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Factors associated with not meeting the recommendations for micronutrient intake in critically ill children

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ABSTRACT

Objective: Children admitted to the intensive care unit (ICU) are at risk of not meeting their nutritional requirements. This study aimed to identify factors associated with failure to meet the dietary recommended intake (DRI) of zinc, selenium, cholecalciferol, and thiamine in critically ill children receiving enteral tube feeding during their stay in the ICU.
Methods: We analyzed prospectively 260 cases, corresponding to 206 patients who received enteral tube feeding for a minimum of 3 days up to 10 days during the first 10 d of ICU stay. Individual intake was compared to estimated average requirement (EAR) and adequate intake (AI) values during the first 10 d of ICU stay. The outcome variable was defined as not meeting the recommended intake of the micronutrients studied. Potential explanatory variables for the outcome were age <1 year, malnutrition (WHO), clinical severity scores, heart disease, severe sepsis or septic shock, use of alpha-adrenergic drugs, and renal replacement therapy (RRT). The effect of the explanatory variables on the outcome was analyzed by logistic regression analysis.
Results: The majority of patients did not meet the recommendations for micronutrients. After adjusting for covariates, age <1 year, malnutrition, heart disease, use of alpha-adrenergic drugs, and renal replacement therapy were associated with failure to meet the recommendations for at least one of the micronutrients studied.
Conclusions: Factors associated with failure to meet the recommendations for micronutrient intake in children receiving enteral tube feeding during their ICU stay are linked to patients' low weight, restriction in fluid intake, and clinical severity of the disease.

Introduction

Micronutrients play essential roles in intermediary and oxidative metabolism and in the immune function [1]. Patients hospitalized in intensive care units (ICU) are more prone to develop micronutrient deficiency due to hypermetabolism, decreased intestinal absorption, insufficient intake, loss from GI tract, skin, and the use of drugs [2–5]. In addition, deficiency in micronutrients may be preexistent, due to chronic disease-related malnutrition [6,7] or inadequate diet.

Zinc, selenium, cholecalciferol, and thiamine will be focused on in this study because of their particular importance in the ICU scenario. Deficiency of these micronutrients is a potential risk factor for morbidity and mortality and may be associated with an unfavorable outcome in patients with severe illnesses [8–12].

The diagnosis of micronutrient deficiency in severely ill patients is difficult, because under such conditions, low plasma concentrations do not necessarily indicate deficiency, being a result of the redistribution occurring during the systemic inflammatory response [2]. Furthermore, information obtained from clinical signs lacks sensitivity and specificity to diagnose deficiency.

The DRIs (dietary reference intakes) estimate the probability of adequate intake of nutrients in the apparently healthy

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population. Although the DRIs were not designed for individuals with medical conditions, they may be used as a guideline if adapted to specific situations [13,14]. Studies are few on the intake of micronutrients in critically ill patients, especially in the pediatric age group [15–18]. In hospitalized adults either in ICU or on a general medical ward, enteral intake for most micronutrients either surpassed [15] or was below [16] the recommendations. In a pediatric study, patients admitted to ICU received insufficient amounts of zinc, selenium, thiamine, and retinol while receiving enteral tube feeding [17]. However, we did not find studies on the factors associated with failure to meet the recommendations for micronutrient intake in severely ill pediatric patients.

Based on the hypothesis that critically ill pediatric patients receiving enteral nutrition do not meet recommendations (DRIs) for the micronutrients zinc, selenium, cholecalciferol, and thiamine during their ICU stay, we sought to identify the factors associated with this outcome.

Materials and methods

This prospective cohort study was carried out in a pediatric ICU classified as a level 1 according to published guidelines [19]. Patients admitted to ICU between June 2009 and January 2012 who received enteral tube feeding for a minimum of 3 days up to 10 days during the first 10 d of their stay were eligible to be included in the study. Those who received parenteral or oral nutrition only were not included. The study protocol was approved by the Federal University of São Paulo Institutional Review Board and was exempted from the informed consent requirement.

A multidisciplinary team followed patients during the entire period of hospitalization and feeding was preferably delivered by enteral route via a nasogastric or nasoduodenal tube [20]. Energy requirements were estimated according to the predicted basal metabolic rate [21], initially 25% to 50% of the total volume, and gradually increasing to reach 100% of this volume between the second and fourth day, according to the patient's tolerance [20].

Assessment of nutritional status

The anthropometric indicators weight/age (W/A), height/age (H/A), and body mass index/age (BMI/A) were compared to the growth standard of the World Health Organization (WHO) [22]. For children younger than 2 y, W/A and H/A were used; for children older than 2 y, H/A and BMI/A were used. Patients with anthropometric indicators in z-score below –2 were considered malnourished. WHO AnthroPlus version 1.0.4 (World Health Organization, Geneva, Switzerland) was used for the calculations.

Clinical assessment

The clinical severity on admission was assessed using the PIM2 score [23] and the Pediatric Logistic Organ Dysfunction score (PELOD) [24]. Inflammatory response syndrome, severe sepsis, and septic shock were defined according to the criteria established at the International Pediatric Sepsis Consensus Conference [25]. Heart disease was defined as congenital or acquired abnormality involving heart structures. Ventilator-free days were defined as the number of days alive and breathing without assistance from admission to day 28 of stay in the ICU. Subjects who did not survive to day 28 or who stayed in the ICU for 28 d or more were assigned zero ICU-free days. ICU-free days were defined as days not needing ICU care in the first 28 d after admission [26].

Dietary assessment

In this ICU, infant formulas, polymeric enteral diets, and lactose-free, oligopeptide, and elemental formulas are used according to the clinical indication. The dietary intake was quantified in the first 10 d of ICU stay, varying from 3 d to 10 d according to the length of ICU stay. The calculation of the intake of zinc, selenium, cholecalciferol, and thiamine was based on the nutritional information provided by the manufacturers.

DRIs (dietary reference intakes) are used to assess and plan individual and group nutrient intakes of healthy people and include the following four reference values: the estimated average requirement (EAR), the recommended dietary allowance (RDA), the adequate intake (AI), and the tolerable upper intake level (UL). In our study, individual intake was compared to EAR, which is the average amount of nutrient intake estimated to meet the requirements of one-half of the healthy individuals in a particular life stage and sex group [13,14,27].

The probability of adequate intake for each micronutrient [13,28] was calculated from a z-score as follows: z-score = (m–EAR)/SD, where m indicates average nutrient ingestion in analyzed days and SD indicates EAR standard deviation, calculated based on the coefficient of variation (CV) for the nutrient, which expresses the individual variation SD = CV × EAR. CV corresponds to 10% of the EAR value for zinc, selenium, cholecalciferol, and thiamine [13].

The adequate intake (AI) was used instead of EAR in the calculations of the micronutrients for patients under 1 y because there are no available EAR values for this age group. In this case, it is not possible to estimate the probability of inadequate intake. This approach only indicates if the patient attends AI or falls below the AI [13,28].

Study variables

The outcome was defined as not meeting recommendations for zinc, selenium, cholecalciferol, or thiamine during the first 10 d of ICU stay. A probability of adequacy below 98% of EAR or intake below the AI was considered as not meeting the recommendation. The following factors were considered as potential exposure variables: age <1 y, malnutrition on admission, severe sepsis or septic shock on admission, scores of clinical severity PIM2 and PELOD, medical or surgical condition, heart disease diagnosis, renal replacement therapy (dialysis), and use of alpha-adrenergic agents (defined as the use of dopamine ≥10 μg/kg/min, norepinephrine or epinephrine at least 24 h before or during enteral nutrition).

Statistical analyses

Data were summarized using frequencies and percentages, median and interquartile range (IQR). PIM2 and PELOD scores were analyzed as continuous variables, and age was categorized as age below 1 y. The effect of the explanatory variables on the outcome was analyzed by simple logistic regression or Pearson χ^2; variables with descriptive level lower than 20% ($P < 0.20$) were selected for inclusion in multiple logistic regression models. In the adjusted models, a cutoff of 5% ($P < 0.05$) was assumed to reject the null hypothesis. The results were expressed in odds ratio and 95% confidence intervals. Intercooled Stata 12.1 software (StataCorp LP, College Station, TX, USA) was used for the statistical calculations.

Results

Of the 777 cases admitted during the study period, 63 received enteral nutrition for <3 d, 92 received oral feedings only, 24 were nil orally, 24 received parenteral nutrition exclusively, and 291 had <3 d of ICU stay, giving a total sample of 283 cases, of whom 23 were excluded because of incomplete data. Two hundred sixty cases corresponding to 206 patients (some patients had more than one admission) were included in the study. Parenteral nutrition was administered to 11 patients for 6 d (IQR 4–8 d) and oral nutrition to 38 patients for 1 d (IQR 1–2 d) during the study period. Twenty-three patients (11.1%) died during the ICU stay. The main characteristics of the patients are summarized in Table 1. Recommendations for zinc were not reached in 153 (58.85%) cases and for selenium in 246 (94.62%) cases; regarding cholecalciferol and thiamine, recommendations were not reached in 246 (94.62%) and 133 (51.15%) cases, respectively.

Simple and adjusted logistic regression analysis for the variables associated with not meeting recommendations for zinc and selenium in the first 10 d of hospitalization are shown in Table 2. In the adjusted analysis, age <1 y, malnutrition, and use of alpha-adrenergic drugs were associated with not meeting recommendations for zinc, and age <1 y and renal replacement therapy were associated with not meeting recommendations for selenium.

Simple and adjusted logistic regression analysis for the variables associated with not meeting recommendations for cholecalciferol and thiamine in the first 10 d of hospitalization are shown in Table 3. In the adjusted model, malnutrition, heart disease, and renal replacement therapy showed significant association with not meeting recommendations for cholecalciferol, and age <1 y, and use of renal replacement therapy were