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Original article

The impact of early enteral nutritional on pediatric acute respiratory failure

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SUMMARY

Background and aims: Children who are critically ill undergo metabolic stress and it is important that they receive adequate calories and protein in order to recover. Our objective was to investigate the impact of early enteral nutrition (EEN) on pediatric intensive care (PICU) patients with acute respiratory failure.

Methods: A retrospective cohort study was performed on all patients admitted to a 20 bed PICU at a tertiary children's hospital over a 30 month period. Inclusion criteria were: intubation on admission or within 24 h of admission, ventilation over 48 h and enteral nutrition initiated on ventilatory support. Baseline patient and nutritional, ventilatory and overall outcome data were collected. Subgroup analysis was performed comparing those that received EEN (goal in 72 h) and those that did not.

Results: Patients that received EEN had a shorter PICU and overall LOS (8.7 vs 10.7 and 17.5 vs 22; $p < 0.05$) and received a higher percentage of goal Kcal and protein (71 vs 54, and 61 vs 51%, $p < 0.002$) in the PICU. After adjusting for age and severity of illness, EEN was still associated with decreased PICU and overall LOS. More patients with feeding intolerance were on vasoactive agents (33 vs 9%, $p = 0.02$), but intolerance was not associated with use of motility agents or degree of respiratory failure. Feeds were interrupted in 19% of patients, most commonly for procedures.

Conclusions: In PICU patients with acute respiratory failure, EEN is associated with shorter PICU and overall LOS and delivery of higher percentage of goal Kcal and protein by tube feeds. Feeds are commonly interrupted despite efforts to achieve EEN and patients receiving vasoactive agents have feeds held more commonly for perceived intolerance.

1. Introduction

Malnutrition is common in patients admitted to the PICU and one recent review found that it affects 50% of hospitalized pediatric patients [1]. Patients who are critically ill are at high risk for energy and protein imbalances due to inflammatory responses, catabolic processes, and increased metabolic demands [2]. Pediatric malnutrition increases risks for complications, death, length of stay (LOS), and healthcare costs [3–8]. During metabolic stress it is important that patients receive adequate calories and protein for metabolic support to prevent malnutrition and promote healing. However, many circumstances in the PICU inhibit this process.

There is emerging evidence on the importance of EEN in critically ill children and that has been highlighted in recently updated nutritional guidelines [9]. Two multicenter studies demonstrated that EEN is associated with survival in critically ill children [10,11]. Although one of those studies included only mechanically ventilated patients, there is still limited data on whether EEN is beneficial to PICU patients with acute respiratory failure. A very recent study found for the first time that EEN was associated with improved survival in PICU patients with acute respiratory distress syndrome (ARDs), but was not associated with decreased length of mechanical ventilation (LOV) [12].

We previously demonstrated success in feeding a select portion of our critically ill PICU patients [13]. As a follow up to our prior study, we trialed a feeding protocol that demonstrated protocol patients reached full feeds sooner without added complications [14]. Based on that study, an algorithm was created for our PICU to

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facilitate early enteral feeding. The purpose of this study was to investigate the impact of EEN on LOV and LOS in PICU patients with acute respiratory failure. We hypothesized that reaching prescribed calories and protein within 72 h of PICU admission would be associated with reduced LOV and PICU LOS.

2. Materials and methods

Approval was obtained from the hospital institutional review board and the need for informed consent was waived. A retrospective cohort study was performed on all patients admitted to a 20 bed PICU at a tertiary children's hospital over a 30 month period. The inclusion criteria were: age 37 weeks to 21 years of age, intubation on admission or within 24 h of admission to the PICU, length of mechanical ventilation greater than 48 h and exclusively enterally fed while on mechanical ventilation and in the PICU. Exclusion criteria included: patients that received parenteral nutrition, post-operative abdominal or cardiac surgery, already on nutrition support at time of admission to the PICU, and chronically ventilated patients.

Patients were identified from our PICU database that is part of the Virtual Pediatric Systems (LLC) database and then data was abstracted from chart review that included: patient's age, sex, PICU LOS, hospital LOS, LOV, admission weight, admission height, admission BMI, pediatric risk of mortality (PRISM 3) score, vasoactive inotropic score (VIS), prescribed calories, prescribed protein, formula order, and daily volume of formula received. Mechanical ventilator parameters including mean airway pressure (MAP), positive end expiratory pressure (PEEP), $Fi0_2$, and arterial blood gas and pulse oximeter saturations were also recorded. Previously described methods were used to calculate oxygenation index (OI), $Pa0_2/Fi0_2$, $S0_2/Fi0_2$ and oxygen saturation index (OSI) [15]. The PRISM 3 scoring system was defined in 1996 and contains 17 physiologic variables subdivided into 26 ranges [16].

The registered dietician utilized a feeding protocol based on our previous work [14]. Patients less than 1 year were started on 24 kcal formula or breast milk at 5 ml/h and advanced by 5 ml every 2 h to a goal feeds, 1–9 years old standard 30 kcal formula at 10 ml/h and advanced by 10 ml every 2 h to goal and children greater than 9 years of age were started on standard 30 kcal formula at 15 ml/h and advanced by 15 ml every 2 h to goal. The prescribed calories and protein were calculated by the registered dietitian in the PICU following our institutional policies and procedures. Prescribed calories were determined using the World Health Organization (WHO) equation to estimate resting energy expenditure (World Health Organization, 1985). Prescribed protein was determined using the A.S.P.E.N. pediatric critical care guidelines [17]. The calories and protein each subject received were calculated using the total volume of formula delivered each day and the formula product received for that day. Each formula has specific calorie and protein content defined per milliliter of formula. Nutrient content of formulas was obtained from the formula companies at the end of the data collection.

Nutrient intake data was recorded until enteral feeding was discontinued, patient transferred or patient expired. Days to reach prescribed calories or protein were calculated as the total number of days from PICU admission date until the first date prescribed calories or protein was reached. Percentage of prescribed calories/protein received was calculated as total calories/protein each patient received divided by the prescribed calories/protein times days on enteral feeds. Early enteral nutrition (EEN) was defined as 80% of goal prescribed calories or protein within 72 h of PICU admission.

Data was analyzed using Statistical Package for the Social Sciences, PASW Statistics for Windows, Version 18.0. Chicago: SPSS Inc. Continuous variables were analyzed by Mann Whitney U testing (non-normal distribution) or student's T test (normal distribution) and categorical variables by Chi square test and $P \leq 0.05$ was considered statistically significant. Multivariate analysis was performed for the variables of early enteral nutrition, age, VIS, PRISM 3, $S0_2/Fi0_2$. Estimates and tests of significance based on poisson regression analyses (additional specification of contrast comparison for categorical factors and Wald Chi-square test in Poisson regression).

3. Results

One hundred and six patients with a median age of 9.5 months were included in this study and the overall mortality was 2.8%. Overall, 7.5% of the patients had moderate to severe wasting on admission, but this was not associated with any worse clinical outcome measure. The patients received 66% of goal Kcal and 56% of goal protein by tube feeding while in the PICU and 55% of patients received EEN while on mechanical ventilation.

Patients that received EEN were younger (4 vs 25.5 months, $p = 0.007$), had a shorter PICU LOS (8.7 vs. 10.7 days, $p < 0.05$) and overall hospital LOS (18 vs. 22 days, $p = 0.015$). They also received a higher percentage of goal Kcal (71 vs 53%, $p < 0.001$) and protein (60 vs 51%, $p = 0.002$) while in the PICU. There was no difference in mortality or length of ventilation between those who received EEN and those who did not. There was also no difference in PRISM 3, VIS, worst $S0_2/Fi0_2$, OSI, incidence of feeding intolerance, complications or admission weight Z scores (Table 1).

Multivariate analysis demonstrated that patient age less than 2 years of age, VIS score of 0 and EEN were all associated with decreased PICU LOS and LOS. PRISM 3 score less than 10 was associated with decreased overall LOS (Table 2). When adjusting for age, VIS, PRISM 3, and $S0_2/Fi0_2$, EEN remained associated with decreased average PICU LOS (10.7 [9.8–11.5] vs 12.9 [11.9–14.0], $p = 0.001$) and hospital LOS (22.0 [20.8–23.3] vs 28.7 [27.1–30.3], $p < 0.001$) (Fig. 1).

A total of 14% of patients had feeding intolerance causing feeds to be held. There was no association between the use of motility agents and feeding intolerance or degree of respiratory failure. However, more patients on vasoactive agents had feeding intolerance (33 vs 9%, $p = 0.02$). Feeds were interrupted 57 times and in 19% of the patients, most commonly for procedures.

Table 1
Characteristics of patient population.

Parameter	EEN (n = 58)	No EEN (n = 48)	P value
Sex (male)	38 (66)	29 (60)	0.558
Age (months)	4 [1.0,17.0]	25.5 [2.0,144.5]	**0.007**
Admit weight Z score	0.56 [-0.9,1.8]	0.56 [-0.5,1.6]	0.504
PRISM 3	5 [3.0,9.0]	5.5 [1.0,11.5]	0.818
Vasoactive agents	10 (17)	12 (25)	0.459
Worst $S0_2/Fi0_2$	193 {62}	185 {64}	0.559
Oxygen Saturation Index	5.8 [4.0,8.6]	6.1 [4.2,9.1]	0.462
LOV (days)	5.8 [4.0,7.7]	5.9 [4.1,10]	0.64
PLOS (days)	8.7 [6.2,11.7]	10.7 [7.5,17]	**0.049**
LOS (days)	18 [11,24]	22 [14,39]	**0.015**
% Prescribed Kcal	71 [64.4, 82.6]	53 [38.8–69.1]	**<0.001**
% Prescribed Protein	60 [50.4,82.7]	51 [31.3–67.9]	**0.002**
Intolerance	6 (10)	9 (19)	0.339
Transpyloric tube	13 (22)	8 (17)	0.621
Viral PNA/Bronchiolitis	23 (40)	17 (35)	0.805
TBI	6 (10)	7 (15)	0.715
Sepsis	6 (10)	4 (8)	0.985

Data presented as median [interquartile range], mean {standard deviation} or count (percentage). Percentage of goal Kcal and protein received is that received by tube feeds in PICU based on RD recommended goal.
Bold indicates statistical significance with p value < 0.05.

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