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Opinion paper

A nutrition strategy for obese ICU patients with special consideration for the reference of protein

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SUMMARY

Hypocaloric, high protein feeding regimens have been proposed for feeding obese critically ill patients. However, the exact amount of energy and protein that should be provided to the obese patients with these regimens is still under discussion. Furthermore, the body compartment to be used as a reference for appropriate protein dosing has not yet been determined. While both actual and ideal body weight have been proposed, neither is an accurate reflection of total body protein content in obese individuals. Alternatively, dosing protein based on lean body mass (LBM), which is highly correlated with total body protein, might be the most appropriate method of calculating protein requirements as defined by actual body composition. LBM can be measured or estimated by various methods. We herein discuss a rationale to determine both the energy and protein needs to use in hypocaloric feeding regimens for obese patients based on the use of Standard Body Weight (SBW) and LBM, using previously published body composition data from 1420 healthy volunteers. When applied to the obese population, and compared to current practices, this method results in highly significant differences for both total and gender-specific protein dosing.

1. Introduction

The practice of appropriately feeding critically ill obese patients is still a widely discussed topic. Although numerous reviews and guidelines have been published on this topic, fundamental issues such as the energy and protein needs remain unanswered. The purpose of this paper is to discuss the available evidence, to show a simple way to calculate the energy provision for obese critically ill ICU patients and to introduce a new method to determine their protein requirements based on lean body mass (LBM).

2. The concept of hypocaloric, high-protein feeding

In 2009, the American Society of Critical Care Medicine (SCCM) together with the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N.) gave the following recommendations for feeding the obese ICU patient [1]:

> “In the critically ill obese patient, permissive underfeeding or hypocaloric feeding with EN is recommended. For all classes of obesity where BMI is >30, the goal of the EN regimen should not exceed 60%–70% of target energy requirements or 11–14 kcal/kg actual body weight (BW)/day (or 22–25 kcal/kg IBW/day). Protein should be provided in a range ≥2.0 g/kg IBW/day for class I and class II patients (BMI 30–40), ≥2.5 g/kg IBW/day for class III (BMI ≥40). Determining energy requirements is discussed in guideline C1 (Grade D) …… For obese patients (BMI >30), the dose of PN with regard to protein and caloric provision should follow the same recommendations given for EN in guideline C5 (Grade D).”

These recommendations were later adopted by other countries, including the Spanish Society of Intensive Care Medicine and Coronary Units (SEMICYUC) together with the Spanish Society of Parenteral and Enteral Nutrition (SENPE) [2].

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However, it should be noted that both recommendations made in 2009 were grade D, i.e. supported by evidence only from non-randomized cohorts with contemporaneous controls. Even this grading is overly optimistic because no clinical trial has been performed in obese ICU patients to date.

In a workshop published in 2011 [3], it was specified that "hypocaloric feeding" and "permissive underfeeding" should be differentiated: "Permissive underfeeding implies that there is an overall reduction in nutrition therapy delivered, which means there is less energy, protein, and other nutrients. Conversely, hypocaloric feeding means that delivery of total energy is reduced principally by reducing carbohydrate delivery while target protein and other nutrient delivery is achieved" [3].

The concept of hypocaloric, high protein feeding in obese hospitalized patients was subsequently evaluated in obese hospitalized patients in two randomized, double-blind trials, two prospective observational trials, and two retrospective studies. The number of patients ranged from 13 to 40. These patients were not critically ill.

Both randomized trials [4,5] published by the same investigators demonstrated that hypocaloric, high protein feeding resulted in comparable nitrogen balance relative to eucaloric feeding. In the first trial [5], 16 patients with a mean BMI of 33 ± 5.5 kg/m^2 (hypocaloric) or 35 ± 4.2 kg/m^2 (control) were randomized to receive isonitrogenous parenteral nutrition (PN) either covering 50% (hypocaloric) or 100% (control) of their measured resting energy expenditure (REE). After 9.6 ± 3.0 days of nutritional support, the average caloric intake was 1285 kcal/d (14 kcal/kg BW) and 2492 kcal/d (25 kcal/kg BW) respectively. The average protein intake was 1.23 g/kg and 1.31 g/kg actual BW (hypocaloric vs. control group). The main outcome parameter, nitrogen balance, was not significantly different between the hypocaloric and control groups (+1.3 ± 3.62 in g/day and +2.8 ± 6.9 g/day, respectively).

In the follow-up trial [4] REE was not measured. Thirty patients with a BMI of 36 ± 5 kg/m^2 (hypoenergetic) resp. 34 ± 6 kg/m^2 (control) were randomized to receive 2 g/kg IBW of protein with either hypoenergetic PN (kcal:nitrogen = 75:1) or control PN (kcal:nitrogen = 150:1). After 10.5 ± 2.6 days of treatment there was no significant difference in nitrogen balance between the hypoenergetic and control groups (+4.0 ± 4.2 g/day and 3.6 ± 4.1, respectively). For a detailed description see the review by Kushner et al. [3].

Despite the paucity of evidence, not only the previously mentioned guidelines but also the majority of reviews published during the last ten years advocate hypocaloric, high protein feeding. Most of the authors expect many favorable metabolic changes to be associated with this concept such as enhanced insulin sensitivity with improved glycemic control and decreased infections, attenuated endogenous protein catabolism, and improvement of body composition with attenuated loss of LBM [6].

3. Metabolic alterations in obesity

It is important to confirm, whether or not there are any differences in the metabolic reaction of obese compared with non-obese critically ill patients. Most authors state that obese individuals have a higher protein breakdown due to their lower effectiveness in utilizing endogenous fat stores as an energy substrate.

This often repeated statement is based on just one study published by Jeevanadam et al., in 1991 [7]. In this study the investigators examined the metabolic reaction to multiple trauma in 7 obese patients by isotope infusion and compared the reaction to that in 10 non-obese patients. Evaluated parameters were whole body lipolysis rate (WBLR), whole body protein turnover (WBPT), protein synthesis, protein synthesis efficiency, 3-methylhistidine excretion, and diverse plasma hormones. Obese patients showed an increase in WBPT and protein synthesis. Although this was not statistically significant in absolute values or when normalized to body weight, when expressed as a function of LBM, both parameters were significantly increased.

Importantly, however, LBM and total body fat (TBF) values were not directly measured. Instead, they were estimated by assuming that obese subjects have 43.4% of their body weight as fat and non-obese subjects 16.5%.The assumption of 43.4% of body fat independent of gender and BMI overestimates body fat in most male subjects, as will be discussed later in the article. This led to the assumption that the obese group had a lower mean LBM (58.5 kg) than the non-obese (65.0 kg) which is contrary to all published evidence [8–11] and which was the reason for the higher protein breakdown per kg LBM described in this paper.

Therefore, there is currently only one very small study which stated that significant metabolic differences exist between obese and non-obese patients, and, as discussed, this study has some serious flaws. Until newer studies are published confirming or rejecting these results, it is therefore appropriate to assume that the metabolic reaction to critical illness in obese and non-obese patients is not significantly different.

4. Determining energy requirements for obese patients

Predicting energy expenditure for obese critically ill patients is even more difficult than is the prediction for non-obese patients, a group for which many energy expenditure equations have been published. Only a few energy predictive equations have been developed explicitly for obese patients (Table 1).

Frankenfield et al. [12] evaluated the Ireton-Jones equation, the Penn State 2 equation, the Harris-Benedict equation, the American College of Chest Physicians (ACCP) standard, and the Faisy equation using ideal, actual, or metabolically active body weight to predict EE. They compared the predicted values with measured EE in 55 patients with a BMI ≥45.0 kg/m^2 and 56 patients with a BMI ≤21.0 kg/m^2. For obese patients, they found the highest accuracy rate (±5% of measured EE) for the Penn State 2 equation. However, even the Penn State 2 formula made a prediction of this accuracy in only 51% of the patients.

These results demonstrate a very limited accuracy of energy predictive equations. This was confirmed by another study, published by Anderegg et al. [13], which also compared the energy prediction by various equations with measured EE by indirect calorimetry in 36 patients with a BMI ≥30. They found the highest level of agreement between the two values was with the Harris-Benedict equation using adjusted body weight with a stress factor. Even in this case, an agreement within ±10% was again found in only 50% of the patients. The authors concluded that indirect calorimetry should be used in hospitalized obese patients for determination of energy needs as estimation strategies are inconsistent and lead to inaccurate prediction of EE in this patient population.

However, if patients are going to receive a hypocaloric feeding, there will be questions about how important the initial energy assessment needs to be. There is no consistent reduction in calories from baseline accepted as the "standard of care" for obese subjects. The ASCCM/A.S.P.E.N. guidelines refer to 11–14 kcal/actual body weight or 22–25 kcal/kg IBW to express this reduction in calories [1]. But what is "IBW" and is it the proper reference to use when calculating EE?

There is some confusion about the terms "standard body weight" (SBW) and "IBW"; SBW is the average weight for height of a population; IBW is the weight to achieve the longest life expectancy. Historically, with the use of punch card computers, American