DOI: 103126/JNPS.V4113

Original Article

Gap Assessment of Calories Prescribed Versus Calories Delivered to Critically Ill Paediatric Patients

Maheen Awan,[1] Asna Zahid,[2] Junaid Rashid,[3] Shadab Masood,[4] Anam Latif[5]

[1] M.Phil. Food and Nutrition, Nutritionist at University of Child Health Sciences, The Children's Hospital, Lahore, Pakistan.
[2] Ph. D. Human Nutrition and Dietetics, Nutritionist at University of Child Health Sciences, The Children's Hospital, Lahore, Pakistan.
[3] Professor, Pro Vice Chancellor at University of Child Health Sciences, The Children's Hospital, Lahore, Pakistan.
[4] Senior Registrar, Department of Paediatrics, University of Child Health Sciences, The Children's Hospital, Lahore, Pakistan.
[5] Assistant Professor, Institute of Food Science and Nutrition, University of Sargodha, University Road, Sargodha, Punjab, Pakistan.

Article History
Received on - 2023 Dec 14
Accepted on - 2024 May 30

Keywords:
Critically ill; calories; feeding barriers; malnutrition; nutritional status; paediatric

Online Access

DOI: https://doi.org/10.60086/jnps1036

Abstract

Introduction: In critically ill paediatric patients, determination and delivery of accurate calories is a prerequisite for positive clinical outcomes. Gap between calories prescribed and delivered are a major cause of longer hospitalization and malnutrition.

Methods: 100 patients from PICU receiving feeds through naso-gastric or post-pyloric tubes were recruited in the study. Patients were divided into three age groups. Age, gender, diagnosis, weight, height, BMI / z-scores for age, EER, nutritional status, calories prescribed, delivered and the main barriers affecting the delivery of calories were determined.

Results: Out of 100 participants, 46 were severely malnourished according to WHO z-scores and 55 were severely malnourished according to SGA score. 24% of the patients met EER whereas 39% patients met prescribed calories, as the difference was less than 15 kcal / kg / day. The major feeding barrier was fluid restriction that affected 55% of the patients.

Conclusions: A large number of patients did not receive prescribed calories due to several interruptions. Protocols should be devised to address barriers in delivery of nutrition.

Introduction

Delivery of optimal nutrition to hospitalized children holds great significance in disease management process of patients.[1,2] Good nutritional intake delays the onset of malnutrition and is an important factor in survival and early discharge of critically ill patients in Paediatric Intensive Care Units (PICUs). One third of patients have some degree of malnutrition at the time of hospital admission and among these, two third decline further due to inadequate nutrition. Furthermore, two-third of well-nourished patients also become malnourished during hospital stay.[3] Adequate nutritional support in critically ill malnourished patients decreases rates of secondary infections, complications, hospital stay and overall cost.[4] Critical illness activates hyper-metabolism resulting in increased energy expenditure. Hence, accurate determination and provision of adequate energy is important for positive clinical outcomes.[5,6] Optimal delivery of nutrients, appropriate mode of feeding and monitoring of feeding strategy success are the aspects of nutrition support that should be thoroughly investigated in PICU's.[7] Delivery of nutrients is hampered by several factors such as poor estimation of protein and energy needs, inadequate nutrition prescription and discrepancies between prescription and delivery of nutrients, fluid

Correspondence

Asna Zahid,
Ph.D. Human Nutrition and Dietetics,
Nutritionist at University of Child Health Sciences,
The Children's Hospital,
Lahore,
Pakistan.
Email: asna.zahid52@gmail.com

restriction, intolerance or procedural interruptions.[8]
Subjective global assessment (SGA) is a reliable tool to diagnose malnutrition. It is a simple bedside method that evaluates overall clinical parameters associated with malnutrition and helps in identifying the patients who need nutrition intervention.[9] SGA determines changes in body weight, dietary intake, functional capacity, gastrointestinal symptoms and presumed metabolic demands from past six months and two weeks.[10] It further examines muscle wasting, subcutaneous fat and presence of edema. Each aspect is scored as A, B and C where A is well-nourished, B is moderately malnourished and C is severely malnourished. Indian Society of Critical Care Medicine practice guidelines suggests that nutritional assessment of critically ill patients should be done by SGA as biochemical assessment is not reliable in critically ill patients as an indicator of malnutrition.[11] Moreover, according to the recommendation of WHO, to compare nutritional status with international reference population z-scores are used.[12]

Primary purpose of the study was to assess the difference between calories prescribed and delivered to children in PICU. For this purpose, nutritional status and individualized measurement of energy requirements was done and number of children getting adequate calories were computed. Factors resulting in suboptimal delivery of nutrients were also analyzed.

Methods

An observational study was conducted in general medical wards of Children's Hospital, Lahore, Pakistan. Each of the four medical wards of The Children's Hospital Lahore consist of two ICUs. Paediatric patients from all medical ICU's participated in the study from January 2023 to July 2023. We calculated sample size by using following formula:

$$N = Z^2 (SD^2 / d^2)$$

where N represents sample size, Z represents z-score based on desired level of confidence interval that was 95%, SD represents standard deviation and d represents precision. All patients admitted to PICU wards were screened for eligibility. Total 566 pediatric patients were screened and 100 patients participated in the study according to calculated sample. Inclusion criteria comprised of children from age of six months to 15 years admitted for at least seven days and receiving nutrition via tube feeding for minimum of 48 hours. Mechanically ventilated patients or the patients on total parenteral feed (TPN) were excluded. The study was approved from Institutional Review Board of University of Child Health Sciences (No. 7389/UCHSCH). All bioethics protocols were followed during the study. Participants were enrolled after seeking written consent from the attendants of the patients. Demographic and clinical characteristics including age, gender, diagnosis, weight, height, BMI, z-scores for age and caloric intake were recorded at the time of admission to PICU. SGA rating questionnaire was filled for each by clinical nutritionists after at least seven days of stay in ICU. Infants were weighed using calibrated MS3500 digital infant scale whilst children above one year of age who can stand independently were weighed using calibrated Beurer digital weight scale. Measurements were repeated three times and average weight was recorded. Weight of bed ridden patients was determined by using the following equation[14]:

Weight (Kg) = 0.5759 x (Arm circumference, cm) + 0.5263 X (Abdominal circumference, cm) + 1.2452 X (Calf circumference, cm) - 4.8689 X (Sex, male = 1 and female = 2) - 32.9241 (R = 0.94)

Height was measured using Prestige infantometer slider for children less than two years of age whilst Seca 213 portable stadiometer was used for mobile children above two years of age. For bedridden patients, ulnar height was measured using following formula[15]:

Height (cm) = 0.59 x ulnar length (mm) + 13.1

Standard growth charts of WHO (Birth to two years and two to five years charts for girls and boys) were used to calculate weight for age z-scores.[16] BMI was calculated for children above five years of age. After computing BMI, z-scores were calculated using WHO's BMI for age charts for girls and boys. Z-score cut points of < - 2 SD and < - 3 SD were defined as underweight and severely underweight respectively. Amount of calories delivered to the patients and calories prescribed during the rounds were measured separately on daily basis. For nutrition delivery indirect calorimetry was not feasible in our PICU so we used predictive equation for calculation of calories as per ASPEN (American Society of Parental and Enteral Nutrition) recommendations 2017 that suggests individualized caloric requirements using Schofield equation without any stress factor.[17] However, calories prescribed were individualized for each patient according to patient's medical condition, clinical assessment and feeding trials. In addition, data reflecting the reasons for inadequate or cessation of nutritional delivery was also recorded. Patients received enteral feeds via nasogastric and post-pyloric tubes. Feedings were continuous or intermittent. Some patients were also receiving intravenous maintenance fluids. Calories from maintenance fluids were also calculated and added to the total calories. Maintenance fluids were given on basis of body weight. A z score of > - 1 SD was considered as normal, - 2 SD was considered as moderate malnutrition whereas - 3 SD and less was considered as severe acute malnutrition.[18] Prescribed calories were compared to estimated energy requirements (EER) and total delivered calories were compared to prescribed calories. Reasons for not delivering prescribed energy intake were recorded. A difference of 15 kcal / kg / day was considered as clinically relevant according to consensus of

team of 4 PICU nutritionists and physicians. Data was analyzed using statistical package for social sciences (SPSS) version 16. The data was expressed as medians except where specified. Medians of estimated energy requirements and prescribed calories and actual delivered calories and prescribed calories were compared using Wilcoxon Signed-Rank test in each specified age group. P-value that was < 0.05 was considered as statistically significant. Children taking adequate calories according to estimated energy requirements and prescribed calories was also recorded over the period of stay in ICU.

Results

Total 566 patients admitted to PICU were screened and 100 patients were enrolled in the study. All enrolled participants were studied over the period of stay in PICU. Baseline of the patient diagnosis and characteristics are summarized in Table 1.

Table 1: Population characteristics and diagnosis

Variable	N, Mean ± S.D, or N (%)
Children (N)	100
Age (%)	
6 months – 1 year	41%
> 1 year – 7 years	44%
7 years - 12 years	14%
Above 12 years	1%
Weight (kg)	
6 months – 1 year	6.02 ± 1.68
1 year – 7 years	10.31 ± 3.41
7 years - 12 years	26.07 ± 9.52
Above 12 years	33*
Height (cm)	
6 months – 1 year	64 ± 6.46
1 year – 7 years	81.47 ± 13.50
7 years - 12 years	128.54 ± 10.31
Above 12 years	69*
Gender	
Male	62%
Female	38%
Primary reason for admission	
Respiratory disorders	34%
GI disorders	23%
Neurologic disorders	21%
Sepsis	6%
Other	16%

*Only one patient was present in group above 12 years. Hence, mean and standard deviation were not computed

Clinical outcomes of patients over the period of the study are described in Table 2. Stay of patients in PICU was from seven to 27 days whereas total stay in hospital was nine to 39 days on average. SGA scores showed that 55% paediatric patients were severely malnourished and had deteriorated over past two weeks. In the same manner, overall nutritional status as determined by z-scores showed 39% children fall in category of severely malnourished. SGA showed higher percentage of malnourished children in comparison to z scores determining that condition of children worsened over past few weeks due to hospital stay.

Table 2. Clinical outcomes of paediatric patients

	Means ± S.D
Length of stay in hospital	18.80 ± 7.20
Length of stay in ICU	13.08 ± 6.08
Days from admission to ICU to start of tube feeding	6.39 ± 4.30
Type of tube feeding	
Nasogastric route	88%
Post-pyloric route	12%
SGA (N, %)	
A	22%
B	23%
C	55%
Nutritional status	
Adequate > - 1 SD	39%
Moderately malnourished - 2 SD	15%
Severely malnourished – 3SD	46%

Prescribed calories vs. delivered calories:

Calories were prescribed on the basis of their energy requirements and tolerance limit and were compared to EER. Medians of EER were more than the medians of prescribed calories as the calories were prescribed based on tolerance level, medical condition and level of fluid administered. Prescribed calories were more than calories delivered because of certain factors discussed below. The difference between EER and prescribed calories and prescribed and delivered calories was expressed in medians for each specified age groups. In each age group difference between EER and calories prescribed was statistically significant $P < 0.05$ whereas the difference between prescribed calories and delivered calories was highly significant $P < 0.001$. Medians of calories prescribed and delivered are mentioned in table 3 along with estimated energy requirements.

Table 3: Medians of prescribed and delivered calories along with estimated energy requirements

Age groups	Estimated energy requirent (kcal / kg / day)	Prescribed calories (Median) (kcal / kg / day)	Delivered Calories (Median) (kcal / kg / day)
6 months to 1 year	90	80.3	56
1 year to 7 years	75	63.1	46.85
7 years to 12 years	60	54.1	30.5
Above 12	30	27*	18*

*Only one patient was present in group above 12 years thus median was not computed

39% of patients had adequate calories delivered according to the calories prescribed as the difference in delivery of calories was less than 15 kcal / kg / day whilst 24% patients had adequate calories according to EER. This was based on the frequency of daily caloric intake over the period of stay in PICU.

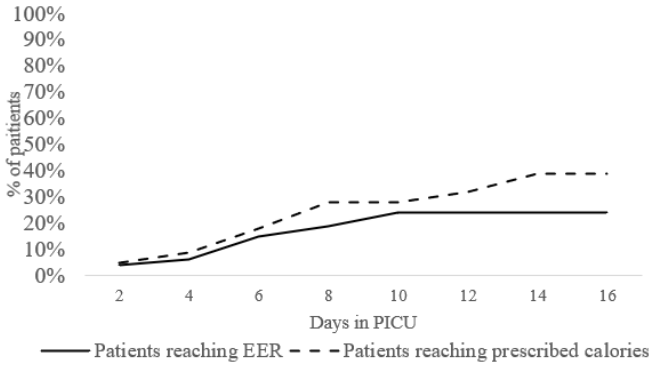

Figure 1: shows patients reaching EER and prescribed calories every morning after the rounds. Maximum patients that reached prescribed calories were 39% achieved in 12 days of stay on average.

Patients had to stop their feeds due to different procedures done for diagnosis and treatment such as extubation, surgical interventions and imaging. In few patients, the reason for decreased caloric intake was not understood after repeated assessment and observation. Major barriers causing calorie deficit among patients that lead to deterioration in nutritional status are mentioned in Table 4.

Table 4: Major feeding barriers among patients

Feeding barriers	% affected
Fluid restriction	55%
Feed intolerance	26%
Diarrhea	13%
Abdominal distention	3%
Gastric residues	10%
Procedural interruptions	12%
Extubation	1%
Surgical interventions	4%
Imaging (CT / MRI)	7%
Undetermined causes	7%

Discussion

In the current study, actual calories delivered to critically ill paediatric patients were compared to EER as guided by ASPEN and to actual calories prescribed based on individualized condition. Despite early initiation of tube feeding, only 24 out of 100 patients met EER while 39 out of 100 patients had delivered calories equal to the calories prescribed after approximately 12 days of PICU stay. We tried our best to initiate feed within 48 hours after admission but few patients were unable to tolerate feeds. No patient was kept NPO for six days. The mean 6.39 ± 4.30 indicated days from admission to PICU to start of tube feeding in a persistent manner. The medium for most of the food deliveries was cow's milk, as patients were unable to afford expensive nutritional formulas. Medium chain triglyceride based oils and Beneprotein powder provided by our hospital was added to feeds according to requirement to increase calorie density. Moreover, fruits, vegetables or cereals were added to the feed in blended forms. All foods were mixed and grounded in cow's milk or meat stock for children above one year of age whereas below one year breastmilk was the preferred medium for mixing of foods. Calories of each feed was adjusted as per the prescription.

We have seen that factors interrupting the feeding are associated with a significant deficit in caloric delivery. Major interruption was fluid restriction that affected more than half of the patients and as tube feeds are liquid based formulations and restriction of fluid hampers proper delivery of nutrition.[20] Second most common cause was feed intolerance due to which feeds were stopped intermittently. It is known that gastrointestinal symptoms causing intolerance is one of the commonest hindrances in proper nutrition delivery and a major reason of intolerance is gastric residual volume.[21] In our study, most common symptom of feed intolerance was diarrhea as it affected 13% of patients. Due to diarrhea, consistency of

nutrition delivered was changed often and eventually we have to deliver less than prescribed calories so that the patient can tolerate the feed and symptoms of diarrhea subsided.

Procedural interruptions affected 12% patients. We had to stop feeds due to procedures. The patients on continuous feeding were more affected due to procedural interruptions. A study conducted by Uozumi and colleagues showed similar results, as different procedures like extubation, airways manipulation or any diagnostic test hampered caloric delivery to patients causing deficit in caloric delivery. In some patients, caloric intake was less than required without any major symptom thus they were labelled as undetermined cause to calorie deficit.[22]

Patients were also assessed for malnutrition at the time of admission. Z-scores showed that 46% of the paediatric patients admitted to PICU were severely malnourished whereas SGA rating showed that 55% patients fall in category of malnutrition after at least seven days of hospitalization. A study described that anthropometric measurements to assess malnutrition have limitations in hospitalized patients and SGA is more practical as it covers changes in past few weeks and involves assessment of functional capacity, caloric intake along with clinical symptoms of malnutrition.[23]

In this study, caloric deficit against prescribed calories was found in 61% patients whereas calories deficit for EER was found in 76% patients even after 13 days of admission. A study conducted by Taylor and colleagues showed that 58% of patients met EER after seven days of PICU admission. These values are more than the present results. Our results could be attributed to various factors such as malnutrition before hospitalization, delay in hospitalization after illness, longer periods illness, lack of awareness in parents or caretakers at home.[23]

Although our study is a novel study in this field from our region, it does have its limitations. The study did not include mechanically ventilated patients. It is a single centered study with a limited sample size thus limiting the generalization of our result. Due to lack of funding we were unable to buy standard formulas for enteral feeding. Effect of total caloric intake on length of stay of patients was not investigated which could reflect the significance of optimal nutrition in recovery of patients.

Conclusion

We found that certain barriers affected delivery of calories prescribed to patients in critical care setting leading to malnutrition. Calorie deficit can be prevented if we develop an efficient protocol for interruptions. For patients with gastrointestinal symptoms, post pyloric tube can be a better option. Duration of fasting should be reduced for children with malnutrition and instead fed with post-pyloric tube feeds. Grounded calorie dense formulas and foods with less fluid should be given in patients with fluid restriction.

Acknowledgment: The authors are grateful to Vice Chancellor University of Child Health Sciences and The Children's Hospital Lahore Prof. Dr. Masood Sadiq for allowing us for the study. We are thankful to nursing staff of pediatric ICUs of medical wards for their cooperation.

Conflict of interests: None

Funding None

References

1. Abdul Manaf Z, Kassim N, Hamzaid NH, Razali NH. Delivery of enteral nutrition for critically ill children. Nutr Diet. 2013 Jun;70(2):120-5. DOI: 10.1111/1747-0080.12007
2. Wheeler DS, Wong HR, Shanley TP, editors. Pediatric Critical Care Medicine: Volume 3: Gastroenterological, Endocrine, Renal, Hematologic, Oncologic and Immune Systems. Springer; 2014 Jul 3. DOI: 10.1007/978-1-4471-6416-6[1]
3. Lew CC, Yandell R, Fraser RJ, Chua AP, Chong MF, Miller M. Association between malnutrition and clinical outcomes in the intensive care unit: a systematic review. J Parenter Enteral Nutr. 2017 Jul;41(5):744-58. DOI: 10.1177/0148607115625638 PMID: 26838530
4. Narayan SK, Gudivada KK, Krishna B. Assessment of nutritional status in the critically ill. Indian J Crit Care Med. 2020 Sep;24(Suppl 4):S152. DOI: 10.5005/jp-journals-10071-23617 PMID: 33354033 PMCID: PMC7724950
5. Kinney JM. Nutrition and metabolism in patient care. 1st ed., vol. 1. Philadelphia: Saunders; 1988 Mar.
6. Ndahimana D, Kim EK. Energy requirements in critically ill patients. Clin Nutr Res. 2018 Apr;7(2):81. DOI: 10.7762/cnr.2018.7.2.81 PMID: 29713616 PMCID: PMC5921333
7. Mehta NM, Compher C. ASPEN Clinical Guidelines: nutrition support of the critically ill child group. 2009;47:22. DOI: 10.1177/0148607109333114 PMID:19398612
8. Bockenkamp B, Jouvet P, Arsenault V, Beauséjour M, Pelletier VA. Assessment of calories prescribed and delivered to critically ill children. e-SPEN, E Spen Eur E J

Clin Nutr Metab. 2009 Aug 1;4(4):e172-5.
DOI: 10.1016/j.eclnm.2009.04.001

9. Duerksen DR, Laporte M, Jeejeebhoy K. Evaluation of Nutrition Status Using the Subjective Global Assessment: Malnutrition, Cachexia, and Sarcopenia. Nutr Clin Pract. 2021 Oct;36(5):942-956.
DOI: 10.1002/ncp.10613
PMID: 33373482

10. Domenech-Briz V, Gea-Caballero V, Czapla M, Chover-Sierra E, Juárez-Vela R, Santolalla Arnedo I, et al. Importance of nutritional assessment tools in the critically ill patient: A systematic review. Front Nutr. 2023 Jan 30;9:1073782.
DOI: 10.3389/fnut.2022.1073782
PMID:36793999 PMCID:PMC9923005

11. Mehta Y, Sunavala JD, Zirpe K, Tyagi N, Garg S, Sinha S, et al. Practice guidelines for nutrition in critically ill patients: a relook for Indian scenario. Indian J Crit Care Med. 2018 Apr;22(4):263.
DOI: 10.4103/ijccm.IJCCM_3_18
PMID: 29743765 PMCID: PMC5930530

12. Seetharaman N, Chacko TV, Shankar SL, Mathew AC. Measuring malnutrition-The role of Z scores and the composite index of anthropometric failure. Indian J Community Med. 2007 Jan 1;32(1):35-9.
DOI: 10.4103/0970-0218.53392

13. Secker DJ, Jeejeebhoy KN. Subjective global nutritional assessment for children. Am J Clin Nutr. 2007 Apr 1;85(4):1083-9.
DOI: 10.1093/ajcn/85.4.1083
PMID:17413109

14. Rabito EI, Vannucchi GB, Suen VM, Castilho Neto LL, Marchini JS. Weight and height prediction of immobilized patients. Rev Nutr Campinas. 2006;19:655-61.
DOI: 10.1590/S1415-52732006000600002

15. Rasouli MA, Newth CJ, Khemani RG, Ross PA. Predicting body height in a pediatric intensive care unit using ulnar length. Front Pediatr. 2018 Jun 22;6:187.
DOI: 10.3389/fped.2018.00187
PMID: 30035103 PMCID: PMC6023995

16. Leroy J. ZSCORE06: Stata module to calculate anthropometric z-scores using the 2006 WHO child growth standards.

17. Kratochvil M, Klucka J, Klabusayova E, Musilova T, Vafek V, Skrisovska T, et al. Nutrition in pediatric intensive care: A narrative review. Children (Basel). 2022 July 11; 9(7)1031-1040.
DOI: 10.3390/children9071031
PMID:35884015 PMCID:PMC9318205

18. Collins S, Dent N, Binns P, Bahwere P, Sadler K, Hallam A. Management of severe acute malnutrition in children. Lancet. 2006 Dec 2;368(9551):1992-2000.
DOI: 10.1016/S0140-6736(06)69443-9
PMID:17141707

19. Braegger C, Decsi T, Dias JA, Hartman C, Kolacek S, Koletzko B, et al. Practical approach to paediatric enteral nutrition: a comment by the ESPGHAN committee on nutrition. J Pediatr Gastroenterol Nutr. 2010 Jul 1;51(1):110-122.DOI: 10.1097/MPG.0b013e3181d336d2 PMID: 20453670

20. Tume LN, Valla FV. A review of feeding intolerance in critically ill children. Eur J Pediatr. 2018 Nov;177:1675-83.
DOI: 10.1007/s00431-018-3229-4
PMID:30116972

21. Uozumi M, Sanui M, Komuro T, Lizuka Y, Kamio T, Koyama H, et al. Interruption of enteral nutrition in the intensive care unit: a single-center survey. J Intensive Care. 2017 Dec;5(1):1-6.
DOI: 10.1186/s40560-017-0245-9
PMID:28794882 PMCID:PMC5545034

22. Hartman C, Shamir R, Hecht C, Koletzko B. Malnutrition screening tools for hospitalized children. Curr Opin Clin Nutr Metab Care. 2012 May 1;15(3):303-9.
DOI: 10.1097/MCO.0b013e328352dcd4
PMID: 22588189

23. Taylor RM, Preedy VR, Baker AJ, Grimble G. Nutritional support in critically ill children. Clin Nutr. 2003 Aug 1;22(4):365-9.
DOI: 10.1016/S0261-5614(03)00033-5
PMID:12880603