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CHALLENGES OF NUTRITIONAL THERAPY IN PATIENTS AFTER PEDIATRIC HEART SURGERY

Simone Pereira Fernandes
Universidade Federal de Ciências da Saúde de Porto Alegre – Porto Alegre (RS), Brazil and Irmandade Santa Casa de misericórdia de Porto Alegre- Porto Alegre (RS), Brazil

Gabriela Grendene
Universidade Federal de Ciências da Saúde de Porto Alegre – Porto Alegre (RS), Brazil and Irmandade Santa Casa de misericórdia de Porto Alegre- Porto Alegre (RS), Brazil

Flavia Kruger Cousseiro
Irmandade Santa Casa de misericórdia de Porto Alegre- Porto Alegre (RS), Brazi

Fabiana Viegas Raimundo
Universidade Federal de Ciências da Saúde de Porto Alegre – Porto Alegre (RS), Brazil

Abstract: Goal: To assess the adequacy of postoperative nutritional support for children undergoing cardiac surgery for seven days after admission to the PICU. **Methods:** Twenty-seven children aged 0 to 50 months were evaluated after admission to a pediatric intensive care unit (PICU). Patients who were born at term, using enteral or parenteral nutritional therapy or both and who remained at least 24 hours after cardiac surgery in the PICU were included. The type of alterations (cyanotic and acyanotic), age and weight of the child in the immediate preoperative period, prescribed diet and respective evolution, intervals and reason for diet interruption were collected. **Results:** The median age was 3 months and 55.6% (n=15) were boys. In the preoperative evaluation, 66.7% (n=18) of the patients had adequate weight for their age, corresponding to a weight-for-age Z score of -1.03± 1.9. In up to 7 days of hospitalization, 55.6% (n=15) reached at least 90% of the established energy goal, representing a daily supply of 137.89 ± 14.3kcal/Kg of total energy needs. Diet suspension occurred in 40.7% (n=11) of the cases, with tube traction (7.4%; n= 2), digestive bleeding (7.7%; n= 2) and vomiting (11.1%; n= 3) the most observed causes. Half of the patients evaluated had a cyanotic heart defect (n=13, 50%). Those who had a cyanotic-type heart defect had a shorter time on mechanical ventilation (p 0.035) when compared with acyanotic patients. **Conclusion:** Almost half of the patients did not meet the predicted nutritional needs within 7 days of PICU stay. These findings indicate important challenges in the care of postoperative patients with heart disease in intensive care.

Keywords: Heart diseases, Nutritional therapy, pediatric intensive care unit.

INTRODUCTION

The common cause of malnutrition and growth retardation is cardiac malformation in children.[1] About 28,000 children born in Brazil have heart disease, representing 1% of the population. In most cases, surgical treatment is necessary and, generally, children undergoing cardiac surgery go to intensive care units.[2]

Congenital heart defects are divided according to physiological change. In those in which unoxygenated blood enters the systemic circulation it is called cyanotic and in the group where there is no obstruction of venous blood in the systemic circulation it is called acyanotic.[3]

Pediatric intensive care of nutritional therapy (NT) is very important in the postoperative period of children and infants with heart disease, especially due to the approximately 50% to 100% increase in metabolism and the high susceptibility to malnutrition after cardiac surgery.[4,5]

According to the 2011 project guideline, nutritional therapy for children with cardiac dysfunction must aim at replenishing body reserves and restoring growth. Nutritional therapy can start based on the assessment of individual energy expenditure, which will depend on the course of the acute phase response, and the progression is controlled with acceptance tolerance, weight gain and height increase.[6]

To ensure nutritional support can be extremely challenging after cardiac surgery, especially as this is a population vulnerable to additional risk, food intolerance, fluid restriction, inadequate mesenteric perfusion and ventilation support.[7]

The objective of this study was to evaluate the adequacy of postoperative nutritional support for children undergoing cardiac surgery for seven days after admission to the PICU, to characterize the profile of these children with congenital heart disease and to discuss the challenges of nutritional therapy in the postoperative patient. of pediatric cardiac surgery in an intensive care unit attended at a tertiary teaching teaching hospital in the State of Rio Grande do Sul.

MATERIAL AND METHODS

This is an exploratory, descriptive, observational, prospective study carried out at the Pediatric Intensive Care Unit (PICU) of the Santo Antônio Children's Hospital at Irmandade Santa Casa de Misericórdia in Porto Alegre, Brazil. This tertiary teaching teaching hospital has 20 SUS beds in the PICU, of which 50 to 60% of the beds are occupied by pediatric cardiology.

Participants were selected for convenience, between March and September 2016. The inclusion criteria were: Being hospitalized in the pediatric ICU for at least 72 hours post-cardiac surgery and being fed enterally or a combination of Parenteral Nutrition (PN) and Enteral Nutrition (HUH). Prematurity, genetic syndrome and oral feeding were considered exclusion criteria.

At the beginning of the study, the following data were collected: age, sex, primary diagnosis of heart disease, number of fasting days and time of caloric adequacy of nutritional therapy in the first seven days of PICU stay. Data recorded in medical records relating to failed extubation and reintubation on more than one occasion, maternal age at birth, number of pregnancies, birth weight and length, and interruptions in nutritional supply and reasons were collected.

The prediction of daily caloric goals and the percentage (%) of energy administered were calculated by the intensive care nutritionist according to NET (total energy requirement) or VCT (total caloric value). The NET or VCT for this population considered was the RDA for children with cardiac dysfunction, according to Diten (2011) (between 120 and 150Kcal/d) multiplied by weight. The weight chosen was the current weight, or average weight or weight at p50. One TEN was considered for estimated energy requirements (Kcal/KgP/d) in mechanical ventilation (MV) and another TEN for without MV, when extubated.

We consider the TEN of patients on MV as: mean between estimated daily needs (NET) and baseline energy expenditure (GEB); and for those without VM, just NET. The (GEB) is calculated by the predictive equation created by Schofield (1985) or RDA heart disease xWeight. The value of 90% was used as a reference for the adequacy of caloric needs.

Nutrition was administered as a bolus or continuous infusion. Patients received infant formula according to Codex Alimentarius and the volume and type of enteral and/or parenteral feedings were recorded daily over the course of seven days. When necessary, patients received, along with infant formula, nutritional supplementation enriched with MCT (1% vegetable oil) and maltodextrin (3% carbohydrate), as tolerated.

Documented body weight was pre-surgical weight. Nutritional classification was performed using a Z score in weight/age (W/A) relationships, using the World Health Organization (WHO, 2006) values and the analysis of nutritional status as a reference. It was performed using the WHO Anthro 3.1.0 software

When the child does not have additional energy sources related to the disease and is hospitalized immobilized in bed, the most appropriate option to determine energy consumption is the use of Basal Energy Expenditure (GEB), as the child is practically in basal metabolism (VITOLO, 2003)

The patient was considered to have met his/her nutritional energy needs when the energy supply (in Kcal/day) was ≥ 90% of the requirements in relation to the Schofield method (GEB) and/or RDA heart disease x Weight.

The ethical aspects of research with human beings were followed according to the Regulatory Guidelines and Norms for Research Involving Human Beings, through Resolution, number: 466/2012, of the National Health Council. The study was submitted for consideration and approved by the Research Ethics Committee of the Irmandade Santa Casa de Misericórdia de Porto Alegre, with Opinion number: 1,589,122. Patients included in the study had their data collected and anonymity was respected.

STATISTICAL ANALYSIS

Descriptive statistics were used to present the results. Quantitative variables were described as mean and standard deviation or median and interquartile range. Categorical variables were described by absolute and relative frequencies. Data were expressed as median and range. To compare calorie consumption and recommendation, Student's t test was used, setting the significance level at 5% (0.05) for rejecting the null hypothesis. The chi-square test was used to compare the frequency of pathologies between the cyanotic group and the acyanotic group. Calculations were performed using the Statistical Package for Social Sciences (SPSS), version 20.0. The significance level adopted was $p<0.05$.

RESULT AND DISCUSSION

The general characteristics of the sample studied are shown in Table 1. Twenty-seven postoperative children with heart disease, from different parts of the country, were evaluated. Among them, the majority were male (53.8%), median age of 4 months (0-50) and carriers of cyanotic congenital cardiopathies of the Tetralogy of Fallot and Tricuspid Atresia type (18.5%). Many of them, 57.7% performing the surgery for the first time.

Comparing patients with cyanotic heart disease and patients with acyanotic heart disease, we found a significant difference in terms of duration of mechanical ventilation $p=0.035$ (Figure 1) No difference was found between gestational age, duration of mechanical ventilation, time of weaning from MV and time to reach the energy goal, as it was shown in figure 2. Leitch et al (2000)8 showed that patients with cyanotic congenital heart disease present a preoperative total energy expenditure of 30% more than healthy children of the same age. In addition, these patients had inadequate energy requirements, reflected by reduced post-surgical growth deficit and weight. Those with cyanotic congenital heart disease had reduced growth and weight at 2 weeks and 3 months of age compared with controls.

A challenge to be considered is the handling of children in postoperative PICUs because they are difficult to move patients, because in general, they need restraint, so that their drains or venous accesses are not lost or even extubated. Thus, anthropometric nutritional assessment in the PICU of critically ill infants and children is particularly difficult, complex and not always possible to be measured daily in critically ill patients. The most chosen parameter for the evaluation of the critically ill child is weight, and it can often be inaccurate due to renal and hepatic malfunction (with consequent edema and ascites), or due to hydroelectrolyte imbalance, or tumor mass [9,10]. But, even considering its limitations, it has been the most universally used method and also the one proposed by the WHO.[11]

Children with congenital heart disease have, in particular, adequate weight and length values for their gestational age.[12,13]. In our

Variables	n	%
Boy Girl	15 12	55,6 44,4
RGS condition Out of RGS condition	23 4	85,2 14,8
Age 1 month of life between 1 month+ 1 day and 24 months of life over 24 months (5%)	 15 10 2	 55,6 37 7,4
Main diagnoses Acyanotic Atrioventricular septum defect (DSAV) Left heart hypoplasia Coarctation of Aorta Cyanotic Tetralogy of Fallot (T4F) Tricuspid atresia Transposition of great vessels Aortic Valve Disease Atrial septal defect (CIA)	 12 6 3 3 14 6 5 2 1 1	 46,2 22,2 11,1 11,1 53,8 22,2 18,5 7,4 3,7 3,7
1ª Surgery Other surgeries previously	16 11	59,3 40,7
Nutritional Diagnosis (pre-surgical) Low weight for age Age-appropriate weight High weight for age	 8 18 1	 29,6 66,7 3,7
Z score - Weight/age	-1,03± 1,9	
Weight - Birth PIG AIG GIG	 2 19 5	 7,4 70,4 18,5
Maternal age at birth	27,42 ±7,4	
Length of stay: PICU < or =7days >7 days	 10 17	 37 63
Weaning failure	4	15,4
Mechanical ventilation time	107,41 ± 91,05	

Variables described by mean ± SD or * median (25th-75th percentiles). n= number of patients %=percentage of patients.

Table 1: General pre-surgical characteristics.

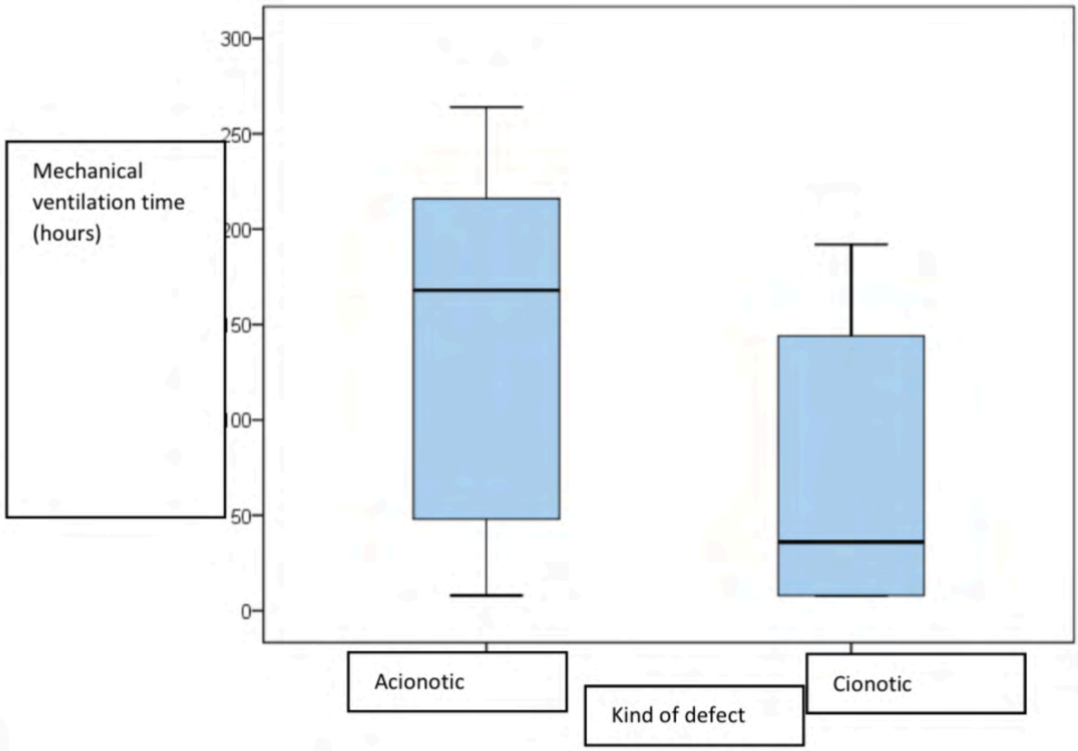

Figure 1: Comparison between cyanotic and acyanotic heart disease patients and duration of mechanical ventilation in 7 days of hospitalization in the Pediatric Intensive Care Unit.

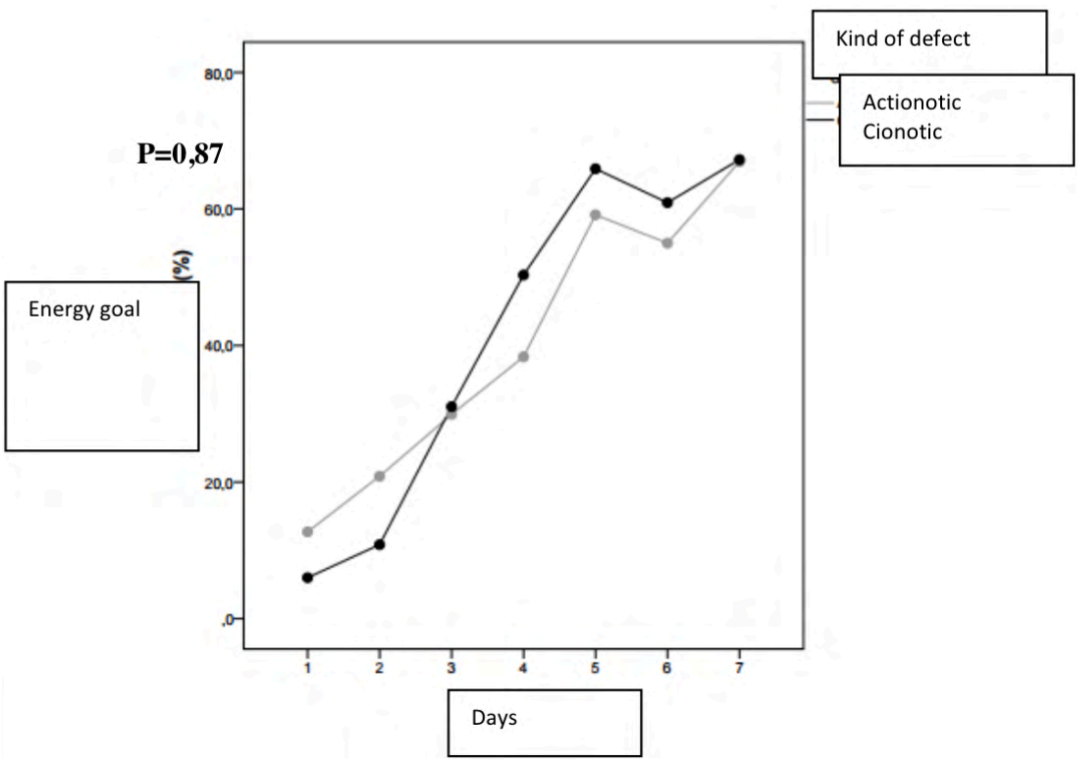

Figure 2: Comparison between cyanotic and acyanotic heart disease patients in achieving energy goals in 7 days of hospitalization in the Pediatric Intensive Care Unit.

study, most of the children were classified at birth as full-term newborns (AGA) and 69.2% were with adequate weight for their age in the pre-surgical evaluation. This relationship was also observed in the Z scores for the same indicators (Table 1). Our findings showed different evidence found in the literature that demonstrated that pediatric patients are often malnourished at the time of admission to the PICU.[14,15] Malnutrition is one of the most common comorbidities in pediatric intensive care units (PICUs), present in about 20% of hospitalizations. [9]

A number of challenges are encountered in studying nutritional adequacy and management in critically ill children in PICUs. These include a reduced number of studies and ethical concerns related to experimental protocols among this critically ill population.[16]

In the immediate postoperative period, hemodynamic stability is the main concern in the PICU and NT must be started as soon as possible in order to reduce the risk of bowel atrophy and loss of intestinal mucosal barrier, which increases the risk of bacterial translocation and bacteremia. NT usually starts when the child has bowel sounds, which usually occurs after the first 24 hours.[17,15]

All individuals in our sample received ventilatory support after cardiac surgery. Children undergoing cardiac surgery are extubated soon after the anesthetic effect ends or decreases. Weaning and duration of mechanical ventilation are shown in Table 3. Many children require a long period of mechanical ventilation and extubation failure after prolonged mechanical ventilation is common, between 15% to 20% of children in critical condition, and 10% of children after cardiac surgery18. Low body weight, nutritional status, functional immaturity of organs, changes in respiratory mechanics, multiple dysfunction are factors that can prolong the use of mechanical ventilation.

The offer of EN, parenteral or a combination of both in this sample, started around the 3rd PO day and 26.9% of them received diet between 25 and 48 hours after cardiac surgery with an average initial volume of 20.3±16.3 ml. The introduction of early enteral nutrition has been associated with lower rates of infectious complications and shorter ICU length of stay. [15,17, 19,20].

The route of administration of enteral nutrition in all patients was 65.4% via the nasogastric route and 11.5% via the orogastric tube, especially those up to 11 months of age, and no patient was fed via the transpyloric route. A retrospective study of 100 newborns undergoing cardiac surgery showed that EN was temporarily interrupted in 21.1% of the procedure time. [21]. In our study, digestive bleeding (7.7%; n= 2), pulling out the tube (7.7%; n= 2) and vomiting (11.5%; n= 3) were observed as the reason for interruptions. of the diet in an average of 12 ±26.8 hours.

Offering the best NET to critically ill children is a challenge to be considered, especially when it refers to a child with a cardiac diagnosis, which affects resting energy expenditure and, therefore, the accuracy of the predictive equations. Currently, data on the optimal practice of nutritional support during the first week in the PICU is limited.[16].

The European Society for parenteral and Enteral Nutrition / European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPEN / ESPGHAN, 2005)[22] recommend using the Schofield equation for children younger than age 10. However, in the absence of indirect calorimetry, the guidelines recommend equations without correction factors to avoid *overfeeding*.

The American Society for Enteral and Parenteral Nutrition [23] recommends the use of indirect calorimetry (IC) in patients who present, among other clinical situations, a body mass index <5 or> 85th percentile,

Mechanical ventilation time	107,41 ± 91,05
Weaning failure	15,4(4)
Time to start Nutritional therapy	%(n)
Up to 24 hours after surgery	40,7(11)
From 24 to 48 hours after surgery	25,9 (7)
Over 48 hours	33,3(9)
Type of Nutritional Therapy	%(n)
Exclusive enteral nutrition	70,4(19)
Enteral Nutrition + Parenteral Nutrition	11,1(3)
Exclusive parenteral nutrition	18,5(5)
Reasons for diet interruption	%(n)
The person did not stop the diet	55,6(15)
The person pulled out the probe	2 (7,4)
The person stopped for tests	1 (3,7)
Vomits	3 (11,5)
Digestive bleeding	2 (7,4)
Anasarca, anuria and mixed acidosis	1 (3,7)
Cardiorespiratory arrest	1 (3,7)
Bronchopneumonia	1 (3,7)
Enterocolitis	1 (3,7)

Variables described by mean ± SD or * median (25th-75th percentiles). n= number of patients %=percentage of patients.

Table 3: Characteristics of postoperative nutritional support for children undergoing cardiac surgery.

weight loss greater than 10%, who are on ventilatory support for more than > 7 days and who are hospitalized in the PICU for more than 4 weeks. However, the use of IC was not considered practical for this study due to the unavailability of this equipment in our PICU.In our study, the tool used to estimate the EN was the use of the Schofield (1985) predictive equation or RDA heart disease x Weight, considering the patient to be on mechanical ventilation (MV) or not. Studies in adult critically ill patients suggest that malnutrition is associated with better survival and shorter hospital stays.[24,25,26,27] However, Coss-Bu al, (2001) characterizes the immediate postoperative period in a hypermetabolic state and negative nitrogen balance.[28]

For Joffe et al (2016) there are differences in the metabolic status of mechanical ventilation in critically ill patients, especially in low metabolic status. Age and types of diseases can affect the metabolic status of patients. Empirical nutritional support is not applicable to patients[16].

Most critically ill pediatric patients have a hypercatabolic state, however, some may experience reduced energy demand due to the use of sedation and analgesic agents, which contribute to a decrease in basal metabolic rate, especially if the patient is on MV.[30] In our study, the estimated mean energy requirement (NET) was calculated to be 214% more than baseline values (BMR) when patients were under mechanical support. Thus, our approach of summing the net with BMR and dividing by two, that is, taking an average for patients on mechanical ventilation, seems to be more appropriate than considering only the NET to avoid *overfeeding*.

Overfeeding of adult critically ill patients is associated with a higher incidence of infections and an increase in ventilation time. However, trophic nutrition or permissive undernourishment appears to have no negative effect on the patient and may even provide a survival benefit.[31]

Many studies indicate that the metabolic rate of children in the first week of critical illness is equal to or lower than the predicted basal metabolic rate in the first week of the disease.[6,32,33,34,35]

Many authors point to the unreliability of predictive equations, as they over or underestimate energy needs and do not consider the metabolic changes of postoperative pediatric cardiac patients.[6,29] In contrast, Avitzur et al (2003) demonstrated accuracy in the use of the Schofield equation to estimate energy needs in postoperative children younger than 3 years of age, with a difference of less than 3% compared to the value measured by indirect calorimetry.[32]

In a comparison between 42 cardiac (post-surgical) and non-cardiac patients in a PICU in Australia, Rogers et al (2003) showed that 52% of patients reached their estimated daily energy requirements during 7 days of hospitalization.[36] In our study, using our predictive calculation format, 53.8% (n=14) of patients reached the prescribed calorie goal above 90%, considering an average target of 138.58 ± 14.12kcal/KgP daily and starting the diet around the 3rd day. The mean energy range up to the 7th postoperative day was 67 ±37.7% of the prescribed goal. In the study by HONG et al (2014) caloric intake took another two weeks to reach the target of 110 to 120 Kcal/Kg/d and started around the 4th day.[37]

A cohort study with 500 pediatric critically ill patients (20% of whom were cardiac surgery patients) showed lower mortality when energy intake was greater than 66.7% of adequacy prescribed by the nutritionist compared with those who reached less than 33.3% of prescription adequacy[38].

According to Joffe et al, (2016) there is, to date, no evidence for or against the need for nutritional support in children during the first week of severe illness or critical condition.[16] During the critical state, overfeeding can cause important adverse effects such as increased production of carbon dioxide, deposition of fat in the liver and increased catabolism, due to excess macronutrients carbohydrate, lipids, and proteins respectively.[39,40] Animal studies have shown that restriction of 30 to 50% calories prolongs survival time and provides greater resistance to oxidative damage, considered similar to the inflammatory cascade of critical illness.[41] In 7 days of follow-up, there were 4 deaths.

As this is a single-center observational study, the external validity of these results is restricted to institutions with the same characteristics and a similar patient population.

The description of our results indicates that, in clinical practice, there are important challenges in the care of postoperative patients with heart disease in intensive care. Further prospective follow-up studies longer than seven days are needed to assess our clinical outcomes and consensus-based nutritional practices in promoting optimal nutritional outcomes in critically ill children.

CONCLUSIONS

Almost half of the patients did not meet the predicted nutritional needs within 7 days of PICU stay. These findings indicate important challenges in the care of postoperative patients with heart disease in pediatric intensive care. There is a need for more studies on the attention to caloric supply and better evidence on avoidance in pediatric patients., the *oververfeeding* and know the real benefits of *underfeeding* permissible in this population.

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