Int J Cur Sci Res. 2012; 2(1): 246-250

Contents lists available at CurrentSciDirect Publications

International Journal of Current Scientific Research

Journal homepage: www.currentscidirect.com

Original article

Medical nutrition therapy and its outcome in the pediatric intensive care unit

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ARTICLE INFO

Keywords:
Critically ill
Nutritional support
Butrient intake
Length of hospitalization
Ventilation support days

ABSTRACT

Background: Malnutrition is common at hospital admission and tends to worsen during hospitalization. Nutrition therapy is therefore essential for the care of critically ill children. Inadequate feeding leads to malnutrition and may increase the patient's risks of morbidity and mortality. Objectives: To assess the nutritional status and then describe the adequacy of early nutritional support in improving outcomes among critically ill paediatric patients. Design: A prospective, cohort study. Setting: Paediatric Intensive care units (ICU) in a multispecialty tertiary care hospital at Chennai, India Patients: 260 patients aged one month to six years, who were expected to stay in the PICU more than 24 hours and who were on early nutrition support were enrolled in the study. Measurements and Main Results: A total of 49.2 % of the children were underweight, 39.6% were wasted and 51.9% were stunted. Nutritional support in these patients was started on an average of 1.66 ± 1.5 days after PICU admission. The average time taken for attainment of 100% goals was 3.79 ± 2.17days after initiation of feeds. Transition to oral feedings was done on an average of 3.17 ± 1.40 days after attainment of goals. The average length of stay and ventilator support days in the PICU for these patients was 10.71± 5.36 days and 3.94± 1.96 days respectively. Conclusions: There was an improvement in nutrient intake, maintenance of body weight and biochemical parameters such as haemoglobin, total protein and albumin, reduced length of stay in the hospital and ventilator support days and decreased gastrointestinal complication observed for these critically ill patients with early initiation and progression of nutritional support as reported by various authors in their research carried out in different hospital settings.

1. Introduction

Despite technological advances, malnutrition is still widespread in pediatric intensive care units (PICUs). Studies have shown that 24% to 55% of patients present with acute or chronic malnutrition on admission and that deterioration of nutrition status commonly occurs during hospitalization [1-3]. Critically ill children have a high risk of malnutrition because of stress-induced changes in intermediary metabolism; these changes are characterized by an increased basal metabolic rate and intensive protein catabolism [4-6]. In general, the development or perpetuation of malnutrition during hospitalization in the PICU is due to illness, unknown nutrition condition and an inadequate supply of nutrients [7,8]. In these patients, malnutrition is associated with physiologic instability. As a result, more intensive clinical care is required and the mortality rate is high [8].

Nutrition care studies have proposed that an early intervention that targets nutrition assessment and provision of optimal nutrition support can prevent or minimize the complications of malnutrition [9,10]. The goal of nutrition support therapies is to augment the short-term benefits of the pediatric stress response while minimizing the long-term harmful consequences. The significance of the optimal nutrition for health and human development is well recognized. Nutrition support is an accepted standard of care in Pediatric Intensive Care Units (PICUs) and the provision of nutrients can prevent malnutrition, can result in improved wound healing, decrease catabolic response to injury, enhanced immune system function, improve gastrointestinal structure and function and thereby improve clinical outcomes. Accurate assessment of energy requirements and provision of optimal nutrition support therapy through the appropriate route is important in pediatric critical care. The prescription of optimal nutrition support therapy during critical illness requires thorough assessment of the risks and benefits associated with the timing, route and quantity of nutrient intake. Ultimately, an individualized determination of nutrient requirements must be made to provide

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appropriate amounts of both macro and micronutrients for each patient at various times during the illness course. The delivery of these nutrients requires careful selection of the appropriate mode of feeding and monitoring the success of the feeding strategy [8].

Based on the beneficial evidence of early nutrition support, this study was undertaken to determine the adequacy and timeliness of nutrition support provided, the influence of these factors on clinical outcomes.

2. Materials and Methodology

The study was conducted on 260 subjects admitted to the Paediatric Intensive Care Unit (PICU) of Sri Ramachandra University and teaching hospital, Chennai, India, for a period of sixteen months from January'10 to April 2011 after obtaining approval from the Institutional Ethics Committee. Simple random sampling technique was adopted in selection of the subjects for the study. Data was collected from the subjects who met the following inclusion criteria: subjects between the age group > 28 days to 6 years with PICU stay of 24 hours or more and eligible of receiving early nutrition support (oral and/or enteral) with functional gastrointestinal tract.

Assessment of nutritional status of the subjects on admission to the PICU was done. All patients' height and weight was measured. The obtained weight was compared with the expected weight using NCHS standards and it was interpreted with IAP Classification for weight for age and Waterlow's classification for weight for height. Weight for Age (W/A) and Weight for Height (W/H) indices were used to identify the incidence of acute malnutrition. Similarly, the obtained height was compared with the expected height using National Centre for Health Statistics standards (NCHS) and it was interpreted with Waterlow's classification for Height for Age (H/A) identifying the extent of prevalence of stunting.

The nutritional requirements were estimated using predictive equations as per Indian Council of Medical Research standards (2009), with care taken to avoid either overfeeding or underfeeding. Nutritional support was provided orally and/or enterally based on the guidance and the judgement of the physician clinically responsible for the individual child, independent of the study. The study subjects were followed up/ monitored on a day to day basis until discharge from the hospital. Daily documentation of 24-hour nutrient intake from the day of initiation till the day of discharge was done.

The time duration from PICU admission to initiation of nutritional support, day of attainment of goals and day of transition from enteral feeding to oral feeding and outcome measures such as weight changes, improvement in biochemical parameters, length of hospitalization, ventilation support days and any gastrointestinal complication were recorded. SPSS, version 17.1 was used for statistical analyses. The tests that analyzed the data statistically were Mean and Standard deviation, Percentages and Student's 't' –test.

3. Results and Discussion

A total of 319 subjects aged one month to six years who were admitted to the multispecialty Pediatric Intensive Care Unit (PICU) of Sri Ramachandra Hospital were initially enrolled in the study. During hospitalization, 17 deaths occurred, 12 went home against medical advice or shifted to other hospital and the rest 30 subjects had missing data in terms of anthropometric measurements, laboratory data etc., so their data was excluded during analysis. Finally the population studied comprised of 260 subjects. These subjects were followed up during the study period. Sixty two percent of the study subjects were less than one year of age and 38% were greater than one year of age. The mean age of the subjects was 1.61±1.64 years. Around 58% were boys and 42% were girls. One hundred and sixty eight (65%) of the cases were hospitalized with acute and 92 (35%) with chronic disease. Most of them (35%) were admitted with medical related problems such as failure to thrive, sepsis, acute gastroenteritis, pneumonia, protein energy malnutrition, dengue, malaria, jaundice, etc followed by respiratory illness (24%) and neurologic related diseases (20%).

3.1. Nutritional Status

Evaluation of the nutritional status of the subjects using W/A, W/H and H/A criteria was done to determine the incidence of acute and chronic malnutrition and it is as presented in table 1.

Table 1: Nutritional Status according to W/A, W/H, H/A criteria

Nutritional Status	W/A (n-260)	W/H (n-260)	H/A (n-260)
	n (%)	n (%)	n (%)
Grade III	43 (16.5)	20 (17)	45 (09)
Grade II	41 (15.5)	40 (18)	47 (14)
Grade I	44 (17)	43 (17)	43 (17)
Normal	132 (51)	157 (48)	125 (60)

Wasting (W/H values) indicates recent or acute malnutrition. Evaluation of W/H values revealed a nutritional disturbance (wasting) in 103 (39.6%) cases, of which severe wasting was observed in 17% of the subjects. Similar research done in Turkey among hospitalized children revealed that 40.9% of their cases had wasting [9-11] which is comparable to findings of our study. In contrary, a study done in Brazil by Marcelle MM [12], reported wasting in only 4.4% of their study population. Though the incidence of wasting rates were lesser than the above reported observation, it does indicate that there is a need for understanding of the prevalent wasting among the critically ill children, which would impair the clinical prognosis. Malnutrition has shown to be associated with increased morbidity and mortality in children [13,14], including a higher risk of infections due to poor immune defense, wound healing problems, reduced gut function, longer dependency on mechanical ventilation, longer hospital stay and increases health care costs [15].

Acute malnutrition in terms of underweight can also be assessed by calculation of W/A values. In the studied population, W/A (according to IAP) analysis showed changes in nutritional status (underweight) in 128 (49.2%) cases, of which 16.5% of the subjects were severely underweight. Ferreira H.S [16], when evaluating weight for age of the patients, reported that 71.2% suffered from malnutrition at the moment of their hospitalization. Overall in our study population, 49.2% according to IAP criteria were underweight.

The calculation based on weight does not help to exclude other obvious syndromes with short stature. Moreover, it does not imply whether the PEM is of recent or past onset. Height indicates past or chronic PEM and is used to grade stunting. Using height measurements the severity of stunting can be identified as Grade I, II or III. The calculation of H/A analysis in our study showed lower height (stunting) in 135 (51.9%) cases of which over nine percent of them were severely stunted. Similarly, a study done by Dogan Y, when their study population was classified according to the height for age, chronic malnutrition was established in 27% of the cases. In our study, a total of 51.9% of the subjects were found to be stunted, which shows that these subjects were chronically undernourished.

A high prevalence of undernutrition (underweight 49.2%, stunting 51.9% and wasting 39.6%) among hospitalized critically ill children in our population with both acute and chronic disease is worth an attention.

3.2.Overview Of Malnutrition Prevalence

The prevalence of undernutrition across all age groups in terms of stunting, wasting and underweight could be better understood from the following Venn diagram.

Figure 1: Prevalence of Undernutrition

It could be observed from fig.1, that out of 260 subjects, 68 (26%) subjects were stunted, 22(8%) subjects were underweight and 39 (15%) subjects had wasting. Three (one percent) subjects had both stunting and wasting, 46 (18%) subjects were both stunted and underweight, 43 (17%) subjects were underweight and also had wasting. All the three forms of undernutrition such as stunting, wasting and underweight was observed among 17 (7%) subjects. Overall, it is understood that only 22 (8%) subjects among the study population were normal and 238 (92%) were malnourished, when all the three parameters were taken into consideration.

Malnutrition in hospitalized children varies between 21% and 80% in proportion with the level of development of the countries [17,18]. A research done in Mexico purports that in 72.2% of 450 hospitalized patients, a varying degree of malnutrition was found [18]. According to two studies done in different areas of Turkey, malnutrition rates varied between 55.1-56.6% [19,20]. In contrary, the overall prevalence of malnutrition was higher (92%) in our study population when compared to the studies cited above.

3.3.Nutrition Therapy

Having assessed the baseline nutritional status optimal nutrition support was provided within 24-72 hours to all the subjects admitted in the critical care unit after hemodynamic stabilization. The estimated average requirement on per day basis was 1098.44±176.18 kcal and 17.44± 4.76 g of protein. Around 79% of our subjects were on oral nutrition support and a small percentage (21%) was on enteral nutrition support usually an intermittent bolus, mostly through the gastric route. For subjects who were in a position to resume oral nutrition support after the initial phase of hemodynamic stabilization, nutrient dense formulas and/or progressive hospital diets in terms of consistency starting from clear liquids and progressing to soft solids was suggested, without compromising the nutritional intake. Subsequently, an individualized nutrition care plan was devised. For subjects on enteral nutrition support, initiation of feeds was done using standard pediatric enteral formulas at the rate of 10 ml-60ml/ 2-3 hourly in children <12 months and at the rate of 30 ml-90ml in children aged 1-6 year.

3.4. Outcomes of Nutrition Support

The outcomes of nutrition support among our study subjects were analyzed and it is as presented in table 2 and discussed in the following section.

Table 2: Outcome Parameters

Parameters	MEAN ± S.D	
Initiation of Feeds (days)	1.66 ± 1.5	
Attainment of Goals (days)	1.73 ± 0.34	
50%	2.81 ± 0.49	
75%	3.79 ± 2.17	
100%		
Difference in Nutrient Intake (Initial and Final)	33.09±41.01	p value
Energy (Kcal)	4.26 ± 3.32	<0.001
Protein (g)		<0.001
Transition of feeds (days)	3.17 ± 1.40	
Difference in Laboratory Parameters		
(Initial and Final)		p value
Hemoglobin (g/dl)	0.14±0.01	NS
Total Protein (g/dl)	0.40±0.05	NS
Albumin (g/dl)	0.50±0.08	NS
Weight Gain (g)	0.55 ± 0.14	NS
Length of Stay (days)	10.71± 5.36	
Ventilation Support Days	3.94± 1.96	
Gastrointestinal Complications	3.94± 1.96	
Diarrhea (%)	4.0%	
Vomiting (%)	8.5%	
Abdominal Distension (%)	2.0%	
Feeding Interruptions		
Respiratory Distress (%)	14.75%	
Aspiration (%)	07.50%	
Radiologic Study (%)	05.75%	
Electrolyte Imbalance (%)	03.00%	
Bedside Procedures (%)	04.50%	

In our study, it was observed that nutrition support was initiated on an average of 1.66± 1.15 days after admission to the PICU. Once having started nutrition support, advancement of feed rate was done to enable early achievement of goal. In this study, for subjects on enteral nutrition support, advancement of feed rate was done as per protocol every second hourly by 10 ml-60ml in children <12 months and 30 ml-90ml in children aged 1-6 year, till the target rate was met as per the enteral nutrition support protocols. For subjects on oral nutrition support the use of dietary supplements and assistance with feeding were adopted depending on the case with care taken to meet the estimated nutrient requirement.

It was observed that using the RDA as the value for optimal energy and protein intake, no children admitted to the Pediatric Intensive Care Unit suffered from considerable cumulative energy and protein deficits. There was an overall improvement in the initial and final nutrient intake and the results were statistically significant ($p<0.001$).

Fifty percent of the estimated requirements were achieved on an average 1.73 ± 0.34 days and 75% goals were achieved on an average of 2.81 ± 0.49 days. Hundred percent goals of energy and protein requirement were achieved at an average of 3.79 ± 2.17 days. A recent meta-analysis noted that initiating feeding within 48 hours of ICU admission helped in achieving at least 60-70% of the patient's overall caloric needs during the first week of ICU admission [21] in contrary to the evidence which shows that nutrition goals are reached only after 5-7 days though nutrition support was started within 48-72 hours. However, in our study it was observed that initiation of nutrition support within 48 hours help achieve 100% goals within 72 hours after initiation of feeds. Transition from tube feeding to oral soft solids was done within 3.17 ± 1.40 days. This can be attributed to the use of a meticulous feeding regimen and supervised nutrition support by a trained nutritionist.

Once nutritional support is started accurate assessment of body weight changes is necessary for planning ongoing nutritional intake and assessing the adequacy of nutritional supportive regimens during critical illness. In our study, the subjects were weighed on admission and at discharge wherever possible using a weighing scale/pan. There was an improvement in weight (0.55 ± 0.14 g) of the subjects between admission and discharge. Overall, in our study subjects there was no weight loss and there was weight maintenance or an insignificant gain in weight observed. Many factors can affect weight and body composition, timely and appropriate nutrition therapy and routine anthropometric monitoring are essential to optimize nutrition care for critically ill children. Nutrition care studies have proposed that an early intervention can prevent or minimize the complications of malnutrition including weight loss [9,10]. By monitoring anthropometric measurements and using a protocol for timely initiation of nutrition therapy in the PICU, demonstrated an adequate intake at day seven, with preservation of lean body mass and minimal loss of adipose tissue.

3.3.Nutrition Therapy

Further, it was observed that the length of stay (10.71± 5.36 days) of the subjects in the hospital was comparatively shorter as defined in the literature (≥25 days) [24]. In a recent prospective study done by, the median length of stay of their study subjects in the PICU was 11 days which is almost comparable to the observations of our study. Patients who receive nutrition support within the first two days of ICU admission have significantly shorter stay in the ICU (≤25 days) and if evidence based protocols are used in the nutritional management of critically ill patients, the length of stay of the patients in the ICU can be shortened based on the disease severity [9,1022] as also observed in our study subjects.

Similarly, the ventilation support days (3.94± 1.96) were comparatively shorter as defined in the literature (< 7 days) [23]. Most authors would agree that adequate nutrition is a necessary prerequisite for successful weaning. Both overfeeding and underfeeding has been linked with the ability to wean patients from mechanical ventilation. Increased carbon dioxide production, due to excessive total kilocalories intake has been identified as a factor in preventing successful weaning from mechanical ventilation. The clinical presentation is excessive ventilatory demand with a high minute ventilation requirement to keep the partial pressure of carbon dioxide normal [24]. Therefore, in our study, subjects on ventilation were provided 35% to 55% of total kilocalories from carbohydrates to prevent overfeeding or underfeeding and help in expediting the weaning off process. Overall, it was observed that a coordinated and timely collaborative care of the multidisciplinary team assisted in effectively expediting the weaning off process from mechanical ventilation in our study subjects.

Further it was observed that there was no significant difference observed in the initial and final serum hemoglobin, total protein and serum albumin values. This can be attributed to adequacy of nutritional support in maintaining the levels rather than deterioration.

In our study population most of the subjects tolerated feeds and low frequency of gastrointestinal tract complications was observed as presented in table 2. This could be attributed to the early implementation of feeding by the digestive route, which may improve tolerance to the nutrients and by strengthening the trophism of the intestinal epithelium.

The observations of our study reiterate the fact that early institution of nutritional support, implemented and supervised by a trained nutritionist, is associated with beneficial outcomes and therefore, it is strongly recommended to improve feeding practices by implementing feeding protocols for optimal nutritional management in paediatric children admitted in a critical care unit.
Despite the known benefits of nutritional support, subsequent maintenance of nutrient delivery remains elusive among PICU patients as nutritional support is frequently interrupted in the intensive care setting for a variety of reasons as also observed in our study (table 2), some of which can be minimized [25,26]. Frequent interruptions in nutrient delivery may affect clinical

outcomes secondary to suboptimal provision of calories and reliance on parenteral nutrition [25]. To realize the potential benefits of nutritional support in the pediatric intensive care unit (PICU), both early initiation and maintenance of enteral feeding must be ensured.

4. Conclusion

The prevalence of malnutrition is high among infants and children admitted to the PICU as also inferred from our study. Adequate nutritional support in order to prevent disease related malnutrition should therefore play an important role in the clinical management of critically ill children both in acute illness and during recovery thereafter. Adequate nutrition is an essential need of all children for survival, mental, motor development and for growth. In our study, provision of early nutritional support showed a significant improvement in physiologic stability and outcomes of PICU patients.

In conclusion, the use of a nutrition management protocol for the early initiation of nutrition support to critically ill pediatric patients will improve time to nutrition initiation and should be considered as part of standard practice in the PICU setting. Our results provide multiple evidences for implementation of quality nutrition support administration to the pediatric critically ill population across a healthcare system by the critical care interdisciplinary team to improve the overall outcome.

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