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Original article

Effects of implementation of a computerized nutritional protocol in mechanically ventilated critically ill patients: A single-centre before and after study

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SUMMARY

Introduction: Optimal nutrition, defined as adequate intake of energy, macronutrients -especially proteins- and micronutrients impacts on outcome of patients admitted to the Intensive Care Unit (ICU). However, both nutrition below and over target have been associated with increased morbidity and mortality. Computerized nutrition protocols may help to improve nutrition adequacy. In July 2014 a computerized nutritional protocol was implemented in our ICU. We designed a study to address the effects of this protocol implementation on energy and protein adequacy and outcome.
Methods: A retrospective pre-post analysis of nutrition adequacy in adult mechanically ventilated critically ill patients before and after the implementation of an electronic nutritional protocol to initiate feeding and with hourly feedback. Primary outcome was adequacy of total caloric intake from day 2–7, secondary outcomes were adequacy of protein intake, clinical outcome results (length of ICU and hospital stay, ICU and hospital mortality, duration of tube feeding, duration of mechanical ventilation, number of patients with parenteral nutrition), and glucose and electrolyte abnormalities.
Results: In total 146 patients were included (73 patients before and 73 patients after implementation). Before implementation we encountered more patients who were fed above target (actual caloric intake >110% of target) than after implementation (during day 2–7: 12% vs. 3%, $P = 0.029$) without significant reduction of protein intake (daily means during day 2–7: 1.18 g/kg vs. 1.08 g/kg, $P = 0.09$). Only on day 6, significantly more patients were fed on target after implementation (80–110%; 47% vs. 67%, $P = 0.028$). No differences in numbers of patients who were fed below target (<80%) were found. Numbers of patients with hypokalaemia after implementation (59% vs. 38%, $P = 0.013$) were lower. The incidence of electrolyte abnormalities (hypernatraemia, hyponatraemia and hypokalaemia) was lower after implementation, however hypomagnesaemia incidence increased. No statistical significant differences in clinical outcome were observed.
Conclusions: The implementation of an electronic nutritional protocol to initiate feeding with hourly feedback in our ICU reduced the rate of mechanically ventilated patients fed above target without reducing protein intake or increasing the rates of feeding below target, while reducing the incidence of electrolyte abnormalities. No statistical significant differences in other clinical outcomes were observed.

1. Introduction

Optimal nutrition, defined as adequate intake of energy, macronutrients – especially proteins – and micronutrients impacts on outcome of patients admitted to Intensive Care Unit (ICU). However, both feeding below and above target have been associated with increased morbidity and mortality. Feeding below target in critically ill patients is associated with more complications, such as impaired wound healing, new infections and higher rates of all-cause mortality [1–4].

Feeding above target is associated with increased insulin resistance and infectious morbidity [5]. Exceeding the target by more than 10% assessed by indirect calorimetry was related to higher

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mortality (odds ratio of 1.6) [6]. Both feeding below and above target are linked to increased ICU length of stay (LOS), at least partly due to longer duration of mechanical ventilation (MV) [2,5]. Therefore the best feeding strategy is to feed on target (80–110% of targeted energy intake). Slight underfeeding 80–90% of energy target is probably the optimum, however protein intake should at least achieve targets of 1.2 g/kg per day [5,7–9].

In order to prevent both feeding below and above target while preserving protein intake we developed a computerized nutrition protocol to initiate feeding and with hourly feedback of energy and protein intake from feeding calories and non-nutritional calories such as glucose infusion, propofol and citrate renal replacement therapy (trisodium citrate). Computerized nutrition protocols have proven to improve nutrition adequacy with nutrient delivery closer to the energy target [10]. In many hospitals, feeding on target is a responsibility of the dietitian. However, dietitians are not always available. Therefore, nutritional support is not always timely and adequate. Moreover, it is difficult to assess non-nutritional caloric intake from propofol, glucose infusion and trisodium citrate frequently and adjust feeding accordingly.

In July 2014 the nutrition protocol to initiate feeding and with hourly feedback was implemented in the clinical information system of our ICU. We designed a retrospective pre-post study to address the effects of implementation of this protocol on energy and protein adequacy, electrolyte abnormalities, glucose regulation, workload and outcome.

2. Methods

2.1. Study design

This study is a retrospective pre-post analysis in a mixed medical-surgical ICU in a tertiary university-affiliated teaching hospital (Gelderse Vallei Hospital, Ede, the Netherlands). On July 1st, 2014 a computerized nutritional protocol was implemented. Two weeks before and two weeks after implementation was considered the wash in and wash out period (June 17th – July 15th, 2014) and in this period patients were excluded.

2.2. Patient population

Inclusion criteria were adult mechanically ventilated critically ill patients (≥18 years and ventilated for at least 72 h) receiving enteral and/or parenteral feeding. Exclusion criteria were readmission during the same hospital stay, oral feeding or oral feeding commenced during the first 7 days of ICU-admission. Patients discharged to other hospitals also were excluded. We decided to select as many patients before implementation as patients that were eligible after implementation until April 2015.

Baseline characteristics before and after implementation were listed; age at admission, gender, primary admission diagnosis, baseline APACHE-II and SOFA-scores, several baseline blood tests, sepsis (yes or no), admission type (medical, elective and non-elective surgery), comorbidities, Malnutrition Universal Screening Tool (MUST) score of 2 or more, Nutrition Risk in Critically ill (NUTRIC) score [12] and percentage of patients who received non-nutritional calories (glucose infusion (5% or more), propofol and renal replacement therapy with trisodium citrate).

2.3. Intervention

In both periods the target of the energy intake was calculated with the FAO/WHO/UNU formula [11], before implementation by the dietitians, after implementation by the computerized protocol. Protein targets were calculated similarly and according to the ASPEN guidelines, aiming at a minimum intake of 1.2 g/kg per day [5]. Before the implementation of the computerized nutritional protocol, dietitians checked the actual intake and set targets for all ICU patients. Physicians, nurses, dietitians and other disciplines reviewed these values during daily multidisciplinary consultations (MDC). Non-nutritional caloric intake was not taken into account; only incidentally large amounts of propofol and glucose infusion were included into calculations. Calories from citrate renal replacement therapy were not included.

After protocol implementation, dietitian consultations during the MDC remained, however the underlying formulas were simultaneously implemented in the gastro-intestinal subsystem of our Patient Data Management System (PDMS; iMDsoft MetaVision®, Tel Aviv, Israel) and can be retrieved by ICU nurses and physicians instantly (example in Fig. 1). Feed selection, protein supplement amounts and infusion rates are suggested by the computer system on ICU admission. During feeding calculations also take into account the non-nutritional caloric intake of propofol, glucose infusion and trisodium citrate. The actual intake (both nutritional and non-nutritional) and the targets per hour (total target divided by 24 h times full hours that have passed) are available in the system, providing hourly feedback. After implementation the role of dietitians changed in such a way that they were only involved in monitoring, protocol development, and for other dietary recommendations as initiation calculations were performed by the computer. Furthermore, in selected patients they recalculated computer recommendations for reasons of safety.

2.4. Outcomes

Primary outcome was the adequacy of mean daily caloric intake (kcal/day) from day 2–7. We measured intake on day 1 as secondary endpoint as typically enteral nutrition is started and gradually increased to full support.

We defined an actual total daily caloric intake of 80–110% of the calculated energy target as feeding on target (calculated as actual caloric intake divided by the target intake), <80% of the energy target as feeding below target, and >110% as feeding above target [6]. We listed actual and target intake for 7 days after ICU admission for all included patients, excluding data from the ICU discharge day as progression to oral and early interruption before discharge precludes optimal analysis [3]. The target intake on day 1 (day of admission) was adjusted for the actual admission hours.

The most important secondary endpoint was protein adequacy. For protein adequacy we report the actual protein intake in grams per kg of body weight during day 2–7 of ICU admission. We aimed for a daily protein intake of 1.5 g/kg per day according to the protocol and considered an intake of 1.2 g/kg per day acceptable. Weight of patients with a Body Mass Index (BMI) of 27 kg/m^2 or more was adjusted to the weight for a BMI of 27 kg/m^2. Similar to calories, the admission day was adjusted for the actual admission hours to ICU and the day of discharge was excluded.

Other secondary endpoints included the following clinical outcomes: ICU LOS (days), hospital LOS (days), duration of MV (days); duration of tube feeding (TF, days), number of patients with (supplemental) parenteral nutrition (PN) and ICU and hospital mortality.

Additionally we looked at hypoglycaemia (blood glucose concentrations of <4 mmol/L (<72 mg/L)), hyperglycaemia (blood glucose concentration of >10 mmol/L (>180 mg/L)) and electrolyte abnormalities: sodium concentrations of <135 or >145 mmol/L (<135 mEq/L or >145 mEq/L), potassium concentrations of <3.5 or >4.7 mmol/L (<3.5 mEq/L or >4.7 mEq/L), phosphate