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Nutrition Therapy in Major Burns

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Major burns lead to a hypermetabolic response that is more dramatic than that observed in any other disease or injury. In addition, major burns increase the metabolic demands of the body and can lead to severe loss of body weight and increased risk of mortality. The hyper-metabolic response is accompanied by severe catabolism and a loss of lean body mass and by a progressive decline of host defenses, which results in impairment of the immunological response. The protective functions of intact skin are lost, leading to increased risk of infection and protein loss. Therefore, adequate and timely provision of nutritional support is an essential component of care of the critically ill burn patient. Nutrition therapy is also important in burn care from the early resuscitation phase until the end of rehabilitation. Careful assessment of the nutritional state of the burn patient is also important to reducing infection, recovery time, and long-term results. Nutritional therapy in severe burns has evidence-based specificities that contribute to improve clinical outcomes.

Key Words: Burns, Nutrition therapy, Hypermetabolic response

INTRODUCTION

Metabolism in the burned patient

Major burn injuries remain a major health care issue through the world. Critically ill burned patients are characterized by a strong oxidative stress, an intense inflammatory

response, and a prolonged months-long hyper-metabolic and catabolic response, all of which are proportional to the severity of injury. Severe burn lead to a hyper-metabolic response that is more dramatic than that identified in any other disease or injury.¹ Metabolic rates may exceed 200% of normal, depending on factors that include total body surface area (TBSA) injured, body mass, age, and time injury to excision of eschar.² The burned body responds by an increase in endogenous catecholamines, cortisol, and other glucocorticoids to physiologically support the body's fight and escape the stress of the burn. Epinephrine and norepinephrine increased 10-fold shortly after 30%~40% of the TBSA in burned.¹ These catecholamines provoke the hypermetabolic response seen in burned patient.³ Loss of lean body mass, decreased immune response, and delayed

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wound healing are all major manifestations associated with the hypermetabolic response that impact hospital length of stay, morbidity, and mortality. Appropriate and adequate nutrition does play a key role in attenuation of this response. This hypermetabolic response lasts for at least 9~12 months after a burn.⁴ Therefore, nutrition therapy is a cornerstone of burn care from the early resuscitation phase until the end of rehabilitation. Nutrition support in the critically ill has been shown to help maintain intestinal barrier function,⁵ prevent bacterial translocation,⁶ and conserve bowel mucosal integrity,⁷ further showing that timely provision of nutritional support is a vital component of burn care.⁸ This review focuses on nutritional care of adults with major burns.

NUTRITIONAL REQUIREMENTS

1. Energy requirements

During the last two decades, nutritional support has emerged as a vital component of the management of critically ill patient. Nutrition supplies vital cell substrates, antioxidant, vitamins, and minerals that optimize recovery from illness. However, calculating the appropriate caloric needs of the burn patient can be challenging. In general, the burned subject's metabolic rate is often double and caloric demands of more than 5,000 cal/d are not uncommon.⁹ But, according to modern literature, the resting energy expenditure (REE) in burned patients ranges from 1.3 to 1.5 times that estimated from the Harris-Benedict equation. REE changes over time, with a peak lasting 2~6 weeks depending on burn severity and on complications.⁹ As both underfeeding and overfeeding do have detrimental consequences, accurate assessment of REE is desirable to adjust the individual caloric intake, particularly in patient with a prolonged and complicated course. In severely burned patients, the access to indirect caloric determination or REE is recommended. Indirect calorimetry (IC) commonly referenced as the gold standard for determining caloric needs in the critically ill, estimates energy expenditure by measuring basal needs along with increased energy requirements from metabolic stress.¹⁰ IC may also be used to monitor the adequacy of feeding by calculating

the respiratory quotient ($RQ = VCO_2/VO_2$) and evaluating substrate uptake. An RQ in the range of 0.7 to 1.0 is seen in the normal uptake of mixed substrates. An RQ of 0.7 or less is consistent with pure fat uptake and is indicative of underfeeding, whereas an RQ higher than 1.0 may indicate fat synthesis from carbohydrate and overfeeding.¹¹ Overfeeding has been shown to be detrimental to critically ill patients and induces a rise in VCO_2 because of increased lipogenesis. Such a rise in VCO_2 may also contribute to difficult weaning from ventilator support.¹² IC is therefore recommended to calculate optimal nutritional requirement in certain patient populations, including the following: (1) severely burned children; (2) ventilator-dependent patients; (3) patients with clinical signs of overfeeding and underfeeding; (4) patients with spinal cord injury or coma; (5) critically ill patients who are morbidly obese.

However, in burn patient a "metabolic cart" has not been documented to be more beneficial than the predictive equations.¹³ Close titration of calorie needs is important because overfeeding patients will lead to storage of fat instead of muscle anabolism.¹⁴ A commonly used formula in nonburned patient is the Harris-Benedict equation, which calculates caloric needs using factor such as gender, age, height, and weight. This formula uses an activity factor for specific injuries, and for burns the basal energy expenditure is multiplied by two. The Harris-Benedict equation may be inaccurate in burns of less than 40% TBSA, and in these patients, the Curreri formula may be more appropriate. This formula estimates caloric needs = $25 \text{ kcal/kg per day} + 40 \text{ kcal/\% TBSA per day}$. Daily weight determination allows the estimate of fluid balance in the short term and the monitoring of the adequacy of nutritional support in the medium to long term.

2. Proteins and specific amino-acids

The goals of nutrition support are to maintain and improve organ function and prevent protein-calorie malnutrition. The composition of the nutritional supplement is also important. However, the hormonal environment of burn injury greatly increases proteolysis. Provision of carbohydrate and fat calories is only partially successful in reducing protein catabolism. Some loss of lean body mass is

obligatory following injury. Therefore, increased protein must be supplied to satisfy ongoing demands, and provide amino acids for wound healing, enzymes and immunocompetence. Provision of 20%~25% of total calories as protein has been suggested.¹⁵ The optimal dietary composition contains 1.5 to 2 g/kg/day of protein, which provides a calorie-to-nitrogen ratio of approximately 100:1 with the caloric intakes suggested earlier.

Glutamine is an amino-acid becoming conditionally essential for burn patients. It is a favorite substrate for lymphocytes and enterocytes. Glutamine supplementation in burned adult improved glutamine levels, promoted protein synthesis, improved wound healing, and shortened hospital stay.¹⁶ The benefits of glutamine supplementation were not consistently seen in comparisons between postoperative and intensive care unit (ICU) patient, provision of 'low dose' (<0.20 g/kg/day) *vs.* 'high dose' (>0.20 g/kg/day) glutamine, or parenteral *vs.* enteral administration.¹⁷ Currently, it is difficult to recommend a precise dose, a route, or duration of administration. Obviously, many questions persist regarding the clinical utility of glutamine supplementation in burn care. Further clinical trials of this amino acid will be needed to clarify this issue.

Arginine is also important in postburn metabolism. Arginine stimulates T-lymphocytes, enhances natural killer cell function, and stimulates synthesis of nitric oxide, which is important is resistance to infection.¹⁸ Arginine supplementation of enteral diets has been associated with improved immune responsiveness and wound healing.¹⁹ Currently, there is no evidence in the literature to recommend arginine supplementation in burn patient.²⁰

3. Carbohydrates and glycemic control

The major energy source for burn patients should be carbohydrates. Glucose is the preferred fuel for healing wounds. The major complication of carbohydrates feeding under stress is glucose intolerance. Aggressive control of hyperglycemia is emerging as a critically important aspect of optimal patient care.

Exogenous insulin administration has been used to decrease hyperglycemia and improve protein catabolism after burn injury.²¹ Intensive insulin therapy in critically ill pa-

tients has shown benefit, presumably from avoidance of hyperglycemia. However, in burn patients, the insulin itself may have a metabolic benefit, with improvements in lean body mass and amelioration of the inflammatory response to burn injury.²² Oral hypoglycemic metformin also help to avoid hyperglycemia and may contribute to prevention of muscle catabolism.²³ The exact cut off for benefit has not yet been defined, leaving the clinician with the general ICU recommendations, of glucose 100~150 mg/dL. It is recommended that at least 60% of the calories administered be in the form of carbohydrates without surpassing 400 g/d or 1,600 kcal/d. The optimal relation of non-protein kilocalories to nitrogen is 150:1.²⁴

4. Lipids

Lipids are an excellent source of calories at 9 kcal/g. Essential fatty acid linoleic acid provides important components for cellular membranes and for prostaglandin synthesis.²⁵ Another important fatty acid is the omega-3 fatty acid. This fatty acid is important the immune response and in tube-feeding tolerance.²⁶ Lipids such as fish oil containing a high proportion of omega-3 fatty acids are metabolized without elaborating pro-inflammatory compounds. Diet high in omega-3 fatty acids have been associated with improved immune response, possible improved outcomes.²⁷ and may reduce problems with hyperglycemia.²⁸ However, the hormonal environment of burn-injured patients suppresses lipolysis and limits the extent to which lipids can be utilized for energy. For this reason, most authorities recommend that fat constitutes no more than about 30% of non-protein calories, or about 1 g/kg/day of intravenous lipids in total parenteral nutrition (PN).²⁹ Both the optimal composition and dose of fat in nutritional support remain topics of substantial controversy. Also, the place of omega-3 fatty acids or other mono- or polyunsaturated fatty acids remains to be defined: in this area also, there are on-going trials.

5. Micronutrient requirements

Patients with major burns have increased micronutrients requirement due to their hypermetabolic response, to their wound healing requirements and to the important cuta-

neous exudative losses which characterize burns with open wounds. However, the requirements have not been established. A few of the important compounds are discussed. Vitamin A is important in wound healing and epithelial growth. Vitamin A also functions as an antioxidant, and in preventing free radical damage. Providing 5,000 IU of vitamin A per 1,000 cal of enteral nutrition is recommended.¹⁵ However, toxicity of vitamin A can also occur. Vitamin C or ascorbic acid is essential for synthesis and cross-linking of collagen and thus for wound healing. It also functions as a circulating antioxidant. Supplementation of up to 1,000 mg per day in burn patients has been recommended.³⁰ According to recent studies, even this quantity may be insufficient during the early phase after burns, when the use of mega-dose may achieve a capillary leak stabilizing effect. Recently, Vitamin C has been administered at very high early doses (0.66 mg/kg/h for 24 h) since the early 2000s in human and animal studies. This treatment appears to stabilize the endothelium, thereby reducing the capillary leak and the fluid resuscitation requirements by about 30%.³¹ Vitamin D is needed for burned patients. Burns cause an impairment of vitamin D metabolism with resultant low 25-hydroxy vitamin D levels and reduced bone formation in adults and children.³² Considerable recent research has demonstrated that bone resorption and osteopenia is a significant problem following burn injury.³³ The exact requirements for calcium and vitamin D in burned subjects have not been determined. Iron is essential in oxygen-carrying proteins and also acts as a cofactor for a number of important enzymes. Burn patients are prone to iron deficiency, partially due to blood loss, but it should also be remembered that blood transfusions deliver a significant amount of iron. Among trace elements, three have been shown to be particularly important in immunity and wound healing of both adult and pediatric burn casualties. Copper (Cu), selenium (Se) and zinc (Zn) are lost in large quantities with the exudative losses, the losses persisting as long as the burns wound are not closed.³⁴ Zinc is required for the function of many metalloenzymes. Zinc deficiency has been documented during the first several days after burn injury. Supplementation of up to 220 mg/day has been recommended.³⁰ Selenium is important in the function of

lymphocytes, and hence, in cell-mediated immunity and essential for glutathione peroxidase activity. Selenium is lost through the skin following burn injury. Therefore, selenium deficiency in burn patients has been documented.³⁵ The duration for elevated substitution requirement is therefore determined by the burned surface: 7~8 days for burns 20%~40%, 2 weeks with burns 40%~60% and 30 days for burns >60% TBSA. The early substitution from admission is associated with reduction of lipid peroxidation, improved antioxidant defenses, improved immunity with lower incidence of infectious complications, improved wound healing and shorter ICU stay.³⁶

ROUTE OF FEEDING

Enteral nutrition is preferred in burns as in other critically ill patients. Early enteral feeding can improve splanchnic perfusion, blunt the hypermetabolic response, stimulate intestinal IgA production and maintain intestinal mucosal integrity. Also, the presence of even small amounts of nutrients within the bowel lumen stimulates the function of intestinal cells, maintains the architecture of intestinal microvilli and normal mucosal function, and may help preserve normal blood supply to the intestine.³⁷ Together, these effects may reduce bacterial translocation and sepsis and preserve gut-associated immune function.³⁸ Enteral feeding has improved outcome. Feedings have served as effective prophylaxis against stress-induced gastropathy and gastrointestinal hemorrhage.³⁹ By the end of the first week after injury most of the patient's energy requirements should be supplied enterally. Nasal jejuna tube feeding may aid in the delivery of enteral nutrients to burned patients who are too ill to take anything by mouth. Placement of enteral tubes during surgery has also been practiced in an effort to minimize the length of time a burned patient is without nutritional support.⁴⁰ Very early enteral feeding, *i.e.*, initiated within the first 6~12 h after injury by the gastric route is associated with numerous clinical and biological advantages, such as attenuation of the stress hormone levels, of the hypermetabolic response, results in increased immunoglobulin production, reduction of stress ulcers, while reducing the risk of malnutrition and of energy deficit.⁴¹

Once patients are hemodynamically stable and able to wean from their vasopressor support, their gastric tolerance is assessed. Patients with low GI output (less than 200 mL) and stable abdominal girth are initiated on gastric feedings at an hourly rate of 0.5 ~ 1 mL/kg.

CONCLUSION

Advances in infection control, early excision and grafting and aggressive nutritional support have greatly improved survival from severe burn injury. However, there is controversy on the level of energy and protein to be provided in burned patients. Also, there is a need for better methods to assess outcomes of nutritional intervention. Enteral nutrition is the first choice, but may be supplemented by PN if nutrient intake is inadequate. Weight changes and energy intakes should be monitored daily. Whenever gastrointestinal function permits, early enteral nutrition is superior to PN in the early stage after burn. Severe burns need an early supplementation with supra-nutritional amounts of zinc, copper and selenium to prevent deficiency related to complications. Further a lot of studies are needed to precise some of their optimal modalities.

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