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Original Communications

Outcomes in a Pediatric Intensive Care Unit Before and After the Implementation of a Nutrition Support Team

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ABSTRACT. *Background:* We evaluated the effect of parenteral nutrition (PN) and enteral nutrition (EN) on in–pediatric intensive care unit (PICU) mortality before and after a continuous education program in nutrition support that leads to implementation of a nutrition support team (NST). *Methods:* We used a historical cohort study of infants hospitalized for >72 hours at the PICU from 1992 to 2003. Five periods were selected (P1 to P5), considering the modifications incorporated into the program: P1, without intervention; P2, basic themes and original articles discussion; P3, clinical and nursing staff participation; P4, clinical visits; P5, NST. The samples were compared in terms of sex, age, admitting service (ie, medical *vs* surgical), prognostic index of mortality, length of stay (LOS), duration of mechanical ventilation, in-PICU mortality rate, and percentage of time receiving EN and PN for each patient. Bi- and multivariate analyses were performed. Statistical significance was set at 0.05 level. *Results:* Progressive increase was observed in EN use (p = .0001), median values for which were 25% in P1 and rose to 67% by P5 in medical patients; there was no significant difference in surgical patients. A reduction was observed in PN use; in P1 medians were 73% and 69% for medical and surgical patients respectively, and decreased to 0% in P5 for both groups (p = .0001). There was significant reduction in-PICU mortality rate during P4 and P5 among medical patients (p < .001). The risk of death was 83% lower in patients that received EN for >50% of LOS (odds ratio, 0.17; confidence interval, 0.066–0.412; p = .000). *Conclusions:* The program motivated an increase in EN and a decrease in PN use, mainly after implementation of NST and reduced in-PICU mortality rate. (*Journal of Parenteral and Enteral Nutrition* **29:**176–185, 2005)

In critically ill pediatric patients, the main objective of nutrition support is to minimize the harmful effects from hypermetabolism and catabolism that occur after an acute insult. In subsequent phases, the objective is to maintain a positive nitrogen balance to promote the return to anabolism and growth. However, adequate maintenance of nutrition support can be difficult to achieve because of the severity of illness, impeding the digestive or even IV route from being used and sometimes, because the initial attention is focused entirely on treatment of the baseline disease, relegating nutrition to a secondary level.

Protein-energy malnutrition (PEM) is associated with increased duration of hospitalization, morbidity, and mortality among hospitalized patients, especially when it is already present at admission.[1,2] In a meta-analysis of pediatric studies, it was found that mild to moderate degrees of malnutrition were associated with higher mortality rates.[3] The prevalence of PEM in critically ill children varies among studies but is reportedly from 18%–65%.[4,5]

The development of parenteral nutrition (PN) reduced part of the difficulties in providing nutrition support by preventing complications caused by malnutrition and promoting consequently less morbidity and mortality.[6,7] On the other hand, the use of PN led to more complications, mainly an increased infections rate, metabolic disturbances, and higher hospital costs.[8–10] The current practice gives preference for use of the gastrointestinal tract,[11] even among critically ill patients. Although such practice is less iatrogenic, it is associated with complications, such as aspiration pneumonia,[12] gastrointestinal disorders, and those related to use of gastrointestinal tubes.[13,14]

In view of the diverse factors involved in nutrition support, a multidisciplinary team composed of physicians, dietitian, nurses, and pharmacists was formed in order to pool their experience and optimize the nutrition support. There have been few pediatric studies approaching this theme. Most demonstrate that the maintenance of a nutrition support team (NST) improves the monitoring and adaptation of nutrient supply, with a concomitant decrease in the use of PN and costs.[15,16]

In March 1993, a continuous education program in nutrition support was started at the Hospital São Paulo pediatric intensive care unit (PICU), with intensification of its activities during the following years. It was based on the learning response of the residents and on the patients' characteristics and clinical course

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while aggregating scientific progress in nutrition support. The project culminated with the formation of the NST in 2001.

The main objective of the NST is to maintain nutrition support for critically ill patients, thereby preventing complications arising from an inadequate supply of nutrients. It should also offer the information necessary for the learning of residents and updated knowledge for the clinical staff. Not all of the intensive care units provide a multidisciplinary team with a focus on nutrition; consequently, in current medicine there is a need to evaluate and divulge their performance, mainly when this is directly related to an improvement in the quality of the service and, indirectly, with a reduction in hospital costs. The work of the NST resulted in modifications to the PICU routine, with the objective of adapting the nutrition support according to the critical illness and degree of stress of each individual patient.

Thus, the objective of the study was to evaluate whether the modifications made by the continuous education program in nutrition support and the implantation of NST led to an increase in the use of enteral nutrition (EN) followed by a decrease in the use of PN and subsequently to verify if there was a corresponding improvement in the patients' clinical outcomes, the latter being defined as a decrease in the duration of mechanical ventilation, length of stay (LOS), and mortality rate in the PICU.

MATERIALS AND METHODS

A historical cohort study[17] was carried out at a tertiary level PICU with 9 beds of the Federal University of São Paulo, São Paulo School of Medicine (UNIFESP-EPM), Brazil, through the analysis of the medical records of patients hospitalized from January 1992 to March 2003. The study was approved by the Committee for Ethics and Research at UNIFESP-EPM, and parents' informed consent was waived.

Inclusion Criteria

The medical records were selected from patients between zero and 2 years of age, with a LOS over 72 hours. Premature newborns aged under 28 days at admission to the PICU were excluded. Of the 361 records selected, complete data were obtained from 323, with average loss of 10.5%, ranging from 8% to 12% between the studied periods.

For the data collection, 15-month periods were considered (January to March) in 5 different periods (P1 to P5) according to the modifications introduced in the continuous-education program in nutrition support and after the formation of the NST, as shown in Figure 1.

Variables Analyzed

The data collection was based on analysis of the records and completion of a specific form by a single observer (GLG), who did the double entry of data. With the intention of avoiding possible mistakes caused by the collection of information on chronic patients that could interfere in the results, all the variables were collected and analyzed until day 30 of admission to the PICU.

The demographical and clinical variables collected were age, sex, weight, admitting diagnosis, admitting service (surgical *vs* medical), and the prognostic score of mortality obtained within the first hour of admission, Pediatric Index of Mortality 2 (PIM 2).[18]

The duration of mechanical ventilation (days), LOS (days), and in-PICU mortality rate were analyzed as clinical outcomes.

The nutrition evaluation was accomplished by the weight-for-age z score at admission to the PICU according to a reference population of the National Center of Health Statistics (1978).[19] Calculations were done using the Epi Info 3.01 software.[20] Patients were considered malnourished or severely malnourished when they presented a z score ≤ -2 or -3, respectively.

Nutritional outcome measures included type of nutrition support (enteral or parenteral) and the relationship between the time each of these was used and the PICU-LOS. Because the period of data collection was limited to 30 days, the duration of EN and PN and time without nutrition support were adjusted according to the LOS using the following ratios:

Duration of EN (days)/LOS (days) $\times$ 100

Duration of PN (days)/LOS (days) $\times$ 100

Duration without nutrition support (days)/LOS (days) $\times$ 100

Statistical Analysis

For comparison of the categorical variables between the study periods, the χ^2 test was used, and for the continuous variables, the Kruskal-Wallis test. Level of statistical significance was set at 0.05. Multiple logistic regression analysis[21] was used to identify the independent predictive factors of mortality, according to stepwise model, where the variables are inserted according to the largest correlation coefficient. Initially, predictive variables were selected according to risk and protective factors commonly related to in-PICU mortality described in the literature: severe malnutrition, PICU-LOS, duration of mechanical ventilation, PIM 2, PN, EN, and age. The variables with $p \leq .200$ in the bivariate analysis were included in multiple logistic regression model. The results are presented as odds ratio (OR) and respective confidence intervals (CIs). Data were analyzed using Stata statistical software, release 8.0.[22]

RESULTS

The demographic clinical characteristics of the 323 patients in the 5 studied periods are shown in Table I. The patients presented differences in relation to the admitting service, with a decrease in the number of surgical hospitalizations in the last 2 periods (p = .013). The most frequent medical diagnosis at admission was acute respiratory failure, with a variation from 40% to 49% between the periods. In the medical patients, PIM 2 presented significant variations during the periods studied (p = .022); when the admitting service was considered, there was a significant differ-

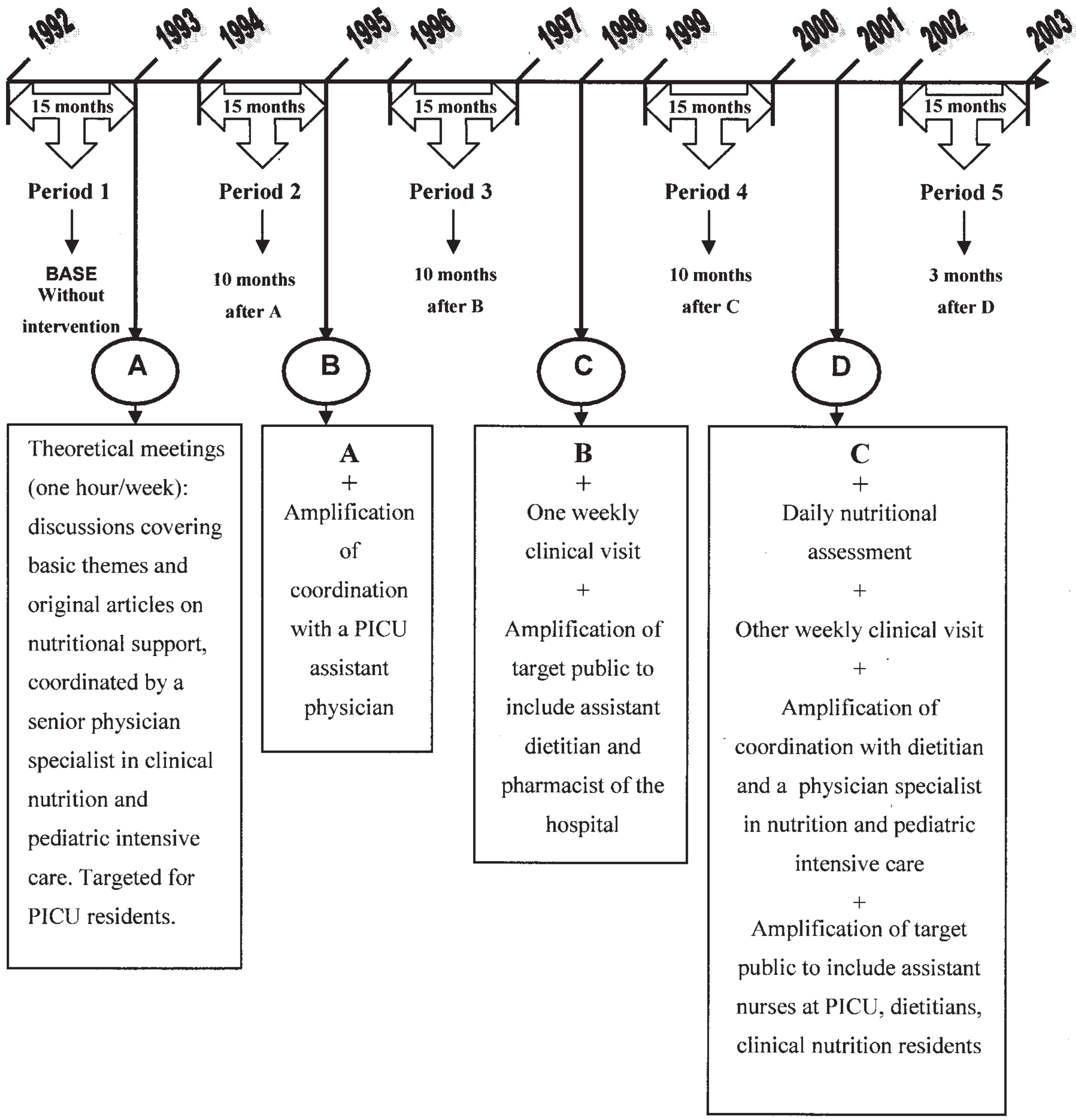

FIG. 1. Development of continuous education program in nutrition support and implementation of the nutrition support team at the pediatric intensive care unit of the Federal University of São Paulo and the studied periods.

ence between the medical patients but not the surgical cases.

The variables related to the clinical outcomes are presented in Table II. There was no significant difference in PICU-LOS and duration of lung mechanical ventilation. The prevalence of PEM (weight-for-age z score ≤ -2) at admission varied from 40% to 56%, with a greater prevalence of malnourished patients in P4.

In relation to nutritional outcomes for medical patients, there was an increase in the percentage of time receiving EN, with a median of 25% (0%–86%) in P1 and 67% (20%–100%) in P5 ($p < .001$). A concomitant decrease occurred in the percentage of time receiving PN with a median of 73% (0%–95%) in P1 and 0% (0%–93%) in P5 ($p < .001$) (Fig. 2).

Among the surgical patients, there was a decrease in the percentage of time receiving PN, with the lowest median of 0% (0%–90%) in P5 and the highest value 69% (0%–91%) in P1 ($p = .001$). However, the increase in the percentage of time receiving EN was not significant, with the lowest median 27% (0%– 67%) in P3 and the highest of 62% (0%–86%) in P5 ($p = .501$), as presented in Figure 3.

The percentage of time without nutrition support varied between the periods for medical patients, with longer times in the last 2 periods: the lowest median value of 15% (0%–100%) was observed in P3, increasing in P4% to 37% (11%–100%) and 23% (0%–77%) in P5 ($p < .001$). Among the surgical patients, medians were 17% (9%–60%) in P1 and 41% (13%–79%) in P4 ($p = .007$), as shown in Figure 4.

The in-PICU mortality rate among the medical patients decreased ($p = .001$) in P4 and P5, though the same was not observed in the surgical patients (Table II). The independent factors of in-PICU mortality analyzed in the multiple logistic regression model are pre-

TABLE I
*Demographic and clinical characteristics**

Variables	Period 1 N = 51	Period 2 N = 88	Period 3 N = 64	Period 4 N = 70	Period 5 N = 50	p Value
Age, mo	3.0 (0–21)	4.0 (0–22)	3.0 (0–22)	6.0 (0–23)	4.0 (0–17)	.354†
Male sex, %	53	53	59	51	42	.480‡
PIM 2 score	6.1 (0.5–96.4)	6.5 (0.5–87.6)	3.9 (0.5–61.4)	6.4 (0.7–58.3)	3.9 (0.1–83.9)	.022†
Medical	10.0 (0.5–96.4)	7.5 (0.5–88.0)	6.8 (0.5–61.4)	8.1 (1.2–58.3)	3.9 (0.1–84.0)	.0.30†
Surgical	2.5 (0.8–19.6)	3.9 (0.6–31.5)	2.6 (0.5–15.6)	3.2 (0.7–21.0)	3.2 (0.1–26.7)	.697†
Admitting service						.013‡
Medical (%)	65	65	61	77	86	
Respiratory failure	49	42	49	41	40	
Cardiovascular disease	33	34	26	20	30	
Sepsis	15	12	23	20	21	
Central nervous system	3	12	2	19	7	
Renal insufficiency	0	0	0	0	2	
Surgical (%)	35	35	39	23	14	

PIM 2, Pediatric Index of Mortality 2.
*Values described as median (minimum-maximum) or percentages, depending on type of variable.
†Kruskal-Wallis test.
‡χ^2.

sented in Table III. The predictive factors for risk of death were duration of lung mechanical ventilation ≥7 days, which presented a risk of death 2.6 times higher (OR, 2.64; 95% CI, 1.301–5.352), and the PIM 2 score, in which the risk of death increases by 2% for every 1% increase in PIM 2 (OR, 1.02; 95% CI, 1.001–1.033). The protective factors were age, with risk of death 9% lower for every additional month of life (OR, 0.91; 95% CI, 0.843–0.971) and percentage of time receiving EN for over 50% of the LOS (OR, 0.17; 95% CI, 0.066–0.412). Therefore, after adjustment for duration of lung mechanical ventilation, age, PIM 2, and severe malnutrition (weight-for-age z score ≤ −3), the children that received EN for over 50% of the LOS presented an 83% lower risk of death.

DISCUSSION

Critically ill children present a greater risk for development of PEM during hospitalization,[23] with increased mortality and morbidity.[24] Pollack et al[24] have demonstrated that critically ill children with associated malnutrition have greater clinical instability and need a higher number of therapeutic interventions. A previous prospective study, carried out in our PICU, has demonstrated that 65% of the patients were malnourished at admission, with predominance of chronic malnutrition, and that 36% of the patients presented alteration in the weight-for-stature curve, with a decrease in channel percentile at the moment of hospital discharge.[5] In the present study, we observed that the prevalence of DEP varied between the study periods, with a mean value ranging from 40% to 56% and with a tendency to increase in the last periods. Because of the lack of consistency of the height data in the medical charts during the first 2 periods, the weight for height could not be evaluated. The risk factors for the development or worsening of malnutrition during the hospitalization are LOS,[23] nutritional condition, and previous diseases,[23] and, according to a pediatric study[25] and adult studies,[26,27] especially when the delivery of nutrients is below the daily requirements and there are frequent interruptions in their supply. Furthermore, critically ill patients present nutritional and metabolic characteristics that are very different from those arising from starvation. A sequence of events is initiated during the acute phase of the disease, leading to an increase in proteic degradation, a decrease in synthesis of some proteins, and

TABLE II
*Clinical outcome variables**

Variables	Period 1 N = 51	Period 2 N = 88	Period 3 N = 64	Period 4 N = 70	Period 5 N = 50	p Value
Length of stay (days)	9 (5–30)	9 (5–30)	10 (5–30)	10 (5–30)	10 (4–30)	.540†
Duration of lung mechanical ventilation (days)	7 (0–25)	6 (0–30)	8 (0–26)	8 (0–30)	8 (0–30)	.520†
Weight-for-age z score at admission	−1.5 (−4.09/1.04)	−2.0 (−5.5/2.4)	−1.6 (−5.4/1.8)	−2.3 (−4.0/1.6)	−1.4 (−5.1/2.2)	.390†
PEM at admission (%) (weight-for-age z score ≤ −2)	40	48	45	56	42	.447‡
In-PICU mortality (%)	20	26	23	7	8	.006‡
Medical	21	33	28	6	7	<.001‡
Surgical	17	13	16	13	14	.994‡

PEM, protein-energy malnutrition; PICU, pediatric intensive care unit.
*Values described as median (minimum-maximum) or percentages, depending on type of variable.
†Kruskal-Wallis test.
‡χ^2.

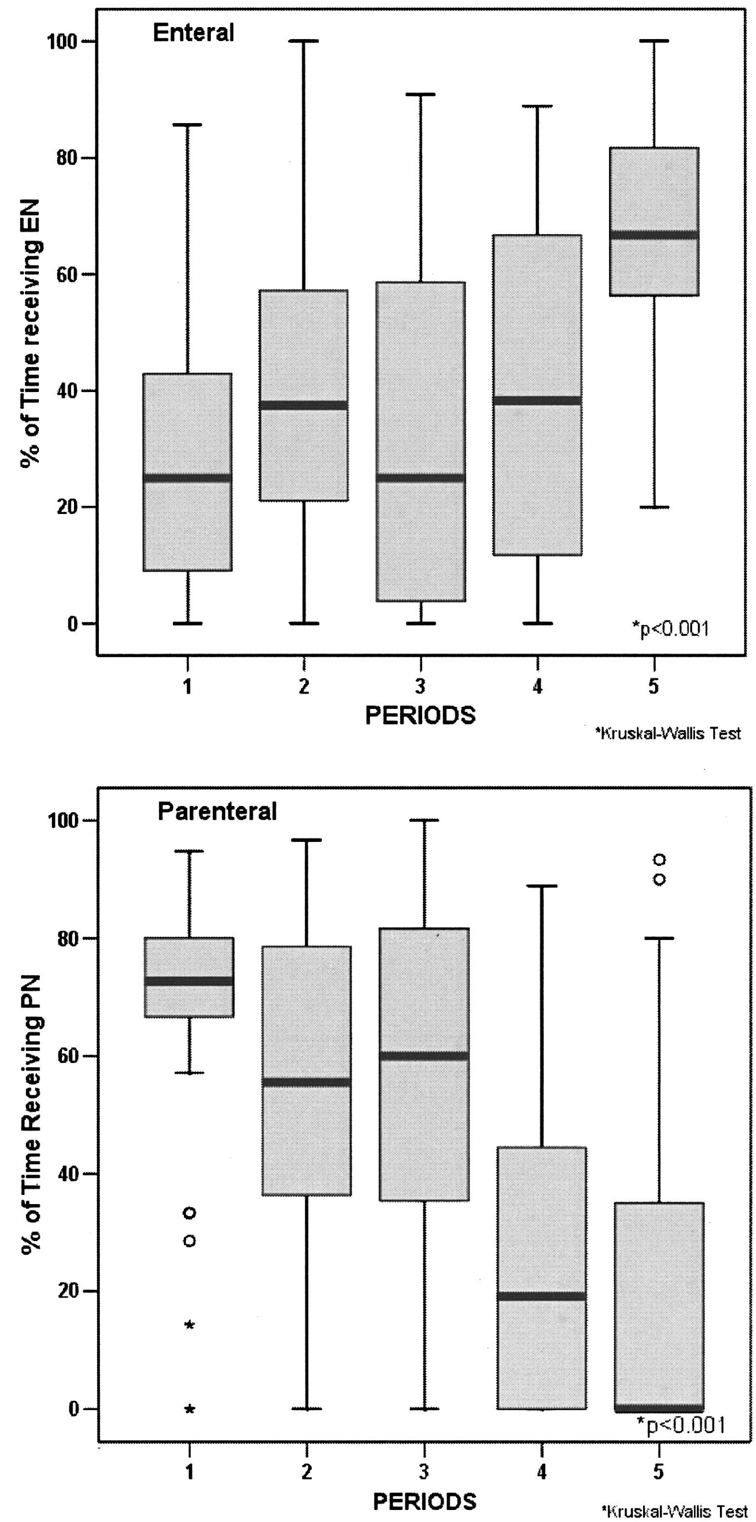

FIG. 2. Median, interquartile interval, and amplitude of the percentage of time receiving enteral and parenteral nutrition support in medical patients, according to the periods studied.

consequent loss of nitrogen.[10] The catabolism of muscular proteins is important for the synthesis of the acute-phase proteins and production of immunological cells, but the intense depletion is associated with an increase in morbidity, mortality, and recovery time.[28]

Because this was an observational study, the amount and quality of the nutrients supplied were not considered; the main objective was to demonstrate the importance of the nutrition support itself and of the need to institute programs of continuous education, implementation of protocols, and the NST. Several studies have demonstrated the benefits obtained with these types of programs and especially creation of the NST, namely, opportune evaluation of the nutritional

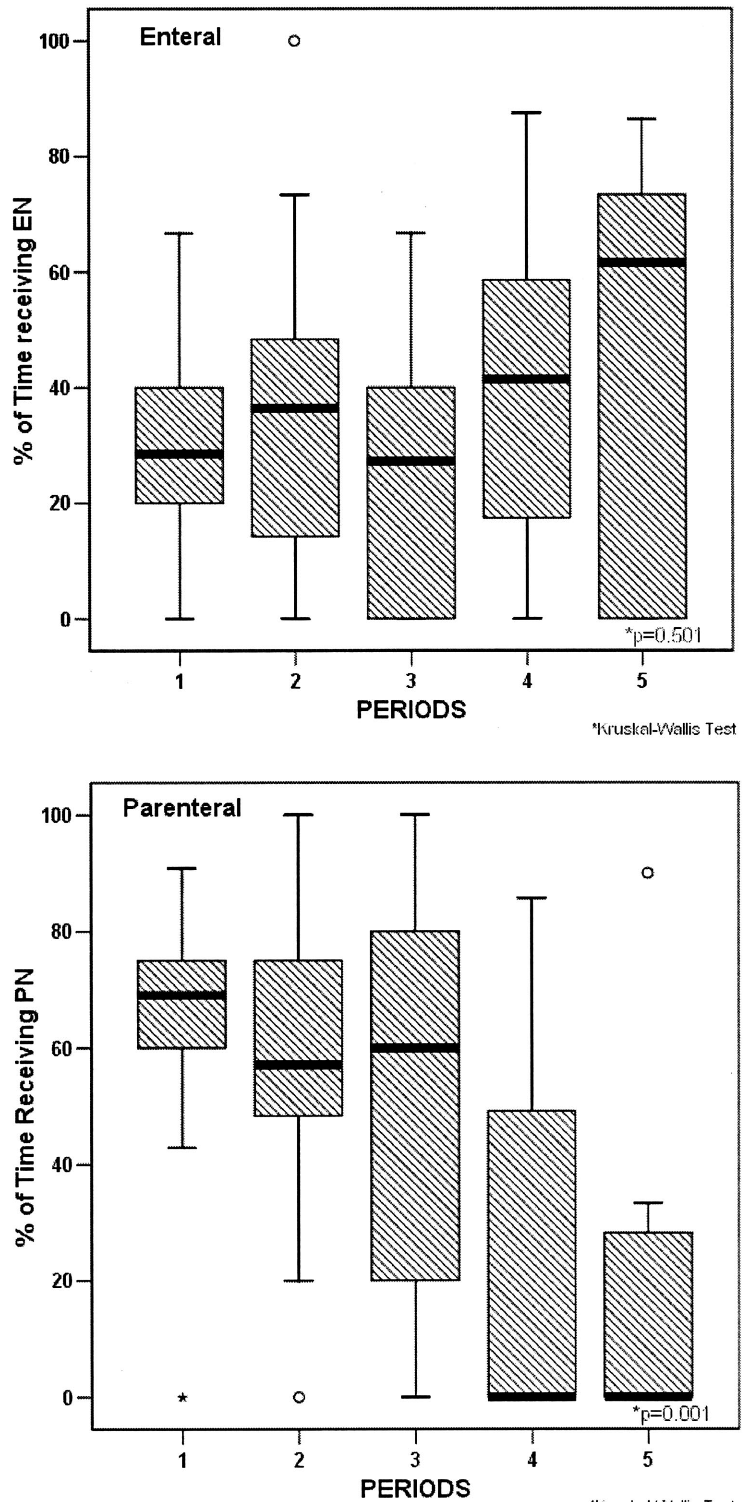

FIG. 3. Median, interquartile interval, and amplitude of the percentage of time receiving enteral and parenteral nutrition support in surgical patients, according to the periods studied.

state; greater understanding among the health professionals involved with the patients' care; reduced use of PN and increased use of the gastrointestinal tract for nutrition support, even among the critically ill and surgical patients; better adaptation of the nutrients; and reduction of the hospital costs.[15,16,29–39] However, the NST may not always achieve its objectives as rapidly as hoped.[30] One of the difficulties found is the degree of acceptance by the medical team.[40,41] In the present study, the team and work methods were modified over time, and it was possible to detect a reduction in the use of PN and increase in EN, especially in the last 2 periods, showing that a theoretical approach alone was not enough to bring about immediate

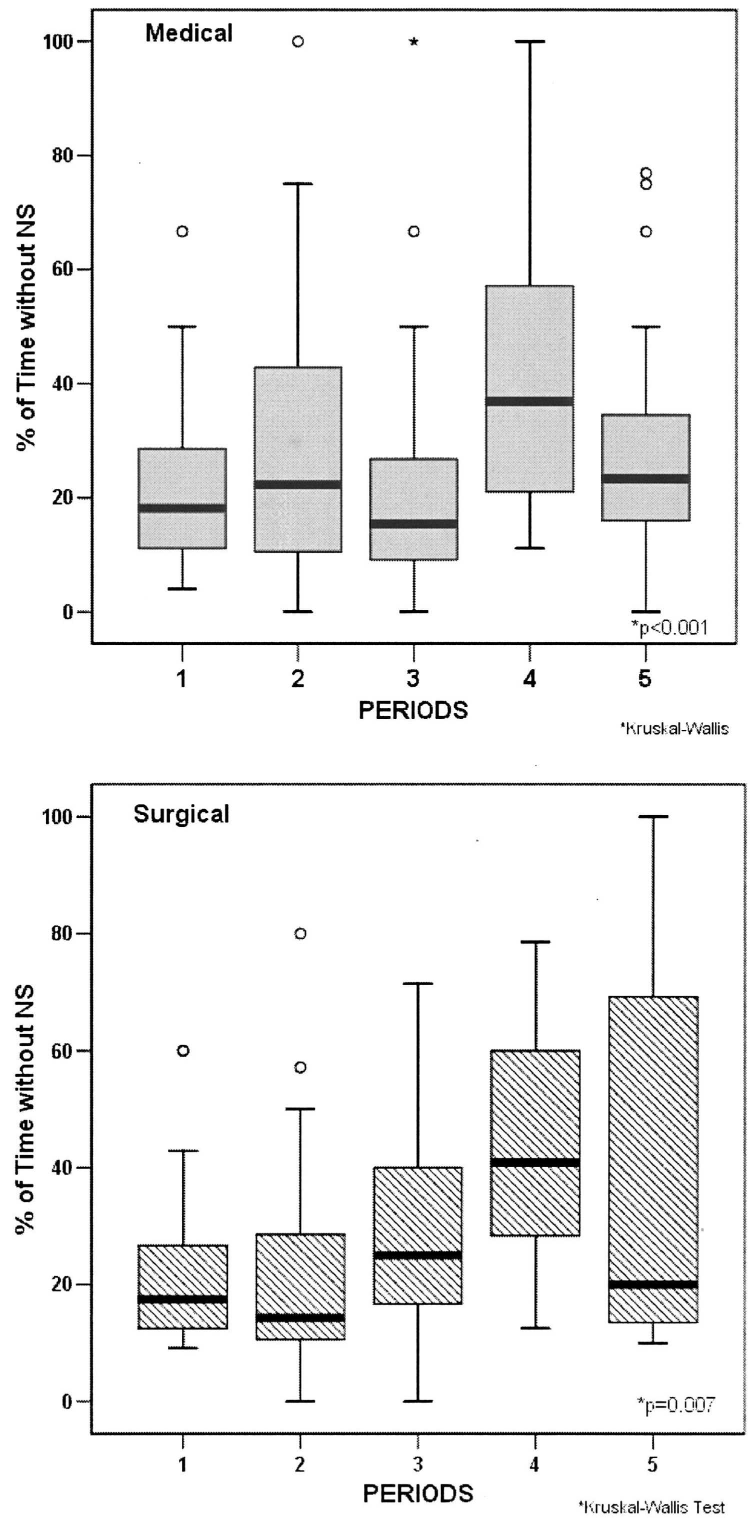

FIG. 4. Median, interquartile interval, and amplitude of the percentage of time without receiving nutrition support in medical and surgical patients, according to the periods studied.

changes and that the health care professionals took some time to understand its importance. According to a preliminary study,[37] modifications were proposed and the contribution of professionals from other related areas ensured that the changes were put into effect, mainly when the NST began to assume total responsibility for the nutrition support, with clinical visits and systematic evaluations.

PN improved the survival of patients with specific diseases, such as short-bowel syndrome, prematurity with low weight, congenital gastrointestinal anomalies, chronic enteropathies, and other diseases in which

TABLE III
Independent predictive factors for risk of death

	Odds ratio	p*	95% confidence interval
Percentage of time receiving enteral nutrition (>50%)	0.17	.000	0.066–0.412
Age (months)	0.91	.005	0.843–0.971
Duration of lung mechanical ventilation ≥7 (days)	2.64	.007	1.301–5.352
PIM 2 (%)	1.02	.035	1.001–1.033
Weight-for-age z score ≤ −3	1.91	.091	0.901–4.054

PIM 2, Pediatric Index of Mortality 2.
*Multiple logistic regression analysis (n = 323).

the energy requirements cannot be met by the oral or enteral route.[11] Nevertheless, PN is associated with complications, mainly related to the use of catheters (infection and thrombosis), metabolic disturbances, hepatobiliary diseases, and sepsis.[8,9,11] Yeung et al[9] evaluated the risk factors for developing sepsis related to the use of PN and reported a 14.8% incidence of sepsis, with 3.1 episodes per patient-year. The risk factors observed were age under 3 months, prematurity with low weight, duration of PN greater than 7 days, use of central venous catheter, and onset of cholestasis. According to Naylor et al[42] in a systematic review of the literature, there is evidence that adult patients accompanied by NST present a reduction in the mechanical complications related to catheters and lower hospital costs. In hospitalized children, a specific clinical protocol optimized the role of PN by restricting unnecessary use and reduced the costs in a tertiary pediatric hospital.[43] In this study, a decrease in the percentage of time receiving PN was observed in the medical and surgical patients after the nutrition-support interventions and implementation of the NST. To date, only 1 study in a PICU has evaluated the use of PN after the introduction of a continuous education program in nutrition support and reported that exclusively PN was used 80.5% and the gastrointestinal route, 19.5% of the time before the program, and afterwards 69.7% and 30.3%, respectively, though this difference did not achieve statistical significance between the 2 phases.[37]

Nonuse of the gastrointestinal tract is associated to an increase in the incidence of bacterial infections because of atrophy of the intestinal mucous membrane, with increased permeability and favoring of bacterial translocation.[10] EN prevents such intestinal atrophy, reduces the risk of hepatobiliary dysfunction, stimulates insulin secretion, and inhibits the secretion of glucagon, which reduces the incidence of hyperglycemia.[10,44] Furthermore, as it is less expensive there is a corresponding reduction in hospital costs.[44] Most of the studies have shown that EN in critically ill children is well tolerated and presents a minimal risk of complications.[14,44] When initiated early (ie, within 72 hours after admission), EN is associated with a better improvement in nitrogen balance[45] and lower mortality.[28] In this study, a greater use of EN was observed in the medical patients after implementation of the program of continuous education in nutrition support and especially after NST; although there was a similar tendency for the surgical patients, the increase was not significant. It was also observed that in the last 2 periods, the patients underwent a higher percentage of time without nutrition support. This might have been related to the greater application of PN in the first periods, which is usually instituted earlier than EN. Because this was a historical cohort study, the reasons why there was a longer time without any type of nutrition support were not investigated. Heyland et al[46] observed that 39.7% of the patients admitted to the ICU do not receive any type of nutrition support. Studies on pediatric and also adult populations have shown that some of the difficulties encountered involve the placement and maintenance of the post pyloric feeding tube, with consequent delays in initiating the nutrition support, besides which there are frequent interruptions in the feedings for examinations, surgery, routine nursing care, and the need for fluid restriction, especially among cardiopathic patients.[13,25,26,47,48]

Unlike the medical patients, no significant increase was observed in the percentage of time receiving EN among surgical patients. This was probably because the PICU physicians and surgeons would be more concerned about introducing EN, especially in cases of abdominal surgery, when there was a trend to wait for bowel sounds to identify the return of intestinal motility, as shown by studies in adult patients.[13,49]

Despite the increase in the percentage of time receiving EN and reduction of PN in the medical patients, there was no significant difference in the duration of mechanical ventilation or PICU-LOS over the periods studied, contrary to that shown by Bines et al,[16] who reported a reduction of 57 to 27 days and 516 hours to 367 hours, respectively, among pediatric patients after introduction of NST.

In the present study, there was a significant decrease in mortality rate among medical patients during the last 2 periods. The probable reasons for this could be related not only to the work of the NST but also to technological progress and changes in clinical practice during the period, to the reduction in the percentage of time receiving PN, to the lower PIM 2 score presented by the medical patients during the last study periods and to the increase in the percentage of time receiving EN. Because of the limitations in the study design, it is hard to reach conclusions regarding the cause and effect, but in the surgical patients it could be observed that there was no reduction in the mortality rate, in spite of the reduction in the use of PN and that they were in the same PICU. This suggests that the use of the gastrointestinal tract for longer periods during hospitalization and the lower PIM 2 score are associated with the reduction observed in the in-PICU mortality. Recently, a meta-analysis showed that in critically ill adult patients, the use of EN as opposed to PN was associated with a significant decrease in infection complications (relative risk, 0.64; 95% CI, 0.47–0.87; p = .004), but there was no difference in mortality rate.[50]

At the present time, there are no pediatric studies that have evaluated the effect of NST on mortality rate for critically ill patients. A recent study on adults has shown that the implementation of a nutrition protocol reinforced the use of EN and decreased the duration of lung mechanical ventilation from 17.9 days to 11.2 days, but there was no reduction in mortality.[51] Another multicentric study with adults found that instituting specific algorithms for EN and PN optimized the nutrition support, increased the use of EN, and tended to reduce the mortality.[52]

In our study, the independent predictive factors for risk of death during hospitalization in the PICU were the PIM 2 score at the moment of admission (OR, 1.02; CI 95%, 1.001–1.033), duration of mechanical ventilation ≥7 days (OR, 2.64; CI 95%, 1.301–5.351), age (OR, 0.91; CI 95%, 0.843–0.971), and percentage of receiving EN for >50% of the LOS (OR, 0.17; 95% CI, 0.066–0.412). Similar results were presented by Barr et al[51] in adult patients; the risk of death was 56% lower in patients that received EN (hazard ratio [HR], 0.44; 95% CI, 0.24–0.8), higher severity score (HR 1.04; 95% CI, 1.02–1.06), advanced age (HR, 1.04; 95% CI, 1.02–1.06) and malnutrition (HR, 1.37; 95% CI, 0.4–4.66). Up to the present moment, these are the only studies demonstrating an association between NE and hospital survival. As for the severely malnourished patients, in the present study it was not possible to show a relation with in-PICU mortality, unlike most other studies.[24,51] Considering the fact that in the last 2 periods there was a greater predominance of malnutrition, duration of lung mechanical ventilation, and LOS, all of which are factors related to increased in-PICU mortality, the higher percentage of time receiving EN was demonstrated to be an independent protective factor against in-PICU mortality, and consequently the work of the NST achieved an improvement in survival and, indirectly, in the quality of care and hospital costs.

CONCLUSIONS

The results of this study showed an optimization of the nutrition support for medical patients, with reduction in the use of PN and increase in EN, after the implementation of the continuous education program in nutrition support and especially once the NST began to assume total responsibility for the nutrition support. Significant differences were not observed in the duration of mechanical ventilation or in the LOS, but there was reduction of in-PICU mortality during the periods in which the NST had been implemented. The infants that received EN for more time during the hospitalization presented an 83% lower risk of death. Regarding the surgical patients, despite the reduced use of PN, no reduction was observed in the mortality rate or increase in EN. As a historical cohort study, there are limitations that impeded a broader approach in relation to the amount and quality of nutrition support provided and the performance of the NST.

Critically ill children present metabolic and nutritional peculiarities that demand closer attention and justify the existence of an NST in PICUs. Future prospective studies should focus on early initiation of nutrition support, strategies for implementation, and greater compliance with the protocols of nutrition management in PICUs.

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