

Gluttony in the ICU: is it really a deadly sin?

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In humans, nutrition is a fundamental requirement for survival. The potential consequences of inadequate nutrition are self-evident, significant and potentially lethal. Similarly, excessive ingestion of calories is harmful. Metabolic consequences include obesity, hypertension, diabetes mellitus, steatohepatitis and premature death, primarily due to the premature onset of cardiovascular disease.

Despite multiple guidelines and extensive literature, optimal feeding for critically ill patients remains one of the most controversial aspects of care. An increase in energy expenditure and a negative nitrogen balance are characteristic findings in critical illness, the latter correlating directly with disease severity. Most literature on feeding in the critically ill has focused on the magnitude of the cumulative energy deficit (particularly early in an intensive care unit admission), the relationship between this and clinical outcomes, and strategies to minimise the energy deficit.

It is possible that the relationship between calorie delivery and mortality may be characterised by a U-shaped curve. Both underfeeding and overfeeding may be associated with worse outcomes, with the “sweet spot” for calorie delivery somewhere in the middle. This sweet spot is believed by many to be the calorie delivery that matches energy expenditure. This popular concept remains unproven, and here we discuss current conceptual problems with the delivery of artificial nutrition in the critically ill. We also explore the need to establish an agreed definition for overfeeding, particularly when all calories are delivered by the enteral route. Finally, we discuss whether there is currently any robust evidence to support the concept that overfeeding with enteral nutrition alone is associated with worse outcomes.

Optimal energy target

It is widely believed that calorie delivery should approximate energy expenditure. Although expenditure can be measured using indirect calorimetry, this technique is unreliable and difficult to use in routine clinical practice. Hence, feeding is one of the few interventions in the ICU which is not titrated to a physiological or clinical end point. Instead, calorie requirement is usually determined using a variety of predictive equations. Delivery of 25–30 kcal/kg/day is thought to approximate energy expenditure but the correlation between predictive equations and measured energy expenditure is poor. Such an approach may seem plausible but the evidence to support the concept that matching calorie delivery to energy expenditure improves clinical outcomes is limited to observational studies and small, randomised trials. The absence of high-quality evidence is reflected in the lack of concordance in

international guidelines, which are vague and inconsistent.^{1,2} The Canadian guidelines, for example, do not even recommend a calorie goal, citing a lack of evidence as the reason.³ Permissive underfeeding is favoured by some clinicians, a practice based on the belief that the catabolism and gas-troparesis that are often observed early in critical illness are teleological adaptations that have evolved to preserve blood flow to essential organs.

Definition of overfeeding in enterally fed patients

With uncertainty about optimal enteral calorie delivery, it is not surprising that there is no clear definition for what constitutes overfeeding. Negative sequelae associated with the delivery of more enteral calories have been reported even in patients receiving less than the recommended daily caloric requirement. For example, in a small observational study by Krishnan and colleagues, mortality was greater in patients receiving more than 60% of their calorie goal when compared with patients receiving less than 60% of their calorie goal.⁴ Similarly, in a small randomised trial, more patients receiving 1250 calories/day died when compared with patients receiving 1000 calories/day.⁵ In one small randomised controlled trial, calorie delivery in excess of the usually recommended 25 kcal/kg/day was compared with a more restrictive group. In patients with traumatic brain injury, enteral calorie delivery of 30 kcal/kg/day was associated with more infections when compared with 19 kcal/kg/day.⁶ These studies are small and conflict with the results from other more robust studies.⁷ More definitive high-quality research is urgently needed. One simple definition of overfeeding could be the delivery of calories in excess of energy expenditure. However, it is not clear at what point additional calorie delivery starts causing problems.

Evidence that overfeeding is harmful in the critically ill

The evidence for overfeeding in the literature is limited. There is little information on the clinical, physiological and biochemical manifestations of overfeeding, when it might occur during the course of critical illness, risk factors for its development and its impact on important patient-centred outcomes.

The concept of overfeeding was initially based on data from studies performed when intravenous hyperalimentation was in favour. The aim of hyperalimentation was to reduce nitrogen loss. However, increasing calorie delivery does not completely ameliorate nitrogen loss. Hyperalimentation fell out of favour when trials suggested that patients developed

fatty liver and had increased mortality.⁸ In patients with burns who were randomised to supplemental intravenous feeding or not, patients who did not survive who had been administered intravenous and enteral feeding had received over 4000 calories/day.⁸

It is important to understand that analysis of observational data on the relationship between calorie delivery and survival is problematic. Patients who stay in the ICU a short time are unlikely to be fed and have a reduced risk of death. Data analysis including these patients will therefore be skewed towards an apparent association between decreased calorie delivery and increased survival.⁹ Further, when patients cease enteral feeding and commence oral nutrition, the daily calorie delivery is rarely charted and calorie intake would be entered as zero. Inclusion of these data would again skew the analysis. Hence in an unadjusted analysis of data from 352 ICUs internationally, it was suggested that increased calorie delivery was associated with increased mortality, with an odds ratio (OR) of 1.28 (95% CI, 1.12–1.48) for patients receiving more than 60% of their caloric prescription compared with those receiving less than 60%⁹ (ie, similar to the groups analysed by Krishnan and colleagues).⁴ When the authors excluded days after progression to oral intake, this attenuated the estimate of harm from overfeeding (OR, 1.04 [95% CI, 0.90–1.20]). When they included only patients who stayed in the ICU for at least 4 days before progression to oral intake, and excluded days of observation after progression to oral intake, they showed a significant benefit of increased caloric intake (unadjusted OR, 0.73 [95% CI, 0.63–0.85]). The method of data collection and analysis is therefore likely to have considerable influence over the interpretation of the results.

Hungry for answers

Despite strongly held beliefs by many clinicians and researchers, the optimal calorie content and macronutrient composition of enteral feed formulae for critically ill patients remains unknown. The influence of chronic comorbidity, baseline nutritional status and the nature of the presenting illness on nutritional requirements are even less understood. It is possible that the relationship between calorie delivery and clinical outcomes is a U-shaped curve and that there is an ideal “dose” of energy delivery associated with optimal outcomes, above and below which negative sequelae develop, but this concept has no evidential base. It is also possible that calorie delivery has no impact on outcomes, particularly early in the course of critical illness and when baseline nutritional status is normal.¹⁰ Finally, it is also possible that delivering goal calories improves clinical, including functional, outcomes. Some overfeeding may be unavoidable when ensuring calorie goals are met, and this may not be associated with harm. Importantly, there appears to be little robust evidence to support the premise that providing more calories than is predicted by

measuring energy expenditure causes harm, particularly when the calories are provided enterally. Further research is needed to clarify the relationship between calorie “dose” and clinical outcomes and to characterise more precisely whether enteral overfeeding is truly associated with harm.

Competing interests

None declared.

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