formulas now contain supplemental glutamine.

Arginine is a nonessential amino acid in humans (compared to dogs and cats, in which it is essential). It has received a great deal of attention in critically ill human patients for its immune-enhancing and wound-healing properties. Arginine induces growth hormone, prolactin, insulin, glucagon, and somatostatin secretion. It also is involved in collagen synthesis and has positive immunologic effects. Like glutamine, however, its clinical benefits in humans are not clear. Whether the critically ill dog and cat require increased intake is not yet known, but some veterinary "critical care diets" now contain increased arginine levels.

Taurine, a well-known amino acid in veterinary medicine, has recently received interest in the human critical care literature as well. Critically ill human trauma patients have been shown to have reduced serum taurine concentrations, primarily due to reduced renal tubular reabsorption.¹² Taurine may be another nutrient that becomes conditionally essential during critical illness or injury. Taurine concentrations in critically ill cats or dogs have not been studied, but the human evidence suggests that taurine supplementation may have a place in the intensive care unit.

Nutritional Immunomodulation

It has long been appreciated that there is an interrelationship between nutrition and immune function, but this area has advanced a great deal in recent years. A number of nutrients have come to the forefront for their immunomodulatory properties, but the one that has received the most attention is the *n*-3 polyunsaturated fatty acids (*n*-3 PUFAs). *n*-3 PUFAs influence the inflammatory system by decreasing inflammatory cytokine production and by producing eicosanoids, which are less potent inflammatory mediators than those generated from arachidonic acid. Because of their antiinflammatory effects, *n*-3 fatty acids have been used commercially in a number of human and veterinary enteral products. These effects may not be ideal for all critically ill patients, however, as there is evidence in some animal models that *n*-3 fatty acids actually increase the risk of infection and mortality.

AVAILABLE PRODUCTS

There are a number of different options for enteral

feeding of traumatized dogs and cats. In general, four types of diets can be used:

- Blenderized dog or cat foods.
- Specialized veterinary "critical care foods."
- Liquid polymeric diets (whole protein, carbohydrate, and fat sources)—Although numerous human products are available, none meets canine or feline requirements; thus all must be supplemented. Veterinary polymeric diets are therefore preferred.
- Liquid elemental diets (diets composed of "predigested nutrients," such as amino acids, triglycerides, and simple sugars)—Only human products are currently available; these are not balanced for dogs and cats and must be supplemented.

The selection of the optimal product depends on the severity of illness, underlying diseases, economic issues, and the type of tube being used. For example, a liquid diet must be used in a nasoesophageal tube to avoid clogging. A thicker diet such as blenderized dog or cat food or a specialized "critical care food" can be used in esophagostomy and gastrostomy tubes because they are larger.

Parenteral nutrition can be supplied through a central vein (TPN) or a peripheral vein (partial parenteral nutrition [PPN]). Although many specialized components such as branched chain amino acids and *n*-3 PUFA-enriched lipids are available, cost usually dictates the use of a standard amino acid preparation, dextrose, and soy-based fat emulsion.

MONITORING

Regardless of the route selected and specific diet administered, one of the most important aspects of nutritional support is monitoring. Careful monitoring of clinical signs (e.g., heart rate, respiratory rate, body temperature, body weight, and appetite) and laboratory data (e.g., serum glucose, electrolytes, lipids, and proteins) can help prevent complications of nutritional support and indicate when adjustments are necessary to meet the trauma patient's changing needs.

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