Macronutrient Provision Recommendations and Considerations for Burn Care

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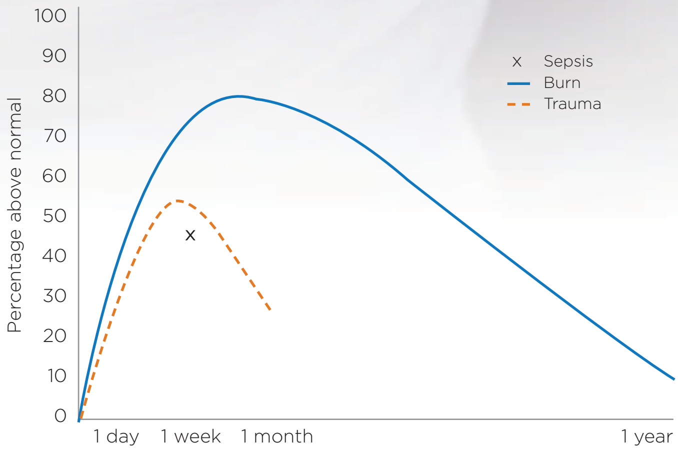
In the United Kingdom, approximately 120,000 people receive medical care for treatment of new burn injuries per year. Of those, <1% will sustain life-changing injuries, requiring intensive treatment and care by multi-professional teams in specialist hospitals across England and Wales.[1]

Burn injuries can illicit significant metabolic changes, relative to increasing severity of injury, which drives relentless turnover and demand for glucose, protein and fluid. Metabolic rates have been recorded to reach 200% of normal and raised metabolic needs can last for over one-year post injury,[2, 3] which is more pronounced and longer lasting than other well-known conditions, e.g. trauma and sepsis (**Figure 1**).

Clark *et al.* state that immediately after a severe burn injury, there is a period of decreased metabolism and reduced tissue perfusion, known as the 'ebb' phase.[4] Soon after, patients enter the phase of hypermetabolic rates and hyperdynamic circulation, referred to as the 'flow' state.[5] This secondary state reflects an increase in whole-body oxygen consumption and a patient is usually considered hypermetabolic when resting energy expenditure (REE) is more than 10% above normal.[6] Patients with >40% total burn surface area (TBSA) have a REE between 40% and 100% above normal.[7, 8] It is important to mitigate this stress response and support the significantly increased metabolic needs of the patient, as unchecked hypermetabolism results in an enormous loss of lean muscle mass, immune compromise and delayed wound healing.

Figure 1: Hypermetabolic Response after Severe Burn, Trauma and Sepsis



Source: Reproduced with kind permission from Clark *et al.*, (2017)[4] Proactive nutrition support strategies, such as enteral feeding (Table 1) and nutritional supplementation have been shown to moderate the hypermetabolic response, minimise lean muscle loss, aid wound healing and contribute to overall recovery of the burn injured person.[3] This is especially the case if used in combination with non-nutritional pharmacological agents, such as propranolol and oxandrolone, and feed is initiated within 6-12 hours of injury for major burns.[3]

A number of healthcare strategies, when implemented in combination, help to moderate the hyper-metabolic response and subsequently the demand for total calories. These include: nursing in a thermal neutral environment, early debridement/skin grafting and pharmacotherapies. Studies have found that average REEs range from 1.3-1.5 times higher than non-burn controls,[10, 11, 12] and that protein catabolism can exceed 150 g/day[13] through a combination of losses in exudate, tissue breakdown and demand for tissue repair.

Nutrient provision, absorption and assimilation of substrates are affected during the different stress response stages. Determining nutrition requirements throughout a patient's stay is difficult to predict, especially if not using an indirect calorimeter (IC) and relying on recommended formulaic equations – e.g. the Toronto or Schofield equation. What is more clearly documented are specific macronutrient provision recommendations – e.g. carbohydrate, fat and protein. Literature produced by Clark *et al.* (2017)[4] and Herndon *et al* (2018)[14] have summarised and promoted evidence for recommended amounts of total daily calorie provision from these macronutrients and their impact on burn clinical outcomes. These recommendations can be considered and help to guide dietitians when devising nutrition interventions and supporting patients with their nutritional intake.

Macronutrients

Carbohydrate

Carbohydrate, in the form of glucose, is the preferred source of energy post burn-injury. Studies have demonstrated that a high carbohydrate provision, instead of high fat, supports protein sparing, reduces protein catabolism and aids wound healing.[15] Failure to provide sufficient glucose from carbohydrate results in additional compensatory protein catabolism to provide amino-acids to support gluconeogensis.[16]

Recommendations state that 50-60% of total calories per day should come from carbohydrates for burn injury or the trauma setting.[3, 17, 18, 19]

However, critically ill adults and children can only oxidise glucose at the maximum rate of 7 g/kg/d (5 mg/kg/min),[3, 12, 14, 18, 20, 21] which can be less than the caloric amount needed to prevent lean body mass loss. This makes the glucose oxidation rate a limiting factor to achieving the desired caloric provision for this macronutrient. If glucose provision exceeds what can be safely utilised it results in hyperglycaemia, the conversion of glucose to fat, glucosuria, dehydration, and respiratory problems.[14] Herndon *et al* suggest titrating nutritional provision up to the 7 g/kg/d carbohydrate limit and provide the remaining carbohydrate caloric deficit as protein.[14]

Optimal glycaemic control has been identified as between 5-8 mmol/l by both retrospective and prospective burn studies[3] with many burn injured people requiring insulin therapy to achieve these levels, particularly in the acute phase of injury.

Fibre

Patients are to be encouraged to consume fibre-containing foods to aid regular bowel function.

Dietitians are also encouraged to prescribe a fibre-enriched feed as first line choice and adjust the feed fibre content depending upon bowel habits as it reduces the incidence of constipation and laxative use.[3]

Fat

Fat is only required in limited quantities for homeostasis, wound healing and to prevent fatty acid deficiency. Burn stress initially up-regulates lipolysis, increasing the amount of circulating free fatty acids (FFA), but shortly after it is suppressed and leads to 70% of FFAs being re-esterified and stored in the liver.[3, 14] The risk of liver steatosis, impact on length of hospital stay (especially when total calories from fat are >35%/day[3]) and the knowledge that increased fat intake can adversely affect immune function, has led many authorities to recommend very low-fat diets (e.g. 3-15% of total calories from lipids).[3, 14]

Presently, it is nigh on impossible to achieve this very low-fat target provision in the UK if feeding via the enteral route. A predominant factor is the current lack of suitable enteral feeding products available. Current product composition most commonly provides 30-52% of total calories as fat,[3] meaning that carbohydrate and protein proportions of feed products are also often out of line with recommendations. An additional, common challenge is the sedative propofol, which is often used in the early phase of critical illness and provides 1.1 calories per ml. Studies have shown that propofol provision can deliver an average of 15-30 g/d of additional fat in adults[3] and contribute a mean of 17% of total energy delivery per day.[23] Together, the lack of appropriate products and propofol use mean that UK burn patients are highly unlikely to be achieving the recommended provision of 3-15% total calories from fat, unless they only receive tailored parenteral nutrition (although this is contraindicated if the person has a working gut and the European Society for Clinical Nutrition and Metabolism [ESPEN] endorses enterally feeding burn patients) in combination with non-lipid providing sedatives.

Considering all these factors, burn teams are strongly encouraged to research nutritional products available to feed their patients and advocate using alternative products to propofol, but if this is not possible, to consider using a double-strength propofol preparation (e.g. 2%) to limit total fat provision.

Table 1: Percentage TBSA and Enteral Feeding Route Recommendations[9]

% TBSA	Age (years)	Type of feeding tube	Comments
≥10	<16 or ≥60	Nasogastric	Partial thickness (PT) to Full thickness (FT) depth burns
≥15	≥16	Nasogastric	PT to FT
≥20	<16 or ≥60	Nasojejunal	*Or those ≥16 and requiring multiple theatre trips PT to FT
≥30	≥16	Nasojejunal	PT to FT

Protein

Proteolysis is a guaranteed outcome of hypermetabolism post burn injury. If the increased metabolism is not attenuated, ongoing systemic proteolysis results in immune dysfunction and retarded wound healing,[14] as well as long-term implications on lean muscle levels and functional recovery.[24]

Recommended protein provision is 1.5-2.0 g/kg/d for adults and 2.5-4 g/kg/day in children.[3, 4, 14] Delivering provision in excess of these values have been found to have limited additional impact on muscle wasting.[13, 25, 26]

There is no published guidance for protein provision for the obese burn injured person. However, it is advised dietitians consider the critically ill obese protein requirement recommendations by the American Society of Parenteral & Enteral Nutrition (ASPEN), which advocates protein provision of 2.0 g/kg/IBW for body mass index (BMI) 30-40 kg/m^2 and 2.5 g/kgIBW/d for BMI >40 kg/m^2.[27]

Considering that recommended carbohydrate provision should be 50-60% of total calories and fat <15%, that leaves approximately 25-35% of calories to come from protein, though this has not been stated in the literature. Knowing current product composition and recommendations, practice at NUH is to aim for a minimum of 20% of calories from protein, 50-60% of calories from carbohydrates and a maximum of 30% of calories from fat when choosing nutritional products, especially when considering the evidence on outcomes for calories from fat. It is important check that the 20% of total calories from protein are within the recommended g/kg provision to avoid excess protein delivery.

Bonus micronutrient recommendation

In burn patients with burns >20% TBSA, additional enteral doses of glutamine (0.3-0.5 g/kg/d) should be administered for 10-15 days as soon as enteral nutrition (EN) is commenced.[22] Currently, there is insufficient evidence to support arginine supplementation in the burn population.[3, 4]

Route of nutritional provision

Meeting estimated nutritional requirements are challenging, not only due to the specific nutrient targets for burn injured people, but also because of common symptoms people suffer following burn injury which hinders their tolerance of nutritional provision (**Figure 2**).

Early and regular patient/carer education and encouragement to manage a high carbohydrate, high protein intake, whilst also considering fat provision and achievable intake is vital. Regular monitoring, review and promotion of appropriate snacks, fluids, food fortification and meal patterns are an integral part of burn nutrition support. Where possible, hospital catering teams and food service assistants should be consulted with to explore the potential to optimise appropriate food provision to this patient group, e.g. an additional fourth meal, high protein and carbohydrate snacks or meal vouchers for hospital canteens.

It is common for those with PT to FT burns ≥10% TBSA to require EN to supplement the person's oral intake and achieve desired nutrient targets. As previously highlighted, consideration of injury severity and medical plans inform choice of EN route. Available feed products should be screened to achieve the most appropriate macronutrient provision possible and enterally fed burn injured people should receive additional enteral glutamine supplementation if % TBSA >20. Review of enteral feed regimens relies on regular assessment of total intake alongside outcomes such as weight, wound healing, symptoms and functional ability. Practice at NUH is to continue enteral feeding until the patient is able to consistently manage a minimum of 75% of all their nutritional needs orally. Once this is achieved, the feed would then be held whilst nutritional supplements are trialed to meet the remaining 25% deficit, before determining if EN can be discontinued completely and the feeding tube removed.

Major burn patients requiring parenteral nutrition (PN) for <10 days are recommended to have lipid free prescriptions. However, it is suitable to provide 0.5-1 g/kg/d fat in PN, one to two times per week, for those requiring PN ≥10 days.[14] Unsurprisingly, many burn injured people require individualised PN prescriptions to achieve the carbohydrate, protein and fat provision recommendations. However, it is appreciated that not all services caring for this patient population will have access to sterile-production units to facilitate this.

Figure 2: Commonly Reported Symptoms Post Burn Injury

- Nausea +/- vomiting
- Fatigue
- Pain
- Dehydration
- Poor appetite
- Pyrexia
- Constipation/ diarrhoea
- Low mood
- Flashbacks
- Agitation/confusion
- Altered swallow
- Decreased physical function

Conclusion

In summary, teams caring for burn injured people should ensure that nutrient provision to meet total caloric and protein needs during recovery are in line with recommendations, as best as possible. Consideration of oral nutritional supplements and enteral and parenteral nutrition products are important to optimise adherence within the limitations of product availability. Furthermore, consideration of non-nutritional sources, especially propofol, should be considered when determining total nutrient provision and managed accordingly.

Considering the documented positive clinical outcomes achieved in burn studies using high carbohydrate, high protein and low-fat nutritional treatment, there is reason to believe that feeding in this way could also benefit other metabolically stressed, critically ill, patient groups. Further research, studies and products would be required to test this hypothesis.

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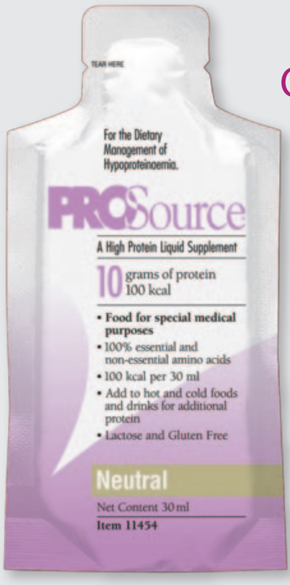

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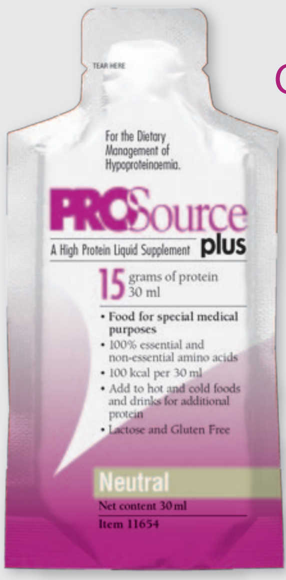

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