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The dilemma of protein delivery in the intensive care unit

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ABSTRACT

Objective: Optimal protein delivery in the intensive care unit (ICU) may offer a significant mortality benefit, whereas energy overfeeding leads to worse outcomes. The aim of the present study was to assess actual protein versus energy delivery in a multidisciplinary adult ICU.

Methods: We conducted a retrospective review of ICU charts to determine total protein delivery and energy delivery, inclusive of non-nutritional energy sources (NNES), from admission until a maximum of 7 d. The outcome variables were protein and energy delivery relative to targets and cumulative protein and energy balance.

Results: We included 71 patients (49% male), with a mean age of 49.2 ± 17.1 y. Of the patients, 68% were medical and 32% surgical. Nutrition therapy was initiated within 14.5 ± 14.1 h. The majority (80%) received enteral nutrition (EN). Median protein delivery and energy delivery were 75 g/d (1.1 g·kg·d^{-1}, range 21–135 g/d) and 1642 kcal/d (26 kcal·kg·d^{-1}, range 740–2619 kcal/d), meeting 89% (range 24–103%) and 100% (range 39–133%) of target, respectively. NNES, mostly from carbohydrate-containing intravenous fluids, contributed 8% (range 0–29%) to total energy delivery (133 kcal/d, range 0–561). Protein and energy underfeeding occurred in 51% and 27% of cases, respectively. Only 59% of those with an adequate energy delivery (90–110% of target) achieved an adequate protein delivery. A significant negative correlation was found between cumulative protein and energy balance and time to initiation of NT (protein: $R = -0.33$, $P = 0.006$; energy: $R = -0.28$, $P = 0.017$).

Conclusions: Early initiation of EN with currently available energy-rich formulas is insufficient to achieve adequate protein delivery. NNES add to total energy delivery. Novel EN formulas with a lower nonprotein energy-to-nitrogen ratio may help to optimize protein delivery without the harmful effects of energy overfeeding.

Introduction

Appropriate nutrient delivery in the intensive care unit (ICU) remains a debatable issue [1,2] and protein delivery in particular has recently been scrutinized in relation to clinical outcomes [1,3–10]. According to two recently published observational studies [9,10], achieving adequate protein delivery in the ICU plays a key role in optimal nutrient delivery and may offer a significant mortality benefit.

However, until recently the importance of protein intake has been relatively neglected with the primary focus directed toward meeting energy targets [4,5]. Perhaps as a consequence, most ICU patients internationally are severely protein underfed during the first 2 wk of ICU care with daily intakes of only 0.8 to 1.0 g/kg in the best of cases [4,5]. It has been suggested that recent prospective studies [11–13] that could not demonstrate benefit from various nutritional interventions may have provided insufficient protein, which could have negatively affected patient outcomes [5,6,8,14]. In these trials [11–13], participants received only 0.6 to 0.8 g protein·kg·d^{-1}, <50% of the 1.5 g/kg protein target most commonly recommended [5]. According to a recent review article, adequate protein delivery (most likely >1.2 g protein·kg·d^{-1}) is critical to maintain protein balance and lean body mass [6]. Another systematic review suggested that an intake of 2.0 to 2.5 g protein·kg·d^{-1} is safe and could be optimal for most critically ill patients [15].

All authors designed the research. L.V. conducted the research, analyzed data with the help of a statistician, and had primary responsibility for final content. All authors wrote, read, and approved the final manuscript. The authors have no conflicts of interest to declare.

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Until recently, protein intake in the ICU has largely been a neglected area of research. There is an urgent need for appropriately designed clinical trials to identify the optimal level of protein provision in critical illness that can only be performed once one has an idea of the amount of protein actually delivered. As such, this study was undertaken as a baseline assessment of actual protein and energy delivery in a critical care unit where every attempt is made to achieve recommended targets.

Materials and methods

This was a retrospective, descriptive, observational study conducted over a 4-mo period (March 18, 2012–July 17, 2012) in the multidisciplinary ICU of a tertiary university hospital. Adults (age ≥18 y) discharged from the ICU or who demised on or after the first day of data collection were screened for eligibility. Exclusion criteria were Acute Physiology and Chronic Health Evaluation (APACHE II) score ≤10; nutrition therapy (NT) (enteral [EN] and/or parenteral nutrition [PN]) administered for ≤72 h; ICU length of stay ≤72 h; and patients with skeletal abnormalities, contractures, and spinal cord injuries. The latter were excluded as "recumbent length" (discussed later) is not an accurate indicator of height in these patients.

ICU charts of eligible patients were reviewed retrospectively to collect all relevant data from admission until discharge, discontinuation of NT, or death, for ≤7 d. Baseline data included age, sex, date and time of ICU admission, type of admission (medical versus surgical), primary admission diagnosis, time to initiation of NT, and route of feeding. Severity of disease was assessed using the APACHE II score on ICU day 1. Body mass index (BMI) was calculated according to anthropometric measurements (height and weight) charted by the dietitian. Height is routinely estimated according to "recumbent length" and dry weight by subtracting the estimated excess extravascular fluid (peripheral edema/ascites) [16]. Ideal body weight for men was determined by the calculation: height^2 (m) × 20 − 25. For women: height^2 (m) × 19 − 24. For obese patients (BMI ≥30 kg/m^2) the adjusted body weight (ideal body weight + 0.25 [actual body weight − ideal body weight]) was calculated. Total nutrient (protein and energy) delivery was recorded from ICU admission until study exit. This included all sources: EN, PN, glutamine supplementation, as well as non-nutritional energy sources (NNES) from crystalloids, colloids, propofol, and immunoglobulins. The ready-to-hang EN formulas used provided between 1 to 1.5 kCal/mL and 4 to 10 g protein/100 mL. PN was given in the form of all-in-one or three-chamber solutions. The decision as to which EN or PN solutions, or a combination of both, were used was made at the discretion of the attending dietitian.

Daily protein and energy targets, expressed in ranges (e.g., 1.3–1.5 g/kg protein and 25–30 kcal/kg), were standardized retrospectively relative to the European Society for Clinical Nutrition and Metabolism clinical practice guidelines [17,18]. The target was said to be met if delivery was >90% of the minimum and <110% of the maximum calculated target. Underfeeding was defined as delivery <90%, and overfeeding >110% of target. The outcome variables were mean percentage of target (i.e., mean daily protein and energy delivery relative to mean daily target), and cumulative protein and energy balance calculated for the entire study period.

To ensure validity of data recorded, all nursing staff was trained before data collection with regard to accurate charting of all relevant data. The unit clinical facilitator was trained and tasked to reinforce training on a regular basis to all nursing staff and to train all new staff introduced to the unit with regard to accurate recording on ICU charts.

Data are presented as means, medians, and ranges. The relationships between continuous response variables (such as mean percentage of target) and nominal input variables (such as sex) were analyzed using appropriate analysis of variance. Relationships between two continuous variables were analyzed with regression analysis and the strength of the relationship measured with Pearson or Spearman correlations if the continuous variables were not normally distributed. $P < 0.05$ represented statistical significance.

The study was conducted in accordance with the Declaration of Helsinki as revised in 1983 and with approval from the University of Stellenbosch Health Research Ethics Committee (reference S12/01/001), the University of the Witwatersrand Human Research Ethics Committee (reference M120240), and the hospital management. Waiver of informed consent was obtained based on the retrospective nature of the study. Data for analysis were anonymous.

Results

Seventy-seven of 309 (24.9%) consecutive admissions to the ICU were enrolled: 6 patients were excluded due to incomplete data or missing charts, leaving 71 for analysis. Figure 1 shows a detailed flow chart for the inclusion of study participants. The study participants' baseline characteristics are reported in Table 1. The distribution between men and women was fairly even, but varied between admission categories with more medical than surgical patients. On admission, the median BMI was 26.8 kg/m^2 (range 16.7–55.1 kg/m^2). Only 5.5% were classified as underweight (BMI <18.5 kg/m^2), 35.5% as normal weight (BMI >18.5 to ≤25 kg/m^2), 28% as overweight (BMI >25 to ≤30 kg/m^2), and 31% as obese (BMI >30 kg/m^2).

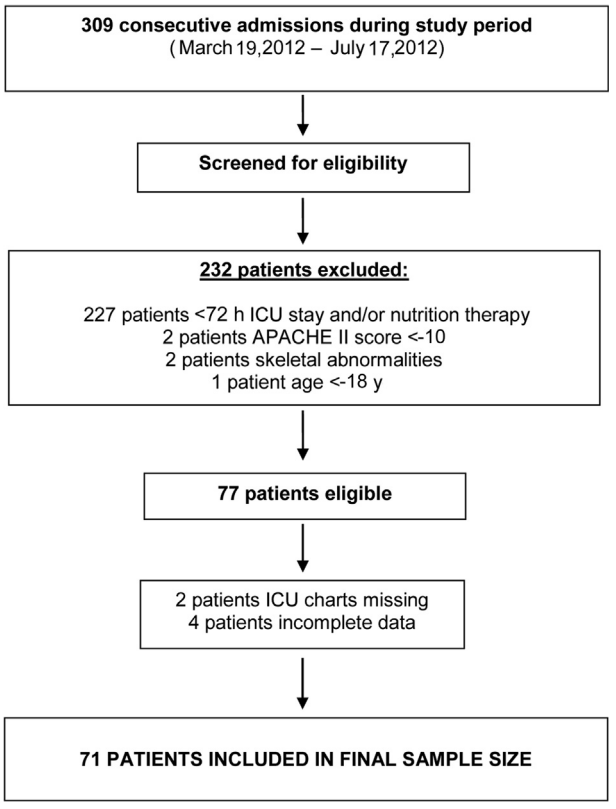

Fig. 1. Flow chart for inclusion of study participants. APACHE, Acute Physiology and Chronic Health Evaluation; ICU, intensive care unit.

NT was most commonly provided via the enteral route: 57 (80.3%) patients were fed via the enteral route alone, 10 (14.1%) received a combination of EN and PN, and 4 (5.6%) received PN alone. Total nutrient delivery was reviewed over a median of 6.3 d (range 3.5–7 d). NT was initiated within a median of 11 h (range 0–69 h) after admission to ICU. The median daily energy delivered was 1642 kcal (range 740–2619 kcal) (26 kcal/kg) (Table 2).

Total energy delivery was derived mostly from carbohydrate sources (51%), whereas lipid and protein sources contributed a further 31% and 18%, respectively. On average, NT contributed 92% (range 71%–100%) to total energy delivery, whereas the remaining 8% (range 0%–29%) was derived from NNES. The latter was mostly derived from carbohydrate-containing intravenous (IV) fluids. Median daily protein delivery was 75 g (range 21–135 g; 1.1 g/kg) (Table 2). The contribution of NNES to total protein delivery was negligible. Intravenous glutamine administration was considered a component of NT and contributed 11.7% (range 1.7%–49.1%) to total protein delivery (n = 16). This was mostly derived from glutamine-containing PN regimens (n = 13). Only three study participants received glutamine supplementation in the form of dipeptiven.