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Early enteral versus early parenteral nutrition in critically ill patients with respiratory distress: a case–control study

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Abstract

Background Nutritional support is essential as enteral or parenteral nutrition to reduce catabolism, to lower the complications rate, and to improve outcomes in critically ill patients.

Results The median, range age of the cohort was (median 10, range 6–18.8 months). One-hundred thirteen (62.8%) were males, and 67 (37.2%) were females. The higher frequency of sepsis, ventilator-acquired pneumonia (VAP), and mortality founded in the group received PN. Frequency of sepsis was 15 (16.7%), VAP was 5 (5.6%), and the mortality rate was 11.1% in EN group, while frequency of sepsis was 37 (41.1%), VAP was 23 (25.6%), and the mortality rate was 27.8% in PN group ($P = 0.001$, 0.001, 0.01, respectively). Median of weight gain on the EN group was 0.17 kg at 2nd week which was more than those in PN group ($P = 0.001$). The mean ± SD time for reaching the caloric target for those receiving early EN was 4.0 ± 1.9 days which is earlier than that of PN group (6.2 ± 1.7 days) ($P = 0.001$). There is no significant difference between both groups as regard pediatric intensive care unit (PICU) stay length and mechanical ventilation stay length.

Conclusion Early EN remains the preferred route for nutrient delivery as the PN route was accompanied by a lot of complication such as sepsis, VAP, and high mortality rate.

Keywords Early enteral nutrition, Early parenteral nutrition, Critical illness, Respiratory distress

Background

The prevalence of malnutrition in hospitalized patients was around 40% and is even higher among critically ill patients [1]. And this is accompanied by poor outcomes such as higher mortality rate, increasing length of mechanical ventilation (MV), and pediatric intensive care unit (PICU) stay length among malnourished critically ill one [2]. So, appropriate nutrition is one of the most important components in the management of those patients [3].

The main goal of nutrition in PICU patients is to give a good nutrition support to those who need it, according to their clinical and nutritional status, metabolic capability, and which route of administration is available [4]. Follow-up of the patients as regard the energy and protein imbalance is a must to avoid under or overfeeding [5].

There are two types of nutrition delivery in PICU: enteral nutrition (EN) and parenteral nutrition (PN). If the critically ill patient has a functioning gastrointestinal (GI) tract, EN should be the preferred mode of nutrition to maintain gut mucosa integrity [6]. This indicated when oral intake cannot be maintained to meet

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the metabolic demands of the patients. Otherwise, when there is impaired gastrointestinal function and contraindications to enteral nutrition, PN which involves the infusion of mixture of amino acids, carbohydrates, and lipids, as well as electrolytes and micronutrients, can be given instead [7].

Recent guidelines for nutrition support in children who need PICU admission recommend early EN within 24–48 h of admission; this greatly improves their clinical outcomes [8].

In addition, delaying PN for 1 week in the PICU will result in lowering the sepsis rate, lowering the length of PICU stay, and overall hospital stay [9].

Based on the conflicting findings of the different reviews, it is fair to say that the question as to the best form and the timing of nutrition start is still largely unanswered. Therefore, the aim of our study is to compare the outcomes of early EN with early PN in critically ill children.

Methods

Study design

A case–control study was conducted at PICU of our University Children's Hospital, Faculty of Medicine.

Objective

It is to compare the outcomes of early EN with early PN in critically ill children with respiratory distress, as regards the clinical and biochemical parameters in children.

Patient selection

We included 180 ill children, randomly selected, aged 2 months–5 years who were admitted to the PICU with respiratory distress on the following: mechanical ventilator, noninvasive CPAP, or high-flow nasal oxygen and then subdivided into two groups: Group (1): 90 cases receive early EN had no contraindication for beginning enteral nutrition &Group (2): 90 cases receive early PN.

We excluded patients expected to die within 12 h, have risk of aspiration, transferred from another PICU after a stay of more than 7 days, suffering from severe gut ischemia, any surgical problems, uncontrolled shock, severe respiratory distress with uncontrolled hypoxemia, and acidosis on admission and patient's suspicious or established inborn metabolic diseases requiring specific diet.

Methodology

Patients will be subdivided to start enteral or parenteral feeding within the first 24 h of admission according to their clinical condition. Firstly, energy requirements in every patient should be individualized. The initial energy calculation is based on the formulas of Schofield and the World Health Organization (WHO) which provide estimates of caloric needs (BMR) [10]. Then, reported BMRs based on ideal weight or estimations of basal caloric expenditure can be multiplied by a stress factor. Then, calculated total energy requirements by the following equation are as follows: TEE = BMR + SDA + energy for activity + energy for growth + energy for thermoregulation [11].

*TEE, total energy expenditure; BMR, basal metabolic rate; SDA, specific dynamic action of food

Patients who assigned to start enteral feeding (artificial formula) started on (1 cc/kg/h) and then increased each feeding by 25%volume until goal is reached.

Patients on parenteral nutrition will start total parenteral nutrition in general by initial proteins and lipids with a dose of 1 g/kg/day with daily increase 1 g/kg/day, with a maximum of 3 g/kg/day. Calculations of macronutrients were done according to Joosten et al., and GIR will be adjusted according to the blood glucose level [10].

All data were recorded from patients' files at days 1, 3, and 7.

Anthropometric measurements are weight (weight gain will be assessed on days 1, 3, 7, and weekly until discharge) and height, clinical assessment, and physical examination.

Type of oxygen support, mechanically ventilated or not, pulmonary indices, i.e. oxygen saturation index (OSI), and So_2/Fio_2 ratio will be calculated and recorded which are used to assessing severity of lung injury [12, 13], length of stay on mechanical ventilation, length of stay on PICU, mortality rate, and complications, e.g. sepsis, VAP, intolerance, aspiration, and diarrhea were recorded.

And the following laboratory investigations were taken from the sheet of patient as follows:complete blood count (CBC): platelets count, hemoglobin (Hb) level and total leucocyte count (TLC), C-reactive protein (CRP), blood urea nitrogen (BUN) and serum creatinine liver enzyme analysis (ALT and AST), and serum Na and K.

Statistical analysis

All data will be collected, tabulated, and analyzed using the Statistical Package for Social Science (SPSS) version 16. The following methods will be employed: mean and standard deviation (SD) or median and interquartile range (IQR) will be estimates of qualitative data. Differences in clinical and biochemical characteristics will be tested by student's paired and unpaired *t*-test, by Mann–Whitney *U*-test for quantitative data, and by chi-square test for qualitative data. *P*-values equal or less than 0.05 will be considered statistically significant.

Results

In total, 180 patients were included in the study: 113 (62.8%) were males, and 67 (37.2%) were females. The mean ± SD for age was 11 ± 8.5 with 10 median and range 6–38/months. The median (IQR) baseline weight was 7.27 (5–11.25)/kg. The commonest underlying diagnosis was pneumonia in 94 (52.2%) and bronchiolitis in 54 (30%). Of them, 79 (43.9%) were put on a mechanical ventilation. The descriptive statistics of the sample are displayed in Table 1.

No significant differences were observed between the PN and EN groups in terms of age and baseline weight; only significant difference was observed as regards gender ($P=0.03$) and admission diagnosis (bronchiolitis & pneumonia) ($P=0.01$, 0.001).

Comparing both groups, we observed that there was highly statistically significant weight gain for patients on EN compared with those on PN ($P=0.001$). The median (IQR) for weight for the EN group was 8.6 (5.2–12.3)/kg, 10 (6–14.5)/kg after 1st and 2nd weeks, while it was 6.1 (4.5–8.5)/kg and 6 (3.8–8)/kg for the PN group as shown in Fig. 1.

As regards Z score, there was no statistically significant difference between both groups at admission times, but after 1 week, there was slightly statistically significant difference between both of them with $P=0.05$; also, at the second week, there was statistically significant difference between both groups with $P=0.01$ (Table 2).

The mean ± SD for time to reach caloric target for those receiving early EN was 4.0 ± 1.9 days which is earlier than that of PN group that was mean ± SD (6.2 ± 1.7 days) ($P=0.001$) as shown in Fig. 2.

As regards laboratory assessment, we found that TLC, CRP, ALT, and urea were elevated in PN group. The mean ± SD for TLC was 15.1 ± 7.4 and 35.4 ± 7.3 × 10^3/μl) at the 3rd and 7th days of admission, respectively, and median (IQR) of CRP was 34.7 (3.1–251) mg/l at the 7th day of admission in PN group. But, in EN group, the mean ± SD for TLC was 11.7 ± 4.2, 10.8 ± 3.5 × 10^3/Ul at the 3rd and 7th days of admission, respectively, and median (IQR) for CRP was 12 (5.1–25) mg/l at the 7th day ($P=0.001$).

The median (IQR) for ALT was 49 (18.3–121) μ/l, and the mean ± SD for serum urea was 16.8 ± 8.8 mg/dl which was elevated on PN group than EN group; the median (IQR) of ALT was 29 (16–49) μ/l, and the mean ± SD of serum urea was 12 ± 6.9 mg/dl ($P=0.001$) as shown in Table 3.

Regarding complications, it was presented in both groups, but we observed high percentage of sepsis 37

Table 1 Baseline demographics and clinical characteristics of the studied population

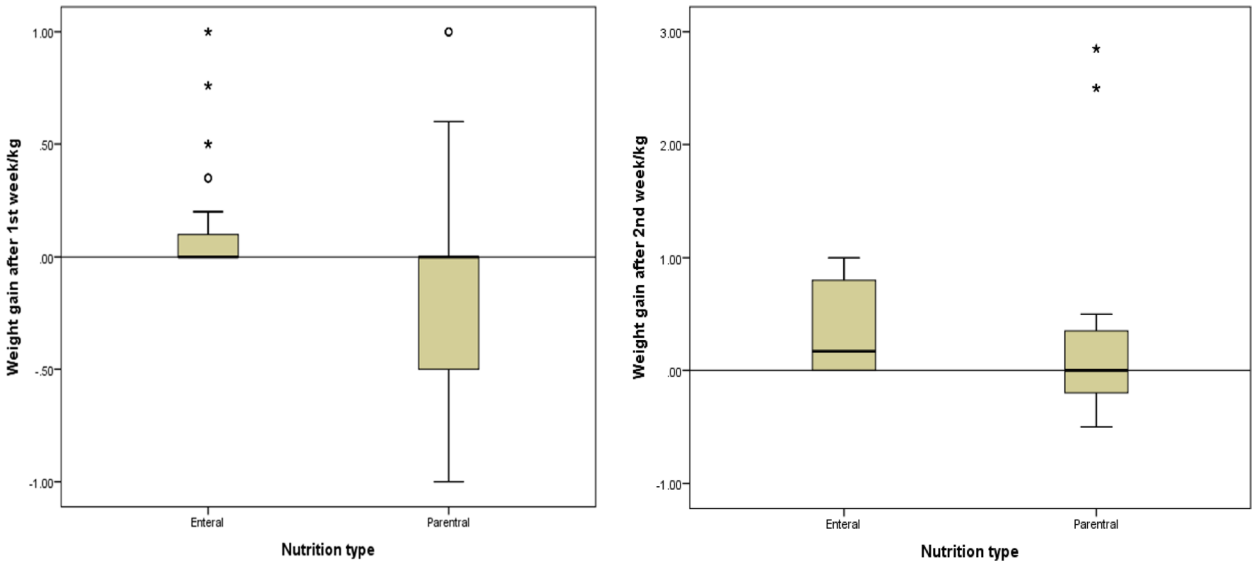
	All patients ($N=180$)	Enteral ($N=90$)	Parenteral ($N=90$)	*p*-value
Age (months)				
Median (IQR)	10.00 (3–38)	17.0 (6.0–38.0)	11.0 (3.0–20.0)	0.2
(Mean ± SD)	11 ± 8.5	15.7 ± 9	8.2 ± 5.6	
Gender				
Male	113 (62.8%)	50 (55.6%)	63 (70.0%)	0.03*
Female	67 (37.2%)	40 (44.4%)	27 (30.0%)	
Weight (kg)				
Median(IQR)	7.27 (5–11.25)	8.5 (5.75–12.25)	8.24 (4.57–8.62)	0.34
OSI (mean ± SD)	6.71 ± 3.38	7.0 ± 4.1	6.3 ± 2.9	0.4
So2/Fio2 (mean ± SD)	263.25 ± 76.34	284.4 ± 86.8	248.6 ± 66.2	0.02*
Diagnosis*				
Bronchiolitis	54 (30%)	19 (21.1%)	35 (38.9%)	0.01*
Pneumonia	94 (52.22%)	57 (63.3%)	37 (41.1%)	0.001**
Pneumonia & others*	8 (4.4%)	4 (4.4%)	4 (4.4%)	0.9
Others**	24 (13.33%)	10 (11.1%)	14 (15.6%)	0.2
Oxygen support*				
MV	79 (43.9%)	36 (40.0%)	43 (47.8%)	0.3
Nasal O2	46 (25.6%)	28 (31.1%)	18 (20.0%)	0.1
High-flow nasal cannula	55 (30.6)	26 (28.9%)	29 (32.2%)	0.7

[*] *MV* Mechanical ventilation, *OSI* Oxygen saturation index, *S/F* SO2/FIO2 ratio

P-value calculated depends on logistic regression analysis.[*]*P*-value < 0.05 is significant. **P*-value < 0.01 is highly significant

[*] Pneumonia and others include the following: myopathy, Guillain–Barre syndrome, Arnold Chiari, bronchiectasis, chronic heart disease, gastroenteritis, pneumothorax, dilated cardiomyopathy, empyema, heart failure. [**]Others include the following: foreign body aspiration or Guillain–Barre syndrome

[*] Age and weight are represented as median with interquartile range (25–75%); the data were analyzed by Mann–whitney *U*-test. While sex, diagnosis categories, and oxygen support are represented as frequency and percent, the data were analyzed by X^2 test. But indices are represented mean ± SD; the data were analyzed by *t*-test



a. Weight gain after 1st week b. Weight gain after 2nd week

Fig. 1 Weight gain in different times of the studied patients regarding nutrition type

Table 2 Comparison between both groups as regard Z-score grade

		Enteral nutrition = 90	Parenteral nutrition = 90	*p*-value
At admission	Normal weight (> − 2)	65 (72.2%)	58 (64.4%)	0.16
	Underweight (< − 2)	25 (27.8%)	32 (35.6%)	0.16
After 1st week	Normal weight (> − 2)	73 (81.1%)	63 (70.0%)	
	Underweight (< − 2)	17 (18.9%)	27 (30.0%)	0.05
After 2nd week	Normal weight (> − 2)	73 (81.1%)	59 (65.6%)	
	Underweight (< − 2)	17 (18.9%)	31 (34.4%)	0.01

Z-score grade at different times is represented as frequency and percent, the data were analyzed by X^2 test (2 ≤ z score ≥ − 2 for weight for age mean normal, z score, and lt; − 2 for weight for age mean underweight)

(41.1%) and VAP 23 (25.6%) on those who received PN ($P = 0.001$) as shown in Table 4.

The mean ± SD for survival time for EN group and PN were 28.0 ± 1.16 days and 20.8 ± 0.72 days, respectively ($P = 0.001$). In the group who received early EN, recovered patients were 88.9%, and the mortality rate was 11.1%, while in the PN group, recovered patient's percentage was 72.2%, and mortality rate was 27.8% ($P = 0.01$) (Table 5).

No significant difference was observed between both groups as regard PICU stay length, MV stay length, and O2 support stay length as shown in Table 6.

The results from a multivariate logistic regression model for mortality are displayed in Table 7 showed that sepsis was related to the mortality (odd ratio = 0.551) ($P < 0.001$).

Discussion

Patients need admission to PICU should be correctly evaluated, and nutritional plane should be put according to their caloric and energy needs [5]. Comparison between the two methods of nutrition (parenteral and enteral nutrition) in PICU is so difficult which is due to physiologic differences between both of them. However, the most preferred route was the EN route as initiation of early PN was associated with a lot of complication, e.g., sepsis, prolonged hospital stay, and mechanical ventilation stay [9].

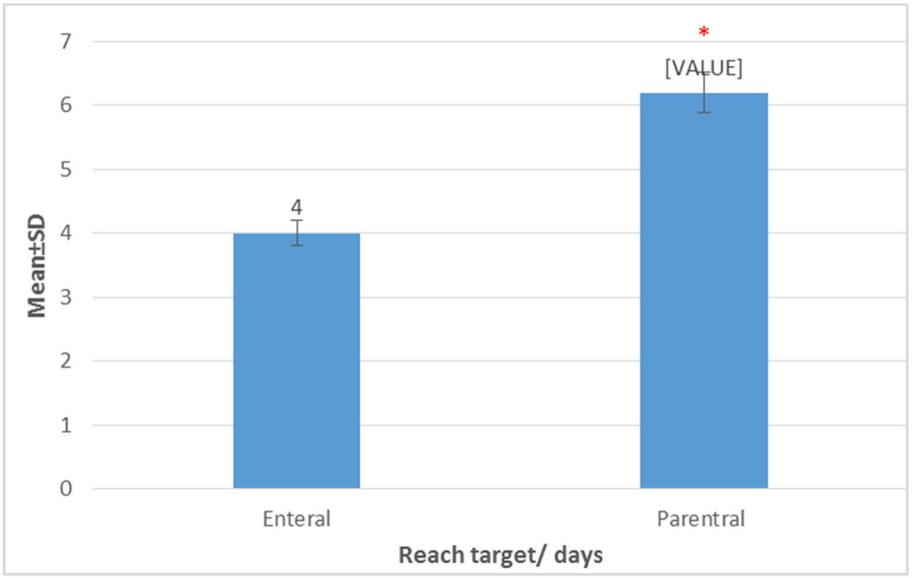


Fig. 2 Comparison between both groups as regard time to reach caloric target

The aim of our study is to compare the outcomes of early enteral nutrition with early parenteral nutrition in critically ill children with respiratory distress. And we concluded that early EN remains the preferred route for nutrient delivery as the PN route was accompanied by a lot of complication such as sepsis, VAP, and high mortality rate.

Importantly, it is essential to prevent malnutrition in critically ill patients, as malnutrition is associated with impaired immune function, as a result of a cascade of metabolic and hormonal derangements especially in critically ill patients [14], which in turn leads to prolonged mechanical ventilation stay and increase rate of morbidity and mortality. EN is an active therapy that can modulate the immune system and prevent intestinal villi atrophy, enterocyte apoptosis, and impairment of gut immune functions especially if it is given at the first 48–72 h of admission.

Our study concluded that the EN route is preferred over the PN route in preventing the malnutrition. As we could detect after the first and second week from admission, significant weight gain for patients on EN compared with those on PN and the mean time for reaching caloric target for those receiving early EN was earlier than that for early PN. In contrary, other study concluded that the weight gain for the adult patients is not significant with a nutrition [15].

On the other hand, we observed high percentage of sepsis and VAP on those who received PN compared with EN group. This is in accordance with studies which revealed that patients who received early EN have a low sepsis and VAP frequencies [16, 17]. This was not in agreement with another study in critically ill adults that revealed no difference in sepsis rate between both routes of nutrition [18].

So again, EN seems to have the upper hand over PN in lowering number of infectious and noninfectious complications. EN has been shown to stimulate the growth and function of the intestine, both directly intra-luminally, as it supplies substrates for enterocyte oxidation, and indirectly, through stimulation of hormone secretion, which could result in reduction of bacterial translocation and the complications accompanied with it [19]. In addition, it maintains the normal pH value of gastric juice, and this in turn lowers the incidence of VAP [17].

On the other hand, the high incidence of sepsis in PN may be related to catheter insertion, uncontrolled glycemic state of the patient, and high lipid content. All of these factors are good media for microorganism growth.

However, PN is recommended within 24–48 h by ESPEN if EN is contraindicated. The following strategies which is: (1) a good control for the blood glucose level, (2) the use of olive oil-based lipid emulsions instead of soybean oil-based ones, (3) the adoption of insertion and care bundles for central venous access devices, and (4) application of a policy of targeting "near-zero" catheter-related blood stream infections, which can be minimized by the following: (i) strict aseptic technique with the line, (ii) the use of a dedicated lumen on a CVC or a PICC line, and (iii) use of antimicrobial-coated lines [20].

Table 3 Comparison between both groups as regards laboratory investigations

		Nutrition type			Risk assessment	
		Enteral ***N*** **= 90**	**Parenteral** ***N*** **= 90**	***p*-value**	**OR (95% *CI*)**	***p*-value**
RBS (mg/d)	1st	115.2 ± 11.8	116.7 ± 20.4	0.5	1.005 (0.986–1.025)	0.6
	3rd	121.5 ± 9.9	122.6 ± 17.2	0.62	1.013 (0.989–1.038)	0.3
	7th	117.7 ± 8.1	116.7 ± 14.6	0.3	0.988 (0.962–1.015)	0.4
Hb (g/dL)	1st	10.8 ± 1.9	10.6 ± 2.5	0.6	0.936 (0.798–1.098)	0.4
	3rd	11.1 ± 1.4	11.2 ± 1.6	0.5	1.274 (0.937–1.734)	0.1
	7th	11.2 ± 1.4	11.1 ± 1.6	0.8	0.848 (0.631–1.139)	0.3
Platelets ($\times 10^3$/μL)	1st	391.3 ± 192.0	428.0 ± 154.7	0.2	1.001 (1.000–1.003)	0.2
	3rd	380.6 ± 157.2	363.0 ± 172.8	0.5	0.998 (0.993–1.002)	0.6
	7th	374.8 ± 153.6	345.1 ± 184.0	0.3	0.999 (0.996–1.003)	0.4
TLC ($\times 10^3$/μL)	1st	14.1 ± 5.3	14.3 ± 7.5	0.8	1.006 (0.961–1.052)	0.8
	3rd	11.7 ± 4.2	15.1 ± 7.4	0.001	1.171 (1.032–1.328)	0.01
	7th	10.8 ± 3.5	35.4 ± 7.3	0.001	1.201 (1.084–1.331)	0.001
STAFF	1st	4.0 (2.0–5.5)	3.0 (2.0–8.0)	0.9	1.014 (0.910–1.129)	0.8
	3rd	2.0 (2.0–4.0)	2.0 (2.0–5.0)	0.5	1.046 (0.893–1.224)	0.6
	7th	2.0 (2.0–6.0)	4.0 (2.0–10.0)	0.04	1.121 (0.978–1.285)	0.1
AST (U/L)	1st	43.0 (27.0–64.0)	46.5 (24.0–75.3)	0.8	1.000 (0.997–1.003)	0.9
	3rd	34.0 (22.0–81.0)	45.0 (30.8–91.3)	0.2	1.006 (1.000–1.012)	0.3
	7th	40.0 (23.0–63.0)	44.5 (27.0–61.0)	0.3	1.008 (1.000–1.016)	0.4
ALT **(**U/L)	1st	31.0 (12.0–65.0)	28.0 (15.0–83.3)	0.3	1.002 (0.999–1.004)	0.1
	3rd	29.0 (16.0–49.0)	49.0 (18.3–121.0)	0.001	1.015 (1.007–1.022)	0.001
	7th	24.0 (12.0–41.0)	35.0 (16.0–85.0)	0.001	1.020 (1.009–1.031)	0.001
Creat. (mg/dL)	1st	0.4 ± 0.2	0.5 ± 0.2	0.1	1.066 (0.748–12.563)	0.1
	3rd	0.4 ± 0.1	0.42 ± 0.1	0.1	1.377 (1.056–1.796)	0.1
	7th	0.4 ± 0.1	0.43 ± 0.2	0.1	1.311 (0.315–3.071)	0.1
Urea (mg/dL)	1st	23.1 ± 12.2	26.8 ± 16.4	0.09	0.982 (0.954–1.010)	0.2
	3rd	12.0 ± 6.9	16.8 ± 8.8	0.001	1.130 (1.060–1.204)	0.001
	7th	15.8 ± 8.1	17.2 ± 8.8	0.3	0.954 (0.908–1.003)	0.07
CRP (mg/L)	1st	30.5 (17.0–106.5)	12.0 (1.7–25.0)	0.001	0.982 (0.967–0.997)	0.02
	3rd	17.9 (13.5–45.3)	16.0 (6.0–108.0)	0.1	0.992 (0.979–1.005)	0.2
	7th	12.0 (5.1–25.0)	34.7 (3.1–251.0)	0.001	1.042 (1.021–1.063)	0.001

RBCs Red blood cells, *Hb* Hemoglobin, *plat* Platelets, *TLC* Total leucocytes count, *CREAT* Creatinine; and urea are represented as mean ± SD; the data were analyzed by *t*-test. While STAFF cells, *AST* Aspartate transaminase, *ALT* Alanine transaminase, and *CRP* C-reactive protein are represented as median with interquartile range (25–75%); the data were analyzed by Mann–Whitney *U*-test

PN can be safely provided without a higher incidence of complications. Moreover, the presence of nutrition support teams may add additional benefits.

In addition, our study revealed that there were elevations in the ALT and urea in patients who received PN than EN groups. These pathologies are grouped together in the acronym parenteral nutrition-associated liver disease (PNALD) [21], which is a multifactorial complication. Sepsis and PN duration are modifiable contributing risk factors [22]. In contrary, a study concluded no significant difference between both groups as regard hepatic and kidney function [23]. So, strict measures should be applied on patients who were receiving PN to decrease the incidence of sepsis and beginning of EN as early as the patients stabilize to minimize the PN duration.

As regards survival analysis, our study concluded that mortality rate was lower in the EN group than the PN group. This is in agreement with Wong et al. study [24]. In contrary, other studies show no difference in mortality rate between both groups of nutritional support [16, 18]. This may be explained by high incidence of underweight together with complication such as sepsis and VAP in group who received PN in comparison with those on EN groups. So, this could be avoided by decreasing the duration of PN and beginning of EN as

Table 4 Comparison between both groups as regard complications

		Nutrition type			Risk assessment	
		Enteral N = 90	**Parenteral N = 90**	***p*-value**	**OR (95% *CI*)**	***p*-value**
Aspiration	No	85 (94.4%)	85 (94.4%)	0.6	1.0 (0.279–3.581)	0.9
	Yes	5 (5.6%)	5 (5.6%)			
Intolerance	No	85 (94.4%)	90 (100.0%)	0.06	0.49 (0.42–0.57)	0.07
	Yes	5 (5.6%)	0 (0.0%)			
Diarrhea	No	85 (94.4%)	81 (90.0%)	0.2	1.889 (0.607–5.875)	0.3
	Yes	5 (5.6%)	9 (10.0%)			
Sepsis	No	75 (83.3%)	53 (58.9%)	0.001	3.491 (1.741–6.997)	0.001
	Yes	15 (16.7%)	37 (41.1%)			
VAP	No	85 (94.4%)	67 (74.4%)	0.001	5.836 (2.107–16.164)	0.001
	Yes	5 (5.6%)	23 (25.6%)			

Complications are represented as frequency and percent; the data were analyzed by X^2 test

VAP Ventilation-acquired pneumonia

Table 5 Comparison between both groups as regard outcome

Discharge cause	**Nutrition type**			**Risk assessment**	
	Enteral N = 90	**Parenteral N = 90**	***p*-value**	**OR (95% *CI*)**	***p*-value**
Recovered	80 (88.9%)	65 (72.2%)	0.01	3.077 (1.378–6.869)	0.01
Died	10 (11.1%)	25 (27.8%)			
Means of survival time/days	28.0 ± 1.16	20.8 ± 0.72	0.001		0.001

Discharge causes of data are represented as frequency and percent; the data were analyzed by X^2 test. *CI* Confidence interval, the data were analyzed by Kaplan–Meier test

Table 6 Comparison between both groups as regard MV, PICU, and oxygen support length of stay

	Nutrition type			Risk assessment	
	Enteral N = 90	**Parenteral N = 90**	***p*-value**	**OR (95% *CI*)**	***p*-value**
PICU stay length/day	12.3 ± 7.2	13.6 ± 6.2	0.2	1.030 (0.986–1.077)	0.2
MV stay length/day	13.4 ± 9.3	13.7 ± 8.2	0.9	1.003 (0.954–1.055)	0.9
O2 support stay length/day	11.0 ± 7.4	12.4 ± 6.9	0.2	1.028 (0.987–1.072)	0.2

Length-of-stay data are represented as mean ± SD; the data was analyzed by *t*-test

MV Mechanical ventilation, *PICU* Pediatric intensive care unit

Table 7 Multivariate logistic regression model for mortality

Parameters	***p*-value**	**CI (level = 0.95)**		
		OR	**Low**	**High**
Diarrhea	0.812	1.008	0.656	1.550
Sepsis	< 0.001	0.551	0.429	0.708
Age (months)	0.91	1.000	0.997	1.004
VAP	0.59	1.094	0.713	1.678
Aspiration	0.028	0.609	0.392	0.946
Nutrition type	0.47	1.007	0.996	1.006

Regression analysis done by the Hosmer–Lemeshow test (HL test)

early as the patients stabilize to avoid the high rate of complication and consequently the high mortality rate.

Strict measures should be taken to manage sepsis occurrence properly as according to the logistic regression model in our study, sepsis is the most leading factor to mortality; this comes with Mathias et al., who concluded that the most common cause of pediatric death worldwide is sepsis [25].

Our study recommends nutrition should be personalized for each patient taking into consideration the state of disease and the present nutritional status of the

patient. EN route should be started whenever possible. If EN is contraindicated, PN can be used with application (near-zero) PN complication strategies.

As study limitation, we did not study the outcomes of the patients shifted from PN to EN route.

Conclusion

Early EN was associated with low frequency of sepsis, VAP, and mortality than early PN, and early EN was associated with preservations of body weight with weight gain compared to PN. Early EN remains the preferred route for nutrient delivery.

Abbreviations

ALT	Alanine transaminase
AST	Aspartate transaminase
BMR	Basal metabolic rate
BUN	Blood urea nitrogen
CBC	Complete blood count
Cc	Centimeters
CICU	Cardiac intensive care unit
CPAP	Continuous positive airway pressure
CRP	C-reactive protein
EN	Enteral nutrition
FIO2	Fraction of inspired oxygen
GIR	Glucose infusion rate
Hb	Hemoglobin
Hr	Hour
K	Serum potassium
KG	Kilograms
MV	Mechanical ventilation
Na	Serum sodium
OSI	Oxygen saturation index
PICU	Pediatric intensive care unit
PN	Parenteral nutrition
SDA	Specific dynamic action of food
SO2	Oxygen saturation
TEE	Total energy expenditure
TLC	Total leucocytes count
WHO	World Health Organization
VAP	Ventilator acquired pneumonia

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Disclaimer
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Authors' contributions
BS, do final revision. SE, idea generation and revise manuscript. MM, analyzed the patient data; HA, collect, analyzed, and interpreted the patient data. EA, was a major contributor in writing the manuscript. The authors read and approved the final manuscript.

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Availability of data and materials
All datasets generated and or analyzed during the current study are available from the corresponding author on reasonable request and consent for publication and participation.

Declarations

Ethics approval and consent to participate
A case–control study was conducted at Pediatric Intensive Care Unit of Cairo University, Children's Hospital, Faculty of Medicine.
The institutional review board at our institution of Cairo University, Children's Hospital, Faculty of Medicine, approved our study with ethical approval no. MS-10–2019.

Consent for publication
Applicable.

Competing interests
The authors declare that they have no competing interests.

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