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REVIEW ARTICLE

Nutrition and Metabolism in Burn Patients

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ABSTRACT

Nutritional support is one of the most critical aspects in treating burn patients, the significance of which cannot be reiterated enough. The management of nutrition in burn patients is challenging and multifactorial. It requires a comprehensive team of intensivists dieticians, plastic surgeons and occupational therapists working in collaboration to achieve the best possible outcome.

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INTRODUCTION

Nutritional support is one of the most critical aspects in treating burn patients, the significance of which cannot be reiterated enough. The hypermetabolic state induced by burn injury lasts not only in the acute phase, but as long as one to one and a half years after the primary insult. Initially, patients have a period of decreased metabolism known as the "ebb" phase followed by the "flow" phase.[1] This hypermetabolic state leads to severe catabolism, a huge loss of lean body mass and unfortunately compromises host immune function as well. A consistent and vigilant approach towards nutrition is imperative in the healing journey of these patients. Meeting the increased energy expenditure demand is critical for their recovery and survival.[2] Surprisingly, there is no consensus regarding nutritional support in burn patients regarding the optimal route, the timing of feed, the volume of feed and the formula used in the population of burn patients. This article will review the salient features of nutrition in the burn population

Pathophysiology of the Hypermetabolic State

Severe burns, especially TBSA > 40% cause an enormous stress response and a hypermetabolic state that can persist years after injury. Patients with sepsis and trauma have a similar response but the duration is considerably shorter. Moreover, sepsis occurring in burn patients further compounds the problem and adds insult to the pre-existing injury.[3]

The pathophysiology of burn hypermetabolism is intricate and complex and the metabolic, inflammatory, and hormonal dysregulation are still being studied. Figure 1 demonstrates the role of ATP in burn hypermetabolism

ROLE OF CATECHOLAMINES

Catecholamines (such as epinephrine, norepinephrine, and dopamine) play a significant role in the body's response to burn injuries. These chemicals are produced by the adrenal medulla and sympathetic nerve endings and activate the "fight or flight" response, helping the body cope with the immediate and long-term challenges posed by burns. They cause vasoconstriction, increase heart rate and cardiac output, and increase metabolic activity by stimulating lipolysis (fat breakdown), glycogenolysis (breakdown of glycogen to glucose) and gluconeogenesis. These processes increase the availability of energy substrates, ensuring the body has enough reserves to heal and respond to the burn trauma. However, the persistent elevation of catabolic hormones like epinephrine, glucagon and cortisol leads to the inhibition of these mechanisms of protein synthesis and lipogenesis, thus depleting the body of reserves. There is more protein breakdown than synthesis leading

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Table 1: Methods to decrease the hypermetabolic response in burn patients and effects on the recovery process.

Method	Description	Comments /impact on hypermetabolism
Nutritional Support and Early Feeding	Early enteral feeding (within 24 to 48 hours). - High-protein diet (amino acids like glutamine). - Balanced intake of carbohydrates, fats, and proteins.	-Prevents excessive catabolism. -Provides energy for wound healing. -Reduces muscle wasting and promotes tissue repair.
Beta-blockers	Drugs like propranolol. Studies have shown that propranolol treatment for 1-year postburn was shown to improve peripheral lean body mass accumulation.5	-Reduces elevated heart rate. -Lowers energy expenditure. -Improves cardiac function.
Anabolic agents	Anabolic steroids like oxandrolone blunt hypermetabolism, improve bone mineral content and density, and increase the accretion of lean body mass pediatric severe burns.6	-Reduces muscle wasting. -Promotes protein synthesis. - Counteracts catabolic effects.
Insulin	Insulin therapy, often combined with nutrition.	- Controls hyperglycemia. - Reduces catabolism. - Enhances protein synthesis and recovery.
Sedation/Analgesia	Pain management through opioids and sedatives.	- Reduces stress response. - Decreases catecholamine release and metabolic demands.
Temperature Management	Cooling blankets and thermal regulation. Prevents fever and controls ambient temperature.	- Stabilizes body temperature. - Prevents increased metabolic demands due to hyperthermia.
Physical Therapy and Mobilization	- Early, gentle physical activity and passive range of motion (ROM) exercises.	- Reduces muscle atrophy. - Improves circulation and muscle strength. - Helps balance metabolism.
Psychological Support	- Counseling, emotional support, and reducing anxiety.	- Reduces psychological stress. - Decreases cortisol and other stress hormones.
Infection Prevention and Control	- Early excision and grafting Wound care, infection control, and timely antibiotics.	- Prevents infections that worsen the hypermetabolic response. Decreases inflammatory cytokines like IL 6 IL-8, C3 complement, and tumor necrosis factor (TNF)-α
Hormonal and Endocrine Modulation	- Corticosteroids (used cautiously) and growth hormone therapy. Recombinant human growth hormone (rHGH) use has been curtailed as two multicentre trials showed increased mortality. Further studies are awaited to establish its safety.7	- Reduces inflammation. - May promote tissue regeneration and counteract hypermetabolism in severe cases.

to considerable cachexia of the skeletal muscle, which unfortunately has been documented to last as long as three years after injury.[4]

Therapies to Decrease Burn-induced Hypercatabolism

Table 1 outlines the methods used to decrease the hypermetabolic response in burn patients and the effects each method has on the body's recovery process.

The Timing and Routes of Nutritional Support: Enteral *versus* Parenteral

Since there is extensive mucosal damage and bacterial translocation, the consensus is that enteral nutrition should be initiated within 4 to 6 hours after injury as recommended by SCCM /ASPEN although most centres adhere to the 24 hours rule. Early initiation of enteral feeding reduces the hypermetabolic state, length of ICU stay, and risk of Curling's ulcer by restoring mucosal integrity and preventing translocation of bacteria. When enteral nutrition is contraindicated, only then parenteral nutrition[19] is given as it has disadvantages like liver dysfunction, overfeeding, increased cost, catheter-related complications and thereby increased mortality. Enteral nurition can be given through the gastric or post-pyloric route (if ileus develops), preferably in a continuous fashion but may also be given intermittently starting with low volumes according

Table 2: Caloric Requirements.

Adult formulas	KCal/day	Comments
Harris Benedict Equation	Men: 66.5 + 13.8(weight in kg) + 5(height in cm) − 6.76(age in years) Women: 655 + 9.6 (weight in kg) + 1.85 (height in cm) − 4.68(age in years)	Estimates basal energy expenditure; can be adjusted by both activity and stress factor, multiply by 1.5 for common burn stress adjustment
Toronto Formula	−4343 + 10.5(TBSA) + 0.23(calorie intake in last 24 h) + 0.84 (Harris-Benedict estimation without adjustment) + 114 (temperature) − 4.5 (number of postburn days)	Monitoring parameters can be adjusted to deliver precise nutrition
Curreri10	Age 16–59: 25(weight in kg) + 40(TBSA) Age >60: 20(weight in kg) + 65(TBSA)	Most commonly used bedside but often overestimated caloric needs
Ireton Jones	Ventilated patient: 1784 − 11 (age in years) + 5 (weight in kg) + (244 if male) + (239 if trauma) + (804 if burn) Non-ventilated patient: 629 − 11 (age in years) + 25 (weight in kg) − (609 if obese)	A complex formula accounting for ventilated and obese patients

to the patient's tolerance.[8] A high carbohydrate and protein diet is essential and parenteral formulas comprise 25% dextrose, 5% crystalline amino acids, maintenance electrolytes and 250 mL of 20% lipid emulsions three times a week to meet essential fatty acid needs. [95, 96].

Caloric Requirements and Common Formulae used in Adult Patients

The formulas to attain the caloric goals of patients are manifold and mentioned below. The Toronto formula involves parameters that can be adjusted daily according to the patient's needs to deliver precise nutrition and avoid underfeeding initially and overfeeding at a later stage.[9]

Figure 1: Use of indirect calorimetry to individualize nutritional care in burn patients..

Caloric Requirements and Formulae in Pediatric Patients

Galveston Formulae

Infant: For children 0–1 years old- 2100 kcal/m^2 + 1000 kcal/m^2 burn

Children 1 to 11 years old -1800 kcal/m^2 + 1300 kcal/m^2 burn

Adolescent children - 1500 kcal/m^2 + 1500 kcal/m^2 burn[11]

Indirect calorimetry (IC) is the current gold standard for measuring energy expenditure, albeit impractical. It measures volumes of expired gases and concentrations of oxygen and carbon dioxide in the inhaled and exhaled volumes, thereby calculating oxygen consumption (VO_2) and carbon dioxide production (VCO_2), respiratory quotient (RQ), which is the ratio of carbon dioxide produced to oxygen consumed (VCO_2/VO_2). Normally Rq is 0.75–0.90. In starvation, RQ is <0.7. whereas in overfeeding states it is >1 which may lead to difficulty in weaning.[12]

Macronutrients

Carbohydrates should make up 55 to 60% of energy intake. Although it is the main source of energy,

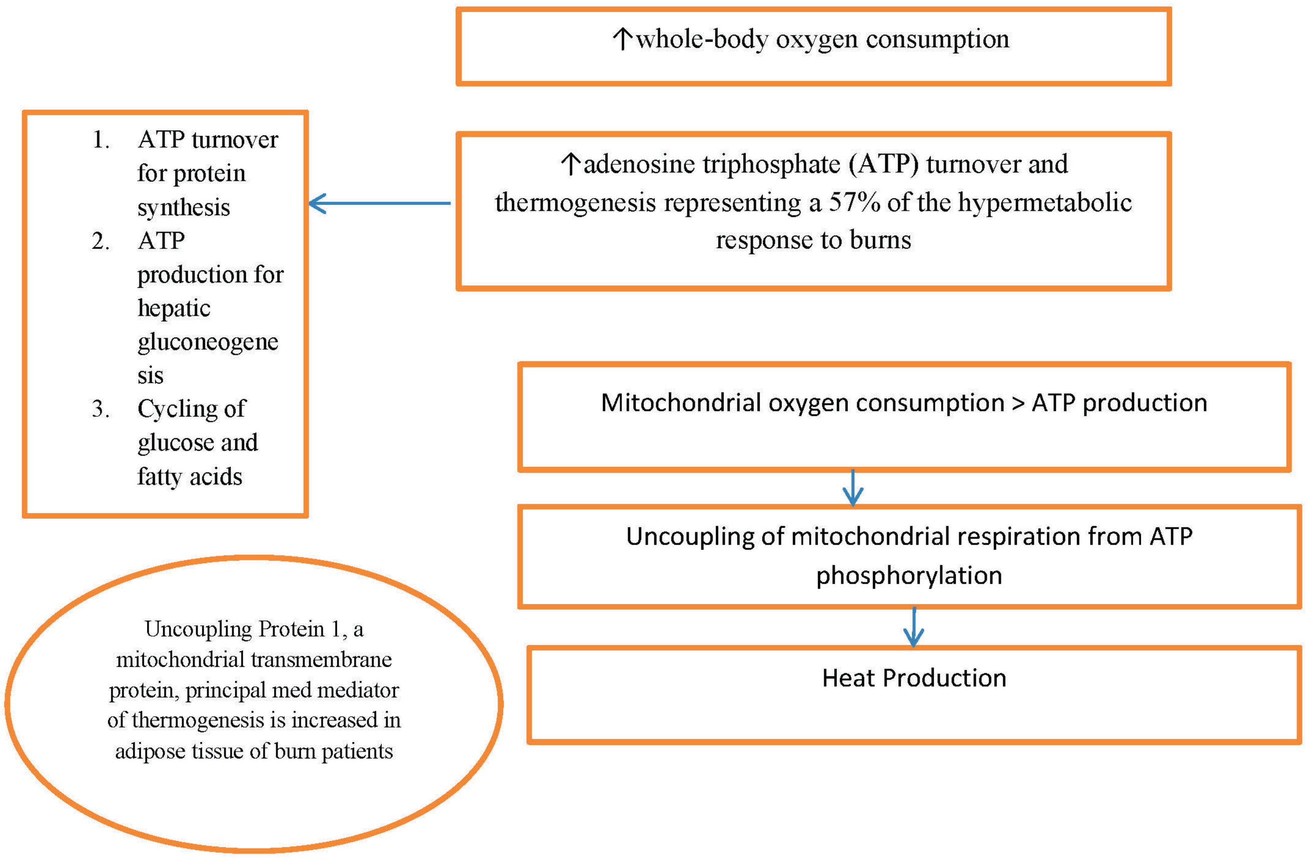

Figure 1. Role of ATP in burn hypermetabolism.

it should not be the sole substrate to meet caloric needs as it may lead to hyperglycaemia. Lipids should be administered as 15 to 30% of energy delivered as excessive use may lead to liver dysfunction.[13] The lipid content of propofol, if administered should also be accounted for. omega 3 rather than omega 6 fatty acids should be preferred. Since burn patients lose muscle mass daily, protein requirements are estimated 1.5 to 2 g/kg/day for adults and 2.5 to 4 g/kg/day for children.[14] Non-protein nitrogen to calorie ratio should be maintained between 100:1 and 150:1. The skeletal muscle loses vital proteins like glutamine, arginine, and alanine. Glutamine maintains small bowel integrity and generates glutathione as an antioxidant and 25 g/kg/day has reduced mortality and hospital stay in burn patients.[15] Arginine supplementation has improved immunity but further studies are warranted.[16] According to ESPEN (European Society of Enteral and Parenteral Nutrition) guidelines, glucose levels should be strictly monitored between 80 to 180 mg/dL.[8]

VITAMINS AND TRACE ELEMENTS

Micronutrients play a vital role in immune modulation and healing. Vitamin A and C aid in wound regeneration and collagen repair respectively, whereas Vitamin D repairs the density of bone and is a well-established anti-inflammatory agent particularly important with paediatric patients with severe burns Trace elements like Zn aid in wound healing and protein synthesis, Fe is a cofactor for various proteins, selenium boosts cell-mediated immunity. Copper is critical not only for collagen synthesis but also for preventing arrythmias. Micronutrient supplementation improves morbidity as studies have proven.[17,18]

Monitoring of Nutritional Support

It is not possible to measure the endpoint of optimum nutrition by one variable. The commonly used parameters are body weight, nitrogen balance , Body Index(BMI) , biochemical markers like prealbumin, albumin and transferrin (increasing levels indicate improved status. Wound Healing outcomes like a faster wound closure, reduced wound bacterial colonization and functional outcomes like improving muscle strength and functional indepenence should also be taken into consideration.

It is challenging to objectively assess the success of nutritional support of a burn patient, as the true endpoint of therapy is global and cannot be measured by one variable. The overall goal of therapy is to reestablish normal body composition and metabolic equilibrium, and commonly measured variables include body weight, nitrogen balance, imaging of lean body mass, and measurement of serum proteins like albumin and prealbumin and imaging techniques like bioimpedance analysis and DEXA (Dual X ray absorption spectrometry), although none of the variables are perfect and have their inherent limitations. For instance, the real body weight is masked by significant fluid shifts both in the acute as well as rehabilitative phase, nitrogen losses are grossly underestimated because of protein rich exudate seeping constantly from wounds, albumin and prealbumin levels do not corelate accurately with nutritional status as they are depressed quickly and recover slowly. No method is considered ideal and a holistic approach with overall clinical status of the patient should be assessed daily.[20,21]

Vitamin C and Burn Sepsis

A study has found that high-dose vitamin C (66 mg/kg/h) reduces organ dysfunction and improves survival in burn patients with sepsis. Similarly, another study has found that vitamin C supplementation (3 g/day) reduced oxidative stress and inflammation in burn patients with sepsis Although it is well established that Vit C in burn sepsis has antioxidant properties, helps in collagen synthesis, reduces organ dysfunction, and improves outcome in burn patients, the optimum dose has not been established.[22-24]

CONCLUSION

The management of nutrition in burn patients is challenging and multifactorial. It requires a comprehensive team of intensivists dieticians, plastic surgeons and occupational therapists working in collaboration to achieve the best possible outcome.

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