Nutrition and metabolism in burn patients

Abstract

- Severe burn causes significant metabolic derangements that make nutritional support uniquely important and challenging for burned patients. Burn injury causes a persistent and prolonged hypermetabolic state and increased catabolism that results in increased muscle wasting and cachexia. Metabolic rates of burn patients can surpass twice normal, and failure to fulfill these energy requirements causes impaired wound healing, organ dysfunction, and susceptibility to infection. Adequate assessment and provision of nutritional needs is imperative to care for these patients.

Goals of nutritional management

- To promote optimal wound healing and rapid recovery from burn injuries.
- To minimise risk of complications, including infections during the treatment period.
- To attain and maintain normal nutritional status.
- To minimise metabolic disturbances during the treatment process

Hypermetabolism

- Severe burns cause a profound pathophysiological stress response and a radically increased metabolic rate that can persist for years after injury. Trauma and sepsis also result in hypermetabolism, although to a much lesser degree and for a significantly shorter duration

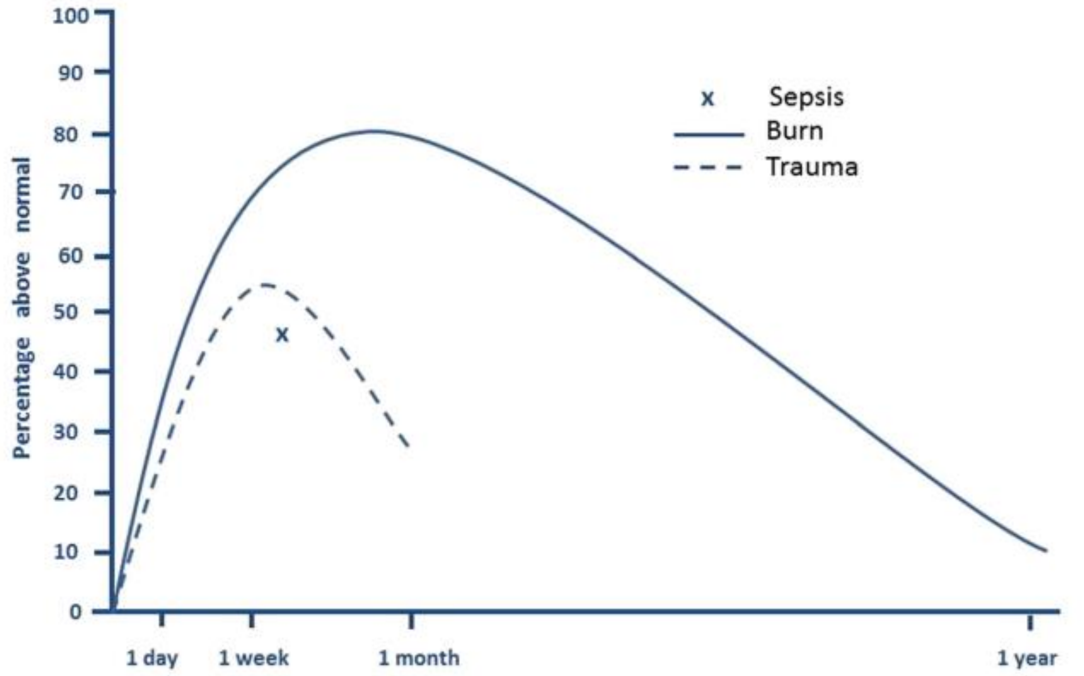

Fig. 1 Hypermetabolic response after severe burn, trauma, and sepsis. Adapted from references [5, 6, 123, 124]

Ebb and Flow

Phase	Duration	Role	Physiological	Hormones
Ebb	<24 hrs	Maintenance of blood volume, catecholamines	Dec BMR, Dec temp, Dec O2 consump, vasoconst, Inc CO, Inc heart rate, acute phase proteins	Catechol, Cortisol, aldosterone
Flow				
Catabolic	3 – 10 days	Maintenance of energy	Inc BMR, inc Temp, inc O2 consump, -ve N2 balance	Inc. Insulin, Glucagon, Cortisol, Catechol but insulin resistance
Anabolic (MOORE)	10 – 60 days	Replacement of lost tissue	+ve Nitrogen balance	Growth hormone, IGF

Timing

- enteral nutrition is started as early as possible. Early is
- superior in its effects on catabolic & hyper metabolic
- response to injury.

energy requirements

- The primary goal of nutritional support in burn patients is to fulfill the increased caloric requirements caused by the hypermetabolic state while avoiding overfeeding.
- Daily caloric requirements in patients with major burns are frequently estimated using the Curreri formula (25 X body weight (kg) + 40 X % BSA burned).

Adult formulas	Kcal/day	Comments
Harris Benedict	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)	Useful in acute stage of burn care; must be adjusted with changes in monitoring parameters
Davies and Lilijedahl	20(weight in kg) + 70(TBSA)	Overestimates caloric needs for large injuries
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)	Complex formula which integrates variables for ventilation and injury status
Curreri	Age 16–59: 25(weight in kg) + 40(TBSA) Age >60: 20(weight in kg) + 65(TBSA)	Often overestimates caloric needs
Pediatric formulas		
Galveston	0–1 year: 2100(body surface area) + 1000(body surface area × TBSA) 1–11 year: 1800(body surface area) + 1300(body surface area × TBSA) 12–18 years: 1500(body surface area) + 1500(body surface area × TBSA)	Focuses on maintaining body weight
Curreri junior	<1 year: recommended dietary allowance + 15(TBSA) 1–3 years: recommended dietary allowance + 25(TBSA) 4–15 years: recommended dietary allowance + 40(TBSA)	Commonly overestimates caloric needs

Route of administration

- enteral
- nutrition is preferred. It improves the protein balance
- & clinical outcome

Substrates

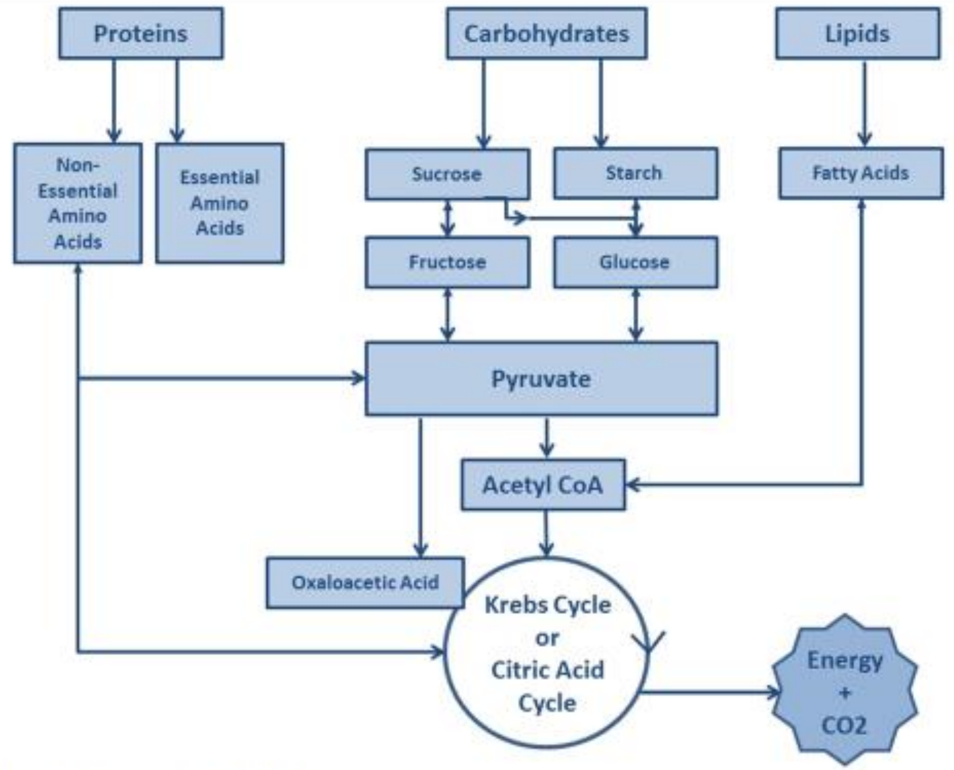

Fig. 2 Metabolism of protein, carbohydrates, and lipids

carbohydrate

carbohydrates are extremely important part of the burn patient’s diet; however, there is a maximum rate at which glucose can be oxidized and used in severely burned patients (7 g/kg/day)

insulin resistance

- The hormonal environment of stress and acute injury causes some level of insulin resistance, and many patients benefit from supplemental insulin to maintain satisfactory blood sugars. Insulin therapy also promotes muscle protein synthesis and wound healing

Fat

- Fat is a required nutrient to prevent essential fatty acid deficiency, but it is recommended only in limited amounts.
- many authorities recommend very low-fat diets (<15% of total calories) in burn patients where no more than 15% of total calories come from lipids.
- In addition to the amount of fat, the composition of administered fat must be considered. The most commonly used formulas contain omega-6 fatty acids such as linoleic acid, which are processed via the synthesis of arachidonic acid, a precursor of proinflammatory cytokines (e.g., prostaglandin E2). Lipids that contain a high percentage of omega-3 fatty acids are metabolized without promoting proinflammatory molecules and have been linked to enhanced immune response, reduced hyperglycemia, and improved outcomes

Protein

- Proteolysis is greatly increased after severe burn and can exceed a half pound of skeletal muscle daily .
- Supplying supranormal doses of protein does not reduce the catabolism of endogenous protein stores, but it does facilitate protein synthesis and reduces negative nitrogen balance .
- Currently, protein requirements are estimated as 1.5–2.0 g/kg/day for burned adults and 2.5–4.0 g/kg/day for burned children. Non-protein calorie to nitrogen ratio should be maintained between 150:1 for smaller burns and 100:1 for larger burns

micronutrients

- vitamin C, zinc, and copper help burns heal. Vitamin E, vitamin C, and selenium are antioxidants. They help to reduce the body's stress response after an injury.

Table 2 Vitamin and trace element requirements [125]

Age, years	Vitamin A, IU	Vitamin D, IU	Vitamin E, IU	Vitamin C, IU	Vitamin K, mcg	Folate, mcg	Cu, mg	Fe, mg	Se, mcg	Zn, mg
0–13										
Nonburned	1300–2000	600	6–16	15–50	2–60	65–300	0.2–0.7	0.3–8	15–40	2–8
Burned	2500–5000			250–500		1000[a]	0.8–2.8		60–140	12.5–25
≥13										
Nonburned	200–3000	600	23	75–90	75–120	300–400	0.9	8–18	40–60	8–11
Burned	10,000			1000		1000[a]	4		300–500	25–40

[a]Administered three times weekly

Mood of feeding

Enteral nutrition support with a high-protein, high-carbohydrate diet is recommended, and timing may be critical.
Feedings started within ~ 4 to 36 hours following injury appear to have advantages over delayed (> 48 hours) feedings.
Enteral support can reduce the burn-related increase in secretion of catabolic hormones and help maintain gut mucosal integrity.
The duodenal route is better tolerated than gastric feeding, due to an 18% failure rate in the latter from regurgitation.

Total parenteral nutrition (TPN) is not recommended, due to its ineffectiveness in preventing the catabolic response to burns.TPN also impairs immunity and liver function and increases mortality, when compared with enteral nutrition.

Table 3 Selected adult enteral nutrition formulas [126]

Formula	Kcal/mL	Carbohydrate, g/L (% calories)	Protein, g/L (% calories)	Fat, g/L (% calories)	Comments
Impact	1.0	130 (53)	56 (22)	28 (25)	IED with arginine, glutamine fiber
Crucial	1.5	89 (36)	63 (25)	45 (39)	IED with arginine, hypertonic
Osmolite	1.06	144 (54)	44 (17)	35 (29)	Inexpensive, isotonic
Glucerna	1.0	96 (34)	42 (17)	54 (49)	Low carbohydrate, for diabetic patients
Nepro	1.8	167 (34)	81 (18)	96 (48)	Concentrated, for patients with renal failure

IED immune-enhancing diet

Table 1 Common formulas used to calculate caloric needs of burn patients

Adult formulas	Kcal/day	Comments
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TBSA total body surface area

Obesity

- After burn, obese patients may respond with amplified inflammation, increased hypermetabolism, brisker and more severe muscle wasting, and severe insulin resistance .Obese patients also have decreased bioavailability of vitamin D3 compared to non-obese patients which can potentially worsen vitamin D and calcium deficiency after burn in this population.

Overfeeding

- The estimation of the nutritional needs of burn patients can be very difficult, and aggressive nutrition in the early post-injury stage can lead to inadvertent overfeeding as the metabolic rate slows and intestinal absorption improves. Overfeeding carries numerous complications, including difficulty weaning from ventilatory support, fatty liver, azotemia, and hyperglycemia. Overfeeding of carbohydrates leads to fat synthesis, increased carbon dioxide, and an increase in the RQ, which worsens respiratory status and makes liberation from the ventilator more challenging

Nutrition after discharge

- the hypermetabolic state can persist for over a year after burn injury, so increased caloric intake with a high protein component is usually recommended for about a year after discharge.
- Resistance exercise is recommended to combat continued loss of muscle mass.