

Short Communication

Comparison of total and partial parenteral nutrition to achieve calorie target among treated children in the intensive care unit

Syafrida Widyastuti¹, Yunnie Trisnawati¹ and Supriatmo Supriatmo¹

¹Department Pediatrics, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia

*Corresponding author: fridawgabe22@gmail.com

Abstract

The achievement of recommended calorie targets for parenteral nutrition in pediatric patients receiving treatment in the pediatric intensive care unit (PICU) in Indonesia remains suboptimal, necessitating cautious implementation of this nutritional intervention alone. The aim of this study was to compare the effectiveness of total parenteral nutrition (TPN) and partial parenteral nutrition (PPN) in achieving the calorie requirements of pediatric patients receiving treatments in the PICU. A cross-sectional study was conducted in the PICU at H. Adam Malik General Hospital, Medan, Indonesia, among patients aged between 28 days to 18 years. The consecutive sampling method was employed to collect samples based on predetermined inclusion and exclusion criteria. The assessments of recommended calorie achievement targets were conducted up to 240 hours after initial nutrition treatment. Other possible factors associated with the achievement of the nutrition target were also assessed between groups, such as demographic data, length of treatment, nutritional status, and underlying diseases. A total of 30 patients were included in each group (TPN and PPN). There were no significant differences in age, weight, height, sex, or underlying diseases between groups. All patients in both groups achieved the target calorie requirements after 168 hours. Our data indicated that the percentage of patients who met the target calorie requirements was significantly different at initial treatment, 72 hours, and 120 hours post-treatment between groups (all had $p < 0.001$). The percentages of patients who met the nutritional requirements (carbohydrate and protein) were also significantly different between the TPN and PPN groups (all had $p < 0.001$). This study highlights that the administration of PPN to children resulted in faster achievement of calorie targets compared to TPN.

Keywords: Nutritional intervention, total parenteral nutrition, partial parenteral nutrition, PICU, calorie target

Introduction

Children who are critically ill and admitted to the pediatric intensive care unit (PICU) often experience challenges with eating, primarily due to food intolerance and eating disorders [1,2]. In fact, malnutrition often occurs in critically ill children when they are admitted to PICU, which begins with a decline in nutritional status. Being underweight can indicate malnutrition due to critical illness and increased energy consumption in critically ill children [3].

A study found that 16.9% of critically ill children in Aghia Sophia Children's Hospital, Greece, in 2001 were found to be at risk of chronic protein-energy malnutrition, while 2.1% were affected by acute protein-energy malnutrition [4]. Additionally, 4.2% and 5.6% of children had already experienced chronic and acute protein-energy nutritional deficiencies, respectively [4]. Another



study conducted at Royal Children's Hospital, Australia, in 2003 reported that only 52% of critically ill children in PICU received all prescribed energy requirements after a seven-day treatment period [5]. A study conducted at Cipto Mangunkusumo Hospital, Jakarta, Indonesia, revealed that sick children were provided with approximately 90% of their total calorie nutritional needs, which is commonly referred to as underfeeding [6].

The most effective method of feeding for critically ill children in PICU remains a subject of debate. The method selected for delivering calories, whether it be orally, enterally, parenterally, or partially parenterally (a combination of enteral nutrition and parenteral nutrition), is determined by the patient's gastrointestinal tract condition and capacity to absorb nutrients. Previous studies have indicated that enteral nutrition yields superior outcomes compared to parenteral nutrition [7,8]. It is recommended to initiate the administration of enteral nutrition within the initial 24 to 48 hours of intensive care for patients with intact gastrointestinal function [9,10]. Nevertheless, for certain medical conditions in ill children when enteral nutrition is contraindicated, the use of total parenteral nutrition (TPN) through a central vein becomes critical. The provision of nutrition in this manner refers to the administration of nourishment to individuals who experience impaired absorption of a specific quantity of food within the gastrointestinal tract for a duration of 5–7 days [9]. Additionally, partial parenteral nutrition (PPN), which involves a combination of enteral and parenteral nutrition, may present a compelling alternative for augmenting nutritional consumption during the acute stage of the illness. Administering PPN can expedite and ensure the attainment of desired nutritional goals, particularly in patients who are at a heightened risk of nutritional deficiencies [11,12].

Therefore, evaluating the initial nutritional condition, accompanied by sufficient nourishment, is a crucial component of clinical treatment management in the PICU. Today, studies comparing the effectiveness of TPN and in achieving the targeted calorie intake among pediatric patients in Indonesia are limited. The aim of this study was to evaluate the effectiveness of TPN and PPN in achieving the targeted calorie intake among pediatric patients treated at PICU.

Methods

Study design

A cross-sectional study was conducted among critically ill children who received treatment in the PICU of H. Adam Malik General Hospital, Medan, Indonesia, from January 1, 2022, to December 31, 2022. The objective was to compare the effectiveness of TPN and PPN in achieving calorie targets. TPN was administered to patients with unstable hemodynamics requiring ongoing fluid resuscitation, those who were suspected or confirmed to have necrotizing enterocolitis or intestinal ischemia, those suffering from mechanical bowel obstruction, those with significant gastrointestinal bleeding, or those experiencing severe motility disorders. On the other hand, PPN was provided to critically ill children who were at risk of or already suffering from malnutrition when oral nutrition alone was insufficient to prevent weight loss.

Patients and eligibility criteria

Critically ill children with different types of diseases who were administered with TPN or PPN during the treatment in the PICU, aged between 28 days and 18 years, with an initial pediatric logistic organ dysfunction 2 (PELOD-2) score of seven or higher, were considered eligible. Sick children who were transferred out of the PICU in less than 72 hours or died within 48 hours were excluded.

Sample and sampling strategy

The target population for this study consisted of all pediatric patients receiving care in the PICU at H. Adam Malik General Hospital in Medan, from January to December 2022. The target population included all these children, while the accessible population was limited to those meeting specific inclusion and exclusion criteria. The study sample was selected using a consecutive sampling technique, with a minimum required sample size of 30 individuals.

Study variables and measurements

The independent variables in this study were TPN and PPN, both measured on a nominal scale. The dependent variable was the achievement of calorie intake targets for TPN and PPN in

critically ill children admitted to the PICU. The caloric needs were calculated using WHO or Schofield formulas based on sex (male or female) and age groups (0–3 years, 3–10 years, and 10–18 years). Protein and fat requirements were determined according to the recommended dietary allowance (RDA). The time required to reach caloric targets from the initiation of TPN and PPN was recorded at specific intervals—upon admission, at 72 hours, 120 hours, 168 hours, and 240 hours—using a nominal scale. Caloric targets were classified as either achieved or not achieved based on the total calories per day.

The nutrients consumed consisted of three macronutrients, namely carbohydrates, protein and fat. The percentage requirements were calculated based on individual total daily caloric needs using the Schofield formula. The daily requirements for carbohydrates, protein, and fat were set at 1 gram/kg/day for protein, 1.5 grams/kg/day for fat, and the remaining calories allocated to carbohydrates. For TPN, Clinimix was used, which contained 75 grams of carbohydrates and 28 grams of protein, along with Smoflipid 20% for lipids. For PPN, nutrition came from TPN and enteral nutrition, including oral nutrition support (ONS), where 1 mL equals 1 kcal. Then, the actual intake of calories, carbohydrates, protein, and fat provided to critically ill patients in the PICU was assessed. Finally, the percentages of carbohydrates, protein, and fat in relation to the total caloric intake and their respective individual requirements were calculated.

Statistical analysis

Dichotomous data related to patients' characteristics were presented as frequency, while other data were presented as mean with standard deviation (SD) or median (minimal-maximal). Chi-squared test, independent Student t-test, Mann-Whitney test, and Kruskal Wallis test were used according to the data type and distribution. The Chi-squared test or Fisher's exact test was carried out to examine the difference between TPN and PPN to target calorie achievement, while the Mann-Whitney test was performed to compare the percentages of the differences. All statistical analyses were performed using SPSS version 21 (IBM, New York, USA).

Results

Baseline characteristics

The study involved a cohort of 60 critically ill children who received treatment in the PICU, with 30 individuals in each group (TPN and PPN). The characteristics of the patients are presented in **Table 1**. The subjects in both groups were predominantly male, with 19 boys (63.3%) in the TPN group and 16 boys (53.3%) in the PPN group. There was no significant difference in sex distribution between the two study groups ($p=0.432$). The mean age of children in the TPN and PPN groups was 10.53 years and 10.13 years, respectively, and there was no significant difference in age between the two groups ($p=0.702$). Similarly, no significant differences were found in the children's weight and height ($p=0.662$).

The mean length of hospital stays in the TPN and PPN groups was 12.43 days and 10.9 days, respectively, with no significant difference ($p=0.056$). Regarding nutritional status at the beginning of the study, most children in the TPN group had normal nutritional status, with 13 children (43.3%), while all children in the PPN group were classified as malnourished. A significant difference in nutritional status was observed between the TPN and PPN groups ($p<0.001$). Respiratory disorders were the most common underlying condition, affecting 18 children (60%) in the TPN group and 16 children (53.3%) in the PPN group. There was no significant difference in underlying conditions between the groups (**Table 1**).

Table 1. Demographic characteristics, nutritional status and type of underlying disease of critically ill children treated at the pediatric intensive care unit receiving total and partial parenteral nutrition (n=60)

Characteristics	Total parenteral nutrition (n=30)	Partial parenteral nutrition (n=30)	p-value
Sex, n (%)			0.432 ^a
Male	19 (63.3)	16 (53.3)	
Female	11 (36.7)	14 (46.7)	
Age, year			0.702 ^b

Characteristics	Total parenteral nutrition (n=30)	Partial parenteral nutrition (n=30)	p-value
Mean±SD	10.53±4	10.13±4.07	
Median (min-max)	10 (3–17)	10 (3–17)	
Weight, kg			0.662 ^c
Mean±SD	26.77±8.33	27.78±12.95	
Median (min-max)	24.5 (12–42)	24.5 (14–75)	
Height, cm			0.190 ^c
Mean±SD	129.33±23.86	121.07±24.96	
Median (min-max)	135 (79–160)	110 (89–165)	
Length of stay, days			0.056 ^c
Mean±SD	12.43±3.2	10.90±3.54	
Median (min-max)	13 (6–18)	10 (6–18)	
Nutritional status, n (%)			<0.001 ^d
Malnutrition	6 (20.0)	30 (100)	
Mild malnutrition	11 (36.7)	0 (0.0)	
Well-nourished	13 (43.3)	0 (0.0)	
Disease, n (%)			0.057 ^d
Respiratory disease	18 (60.0)	16 (53.3)	
Cardiac disease	3 (10.0)	2 (6.7)	
Gastrointestinal disease	3 (10.0)	0 (0.0)	
Post-surgery	2 (6.7)	10 (33.3)	

^a Analyzed using Chi-squared test

^b Analyzed using independent Student t-test

^c Analyzed using Mann-Whitney test

^d Analyzed using Kruskal-Wallis test

Comparison of achievement time of target calorie between total and partial parenteral route

Comparisons of the achievement status of target calories required between the TPN and PPN groups based on the duration of observation are presented in **Table 2**. The duration of observation was conducted in four periods: the initial observation, 72 hours, 120 hours, 168 hours, and 240 hours after the critically ill children were admitted to PICU. In the initial observation, none of the children in the group receiving TPN were able to meet the target calorie requirement, while 53.3% of children within the PPN group achieved the calorie target (**Table 2**). After a period of 72 hours, none of the children in the TPN group were able to meet the target calorie requirement, while 36.7% of children who received PPN successfully met the target (**Table 2**).

Table 2. Comparisons of target calorie achievement between total and partial parenteral nutritional routes based on observation times

Observation time	Total parenteral nutrition	Partial parenteral nutrition	p-value
Initial, n (%)			
Not achieved	30 (100)	14 (46.7)	<0.001 ^a
Achieved	0 (0.0)	16 (53.3)	
72 hours, n (%)			
Not achieved	30 (100)	19 (63.3)	<0.001 ^a
Achieved	0 (0.0)	11 (36.7)	
120 hours, n (%)			
Not achieved	30 (100)	4 (13.3)	<0.001 ^a
Achieved	0 (0.0)	26 (86.7)	
168 hours, n (%)			
Not achieved	0 (0.0)	0 (0.0)	-
Achieved	30 (100)	30 (100)	
240 hours, n (%)			
Not achieved	0 (0.0)	0 (0.0)	-
Achieved	30 (100)	30 (100)	

^a Analyzed using Fischer's exact test

At 120 hours of observation, none of the children in the TPN group were able to meet the calorie target, while 86.7% of children within the PPN group met the target (**Table 2**). After 168 hours, all children in both groups successfully met the specified calorie requirements. Significant disparities were observed in the attainment time of target calorie requirements at the initial, 72 hours, and 120 hours of observation (all had $p < 0.001$) (**Table 2**).

Comparison of target calorie requirement based on type of nutrients

None of the children in the TPN group met the recommended calorie intake for carbohydrates (**Table 3**). Conversely, among the cohort of children who received PPN, all of them successfully met the prescribed calorie intake for carbohydrates. Out of the cohort of children administered TPN, three children (10%) achieved the desired calorie intake for protein, while 11 children (36.7%) successfully met the protein-calorie requirement among those who received PPN. There was a statistically significant disparity in the attainment of carbohydrate and protein targets between the cohorts of children administered with TPN and PPN ($p < 0.001$) (**Table 3**). Among the cohorts of children administered TPN and PPN, 25 children (83.3%) and 19 children (63.3%) successfully met the recommended calorie intake for fat, respectively, with no statistically significant difference (**Table 3**).

Table 3. Achieving target nutritional requirements between total and partial parenteral nutritional routes based on nutrient types

Nutrition	Total parenteral nutrition	Partial parenteral nutrition	<i>p</i> -value
Carbohydrate, n (%)			
Not achieved	30 (100.0)	0 (0.0)	<0.001 ^a
Achieved	0 (0.0)	30 (100.0)	
Protein, n (%)			
Not achieved	27 (90.0)	19 (63.3)	0.015 ^b
Achieved	3 (10.0)	11 (36.7)	
Fat, n (%)			
Not achieved	5 (16.7)	11 (36.7)	0.080 ^b
Achieved	25 (83.3)	19 (63.3)	

^a Analyzed using Fischer's exact test

^b Analyzed using Chi-squared test

The TPN group had a target achievement rate of 40.80% in meeting their calorie requirements for carbohydrates, whereas the PPN group demonstrated an average achievement rate of 106.13% (**Table 4**). Our analysis indicated a significant disparity ($p < 0.001$) in the proportion of children who met the optimal carbohydrate calorie intake between the group administered with TPN and the group administered with PPN (**Table 4**). Similarly, there was a significant difference in the proportions of children meeting target protein calorie requirements to protein calories, target protein calorie requirements to total calories, and target fat calorie requirements to total calories between the cohort of children administered with TPN and the cohort of children administered with PPN (all had $p < 0.05$). No statistically significant difference ($p = 0.482$) was observed in the percentage of children who achieved the target fat calorie requirements for fat calories between the TPN and PPN groups (**Table 4**).

Table 4. Comparison of the percentage of targets achieved for calorie requirements based on nutrients between total and partial parenteral nutritional routes

Nutrition	Total parenteral nutrition	Partial parenteral nutrition	<i>p</i> -value ^a
Carb to carb, %			
Mean±SD	40.80±4.46	106.13±34.18	<0.001
Median (min-max)	40 (33–51)	100 (25–242)	
Carb to total, %			
Mean±SD	28±4.18	69.8±18.98	<0.001
Median (min-max)	28 (22–36)	67 (21–126)	
Protein to protein, %			
Mean±SD	116.87±43.61	143.27±49.3	0.020
Median (min-max)	114.5 (67–233)	142 (47–246)	
Protein to total, %			
Mean±SD	10.53±1.63	13.63±3.76	<0.001
Median (min-max)	10 (8–14)	13 (4–25)	
Fat to fat, %			
Mean±SD	84.37±46.15	88.83±47.96	0.482
Median (min-max)	91 (0–167)	98 (6–170)	
Fat to total, %			
Mean±SD	84.37±46.15	19.4±10.82	<0.001
Median (min-max)	91 (0–167)	20.5 (3–38)	

^a Analyzed using Mann-Whitney test

* Statistically significant at $p = 0.05$

Discussion

Partial parenteral nutrition (PPN) has the potential to enhance intestinal blood flow, improve perfusion, elevate gastric pH, and mitigate ischemia in the splanchnic arteries. However, in patients who are unable to tolerate administering PPN, the alternative option is to administer TPN. A study found that TPN was administered to less than 16% of children in the PICU to provide initial nutrition, as TPN was associated with a higher risk of infection compared to PPN [7].

In this study, the average duration of treatment required for children in the TPN group to reach the calorie target was 12.43 days, whereas it was 10.90 days in the PPN group, suggesting that the PPN group achieved the target calorie needs more quickly than those who received TPN. As a result, the child's recovery period was shorter in the PPN group, leading to a shorter treatment duration. A study indicated that the duration of treatment required to reach the target calorie for children treated in PICU ranged from 4 to 7 days [7]. Another study found that only 51% of the target calorie requirement was achieved on the sixth day of treatment in children treated in the PICU [13]. A study found that the median time to reach the energy goal decreased from 4 days to 1 day, and this improvement was attributed to the implementation of the enteral nutrition algorithm, which significantly improved enteral nutrition delivery and reduced dependence on parenteral nutrition in critically ill children; this leading to more patients reaching their energy intake goals more quickly [14]. A study found that reaching 60% of energy or protein delivery targets within the first 7 days after admission to the PICU was linked to a lower 60-day mortality rate in mechanically ventilated children [15,16].

Our study indicated that a significant percentage (43.3%) of children in the TPN group exhibited malnutrition. Conversely, all children in the PPN group were found to be malnourished. This finding suggests that the nutritional status of children in PICU care should not be used as the sole determining factor for appropriate nutrition interventions. The determination of appropriate nutrition for sick children is contingent upon their condition and hemodynamic stability, taking into consideration the indications and contraindications for administering TPN and PPN. This study found that none of the children in the TPN group met the target calorie requirements within the first 72 hours in the PICU, while 53.3% in the PPN group and 36.7% in the TPN group eventually achieved their prescribed calorie targets. This achievement was observed at 168 hours and 240 hours when all children in both groups had reached their target calorie needs. Delays in meeting calorie goals through the administration of TPN nutrition to sick children in the PICU can be attributed to various factors. These include delays in providing nutrition due to necessary preparations, such as the placement of a central venous catheter for intravenous access, laboratory tests like lipid profile analysis, and inconsistencies between nutrition and prescriptions [17].

The objective for attaining daily caloric intake in the PICU is to achieve 80% of the daily caloric requirement, as children in the PICU are confined to bed rest. A study showed that 71% of patients met caloric targets by the fourth day, and 81.7% by the seventh day, with calorie administration typically starting within 24–48 hours of treatment [7]. Delays in nutrition initiation are often due to factors such as shock, gastrointestinal bleeding, inotropic medication use, and food intolerance, all of which reduce calorie intake [1,18]. A study found that the PPN group outperformed the TPN group in meeting protein and fat goals, partly due to compliance issues with TPN fat administration [19].

Studies in Indonesia found that a significant number of children did not meet carbohydrate targets, fell short of protein, and missed fat goals [8,20]. Overfeeding, where nutrition exceeds basal metabolic rate requirements, was also observed, with 17.8%, 2.2%, and 15.6% of patients exceeding calorie, protein, and fat targets, respectively [8,21]. Therefore, comprehensive guidelines for TPN and PPN administration are crucial for ensuring sufficient enteral nutrition and improving outcomes [22-25].

In order to enhance the provision of nutrition to children with PICU-prone illnesses, it is imperative to adopt an evidence-based approach. The role of this factor is crucial in ensuring the efficacy of TPN and PPN, as the provision of these forms of nutrition is predominantly reliant on subjective judgment rather than empirical evidence. This is a contributing factor to the undernourishment of critically ill children, leading to malnutrition. Hence, it is imperative for healthcare professionals to have access to clear guidelines and protocols pertaining to the

administration of TPN and PPN in order to effectively facilitate the delivery of sufficient enteral nutrition.

This is the first study to compare the achievement of calorie targets in critically ill children treated in the PICU by administering TPN and PPN to meet the target calorie requirements. However, the research design used has a limitation, as data were compared at a single point in time. The sample size in this study was relatively small, potentially impacting the statistical analysis. Furthermore, previous treatments were not assessed in this study.

Conclusion

The proportion of patients meeting carbohydrate and protein requirements differed significantly between the TPN and PPN groups. Our study suggested that that PPN facilitated quicker achievement of calorie targets in children compared to TPN. However, further research is needed to validate these findings, especially considering that the severity of underlying diseases, which could act as potential confounding factors, was not accounted for in this study.

Ethics approval

This study was approved by the Health Ethics Committee, Universitas Sumatera Utara, Medan, Indonesia, with No.511/KEPK/USU/2023.

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Competing interests

All authors affirm that they have no conflicts of interest.

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Underlying data

Data derived to support the conclusions of this study can be obtained by contacting the corresponding author upon request.

How to cite

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