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Original article

Achieving energy goals at day 4 after admission in critically ill children; predictive for outcome?

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SUMMARY

Background & aims: Adequate nutritional intake is essential during pediatric intensive care admission. We investigated whether achievement of energy intake goals at day 4 after admission and route of nutrition were associated with improved outcome.

Methods: Observational study using prospectively acquired data. Patients receiving enteral and/or parenteral nutrition were included. The energy intake target range at day 4 after admission was 90–110% of resting energy expenditure +10%. Acute malnutrition was defined as weight-for-age <−2 SD. Clinical outcome measures were length of stay, days on ventilator, duration of antibiotics and number of new infections. Data as median (min–max).

Results: Of 325 subjects (age 0.14 (0.0–18.0) year), 19% were acutely malnourished upon admission. Median 86% of energy goals were administered via the enteral route. With enteral energy intake, 7% of patients were fed within the target range, 50% were fed below and 43% were fed above the target range. In a subgroup ($n = 223$) the acutely malnourished proportion at discharge (26%) was not significantly different from that upon admission (22%). Whether the energy intake was below, within or above the target range did not affect changes in clinical outcome, nor did the route of nutrition.

Conclusions: Acute malnutrition was highly prevalent upon admission and at discharge. With our nutritional protocol we achieved high rates of (enteral) energy intake. A high percentage of our population received enteral energy above the target energy range. However, there was no association between the amount of energy intake or route of nutrition and clinical outcome.

1. Introduction

The prevalence of acute malnutrition, defined as weight-for-age <−2 SD, at the pediatric intensive care unit (PICU) is up to 24% and has hardly improved over the past decades.[1] Additionally, poor nutritional support results in cumulative energy and protein deficits, which are associated with deteriorated anthropometrics at discharge.[2] Furthermore, malnutrition is associated with increased morbidity and mortality in critically ill children.[3] It follows that adequate nutritional intake is essential in critically ill children. However, energy and protein requirements are not clearly defined and differ among guidelines.[4,5] Energy requirements for critically ill children are considered to be at resting energy expenditure as measured with indirect calorimetry, although there are indications that total energy expenditure is somewhat higher due to physical activity.[6] Enteral nutrition administration is the route of preference. As such, Mehta et al. recently showed that in ventilated children during 10 days of PICU admission a higher average percentage of goal energy intake via enteral nutrition was associated with a lower 60-day mortality, whereas this association was not found with total energy intake including parenteral nutrition.[7]

Abbreviations: BW, body weight; EN, enteral nutrition; EN & PN, combined enteral and parenteral nutrition; PDMS, patient data management system; PICU, pediatric intensive care unit; PN, parenteral nutrition; REE, resting energy expenditure; SDS WFA, SD-score for weight-for-age.

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However in the latter study on average only 51% of prescribed energy intake were delivered.[7] This underlines the difficulty to achieve adequate nutritional intake in the PICU, to which fluid restrictions and interruptions for interventions contribute. Apart from feeding protocols,[8–10] protein-energy enriched formulas may help to improve protein and energy balances, as we have previously shown.[11,12] In our center we use both measures to achieve high energy and protein intakes as early as day 2 after admission.

In the Netherlands the government assesses quality of health care with performance indicators. One of these assesses the proportion of malnourished hospitalized children in general wards and the PICU that achieves intake goals at day 4 after admission. In the current observational study we determined whether patients achieved their energy goals at day 4 after PICU admission and whether this was associated with improved clinical outcome as compared to patients who were fed below or above energy goals. Furthermore, we evaluated whether the route of nutrition (parenteral and/or enteral route) affected clinical outcome.

2. Material and methods

2.1. Patients and setting

Eligible subjects were all patients (both ventilated and non-ventilated patients) admitted to the Intensive Care of Erasmus MC – Sophia Children's Hospital, Rotterdam, the Netherlands, in a 20-month period (January 2008–August 2009) with a minimal length of stay of 4 days and receiving enteral nutrition (EN) and/or parenteral nutrition (PN). Patients with oral food intake other than breast milk or formula were excluded, because energy intake cannot be accurately calculated. Patients were classified by age as: newborns, 0–≤28 days; infants, >28 days–<1 year; children, ≥1 year. Because of the non-invasive character of the study and restriction to prospective dataset analysis, the local medical ethical review board waived the need for medical ethics review and informed consent.

2.2. Nutritional protocol

On admission glucose is provided by maintenance infusion at 4–6 mg/kg/min in children <30 kg body weight (BW) and 2–4 mg/kg/min ≥30 kg BW. Nutrition is introduced within 8 h after admission; the route of nutrition is determined with an algorithm (Fig. 1). The preferred route is EN via transpyloric tube. Children and ventilated newborns and infants receive age specific enteral formulas (1 kcal/ml; protein-energy ratio of ~10–11 energy%); non-ventilated newborns and infants receive fortified breast milk or concentrated standard infant formula (~0.8 kcal/ml). PN is provided when EN is contra-indicated or not tolerated and weaned when EN is tolerated. Our pharmacy provides customized age/weight specific PN compositions in individual containers; Intralipid® (Fresenius Kabi, Bad Homburg, Germany) is the standard fat component.

2.3. Intake goals

The energy goal on day 4 after admission to the PICU was set as: REE +10% where REE is calculated with the BW-based Schofield formula.[13] The factor 10% was used to correct for physical activity, since there are indications that REE underestimates total energy expenditure in critically ill children.[6] Margins of ±10% of the energy goal were used to define the target energy intake range, i.e. 90–110% of (REE + 10%). These margins were chosen because it has been shown that predicted REE is often over- or underestimated as compared to REE measured with indirect calorimetry.[14,15]

2.4. Data collection

Data of subjects were retrieved from the electronic Patient Data Management System (PDMS). In PDMS prospectively acquired data are stored on, among others, continuous physiologic parameters, interventions, mechanical ventilation and administration of all medication and nutrition. Additional data, e.g. diagnoses, were collected from medical records.

2.5. Nutritional intake

Total energy intake as provided by parenteral nutrition, enteral nutrition and/or IV maintenance at day 4 after admission was compared with the energy goal. Also enteral energy intake was compared with the energy goal. Patients were grouped by energy intake as: intake below the target range, intake within target range or intake above the target range for both total energy intake and enteral energy intake. The proportion of patients receiving energy intake within the target range via the enteral route was the primary outcome measure. Protein intake and the protein-energy ratio (%) were also recorded.

Patients were also grouped by route of nutrition, i.e. EN, PN and EN & PN. Patients who received maintenance infusion besides EN were assigned to the EN-group if ≥ 50% of total energy intake were provided via the enteral route; if <50% of total energy intake to the EN & PN-group. Also, EN combined with intravenous amino acids and/or intravenous fat was classified as EN & PN.

2.6. Anthropometrics

Data on weight upon admission and discharge were collected. SD-scores (SDS) for weight-for-age (WFA) were determined using the software Growth Analyser 3 (Dutch Growth Research Foundation, Rotterdam, the Netherlands), with Dutch growth charts for term children >2 weeks of age[16] and for children <42 weeks gestational age.[17] SDS WFA of children born <37 weeks gestational age was corrected for prematurity until 2 years of age. Acute malnutrition was defined as <−2 SDS WFA. SDS >+2 WFA was not included in mal nutrition. Difference in SDS WFA between admission and discharge, corrected for length of stay, was a secondary outcome measure.

2.7. Clinical outcome

Severity of illness was assessed by Pediatric index of mortality score 2 (PIM2),[18] and Pediatric risk of mortality score III (PRISM III) upon admission.[19] For both, higher scores indicate more severe illness. Secondary clinical outcome measures were: number of days until discharged alive, number of days on ventilator after day 4, number of days on antibiotics after day 4, number of new infections after day 4. Mortality was recorded, but not used as outcome measure, because it requires very large sample sizes. New infections were determined as a positive culture; a note of a suspected new infection in PDMS or medical records and/or taking of specimens for culture; start of antibiotics or a switch in antibiotics in combination with a rise in C-reactive protein. New infections were classified as proven by positive culture or suspected. The (suspected) site of infection was classified as bloodstream, airway, wound or other (e.g. abdominal, urinary tract), as deduced from definitions of nosocomial infections by the World Health Organization.[20] We compared outcome variables between the different energy intake groups, as well as between the groups classified by route of nutrition.

2.8. Statistical analysis

Data were analyzed using SPSS 17 for Windows, Microsoft (IBM, Armonk, NY, USA). Continuous variables are described as median

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