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Critical care: Meeting protein requirements without overfeeding energy

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SUMMARY

Background and aims: Relatively high protein input has been associated with improved clinical outcome in critical illness. However, until recently differences in clinical outcome have been examined in terms of the energy goal-versus under-feeding. Most studies failed to set the energy goal by an accurate measure or estimate of expenditure or independently set protein prescription. This leads to under-prescription of protein, possibly adversely affecting outcome. We determined whether an enteral nutrition prescription could meet local and international protein guidelines.

Methods: Protein prescriptions of consecutive patients admitted to Southmead Hospital ICU and requiring full enteral nutrition were audited against local and international guidelines. Prescriptions were designed to not exceed energy expenditure based on a validated estimation equation, minus non-nutritional energy, and protein requirements were based on local or international guidelines of between 1.2 and 2.5 g protein/kg/d or 2–2.5/kg ideal body weight (Hamwi ideal body weight)/d.

Results: From 15/1/15 to 12/4/15 139 ICU patients were prescribed full enteral nutrition. Protein prescriptions failed to meet local guidelines in 75% ($p < 0.001$) and international guidelines in 45–100%. Prescriptions meeting at least 90% of protein guidelines and 130 g of carbohydrate could be increased from between 0 and 55%, depending on the guideline, to between 53 and 94% using a protein supplement and 82 and 100% using a protein plus glucose supplement. Non-nutritional energy (NNE) proportionately reduces feed protein prescription and contributed 19% of energy expenditure in 10% of patients.

Conclusions: We need feeds with a lower non-protein energy: nitrogen (NPE:gN) ratio and/or protein supplementation if prescriptions are to meet protein guidelines for critical illness. NNE must be adjusted for in prescriptions to ensure protein needs are met.

1. Introduction

Relatively high protein input whilst not exceeding energy expenditure appears to be beneficial in terms of preserving lean body mass (LBM) during catabolism, reducing mortality and improving wound healing [1–3]. Conversely overfeeding energy is associated with hyperglycaemia, infection and increased protein catabolism [4]. Early in severe inflammatory states, optimal protein supply may help maintain vital LBM and supply amino acids to maintain acute-phase protein synthesis, wound healing and immunity [2]. Prolonged negative nitrogen balance is associated with poor outcome [1,5].

Guidelines for critical illness suggest 1.2–2.5 g protein/kg/d [6,7] compared to 0.83 g/kg/d in health [8]. Amino acid toxicity is rare except where continuous renal replacement therapy (CRRT) is unavailable in renal failure or during unbalanced amino acids loads from GI haemorrhage in liver failure [9]. Conversely, in patients who are energy substrate intolerant, giving a high protein prescription but less than the energy expenditure may be optimal [10]. However, most enteral feeds and parenteral solutions have a non-protein energy: nitrogen (NPE:gN) ratio too high to provide adequate 'protein' without overfeeding energy in critically ill patients [11].

In a 'baseline' audit we determined whether protein prescription met the local and international guidelines for our critically ill

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Abbreviations

ASPEN	American Society of Parenteral and Enteral Nutrition
BMI	body mass index
CRRT	continuous renal replacement therapy
EN	enteral nutrition
ESPEN	European Society of Parenteral and Enteral Nutrition
IBW	ideal body weight
IQR	inter-quartile range
LBM	lean body mass
NAP	nutrison advanced protison
NNE	non-nutritional energy
NPE:gN	non-protein energy: nitrogen
NPP	nutrison protein plus
PSUm	Penn-State University (mifflin) equation from Frankenfield et al., 2009; 2011.
REE	resting energy expenditure

population and, if not, whether protein supplementation could reduce the deficit. In a follow-on 'supplementation' audit we examined whether actual prescriptions of a protein supplement or very high protein feed would improve adequacy.

2. Methods

We prospectively compared protein prescription with local and international guidelines. We determined protein adequacy of current feed prescription in a 'baseline' audit and then the effect of added protein in a pilot 'supplementation' audit. The primary outcome was the difference between protein prescription and the local guidelines on days 1–3. Secondary outcomes compared this prescription with other guidelines and the effect of prescribing protein supplements in addition to feed. In addition to protein needs, there is an obligatory glucose requirement (130 g/d) [8]. While glucose can be derived via gluconeogenesis from glycerol or amino acids we made the assumption that to provide at least 130 g of glucose-equivalent carbohydrate would optimise protein utilisation. Because protein supplementation was rounded down to nearest pack, prescription could never equal 100% of the requirement. For this reason, 'prescription adequacy' was set at >90% of the estimated protein requirement and 130 g of carbohydrate.

2.1. Study population and setting

Consecutive patients admitted to Southmead Hospital ICU and requiring full enteral nutrition (EN) were assessed between days 1–3, 5–7, 8–10 and 18–20. Patients were excluded or data collection stopped if oral or parenteral nutrition commenced or EN or protein prescription was restricted, for example, in patients with liver dysfunction refractory to medical treatment, renal dysfunction requiring conservative (non-CRRT) treatment, short-bowel syndrome or severe refeeding risk. We calculated the protein deficit using feeds alone and feeds plus protein supplements.

2.2. Estimating requirements

Experienced nutrition support dietitians prescribed feed type and volume as closely as possible to estimated protein and energy requirements. Protein requirements were calculated according to the estimated level of catabolism [11].

- Mild: 1.25 g/kg/d (major surgery, no infection).
- Moderate: 1.875 g/kg/d (major trauma or systemic infection but not septic).
- Severe: 2.0 g/kg/d (sepsis).
- Very severe 2.5 g/kg/d (severe sepsis on CRRT) and
- ICU obese 1.9 g with 20Kcal/kg Hamwi ideal body weight (IBW)/d [12].

We compared these with the following international guidelines:

- ASPEN: 1.2–2.5 g/kg/d and 2.0 or 2.5 g/kg Hamwi IBW/d if BMI >30 or >40, respectively [6].
- ESPEN: 1.3–1.5 g/kg/d [7].
- Weijs et al., 2012 [13]: 1.2 g/kg or adjusted kg/d where 'Adjkg' is normalised to BMI 20 and 27.5 kg/m^2 when <20 and > 30, respectively.

We estimated energy requirements (EER) from equations that were either validated, used a physiological parameter or that were specific to condition and basal metabolic rate formula [11]. Calculations were done using FeedCalc v1.56 and v1.68 software (see Supplementary file). To avoid consequences of overfeeding, prescriptions did not exceed 105% of EER. In instances of substrate intolerance (blood glucose >10 mM, high insulin requirements or feed-related hypercapnia), hypocaloric feeding (about 75% EER) was considered. Feed prescription was proportionality reduced after deducting non-nutritional energy (NNE).

Sources of NNE included Propofol, IV glucose and CRRT fluid. For CRRT we made a conservative estimate that 200 Kcal per day was absorbed by patients receiving our pre-dilution method of regional citrate anti-coagulation [14].

2.3. Feed prescription

In the 'baseline' audit, we used feeds from the Nutrison range that had a non-protein energy (Kcal): nitrogen ratio (NPE:gN) of between 100 and 142:1. We also calculated the effect of substituting a higher protein feed, Nutrison Advanced Protison (NPE:gN ratio: 80:1), or, alternatively, supplementing with ProSource® TF (11 g protein, 1 g carbohydrate, 44 Kcal per 45 mL) or ProSource® Plus (15 g protein, 11 g carbohydrate, 100 kcal per 30 mL). In the 'supplementation' audit we prescribed ProSource® TF in gastric feeding or Nutrison Advanced Protison for intestinal feeding, when proteins needs were not met by standard feeds.

2.4. Study size

In a pilot study (n = 23), patients categorised as having mild, moderate and severe catabolism had protein prescribed that was 9%, 19% and 33% less than their estimated requirement, respectively. To show similar deficits, without exceeding 105% of the EER, required 133 patients (catabolism level: 100 mild, 11 moderate, 11 severe, 11 very severe) using a power of 0.99 and a significance level of $p < 0.05$ in a paired, two-tailed test. The sample was pooled if too few 'mildly' catabolic patients were recruited.

2.5. Statistics

Analysis was undertaken using 'R Studio' Version 0.98.977. We used the Shapiro–Wilk test to determine whether data variables were normally distributed. Differences between the protein guideline and prescription were determined using paired t-test or Wilcoxon's signed-rank test, as appropriate. We also determined the proportions of patients falling below thresholds of protein