A Training Program for Anthropometric Measurements by a Dedicated Nutrition Support Team Improves Nutritional Status Assessment of the Critically Ill Child*

Frederic V. Valla, MD[1]; Carole Ford-Chessel, BS[2]; Rosan Meyer, PhD[3]; Julien Berthiller, MSc[4,5,6]; Christine Dupenloup, BSN[1]; Nathalie Follin-Arbelet, BSN[1]; Anna Hubert, MD[1]; Etienne Javouhey, MD, PhD[1]; Noel Peretti, MD, PhD[7]

Objectives: The cornerstone of an optimal nutrition approach in PICUs is to evaluate the nutritional status of any patient. Anthropometric measurements and nutritional indices calculation allow for nutritional status assessment, which is not often part of routine management, as it is considered difficult to perform in this setting. We designed a study to evaluate the impact of a training program by the PICU nutritional support team on the implementation of routine anthropometric measurements on our PICU.

Design: A prospective study was performed over a 2-year period, which included: a baseline evaluation of nutritional assessment, knowledge, anthropometric measurements (weight, height, and head and mid upper arm circumferences), and nutritional indices calculation in patient files. This was followed by a training program to implement the newly developed nutrition assessment guidelines, which included anthropometrical measurements and also the interpretation of these. The impact of this nutritional assessment program was reviewed annually for 2 years after the implementation.

Setting: PICU–Lyon, France.

Patients and Subjects: PICU nursing and medical staff, and patients admitted in February 2011, 2012, and 2013.

Interventions: Training program.

Measurements and Main Results: Ninety-nine percent of staff ($n = 145$) attended the individual teaching. We found significant progress in nutritional awareness and confidence about nutritional assessment following the teaching program. In addition, an improvement in staff knowledge about undernutrition and its consequences were found. We enrolled 41, 55, and 91 patients in 2011, 2012, and 2013, respectively. There was a significant increase in anthropometric measurements during this time: 32%, 65% ($p = 0.002$), and 96% in 2013 ($p < 0.001$). Nutritional indices were calculated in 20%, 74% ($p < 0.001$), and 96% ($p < 0.001$) of cases.

Conclusions: This is the first study, showing that a targeted nutritional assessment teaching program that highlights both the importance and techniques of anthropometrical measurements has successfully been implemented in a PICU. It managed to improve staff knowledge and nutritional practice. (*Pediatr Crit Care Med* 2015; 16:e82–e88)

Key Words: critically ill child; intensive care; malnutrition; nutrition support team; nutritional status; training program

***See also p. 301.**

[1]Pediatric Intensive Care, Pediatric Department, Réanimation Pédiatrique, Hôpital Femme-Mère-Enfant, Lyon-Bron, France.

[2]Service diététique, Nutrition Department, Hôpital Femme-Mère-Enfant, Groupe Hospitalier Est, Lyon, France.

[3]Department of Paediatrics, Imperial College London, London, United Kingdom.

[4]Pôle Information Médicale Evaluation Recherche, Equipe d'Accueil 4129, Hospices Civils de Lyon et Université de Lyon, Lyon, France.

[5]Inserm, CIC201, EPICIME, RIPPS, CNRS UMR 5558 France.

[6]CHU Lyon, Hop L. Pradel, Service de Pharmacologie Clinique, Université Lyon, Lyon, France.

[7]Hépatologie Gastroentérologie et Nutrition Pédiatrique, Pediatric Department, Hôpital Femme-Mère-Enfant, Lyon-Bron, France.

Supported, in part, by Groupe d'étude Francophone de Nutrition en Soins Intensifs Pédiatriques and D Brottes and A Huriez–Centre de Ressource et Gestion de Projets–Hospices Civils de Lyon.

Dr. Valla consulted for Baxter global; received grant support from Baxter, Fresenius Kabi, and Aguettant; lectured for Baxter; received support for the development of educational presentations from Baxter; and received support for travel from Nutricia, Fresenius Kabi, and Nestle. Dr. Meyer served as a board member for the Mead Johnson and Nutricia Paediatric Board; consulted for Danone, Nutricia, Mead Johnson, and Nestle; lectured for Danone, Nutricia, Mead Johnson, and Nestle; and received support for the development of educational presentations from Danone, Nutricia, and Mead Johnson. The remaining authors have disclosed that they do not have any potential conflicts of interest.

For information regarding this article, E-mail: frederic.valla@chu-lyon.fr

DOI: 10.1097/PCC.0000000000000363

In developed countries, undernutrition at admission and during the stay on a PICU is diagnosed in 15–24% of cases (1–4). Children either develop undernutrition acutely during the stay or have underlying chronic diseases with already impaired nutritional status, affected further by inadequate nutritional support (1, 5). Unfortunately, there has been no change in the prevalence of undernutrition over time, which may be related to a combination of factors including lack of knowledge on the importance of optimal nutritional support by critical care staff and also the well-documented difficulties in establishing nutritional status and optimal support (6, 7). Undernutrition contributes significantly to morbidity and mortality in this population and has been linked to an increased length of hospital stay (4, 8–10).

The cornerstone of an optimal nutrition approach is to evaluate the nutritional status of any patient admitted to PICU (3, 11). There is no current consensus about the best method to evaluate nutritional status. Bioelectric impedance analysis, dual-energy x-ray absorptiometry, and serum nutritional biomarkers (albumin, prealbumin, etc.) are not recommended due to being influenced by fluid and electrolyte shifts, the acute inflammatory cascade liver dysfunction, and the technical limitations of the equipment (12).

Anthropometric measurements, including weight (W), height/length (H), skinfold thickness (TSF), and mid upper arm circumference (MUAC) are most commonly used. They are simple, reproducible, and cost-effective (13); however, they can be influenced by edema. These simple measurements enable the calculation of body mass index (BMI), weight for height ratio (WfH), height for age (HfA), weight for age, and MUAC-head circumference ratio (MUAC/HC). They allow for dynamic nutritional monitoring during PICU stay (14, 15).

Nutritional status assessment (NSA) was not part of routine management in our PICU due to the perception that it was not a priority and that anthropometrical assessments are difficult to perform in this setting. We therefore designed a study to evaluate the impact of a training program by the PICU nutritional support team (NST) (11, 16, 17) on the implementation of routine anthropometric measurements, to calculate nutrition indices, and to aid nutritional assessment on our PICU.

MATERIALS AND METHODS

A single-center prospective study was conducted in our 23-bed PICU (Lyon University Hospital—France) from February 2011 to February 2013. Local ethics approval was obtained for the study. No preterm infants are admitted to this unit.

The study was conducted in three phases. A baseline evaluation of nutritional assessment procedures and knowledge (**Table 1**) of medical and nursing staff was performed in February 2011 (preintervention cohort 1), which informed the NST on the training needs of the staff and a training program was developed accordingly. This teaching program consisted of the implementation of newly developed local nutrition assessment guidelines, which were taught in regular sessions on the unit that included the anthropometric measurements and also the interpretation of these. After 1 year, in February 2012, the impact

TABLE 1. Knowledge Questionnaire on Nutritional Assessment That Was Performed Before the Teaching on Nutritional Assessment

Question	Answer			
How many children in your opinion suffer from undernutrition at admission in our PICU?	%			
What is the percentage of children weighed at least once during PICU stay in our unit?	%			
How many children get a global nutritional assessment (including height, mid upper arm circumference, and head circumference measurements)?	%			
Is undernutrition at admission correlated with length of stay?	Yes		No	
Is undernutrition at admission correlated with acquired infections?	Yes		No	
Is undernutrition at admission correlated with morbidity and mortality?	Yes		No	
Does undernutrition at admission induce mild immune suppression?	Yes		No	
Is undernutrition at admission correlated with poor wound healing?	Yes		No	
Is undernutrition at admission correlated with delayed recovery?	Yes		No	
What tissue does undernutrition in PICU affect?	Fat mass	Lean mass	Both	
Is undernutrition in PICU preventable?	Yes		No	
Who do you think should be involved in detection, prevention, and treatment of undernutrition?	Doctors	Nurses	Dietitian	Parents
How confident do you feel about nutritional status assessment:	Not at all	Moderately confident	Confident	Very confident
Any further comments:				

of the teaching on NSA was reviewed (early postintervention cohort 2). This was followed by another review in February 2013 (late postintervention cohort 3) of the NSA and also the repeat of the knowledge questionnaire. We chose the same month to minimize the seasonal impact on the PICU population.

In order to ensure accuracy of measurements, all nurses and clinicians had an individual session on how to measure W, H, HC, and MUAC. The method described by World Health Organization (WHO) for HC and MUAC measurements were taught to staff (15). The precise use of scales was explained (Enterprise 9000 ArjoHuntleigh beds, Getinge Group, Malmo, Sweden; SECA757, SECA, Hamburg, Germany; CWB7726, Soehnle, Backnang, Germany), and nurses were also taught to take factors that may influence its accuracy (over hydration or dehydration) into account. Most of the children were weighed safely in their beds with incorporated scales (Giraffe, GE Healthcare, Chalfont St. Giles, UK; for infants under 5 kg; Enterprise 9000 ArjoHuntleigh for children over 3 yr); other patients were weighed on external scales by two trained caregivers, not to compromise their safety but to ensure accuracy. In addition, measurement methods for supine length (skull to heel) for patients under 1 month were taught (SECA207, SECA); for children greater than 1 month, ulna length to extrapolate the H was used, as per method described by Gauld et al (18, 19). Extrapolation calculation was automatically made by our computerized flowchart (ICIP-Philips Health Care, Amsterdam, The Netherlands). This program allowed for the dynamic monitoring of nutritional status based on growth curves, for BMI, WfH, and HfA using *z* scores for age from the WHO. We also used the WHO definitions for malnutrition: WfH and HfA less than –2 *z* scores defined wasting and stunting; BMI less than –2 *z* score and a BMI less than –3 *z* score were, respectively, defined as moderate and severe undernutrition; a MUAC/HC less than 0.3 would be a sign of undernutrition in patients younger than 4 years. The PICU NST was always available wherever there were difficulties with the measurements and interpretation of data. The teaching program was also used for any new staff members joining the PICU.

We collected measurements of W, H, MUAC, and HC, calculated nutritional indices (BMI, WfH, HfA, and MUAC/HC), and whether any medical conclusion on the child's nutritional status was drawn in the record from these calculations. TSF was not used as a marker of nutritional status, as it would be difficult to maintain the level of training to ensure accuracy of between-person variability in measurements (13). Patient characteristics were also collected to compare the three cohorts. Variables that could further limit the NSA were also collected which included: short length of stay (LOS), older age, and high Pediatric Index of Mortality (PIM)-2 severity of disease score.

Statistical analysis was conducted using SAS version 9.1.3 (SAS Institute, Cary, NC). Categorical variables were expressed as number (n) and percentage and quantitative variables as means ± SD. The hypothesis of normal distribution of quantitative variables was tested using the Kolmogorov-Smirnov and graphically confirmed with a histogram. Categorical variables were compared using the chi-square or Fisher exact test when the conditions of application of chi-square test were not met. Continuous variables were compared between groups using Student t test for normally distributed data and the Wilcoxon signed rank test for the nonparametric continuous data. Statistical significance was set at 5% ($p < 0.05$).

RESULTS

Ninety-eight percent of the nursing team ($n = 120$) and 100% of the clinicians ($n = 25$) attended the individual teaching. Eighty-six percent responded anonymously to the preintervention questionnaire and 70% to the postintervention one (**Table 2**). Its analysis revealed that before the intervention phase, the staff thought that approximately 16% of patients admitted to PICU suffered from undernutrition, but believed that 62% had a nutrition assessment performed in the unit. We found progress in the staff concerns and confidence about nutritional assessment following the teaching program, in addition to an improvement in staff knowledge about undernutrition, especially in regard to its consequences (LOS, morbidity, infection rate, wound healing, and rehabilitation), as outlined in Table 2.

Forty-one patients were enrolled in cohort 1, 55 in cohort 2, and 91 in cohort 3 (no missing data). No significant difference was found between the three cohort profiles, regarding age, LOS, severity score, sex, mortality rate, and nonsurgical/surgical or planned/unplanned admission (**Table 3**). No correlation with the process of nutritional assessment was found between the potential NSA confounding variables (using Spearman rank correlation coefficient): –0.12 ($p = 0.26$) between age and LOS; 0.19 ($p = 0.06$) between PIM-2 score and LOS; and 0.17 ($p = 0.10$) between age and PIM-2 score.

We compared cohort 1 to cohorts 2 and 3, respectively (**Table 4**), and found no significant difference in the proportion of W measurements. However, significantly, more patients had H (32%, 65%, and 99%), MUAC, and HC measurements (26%, 60%, and 96%) performed. Similarly, nutritional indices calculations also increased significantly, with an increase in calculation for WfH (38%, 75%, and 99%), HfA (20%, 75%, and 99%), BMI (40%, 75%, and 99%), and MUAC/HC (26%, 60%, and 96%). Finally, the outcome and assessment of nutritional status was significantly more documented in medical files (15%, 60%, and 70%).

DISCUSSION

This study aimed to assess the impact of a targeted nutritional assessment teaching program that highlighted both the importance and techniques of anthropometrical measurements. Our study included a preintervention questionnaire to identify knowledge gaps and to develop the training program. The nutritional training program included the following: general reading material (information about anthropometric measurement techniques, correct answers to the questionnaire), small group courses on the importance of nutrition in PICU, and individualized teaching to practice and interpret anthropometric measures and indices. Staff was also supported by the NST on a day-to-day basis for nutritional assessments and associated prescriptions. To the knowledge of the authors, this is the

TABLE 2. Knowledge, Awareness, and Concern of Medical and Nursing Staff About Nutritional Assessment Before and After Training Program

Questions	Preintervention Phase (*n* = 124): % (±SD)	Late Postintervention Phase (*n* = 101): % (±SD)	*p*
Think there is a link between undernutrition and			
Length of stay	75	95	< 0.0001
Morbidity-mortality	67	95	< 0.0001
Immune suppression	54	85	< 0.0001
Infection rate	75	93	< 0.0001
Bad wound healing	86	95	0.03
Prolonged rehabilitation	59	95	< 0.0001
Think acquired undernutrition in PICU concerns lean mass	46	93	< 0.0001
Feel concerned about undernutrition prevention and detection	67	95	< 0.0001
Feel confident with nutritional assessment	47	87	< 0.0001
According to you, which % of PICU patients			
Is concerned by undernutrition	16 (±10)	Not repeated	
Is weighed at admission	88 (±8)	Not repeated	
Has a global nutritional assessment at admission (weight, height/length, mid upper arm circumference, head circumference)	62 (±16)	Not repeated	

TABLE 3. Demographic and Clinical Characteristics at Admission

Characteristics	Cohort 1 (*n* = 41)	Cohort 2 (*n* = 55)	Cohort 3 (*n* = 91)	*p*2[a]	*p*3[b]
Age in months[c]	12 (1.5–70.0)	25.0 (1.0–95.0)	19 (1–84.0)	0.52	0.71
Length of stay in days[c]	6 (3–11)	6 (4–8)	4 (2–9)	0.99	0.66
Pediatric Index of Mortality 2 severity score[c]	1.6 (0.9–5.7)	3 (1–5)	2.8 (0.9–5)	0.31	0.55
Male (%)	25 (61.0)	33 (60.0)	56 (61.0)	0.92	0.95
Nonsurgical patients (%)	27 (65.9)	45 (81.8)	71 (78.0)	0.07	0.14
Planned admission (%)	9 (21.9)	5 (9.1)	15 (16.5)	0.08	0.45
Mortality (%)	1 (2.4)	1 (1.8)	2 (2.2)	0.99	0.99

[a]Comparison between cohorts 1 and 2.
[b]Comparison between cohorts 1 and 3.
[c]Median (Q25–Q75).

first publication that describes the development of a teaching program specifically for PICU with associated improvement in nutritional assessment. We have shown that over a 2-year period, the percentage of children with completed nutritional indices increased from 20% to 99% and found that 70% had a written nutritional plan as a result in their medical records. Lipman et al (20) found in a randomized trial that accuracy of linear growth could be improved in children in primary care centers through a nursing training program that combines both optimal equipment and growth assessment. A systematic review by Sunguya et al (21) evaluated clinical trials aiming to improve caregivers' feeding practices after nutrition training of health workers and identified 10 studies where feeding frequency, energy intake, and dietary diversity of children 6 months old to 2 years old improved. Nutritional training was also effective in countries where access to food was not a limiting factor as described by Penny et al (22). There is paucity of data on such training programs in the PICU setting; however, further studies are certainly warranted, in particular the impact on morbidity and length of hospital stay as a result of improved nutritional assessment.

The assessment of knowledge provided valuable information in regard to the teaching program. Although the majority of healthcare professionals were aware that LOS and wound

TABLE 4. Comparison Between Cohorts 1 (Preintervention Cohort) and 2 (Early Postintervention Cohort) and Between Cohorts 1 and 3 (Late Postintervention Cohort) for Anthropometric Measurements, Nutrition Indices Calculation, and Nutritional Status Conclusion Found in Patients' Medical Files

Nutritional Status Assessment	Cohort 1 (*n* = 41)	Cohort 2 (*n* = 55)	p^a	Cohort 3 (*n* = 91)	p^b
Weight, *n* (%)	38 (95)	51 (93)	0.99	91 (100)	0.9
Height, *n* (%)	13 (32)	36 (65)	0.002	90 (99)	< 0.001
HC, MUAC, *n* (%)	9 (26)	24 (60)	0.004	87 (96)	< 0.001
Weight for height, *n* (%)	15 (38)	41 (75)	< 0.001	90 (99)	< 0.001
Height for age, *n* (%)	8 (20)	41 (75)	< 0.001	90 (99)	< 0.001
Body mass index, *n* (%)	16 (40)	41 (75)	< 0.001	90 (99)	< 0.001
MUAC/HC, *n* (%)	9 (26)	24 (60)	0.004	87 (96)	< 0.001
Nutritional status assessment medical conclusion, *n* (%)	6 (15)	33 (60)	< 0.001	77 (70)	< 0.001

HC = head circumference, MUAC = mid upper arm circumference.
[a]Difference between cohorts 1 and 2.
[b]Difference between cohorts 1 and 3.

healing were affected by nutritional status, we were surprised to see that only 54% and 67% were aware of its role in the immune system and morbidity/mortality, respectively. The fact that only 47% felt confident in nutritional assessment was also an important indicator to the NST that teaching was required. In our study, we succeeded to significantly improve general knowledge about undernutrition consequences and the confidence of the nursing team to perform nutritional assessment. This was a result of our training program, which proved to be sufficient to achieve our aim of improving nutritional assessment on our unit. No previous studies have been published in a PICU setting on a training program and its content to improve nutritional assessment for us to compare our data with. However, it is known that training can improve knowledge and behavior in a healthcare setting. Gance-Cleveland et al (23) showed that a short training session on the healthy eating and activity was efficient on nurse practitioners' knowledge and behaviors. Pedersen et al (24) and Bjerrum et al (25) described a similar positive effect of a nurse training program to implement nutritional guidelines in adults, using "experimental learning theories" and the steps of "look, think, and act."

Undernutrition in PICU has been shown in recent studies to impact on the prognosis of critically children (4, 9, 26). Although there is a plethora of data in PICU on inadequate delivery of nutrients that impacts on morbidity and length of hospital stay (3), very little data focus on the cornerstone, which is a proper nutritional assessment. This is important not only in assessing the nutritional risk but also in the estimation of energy requirements (27). Anthropometric measurements are easily performed by trained nurses, and we found that more complex measurements, such as the ulna length, were quickly mastered by the team. The major impact of our training program was seen on height measurements that were considered difficult to perform before the teaching program. It then allowed nutritional indices calculation, necessary to an accurate NSA. The nursing team felt confident with NSA and found the measurements easy to perform after the training. Regular checks by the NST showed continued high standard measurement techniques.

Our study has also highlighted the importance of having an NST, which was essential in developing and implementing this teaching program (16, 17). It has been shown that a specialized PICU NST can improve the use of enteral nutrition in addition to increasing energy and protein delivery (28, 29). This is also reflected in guidelines by American Society of Parenteral and Enteral Nutrition that recommend the implementation of an NST in each PICU (11). Our PICU NST consisted of several PICU members, including a dietitian, a nurse, a nurse assistant, and an intensivist, all specialized in pediatrics. In our experience, having a PICU-specific NST was proven very effective: as its members belong to PICU staff, they are available daily for ward rounds and also know the nutritional and medical problems facing staff on a unit. In our hospital, the PICU NST works together with the institutional NST who provides further support when required. We recruited no extra personnel to form the NST as each member already belonged to the unit. We, however, did calculate the fiscal burden to the NST and estimated the time spent in implementing the training program to be 26 physician hours (2,800$), 40 dietitian hours (1,320$), and 108 nurses hours (3,560$). This program was then delivered to 120 staff members also as part of their daily work (clinical research and education).

Limitations of our training program included difficulties to perform anthropometric measurement in certain conditions (e.g., weight can be difficult to measure in extremely severe conditions, without compromising patient's safety; plasters can also prevent length and HC measurements). The aim of our NST to deliver the teaching program to the entire team

TABLE 5. Multistep Nutritional Assessment Training Program

Multistep Training Program	Lyon Children Hospital Local Experience
Step 1: Establishing a local PICU NST	
1.1 Selection of members: should include PICU members from nursing staff, physician, and dietitian	1.1 Motivated volunteers: one dietitian, one nurse, one nurse assistant, and one intensivist (pediatrician)
1.2 Intensive nutrition training program for the nutrition support team	1.2 University nutrition degree, purchase of nutrition textbooks, PICU nutrition literature, Nutrition international society LLL ("Life-Long Learning") programs (ESPEN), attending courses
1.3 Regular contact and exchanges with the institution nutrition support team	1.3 PICU NST members belonged to or applied for the institutional nutritional committee (CLAN: "Comité de Liaison Alimentation et Nutrition")
Step 2: Determination of nutrition objectives of the PICU	
2.1 Nutritional status assessment	2.11 Nutritional status assessment on any admission; follow-up of nutritional assessment during PICU stay
2.2 PICU team knowledge on nutrition basics and concomitant factors affecting nutritional status	2.2 Basic knowledge on pediatric nutritional needs and goals, interpretation of nutritional indices, and indications for enteral and parenteral nutrition
Step 3: Assessment of local needs	
3.1 Assessment of PICU team current knowledge on nutrition	3.1 Knowledge questionnaire on nutrition importance and consequences in PICU
3.2 Assessment of nutrition current practices	3.2 Nutritional status assessment (i.e., percentage of children assessed), anthropometry measurement techniques, nutrition goals, quality of prescriptions, available tools, and material (weighing scales, stadiometer, etc.)
3.3 Assessment of equipment	3.3 Purchase of weight scales adapted to PICU patients (bed integrated scales), stadiometers, and growth curves
Step 4: Development and implementation of a training program adapted and dedicated to the PICU team	
4.1 Based on steps 2 and 3	4.1 Based on our objectives on knowledge questionnaires
4.2 Development and implementation of tools adapted to local training culture: for example, protocols, lectures, and bedside teaching	4.21 Locally adapted protocols for good practices (e.g., systematic nutritional assessment)
	4.22 Lectures on nutrition assessment technique, interpretation of nutritional indices: oral presentation, posters, protocols, bedside training courses
	4.23 All-year-long individual or small groups bedside teaching (anthropometric measurement techniques)
Step 5: Evaluation of the training program	
5.1 Impact on PICU team involvement and knowledge	5.1 Practice audit at year +1 and year +2 after the implementation of the nutritional assessment
	Use of same knowledge questionnaires than step 3, knowledge about measurement techniques, etc
5.2 Impact on practice	5.2 Percentage of children getting nutritional assessment, accuracy of measurements
Step 6: Ensuring sustainability of the program	
6.1 Regular assessment of objectives achievement and team practices	6.1 NST continuous involvement inside the unit, PICU team awareness, and support in case of specific nutritional issues
6.2 Training of new members of PICU team	6.2 Steps 4 and 5
6.3 Training and continuous education of PICU NST	6.3 Nutrition literature, attendance of congresses, research, collaboration with institutional NST, and collaboration with other centers
6.4 Nutrition practices improvement, new objectives: follow steps 1.2 to 6 again	6.4 Clinical research, extended good practices implementation (e.g., feeding protocols elaboration and implementation, follow-up of nutrition goals achievement, use of one predictive equation, and early enteral feeding)

NST = nutrition support team.

might have led to a relative decrease of measurements accuracy compared with those made by an expert team. But we thought it would be the only way to get all the patients assessed at admission. Finally, PICU team has rapidly rotating members that obliged to permanently train the new recruits, even if we experienced self-training between nursing staff.

Another limitation of our study is that it was performed only in one unit and used a very specific teaching program tailored to the needs of the unit, which may not be applicable to other PICUs. However, by keeping it to one unit, confounding factors such as differences in general medical practice, staffing, and resources were reduced. Based on our experience, this study provides a valuable multistep program (**Table 5**) that can be adjusted for other PICUs to implement a nutritional assessment program. In addition, we performed the study over 2 years, where we have shown improvement of nutritional assessment; we have not shown retainment of knowledge and continuation of this level of assessment beyond this time. However, we will continue to monitor the practice through the NST and aim to report the effectiveness of this teaching program in the long run. This study also did not aim to assess the impact of this nutritional assessment program on delivery of nutrients and ultimately functional outcome. Based on an accurate nutritional assessment approach, future studies should assess this, which potentially may impact on clinical practice and functional outcome.

CONCLUSIONS

This study has shown that a teaching program on NSA of the critically ill child has improved the frequency of measurements which in turn have led to an increase in awareness and documented outcomes of the nutritional assessment. We have also shown that staff can be taught to perform these measurements, including ulna length and MUAC, which then contribute to the assessment. Future studies need to address whether there is retainment in knowledge of nutritional assessment and also the impact on aim requirements and delivery of nutrients.

REFERENCES

1. Hulst J, Joosten K, Zimmermann L, et al: Malnutrition in critically ill children: From admission to 6 months after discharge. *Clin Nutr* 2004; 23:223–232
2. Briassoulis G, Zavras N, Hatzis T: Malnutrition, nutritional indices, and early enteral feeding in critically ill children. *Nutrition* 2001; 17:548–557
3. Mehta NM, Bechard LJ, Cahill N, et al: Nutritional practices and their relationship to clinical outcomes in critically ill children–An international multicenter cohort study. *Crit Care Med* 2012; 40:2204–2211
4. Prince NJ, Brown KL, Mebrahtu TF, et al: Weight-for-age distribution and case-mix adjusted outcomes of 14,307 paediatric intensive care admissions. *Intensive Care Med* 2014; 40:1132–1139
5. Delgado AF, Okay TS, Leone C, et al: Hospital malnutrition and inflammatory response in critically ill children and adolescents admitted to a tertiary intensive care unit. *Clinics (Sao Paulo)* 2008; 63:357–362
6. McClave SA, Sexton LK, Spain DA, et al: Enteral tube feeding in the intensive care unit: Factors impeding adequate delivery. *Crit Care Med* 1999; 27:1252–1256
7. de Oliveira Iglesias SB, Leite HP, Santana e Meneses JF, et al: Enteral nutrition in critically ill children: Are prescription and delivery according to their energy requirements? *Nutr Clin Pract* 2007; 22:233–239
8. Mikhailov TA, Kuhn EM, Manzi J, et al: Early enteral nutrition is associated with lower mortality in critically ill children. *JPEN J Parenter Enteral Nutr* 2014; 38:459–466
9. de Souza Menezes F, Leite HP, Koch Nogueira PC: Malnutrition as an independent predictor of clinical outcome in critically ill children. *Nutrition* 2012; 28:267–270
10. Pollack MM, Ruttimann UE, Wiley JS: Nutritional depletions in critically ill children: Associations with physiologic instability and increased quantity of care. *JPEN J Parenter Enteral Nutr* 1985; 9:309–313
11. Mehta NM, Compher C; A.S.P.E.N. Board of Directors: A.S.P.E.N. Clinical Guidelines: Nutrition support of the critically ill child. *JPEN J Parenter Enteral Nutr* 2009; 33:260–276
12. Ong C, Han WM, Wong JJ, et al: Nutrition biomarkers and clinical outcomes in critically ill children: A critical appraisal of the literature. *Clin Nutr* 2014; 33:191–197
13. Ulijaszek SJ, Kerr DA: Anthropometric measurement error and the assessment of nutritional status. *Br J Nutr* 1999; 82:165–177
14. Lee R, Nieman D: Nutritional Assessment. Sixth Edition. Singapore, McGraw-Hill Education, 2012
15. World Health Organization: Training course and other tools. Available at: http://www.who.int/childgrowth/training/en/. Accessed January 1, 2014
16. Agostoni C, Axelson I, Colomb V, et al: The need for nutrition support teams in pediatric units: A commentary by the ESPGHAN committee on nutrition. *J Pediatr Gastroenterol Nutr* 2005; 41:8–11
17. DeLegge MH, Kelly AT: State of nutrition support teams. *Nutr Clin Pract* 2013; 28:691–697
18. Gauld LM, Kappers J, Carlin JB, et al: Height prediction from ulna length. *Dev Med Child Neurol* 2004; 46:475–480
19. Gauld LM, Kappers J, Carlin JB, et al: Prediction of childhood pulmonary function using ulna length. *Am J Respir Crit Care Med* 2003; 168:804–809
20. Lipman TH, Hench KD, Benyi T, et al: A multicentre randomised controlled trial of an intervention to improve the accuracy of linear growth measurement. *Arch Dis Child* 2004; 89:342–346
21. Sunguya BF, Poudel KC, Mlunde LB, et al: Effectiveness of nutrition training of health workers toward improving caregivers' feeding practices for children aged six months to two years: A systematic review. *Nutr J* 2013; 12:66
22. Penny ME, Creed-Kanashiro HM, Robert RC, et al: Effectiveness of an educational intervention delivered through the health services to improve nutrition in young children: A cluster-randomised controlled trial. *Lancet* 2005; 365:1863–1872
23. Gance-Cleveland B, Sidora-Arcoleo K, Keesing H, et al: Changes in nurse practitioners' knowledge and behaviors following brief training on the healthy eating and activity together (HEAT) guidelines. *J Pediatr Health Care* 2009; 23:222–230
24. Pedersen PU, Tewes M, Bjerrum M: Implementing nutritional guidelines–The effect of systematic training for nurse nutrition practitioners. *Scand J Caring Sci* 2012; 26:178–185
25. Bjerrum M, Tewes M, Pedersen P: Nurses' self-reported knowledge about and attitude to nutrition–Before and after a training programme. *Scand J Caring Sci* 2012; 26:81–89
26. Leite HP, de Lima LF, de Oliveira Iglesias SB, et al: Malnutrition may worsen the prognosis of critically ill children with hyperglycemia and hypoglycemia. *JPEN J Parenter Enteral Nutr* 2013; 37:335–341
27. Meyer R, Harrison S, Sargent S, et al: The impact of enteral feeding protocols on nutritional support in critically ill children. *J Hum Nutr Diet* 2009; 22:428–436
28. Gurgueira GL, Leite HP, Taddei JA, et al: Outcomes in a pediatric intensive care unit before and after the implementation of a nutrition support team. *JPEN J Parenter Enteral Nutr* 2005; 29:176–185
29. Lambe C, Hubert P, Jouvet P, et al: A nutritional support team in the pediatric intensive care unit: Changes and factors impeding appropriate nutrition. *Clin Nutr* 2007; 26:355–363