Kushner et al. were not wrong when they said that the assessment and calculation of energy and protein requirements in the critically ill obese patient is ‘one of the most problematic and controversial aspects of nutrition support’.

International guidelines and review articles debate the right strategy for nutrition support in this group, one of hypocaloric high protein verses eucaloric high protein feeding. The 2016 joint Society of Critical Care Medicine and American Society of Parenteral and Enteral Nutrition guidelines for nutrition support in the critically ill recommended a hypocaloric high protein feeding (HCHP) approach in the critically ill obese, based only on expert opinion and best practice. The lack of strength to this recommendation only compounds the controversy. The wider and more pressing problem of underfeeding in the critically ill obese, regardless of the chosen feeding strategy, is often overlooked. This article investigates the evidence behind HCHP feeding in the critically ill obese alongside the alternative calculation of energy requirements. It also highlights the degree of underfeeding in these patients and strategies critical care dietitians can implement to optimise energy and protein delivery.

The problem
When inflammation, stress and raised metabolism in critical illness encounters the baseline metabolic complications associated with obesity, such as insulin resistance, hyperlipidaemia and hypercapnia, macronutrient utilisation in this cohort becomes increasing difficult. To ensure optimal outcomes, the aim of nutrition support in the critically ill obese should be to prevent overfeeding and minimise metabolic complications, while maintaining lean body mass. This is a challenge for dietitians for a number of reasons. Despite indirect calorimetry (IC) being the most accurate and precise measure of resting energy expenditure (REE) in the critically ill, it is expensive and has a number of methodological limitations. Even when available, the withdrawal of the gold standard indirect calorimeter from the market makes accurate and precise calculations of REE in the critically ill obese impossible. The lack of a validated bedside measure to determine lean body mass in the critically ill also makes accurate protein dosing difficult. Dietitians are therefore left having to rely on weight-based predictive equations to calculate energy and protein requirements. The disproportionate ratio of fat mass compared to fat free mass in obesity increases the risk of overfeeding energy when using weight-based predictive equations to calculate resting energy expenditure (REE). Dosing of protein is also unlikely to be representative of lean body mass. A HCHP feeding strategy has been recommended for the critically ill obese by the most recent 2016 Society of Critical Care Medicine (SCCM) and American Society for Parenteral and Enteral Nutrition (ASPEN) guidelines to help dietitians achieve their aims. This recommendation is only supported by expert opinion and best practice. Where is the evidence to support its use in the critically ill obese?

Hypocaloric high protein feeding in the critically ill obese
HCHP feeding is the delivery of energy that is reduced from total energy expenditure principally through the reduction in carbohydrate input, while targeting high protein and adequate delivery of other nutrients.
Achieving both the recommended energy and protein targets in a HCHP feeding regime should, therefore, be viewed with equal importance. Also, the 2016 SCCM/ASPEN guidelines do not provide direction on the method to calculate IBW. The studies from which the protein target (2-2.5 g/kg IBW) have been derived used the Hamwi equation to calculate IBW (Figure 1). When adopting this HCHP feeding approach, I feel the Hamwi equation should be used over alternative methods of calculating IBW.

Monitoring of blood urea levels in obese critically ill patients is recommended, alongside the avoidance of HCHP feeding in those with severe renal or hepatic dysfunction. The suitability of HCHP feeding to replete muscle mass and body stores during the recovery phase of critical illness has also yet to be investigated. The use of a HPHC feeding strategy should not be universally applied to the critically ill obese; it should be adjusted and tailored based on the individual patient and their clinical condition.

Is there an alternative to hypocaloric feeding?

Predictive equations of REE in the critically ill obese do not all provide the same level of precision and accuracy. Amongst the many published predictive equations for ventilated critically ill patients, the Penn State University 2009 (PSU 09) (<60 yrs, any BMI) and modified Penn State University 2011 (mPSU 11) (>60 yrs BMI >30 kg/m²) provide the most accurate estimates of REE in obesity, 70% and 74% (+/- 10% of MEE) respectively. Accuracy rises to 80% (+/-10% of MEE) in those with a BMI >45 using the PSU 09 equation regardless of age. Frequently performed equations of REE using the PSU equations has also been shown to track the intra-individual variation in energy expenditure during critical illness, reducing the risk of over and underfeeding. The use of these equations for the estimation of REE in the critically ill obese has been strongly recommended in the ASPEN guidelines for hospitalised obese patients.

It is important to remember that although PSU equations provide the most accurate estimates of REE, 26-30% of calculations for REE can over and under estimate to a high (> +/-10%) level. Close monitoring for overfeeding, which includes hyperglycaemia, high insulin requirements, hyperlipidaemia and hypercapnia, are required. A large RCT comparing eucaloric feeding, using a validated equation to measure REE, to HCHP feeding in the critically ill obese is still required.

Is the feeding strategy debate missing a more important point?

Critically ill obese patients are fed lower amounts of energy and protein compared with critically ill patients with a normal BMI. As BMI increases over 35 kg/m², energy delivery has been found to be 3 kcal/kg below the lower target requirements of a hypocaloric feeding strategy. Protein delivery per kg actual body weight also reduces with increasing BMI. An international audit of feeding practices in the critically ill found that 78% of mechanically ventilated patients with a BMI >35 kg/m² receive <80% of their energy and protein requirements. Given that receiving >80% of energy targets is associated with reduced mortality, these patients are at high risk. Despite the recommended higher protein requirements in the critically ill obese, this cohort also receives some of the lowest additional protein supplementation. This highlights the important role of critical care dietitians to regularly monitor the delivery of energy and protein against estimated requirements, in addition to utilising tools to maximise the delivery of energy feeding targets and protein closer to requirements.

Achieving hypocaloric or eucaloric feeding targets, alongside high protein requirements, using commercially available enteral formulations in the intensive care unit is challenging. The use of early enhanced enteral nutrition (Figure 2) in critical illness can safely increase both energy and protein delivery by 12-15%. The use of enteral formulas with a low energy high protein content, alongside protein supplements improves the attainment of protein targets without overfeeding energy. Reducing pre-operative fasting times and using 2% over 1% lipid containing sedatives (Propofol) also improves enteral calorie and protein delivery.

Figure 1: Calculation of Ideal Body Weight using Hamwi Equation

<table>
<thead>
<tr>
<th>Hamwi Ideal Body Weight</th>
<th>in = height in inches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>48 + (in - 60) × 2.7</td>
</tr>
<tr>
<td>Women</td>
<td>45.5 + (in - 60) × 2.2</td>
</tr>
</tbody>
</table>
The use of total parenteral nutrition (TPN) or supplementary parenteral nutrition (SPN) to optimize energy and protein delivery in the critically ill obese is a contentious tool. The joint SCCM/ASPEN 2016 guidelines recommended that early (<day 7) initiation of TPN should only be undertaken in those at highest nutrition risk, whereas SPN should be delayed to day 7-10 regardless of nutrition risk. Despite this, it is likely early SPN is still a useful tool to bridge the energy and protein gap in critically ill patients with a high nutrition risk. The initiation of early TPN and SPN should be taken on a case by case basis, led by a dietitian who can assess nutrition risk while monitoring closely for the risk of overfeeding. Even with a high nutrition risk score, achieving energy and protein requirements using SPN or TPN can still be problematic. Fixed nitrogen calorie multi-chamber parenteral formulations can still make it difficult to achieve protein requirements without overfeeding energy. Bespoke parenteral nutrition formulations may therefore be required but access to these products is not universally available.

To guide the assessment of nutrition risk, a conceptual model of nutrition risk specifically for the critically ill obese has been proposed by Dr Daren Heyland, et al. (Figure 3) but is as yet unpublished. The influencers within this model have either been taken from previous nutrition risk research or original research in obese and non-obese critically ill subjects. Many of them could, therefore, still be considered as part of a dietetic assessment of nutrition risk in the critically ill obese.

The degree of obesity (BMI >35 kg/m²), number of prior co-morbidities (>2), age (>50yrs) and length of hospital stay before admission to the intensive care unit (>1 day) should be considered when assessing high nutrition risk in the critically ill obese. Assessments of low muscle mass has been proposed by Dr Daren Heyland, et al. (Figure 3) but is as yet unpublished.

**Figure 2: Components of Early Advanced Enteral Feeding on the Intensive Care Unit**

**Figure 3: Conceptual Nutrition Risk Assessment in the Critically Ill Obese**

**Summary**

Critically ill obese patients remain underfed regardless of the feeding strategy and this trend must be reversed. Tools to optimise energy and protein delivery should be considered and implemented; the critical care dietitian is best placed to oversee this. The early initiation of parenteral feeding as one of these tools should be considered along side the assessment of nutrition risk. While we wait for a validated risk tool to predict the obese, a more simplified assessment can be carried out at the bedside.

**References**
