Original article

Impact of energy deficit during hospitalization and biomarkers at admission on clinical outcomes in critically ill children: A longitudinal study

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SUMMARY

Background & aims: To evaluate the impact of energy deficit during hospitalization and the biomarkers albumin and C-reactive protein (CRP) on the clinical outcomes length of stay (LOS) and duration of mechanical ventilation (DMV) in children and adolescents admitted to the pediatric intensive care unit (PICU) of a private hospital in Rio de Janeiro.
Methods: A longitudinal, retrospective study was conducted of the medical records of patients admitted to the PICU from May 2016 to June 2017 who received enteral nutrition (EN) for 72 h or longer. The cut-off points for serum albumin and CRP were set at ≥ 3.5 and <2.0, respectively. The energy balance was calculated as the difference between the energy prescribed and the energy received by the patient. The comparison of continuous variables related to LOS and DMV was assessed using Student's t-test and the Mann—Whitney test. The significance value was set at $p < 0.05$.
Results: Ninety-three patients were selected, with a median age of 32 (± 39.49) months. The mean serum albumin and CRP levels were 4.04 (± 0.59) and 4.67 (± 7.40), respectively. In linear regression models adjusted for length of stay, reduced albumin, increased CRP, and negative energy balance were positively associated. In the models adjusted to DMV, the values for reduced albumin and increased CRP were significant.
Conclusion: A significant association was found between serum albumin and CRP at admission and the outcomes under investigation, LOS and DMV. Energy deficit was also associated with LOS.

1. Introduction

In pediatric intensive care units (PICUs), enteral nutrition (EN) is often chosen as a feeding route because of its recognized role in the treatment of critically ill patients, when it is preferred over

parenteral nutrition [1,2]. The equations that are most widely used to calculate nutritional needs in EN the ones proposed by Schofield [3] and Holliday and Segar [4—6]. To define protein needs, researchers and practitioners follow the ASPEN recommendation of 1.5 g/kg/day for critical children and adolescents [1,6—11], although some authors suggest protein intake of over 2.5 g/kg/day [12].

Laboratory parameters, such as albumin, transferrin, pre-albumin, and C-reactive protein (CRP), are routinely measured in hospitals and can be used to supplement the nutritional evaluation of critically ill children [7,12—14].

In critical patients, drops in plasma albumin concentrations may be caused by decreased liver synthesis, increased degradation, and/or capillary leakage caused by infection or inflammation.

Nevertheless, this protein is used as a marker of nutritional status, and some authors have found results relating hypoalbuminemia to worse clinical outcomes [13,15,16].

CRP is often measured on admission because it is a marker of acute inflammation. This biomarker has not been shown to be effective in the prognosis of critically ill children, and researchers have recommended further investigation of this relationship in the PICU setting [17,18].

A high percentage of critical pediatric patients on EN receive a lower calorie and protein intake than recommended and pre- scribed for them, and consequently lose weight and become malnourished during their stay in the PICU. Several studies have shown that when patients' nutritional status is impacted by calorie and protein deficits, this has a negative impact on their outcomes [1,10,11,13,19,21].

Although some authors have shown, by comparing the pre- scribed and actual dietary intake of patients, that a negative energy and protein balance is common in PICUs, there are few results in the literature on the effect of such deficits on two specific clinical outcomes: length of stay (LOS) and duration of mechanical venti- lation (DMV).

The aim of the study was to evaluate what impact an energy deficit throughout hospitalization and albumin and CRP measured on admission have on LOS and DVM in patients in a PICU.

2. Materials and methods

2.1. Study design, population, and sample

A retrospective longitudinal study was conducted of children and adolescents admitted to a private PICU in Rio de Janeiro, Brazil, who received EN during hospitalization. The sampling method chosen was non-probabilistic, meaning that all the eligible patients in the 14 months prior to the beginning of data collection were included.

2.2. Eligibility criteria

Patients of both sexes aged between 1 month and 16 years on exclusive EN who were admitted to the PICU under study were included. The exclusion criteria were: patients with exclusionary diseases, patients receiving palliative and/or end-of-life care, pa- tients with less than three days' stay in the PICU, and patients who died within 48 h of admission.

2.3. Data collection

Data for up to 60 days per patient were collected from paper files with the aid of a data collection instrument developed for the research.

2.4. Anthropometric evaluation

For the nutritional status evaluation, weight, height and body mass index (BMI) data were collected and the following ratios were calculated for the classification: weight/age, weight/height, and BMI/age.

Subsequently, the z-score was calculated using the software of the WHO Anthro and AntrhoPlus: Anthro for children up to 5 years of age and AnthroPlus for patients between 5 and 18 years of age, version 3.2.2 [22].

2.5. Laboratory evaluation

The variables used included serum albumin and CRP, which were determined by colorimetric assay and immunoassay, respec- tively. The results of all the exams requested within 60 days of admission to the PICU were collected.

2.6. Calculation of nutritional needs

The equation proposed by Holliday and Segar was used to es- timate energy requirements [4].

In order to estimate protein requirements, the ASPEN [5] rec- ommendations were used, which range from 3 to 4 g/kg/day for children under 1 year of age with low birth weight to 2–3 g/kg/day for children under 1 year of age, and 1.5 g/kg/day for seriously ill children and adolescents.

2.7. Nutritional therapy

For nutritional therapy (NT) monitoring, data on the type of catheter used (gastrostomy or nasoenteric tubes), NEC (gastric or enteric) positioning, the start date of NT, type of enteral formula (polymeric, oligomeric, or elemental), the prescribed and admin- istered volume of EN, the type of administration (intermittent or continuous), duration of NT, the reason for EN suspension, fasting time, and time taken to reach target energy intake were collected and evaluationed.

2.8. Clinical evaluation

Patients' risk was classified by the medical team at the time of admission according to the severity of the disease using the Pedi- atric Risk of Mortality (PRISM [23]) score and the Pediatric Index of Mortality 2 (PIM 2 [24]) score. We also collected the number of days the patients were on mechanical ventilation and the patients' main diagnoses upon hospitalization.

2.9. Variables

2.9.1. Independent variables
Weight, height, and BMI were evaluated continuously and categorically.

CRP was evaluated continuously and categorically, and its reference value was set at <2 mg/dL.

Serum albumin was evaluated continuously and categorically, and its reference value was set at ≥3.5 g/dL.

Assessment of severity was based on PRISM and PIM 2, as recorded in the PICU database by the pediatric intensivist physi- cian; the data are expressed in points.

Cumulative energy deficit was obtained by calculating the difference between estimated energy needs and the energy in the NE received by the patient, and was expressed as an average [5].

Cumulative Protein Deficit was obtained by calculating the difference between estimated protein requirements and the pro- tein in the NE received by the patient, and was expressed as an average [5].

2.9.2. Dependent variables (clinical outcomes)
Length of stay (LOS) was defined by the number of days of hospitalization, from admission to discharge from the PICU.

Duration of mechanical ventilation (DMV) was defined as the number of days of ventilatory support during the stay in the PICU.

2.10. Data analysis

The data obtained were inputted into the statistical program Statistical Package for the Social Sciences (SPSS) for Windows, version 21.0. In the description of the sample, descriptive statistics were calculated for the data according to the nature of the variables under study.

The means/medians of the continuous variables related to LOS and DVT were compared using Student's t-test and the Mann–Whitney test, according to the distribution of the variables. For the categorical variables, statistical association was verified by the chi-square test and Fisher's exact test, according to the frequencies in the contingency tables.

Additionally, the linear regression models were adjusted. Simple linear regression models were used to estimate the crude effect of each covariate on the study outcomes. Later, in order to estimate the effect adjusted by the variables considered important by either statistical or clinical criteria, a multiple linear regression model was used. The explanatory capacity of the models was measured by the coefficient of determination (R^2). A residue analysis was also performed for each multiple regression model. The level of significance adopted in all the analyses was 0.05.

2.11. Ethical considerations

The research was conducted in accordance with the standards set forth in Brazilian National Health Council (Conselho Nacional de Saúde) and received approval from the Research Ethics Committee of Instituto D'Or de Pesquisa e Ensino (protocol 63829317.5.0000.5249) on January 26, 2017.

3. Results

The medical records of 93 patients who received EN in the PICU and fitted the eligibility criteria were included (Fig. 1). Of this total, 49 patients (52.7% of the sample) were female, with a mean age of 32 months. Despite being a mixed unit, most of the patients had
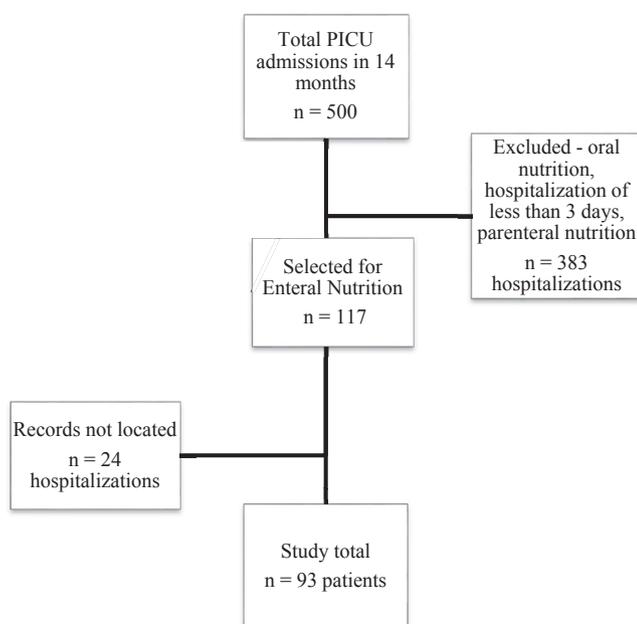

Fig. 1. Sample flowchart.

Table 1
Characteristics of the population sample in the private PICU (pediatric intensive care unit) in Rio de Janeiro.

Variables	Average (interquartile range)/% (n)
Age (months; n = 93)	32.4 (26.5)
Sex (n = 93)	
Female	52.7 (49)
Male	47.3 (44)
Weight (kg; n = 92)	12.4 (6.2)
Height (cm, n = 29)	80.9 (23.8)
Diagnosis during hospitalization (n = 91)	
Respiratory insufficiency	70.3 (64)
Sepsis	9.9 (9)
Hematological cancer	3.3 (3)
Solid tumors	2.2 (2)
Post operative	1.1 (1)
Others	13.2 (12)
Albumin on admission (g/dL; n = 71)	4.0 (0.8)
CRP at admission (mg/dL; n = 85)	4.7 (6.0)
PRISM score (n = 93)	1.5 (1.2)
PIM 2 score (n = 93)	5.3 (3.7)
Length of hospital stay (days; n = 93)	13.6 (5.5)
Time on mechanical ventilation (days; n = 93)	11.7 (5.8)

CRP = C-reactive protein; PRISM = Pediatric Risk of Mortality; PIM 2 = Pediatric Index of Mortality 2.

Table 2
Details of nutritional therapy.

Variables	Average (interquartile range)/% (n)
Fasting time before onset of NT (hours; n = 89)	21.1 (17.5)
Time to reach target energy intake (days; n = 93)	2.8 (3.0)
Type of EN administration (n = 93)	
nasoenteric	80.6 (75)
gastrostomy	19.4 (18)
Infusion type (n = 87)	
Continuous	85.1 (74)
Intermittent	14.9 (13)
Type of formula (n = 93)	
Polymeric	79.6 (74)
Hydrolyzed	16.1 (15)
Elementary	1.1 (1)
Modulated	3.2 (3)
Complications (n = 29)	
Diarrhea	8.6 (8)
Intestinal constipation	18.5 (17)
Nausea and vomiting	3.2 (3)
Obstruction	1.1 (1)
Interruption of diet (n = 22)	
Intolerance	4.3 (4)
Exams and procedures	19.4 (18)

NT = nutritional therapy; EN = enteral nutrition.

clinical diagnoses on admission, 70.3% of which were for respiratory failure. The characteristics of the sample are shown in Table 1.

NT was evaluated as shown in Table 2. The mean time to onset of the diet was 21 h and the mean time to reach target energy intake was 2.8 days. The most frequent route of administration, type of infusion, and type of formula were nasoenteric, continuous infusion, and polymeric formula, respectively. There were interruptions

Table 3
Average estimated energy requirement and energy received by the sample.

Variables	Average ± SD
Estimated energy requirement (Kcal, n = 93)	1024.5 ± 344.4
Energy received (Kcal, n = 93)	809.3 ± 187.7

SD = standard deviation; Kcal = kilocalorie.

Table 4
Adjusted linear regression models of energy deficit and clinical and laboratory variables for the outcome "length of stay" in days.

	Models not set			Adjusted models		
	Estimate	CI 95%	P	Estimate	CI 95%	P
Energy deficit (%)	0.25	0.07 − 0.43	0.01	0.23	0.07 − 0.40	<0.01
PRISM	1.18	−0.43 − 2.79	0.15	0.18	−1.39 − 1.76	0.82
Albumin on admission	−11.31	−17.40 − 5.21	<0.01	−13.35	−20.18 − 6.52	<0.01
CRP on admission	0.03	−0.44 − 0.49	0.91	−0.58	−1.07 − 0.09	0.02
Fasting time before onset of NT (hours)	0.26	0.05 − 0.47	0.02	−0.02	−0.22 − 0.19	0.84
Time taken to reach target energy intake (days)	0.87	−0.57 − 2.32	0.23	0.88	−0.47 − 2.24	0.2
Aged up to 24 months	−7.7	−14.66 − 0.75	0.03	−0.84	−7.70 − 6.02	0.81

CI = confidence interval, PRISM = Pediatric Risk of Mortality, CRP = C-reactive protein, NT = nutritional therapy. R^2 of the adjusted model = 0.32.

Table 5
Adjusted linear regression models of energy deficit and clinical and laboratory variables, for the outcome "duration of mechanical ventilation".

	Models not set			Adjusted models		
	Estimate	CI 95%	P	Estimate	CI 95%	P
Energy deficit (%)	0.22	0.02 − 0.42	0.03	0.19	−0.02 − 0.39	0.08
PRISM	0.95	−0.77 − 2.68	0.28	−0.09	−2.04 − 1.86	0.93
Albumin on admission	−11.4	−18.29 − 4.51	<0.01	−13.98	−22.50 − 5.47	<0.01
CRP on admission	0.02	−0.49 − 0.53	0.93	−0.66	−1.27 − 0.05	0.03
Fasting time before onset of NT (hours)	0.26	0.04 − 0.49	0.02	0.02	−0.23 − 0.27	0.85
Time taken to reach target energy intake (days)	0.94	−0.61 − 2.48	0.23	0.81	−0.88 − 2.50	0.34
Age up to 24 months	−8.56	−15.98 − 1.13	0.02	−1.33	−9.88 − 7.23	0.76

CI = confidence interval, PRISM = Pediatric Risk of Mortality, CRP = C-reactive protein, NT = nutritional therapy. R^2 of the adjusted model = 0.20.

in the diet in 23.7% (n = 22) of the patients and complications associated with NT in 31.4% (n = 29) of the sample. The cumulative energy deficit was calculated as the difference between the estimated energy requirements and actual energy administered (see Table 3). On average, the patients in the sample received 21% fewer calories than were prescribed by the PICU team.

For the analysis of the clinical outcomes, the adjusted linear regression models (Tables 4 and 5) related serum albumin and CRP on admission to both outcomes, LOS and DVT. The cumulative energy deficit significantly increased LOS.

4. Discussion

In this study, we found an association between the clinical outcomes length of stay (LOS) and duration of mechanical ventilation (DMV) and the serum albumin concentration and CRP of critically ill children on admission to a PICU. The energy deficit in the EN received during hospitalization was associated with a longer LOS in the children in the PICU, but not with DMV.

Hypoalbuminemia is well established as a predictor of mortality in critically ill patients, including children, however its association with LOS and DMV is not well established [15]. In a review, Ong et al. [13] found eight studies that evaluated albumin and clinical outcomes in critically ill children, five of which were conducted in mixed PICUs, like the unit under study here. Only one study revealed an association between albumin and LOS. Kittisakimontri et al. [15] found a similar result to that of the PICU under study here when comparing the variables between the hypoalbuminemic and nonhypoalbuminemic groups. Patients with hypoalbuminemia had prolonged LOS and DMV.

A Brazilian study of a PICU in a teaching hospital that evaluated 60-day mortality, LOS, and DMV revealed that albumin and CRP on admission were associated with the outcomes under study, in line with our findings. Hypoalbuminemia was found to be a factor independent of the magnitude of the inflammatory response, severity of the disease, and nutritional status [16].

In the models adjusted to the other variables, CRP was significantly associated with LOS and DMV. In a classic study of critically ill postoperative children, Alaedeen et al. [25] found CRP to be a major determinant of clinical outcomes, obtaining significant results in the relation between CRP and LOS. However, in Rey et al.'s [17] evaluation of biomarkers, including CRP, they reported no relationship between protein and mortality among critically ill children. Evaluating associations with patient mortality was not an objective of this research, an event that was not significant among the sample (n = 3), but the other clinical outcomes were still questioned, making the association found important data for the literature.

Both biomarkers, albumin and CRP, have known limitations in critically ill patients and require further studies to define cutoff points suitable for use in PICUs, but they are nonetheless widely available in clinical practice and could be used both for assessments of prognostic impact and for nutritional assessments [13,15].

The inadequate energy intake of patients receiving EN, causing energy deficits, is common in PICUs and is corroborated by this research. Kyle et al. [9] found that 75% of the calories and 40% of the estimated total proteins were infused in the patients eight days after initiation of NT. In another PICU, 49% and 44% of critically ill children received an adequate supply of calories and protein, respectively [26]. In Brazil, 40% of patients in a PICU had a satisfactory total energy intake [20].

Currently, energy and protein deficit in NT has been widely studied and has been found to have a significant impact on the outcomes of critically ill children [27]. Mehta et al. [1], associating a negative balance of EN with higher mortality in PICUs, but the literature is scarce in relation to clinical outcomes. Corroborating the results of the present study, Larsen et al. [27] evaluated 139 children in a PICU and found a significant association between calorie deficit and the outcomes LOS and DMV when comparing underfeeding, overfeeding, and appropriate feeding, while protein balance was not effective in demonstrating this association.

There may be practical reasons for energy deficits to occur in NT in PICUs, such as inadequate energy requirement estimates, late onset of NT (over 48 h), frequent interruptions of the diet, and factors related to the treatment and the patient (severity of

the disease, use of vasoactive medications) [26,28]. In the unit where the research was conducted, the time lapse between admission and commencement of ET was considered satisfactory (average of 21 h) according to the most recent ASPEN guidelines for critically ill children, which sets this time at 24 h, and this data was related to both outcomes when analyzed independently [7]. Similarly, the number of interruptions (n = 22) was below the average of two interruptions per patient found in the literature [29].

The PICU under study used the energy requirement calculation proposed by Holliday and Segar [4], but several authors have suggested that the predictive equations may underestimate patients' energy expenditure. This could influence whether calorie intake is sufficient and could impact nutritional status during hospitalization and be related to worse outcomes [9,10]. In a review of data on nutritional status in association with mortality, LOS, and DMV, Costa et al. [14] found a significant association with at least one of the outcomes in all the selected studies.

An important limitation of this research is related to nutritional assessment. Since this was a retrospective study, the lack of data on patients' height in the medical records made it impossible to classify BMI/height, weight-for-height, and height-for-age for much of the sample. The ASPEN guidelines recommend that weight and height be measured on admission, and thenceforth classified as BMI/height and in the absence of stature, weight-for-age should be used. In a systematic review, Costa et al. [14] found that these indices are the most frequently used nutritional assessment methods in PICUs, but that many of the studies mentioned the difficulty of making anthropometric measurements a limiting factor for this population.

Poor nutrition was not a significant finding in this study, and probably would not be statistically associated to the outcomes. Weight-for-age was used to calculate the z-score; 75.5% of the patients were found to be normal weight and 13% were malnourished on admission. When using this isolated index for evaluation, our sample was found to have a better nutritional status than the children and adolescents from the PICU in southern Brazil, where 41.2% of the patients were classified as malnourished. Nutritional status at admission in this Brazilian study was considered a predictor of DMV [30].

5. Conclusion

The cumulative energy deficit in this PICU was related to higher LOS, corroborating other studies. This fact underscores the importance of the existence of defined protocols, the use of quality indicators in NT, and trained staff, all of which could help reduce LOS, which could result in lower costs for the hospital unit.

Albumin and CRP upon admission were related to worse clinical outcomes for the critically ill children in our study, in terms of LOS and DMV. This finding reaffirms the importance of using these parameters in the evaluation of critical pediatric patients even though they may be altered.

Statement of authorship

All the authors contributed to the literature search, analysis of the data published, writing of the manuscript, and revisions of the paper.

Conflict of interest statement

The authors declare no conflicts of interest of this research.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.clnesp.2019.04.011.

References

[1] Mehta NM, Bechard LJ, Cahill N, Wang M, Day A, Duggan CP, et al. Nutritional practices and their relationship to clinical outcomes in critically ill children—an international multicenter cohort study. Crit Care Med 2012;40(7):2204–11.

[2] Mehta NM, Bechard LJ, Zurakowski D, Duggan CP, Heyland DK. Adequate enteral protein intake is inversely associated with 60-d mortality in critically ill children: a multicenter, prospective, cohort study. Am J Clin Nutr 2015;102(1):199–206.

[3] Schofield WN. Predicting basal metabolic rate, new standards and review of previous work. Hum Nutr Clin Nutr 1985;39(1):5–41.

[4] Holliday MA, Segar WE. The maintenance need for water in parenteral fluid therapy. Pediatrics 1957;19(5):823–32.

[5] Hulst JM, van Goudoever JB, Zimmermann LJ, Hop WC, Albers MJ, Tibboel D, et al. The effect of cumulative energy and protein deficiency on anthropometric parameters in a pediatric ICU population. Clin Nutr 2004;23(6):1381–9.

[6] Moreno YMF, Hauschild DB, Barbosa E, Bresolin NL, Mehta NM. Problems with optimal energy and protein delivery in the pediatric intensive care unit. Nutr Clin Pract 2016;31(5):673–80.

[7] Mehta NM, Skillman HE, Irving SY, Coss-Bu JA, Vermilyea S, Farrington EA, et al. Guidelines for the provision and assessment of nutrition support therapy in the pediatric critically ill patient: society of critical care medicine and American society for parenteral and enteral nutrition. JPEN 2017;41(5):706–42.

[8] Zamberland P, Delgado AF, Leone C, Feferbaum R, Okay TS. Nutrition therapy in a pediatric intensive care unit: indications, monitoring, and complications. JPEN 2011;35(4):523–9.

[9] Kyle UG, Jaimon N, Coss-Bu JA. Nutrition support in critically ill children: underdelivery of energy and protein compared with current recommendations. J Acad Nutr Diet 2012;112(12):1987–92.

[10] Velazco CS, Zurakowski D, Fullerton BS, Bechard LJ, Jaksic T, Mehta NM. Nutrient delivery in mechanically ventilated surgical patients in the pediatric critical care unit. J Pediatr Surg 2017;52:145–8.

[11] Hauschild DB, Ventura JC, Mehta NM, Moreno YMF. Impact of the structure and dose of protein intake on clinical and metabolic outcomes in critically ill children: a systematic review. Nutrition 2017;41:97–106.

[12] Prieto MB, Cid J. Malnutrition in the critically ill child: the importance of enteral nutrition. Int J Environ Res Publ Health 2011;8:4353–66.

[13] Ong C, Han WM, Wong JJ, Lee JH. Nutrition biomarkers and clinical outcomes in critically ill children: a critical appraisal of the literature. Clin Nutr 2014;33(2):191–7.

[14] Costa CAD, Tonial CT, Garcia PCR. Association between nutritional status and outcomes in critically ill pediatric patients – a systematic review. J Pediatr 2016;92(3):223–9.

[15] Kittisakmontri K, Reungrongrat S, Lao-Araya M. Hypoalbuminaemia at admission predicts the poor outcomes in critically ill children. Anaesth Intensive Ther 2016;48(3):158–61.

[16] Leite HP, Rodrigues da Silva AV, de Oliveira Iglesias SB, Koch Nogueira PC. Serum albumin is an independent predictor of clinical outcomes in critically ill children. Online Clin Investig 2016;17(2):50–8.

[17] Rey C, Garcia-Hernandez I, Concha A, Martinez-Camblor P, Botran M, Medina A, et al. Pro-adrenomedullin, pro-endothelin-1, procalcitonin, C-reactive protein and mortality risk in critically ill children: a prospective study. Crit Care 2013;17(5):240–9.

[18] Siddiqui I, Jafri L, Abbas Q, Raheem A, Haque AU. Relationship of serum procalcitonin, c-reactive protein, and lactic acid to organ failure and outcome in critically ill pediatric population. Indian J Crit Care Med 2018;22:91–5.

[19] Menezes FS, Leite HP, Nogueira PCK. Malnutrition as an independent predictor of clinical outcome in critically ill children. Nutrition 2012;28:267–70.

[20] Menezes FS, Leite HP, Nogueira PCK. What are the factors that influence the attainment of satisfactory energy intake in pediatric intensive care unit patients receiving enteral ou parenteral nutrition? Nutrition 2013;29:76–80.

[21] Hamilton S, McAleer DM, Ariagno K, Barrett M, Stenquist N, Duggan CP, et al. A stepwise enteral nutrition algorithm for critically ill children helps achieve nutrient delivery goals. Pediatr Crit Care Med 2014;15(7):583–9.

[22] WHO. WHO anthro (version 3.2.2, January 2011) and macros. 2011. http://www.who.int/childgrowth/software/en/.

[23] Pollack MM, Ruttimann UE, Getson PR. Pediatric risk of mortality (PRISM) score. Crit Care Med 1988;16(11):1110–6.

[24] Slater A, Shann F, Pearson G. PIM2: a revised version of the paediatric index of mortality. Intensive Care Med 2003;29(2):278–85.

[25] Alaedeen DI, Queen AL, Leung E, Liu D, Chwals WJ. C-Reactive protein-determined injury severity: length of stay predictor in surgical infants. J Pediatr Surg 2004;39(12):1832–4.

[26] Leroue MK, Good RJ, Skillman HE, Czaja AS. Enteral nutrition practices in critically ill children requiring noninvasive positive pressure ventilation. Pediatr Crit Care Med 2017;18(12):1093–8.

[27] Larsen BMK, Beggs MR, Leong AY, Kang SH, Persad R, Garcia Guerra G. Can energy intake alter clinical and hospital outcomes in PICU? Clin Nutr ESPEN 2018;24:41–6.

[28] Canarie MF, Barry S, Carroll CL, Hassinger A, Kandil S, Li S, et al. Risk factors for delayed enteral nutrition in critically ill children. Pediatr Crit Care Med 2015;16(8):283–9.

[29] Keehn A, O'Brien C, Mazurak V, Brunet-Wood K, Joffe A, de Caen A, et al. Epidemiology of interruptions to nutrition support in Critically ill children in the pediatric intensive care unit. JPEN 2015;39(2):211–7.

[30] Grippa RB, Silva PS, Barbosa E, Bresolin NL, Mehta NM, Moreno YM. Nutritional status as predictor of duration of mechanical ventilation in critically ill children. Nutrition 2017;33:91–5.