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# Impact of parenteral nutrition standardization on costs and quality in adult patients

David Berlana[1], Anna Barraquer[1], Pilar Sabin[1], Luisa Chicharro[2], Agueda Pérez[3], Carolina Puiggrós[2], Rosa Burgos[2] and Julio Martínez-Cutillas[1]

*[1]Servicio de Farmacia. Hospital Vall Hebron. Barcelona. España. [2]Unidad de Soporte Nutricional. Hospital Vall Hebron. Barcelona. España. [3]Servicio de Medicina Intensiva. Hospital Vall Hebron. Barcelona. España.*

**Abstract**

***Background:*** **Parenteral nutrition (PN) is a costly therapy that can also be associated with serious complications. Therefore, efforts are focusing on reducing rate of complications, and costs related to PN.**

***Objective:*** **The aim was to analyze the effect of the implementation of PN standardization on costs and quality criteria. Secondary aim was to assess the use of individualized PN based on patient's clinical condition.**

***Methods:*** **We compare the use of PN before and after the implementation of PN standardization. Demographic, clinical and PN characteristics were collected. Costs analysis was performed to study the costs associated to the two different periods. Quality criteria included were: 1) PN administration; 2) nutrition assessment (energy intake between 20-35 kcal/kg/day; protein contribution according to nitrogen balance); 3) safety and complications (hyperglycemia, hypertriglyceridemia, hepatic complications, catheter-related infection); 4) global efficacy (as serum albumin increase). Chi-square test was used to compare percentages; logistic regression analysis was performed to evaluate the use of customized PN.**

***Results:*** **296 patients were included with a total of 3,167 PN compounded. During the first period standardized PN use was 47.5% *vs* 85.7% within the second period ($p < 0.05$). No differences were found in the quality criteria tested. Use of individualized PN was related to critical care patients, hypertriglyceridemia, renal damage, and long-term PN. Mean costs of the PN decreased a 19.5%. Annual costs savings would be € 86,700.**

***Conclusions:*** **The use of customized or standard PN has shown to be efficient and flexible to specific demands; however customized PN was significantly more expensive.**

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Key words: *Parenteral nutrition. Parenteral nutrition quality. Parenteral methods. Parenteral nutrition economics.*

**Correspondence:** David Berlana.
Servicio de Farmacia.
Hospital Vall Hebron.
Pg Vall Hebron, 119.
08035 Barcelona. España.
E-mail: dberlana@vhebron.net

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## IMPACTO DE LA ESTANDARIZACIÓN DE LA NUTRICIÓN PARENTERAL EN COSTES Y CALIDAD EN PACIENTES ADULTOS

**Resumen**

***Introducción:*** **La nutrición parenteral (NP) es una terapia costosa asociada a serias complicaciones. De manera que muchos de los esfuerzos se centran en reducir éstas complicaciones, así como los costes asociados.**

***Objetivos:*** **Analizar el efecto de la estandarización de la NP en los costes y en indicadores de calidad. El objetivo secundario es estudiar la utilización de NP individualizadas en función de las condiciones clínicas de los pacientes.**

***Métodos:*** **Se compara la utilización de NP antes y después de la estandarización de la NP. Se recogen los datos demográficos, clínicos y características de la NP. Se realiza un análisis de costes asociados a los dos periodos de estudio. Se incluyen los siguientes indicadores de calidad: 1) Administración de NP; 2) Valoración nutricional (aporte calórico 20-35 kcal/kg/día; aporte proteico en función del balance nitrogenado); 3) seguridad y complicaciones (hiperglicemia, hipertrigliceridemia, complicaciones hepáticas, infección de catéter); eficacia global (aumento albúmina sérica). Se utiliza test de chi-cuadrado para comparación de porcentajes, y regresión logística para evaluar la utilización de NP individualizada.**

***Resultados:*** **Se incluyeron 296 pacientes para un total de 3,167 NP. Durante el primer período el uso de NP estandarizada fue del 47,5% frente 85,7% en el segundo ($p < 0,05$). No se encontraron diferencias en los indicadores de calidad estudiados. La utilización de NP individualizada fue relacionada con pacientes críticos, hipertrigliceridemia y NP de larga duración. El coste medio de NP disminuyó en un 19,5%; pudiendo resultar un ahorro anual de 86,700 €.**

***Conclusiones:*** **La utilización de NP individualizadas o estándar ha mostrado ser eficiente y flexible; aunque el coste de la individualizada fue significativamente mayor.**

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Palabras clave: *Nutrición parenteral. Nutrición parenteral calidad. Nutrición parenteral métodos. Nutrición parenteral economía.*

**Abbreviations**

PN: Parenteral nutrition.
MCB: Multichamber bags.
IPN: Individualized period.
SPN: Standardized period.
GGT: Gamma-glutamyl-transferase.
ALT: Alanine aminotransferase.
AST: Aspartate aminotransferase.
CRI: Catheter-related infection.
SD: Standard deviation.
OR: Odds ratio.

## Introduction

Parenteral nutrition (PN) is an important supportive therapy indicated for patients whenever oral or enteral nutrition is not possible, insufficient or contraindicated. However, PN is a costly technology and can also be associated with complications such as electrolyte disturbances, hyperglycaemia, hypertriglyceridaemia, as well as hepatobiliary, infectious and mechanical complications.[1,2]

Considerable research has focused on reducing complications and preventing errors associated with the administration of PN formulations. These complications can be minimized by careful patient selection, appropriate formulation, and close monitoring of the patient. Several guidelines have been developed to help clinicians with these complications of PN therapy.[3] Therefore, an optimal implementation of PN plays an important role in reducing the risk of complications and optimizing the clinical outcome and the cost-efficiency ratio.

In times of budget constraints, attention is focused on cost-effectiveness treatments. In this way, since advantages in efficiency, economy, and clinical appropriateness with the use of standardized PN formulations compared with individualized PN formulations are suggested, a standardized process for PN management was developed in our hospital. The aim of this process was to reduce costs, reduce variation in PN formulations and promote uniformity among clinicians. The implementation of standardization of PN should have an optimal cost-efficiency ratio, seeking to reduce costs, reduce the risk of complications and optimize clinical outcomes.

The aim of this study was to assess the economic and quality implications that might result from the implementation of PN standardization and greater use of standard PN in adult patients. The secondary aim was to report and assess the use of individualized PN based on the patient's clinical condition.

## Methods

In June 2010, a standard PN regime in adult patients was introduced in our hospital for routine use. Following implementation of this new procedure the effects were assessed by retrospective analysis. Costs and type of PN formulations, and quality criteria on PN episodes in adult patients between February 2010 and May 2010 (IPN period) were compared with a similar group of patients who had received PN formulations between September 2010 and December 2010 (SPN period).

The Pharmacy Service, in agreement with the Nutrition Support Unit, developed a protocol for PN standardization, in compliance with accepted standards in the literature. Work was initiated in the Pharmacy Service to make standard PN solutions prepared in the pharmacy, based mainly on commercial multichamber bags (MCB). The compositions of these standardized solutions were chosen after considering normal requirements of adult patients with reference to the published literature and our own experience of PN. Standard commercial MCB used are listed in table I. The PN formulations were either prescribed individually or as standard solutions each morning based on the individual patient's clinical conditions and nutritional needs. The research protocol was authorized by the Ethics Committee of the Hospital.

Modification of standard PN solutions (by the addition of electrolytes and micronutrients to standard PN solutions) and preparation of individual PN solutions were performed by the pharmacy staff under laminar air flow units. However, most of the individualized PN solutions were prepared by subcontractor. We evaluated the frequency of standard solution prescriptions as MCB, and compared the utilization with standard vs. individual PN solutions in the following clinical conditions: renal impairment (defined as estimated glomerular

**Table I**
*Standard MCB composition*

| | *Nitrogen (g)* | *Glucose (g)* | *Lipid (g)* | *Volume (mL)* |
|---|---|---|---|---|
| Oliclinomel® N7 | 6.6 | 160 | 40 | 1000 |
| Oliclinomel® N4 | 7.3 | 160 | 40 | 2000 |
| Nutriflex Lipid Special® | 10 | 186 | 50 | 1250 |
| Smofkabiven® | 12 | 187 | 56 | 1500 |
| Clinimix® | 12 | 200 | 0 | 2000 |
| Oliclinomel® N8 | 16.5 | 250 | 60 | 2000 |

filtration rate < 60 mL/min calculated by MDRD-4), long-term PN therapy (defined as patients who received at least 21 days of PN), hepatic impairment (defined as alkaline phosphatase > 280 IU/L, GGT > 50 IU/L or bilirubin > 1.2 mg/dL plus AST > 40 IU/dL or ALT > 42 IU/dL),[4] critical illness (defined as inpatients in critical care units, included the intensive care post-recovery units), and hypertriglyceridemia (defined as serum triglyceride value > 400 mg/dL). Univariate logistic regression analyses were performed to estimate the association between the use of individualized PN and the variables such as the study period, and patient's clinical condition (renal impairment, long-term, hepatic impairment and critical illness).

The percentage of compliance in each quality criteria was compared to assess the quality implications resulting from the change of practice. Many factors might influence the quality of the PN therapy (e.g., compounding and administration of the solution, amounts of macro and micronutrients, nutrition assessment). To prevent under or overestimation of the effect of standardization in PN quality, only the quality criteria clearly related to this change of practice were assessed. These included 10 quality criteria that examined the following different areas: 1) PN administration; 2) nutrition assessment, adequacy of the nutrition support, and monitoring; 3) safety and complications; and 4) global efficacy of the PN regimen.[5-7]

1) PN administration:
   a) Percentage of PN bags not administered and returned to Pharmacy Service.
2) Nutrition assessment, adequacy of the nutrition support, and monitoring:
   a) Percentage of PN days with energy intake between 20-35 kcal/kg. Exceptions were peripheral PN and situations of hypertriglyceridemia (> 400 mg/dL).
   b) Protein intake based on nitrogen balance. Percentage of PN days with insufficient protein intake. Protein intake is considered to be insufficient if nitrogenous balance is ≤ -2 if input is < 1.1 g protein/kg (except for patients in intensive care and post-recovery units, as their hypercatabolic state might be in an acute phase) Exceptions were patients with renal failure and peripheral PN.[3,6,8]

The weight used for calculations was the actual body weight for all patients, except in obese subjects (body mass index > 30 kg/m$^2$) where the ideal body weight was used.

3) Safety and complications.
   a) Percentage of days with hyperglycemia, defined as glucose concentrations > 180 mg/dL.
   b) Percentage of patients with hepatic complications; defined as the presence of 2 or more of the following serum values: alanine aminotransferase (ALT) > 60 IU/L, aspartate aminotransferase (AST) > 60 IU/L, alkaline phosphatase > 220 IU/L, gamma-glutamyltransferase (GGT) > 80 IU/L, and/or bilirubin > 2 mg/dL after at least 10 days of PN. Hepatic complications rate was assessed separately as follows:
      i) Patients were excluded if any baseline liver function test was above the maximum reference value.
      ii) Patients were excluded if baseline values met our definition of liver impairment.
   c) Percentage of patients with hypertriglyceridemia, defined as triglyceridemia > 400 mg/dL. Patients with baseline serum triglyceride value > 250 mg/dL were excluded.
   d) Percentage of patients with at least a suspected catheter-related infection (CRI) that met diagnostic criteria. CRI was defined as the clinical signs of infection (fever, chills) in a patient with one or more positive blood culture obtained from a peripheral vein, and no apparent source of bloodstream infection except the catheter. In addition, the semi quantitative culture of the removed catheter was positive for the same microorganism isolated from the blood.[9]
4) Global efficacy of the PN regimen.
   a) Percentage of patients who maintained or improved their nutrition status after PN. Defined as serum albumin level maintained or increased after at least 7 days of PN.
   b) Percentage of patients who improved their nutrition status after PN. Defined as serum albumin level increased at least 0.2 g/dL from baseline after at least 7 days of PN.

A cost accounting model was used to perform a cost minimization analysis of the implications of transitioning to MCB use.[10] The costs per PN included: cost of personnel, nutrition solutions, additives and medical supplies needed. The cost accounting model, manpower PN bag compounding time, and costs for all the processes involved in PN provision were based on our own data previously obtained. Price of the hospital-compounded bags used was the mean value obtained in the previous study. Meanwhile, the price of the individual PN bags performed by subcontractor was calculated using the combination of the average of the subcontractor selling price plus the costs of personnel, following the cost accounting model used. In the same way, for MCB, the costs of the nutrition solutions used were average manufacture's selling prices to our hospital for each commercial admixture used adding the costs of personnel obtained previously. Therefore, nutrient solutions and total cost date were recalculated.

We used a cost minimization model assuming the fact (under the hypothesis) of no change in quality in

**Table II**
*PN and patients characteristics*

| | *IPN period* | *SPN period* | *Total* |
|---|---|---|---|
| *PN bags* | 1769 | 1398 | 3167 |
| MCB | 840 (47.5%) | 1198 (85.7%)* | 2038 (64.4%) |
| Hospital & subcontractor-compounded | 929 (52.5%) | 200 (14.3%) | 1129 (35.6%) |
| *PN characteristics* | | | |
| Peripherally/ Central PN | 189/1580 | 181/1217 | 370/2797 |
| Nitrogen (g) | 11.9 ± 3.1 | 11.1 ± 3.0* | 11.5 ± 3.1 |
| Glucose (g) | 200.5 ± 27.8 | 192.7 ± 27.9* | 197.1 ± 28.1 |
| Lipid (g) | 43.8 ± 14.0 | 47.1 ± 15.5* | 45.3 ± 14.8 |
| Volume (mL) | 1812.7 ± 266.0 | 1625.7 ± 338.5* | 1730.1 ± 314.2 |
| Total Kcal | 1536.4 ± 276.3 | 1520.2 ± 283.2 | 1529.3 ± 279.4 |
| *Patients* | 145 | 151 | 296 |
| Male (%) | 64.8 | 54.3 | 59.5 |
| Age (y) | 62.8 ± 16.3 | 64.9 ± 15.3 | 63.9 ± 15.8 |
| BMI (kg/m$^2$) | 26.0 ± 12.1 | 25.3 ± 5.3 | 25.6 ± 9.2 |
| PN days | 14.1 ± 12.1 | 11.7 ± 14.3 | 12.9 ± 13.3 |
| PN indication (%) | | | |
| Postoperative ileus & complications | 37.2 | 43.0 | 40.2 |
| Bowel rest | 14.5 | 18.5 | 16.6 |
| Obstruction | 12.4 | 9.3 | 10.8 |
| Malabsorption | 6.2 | 10.6 | 8.4 |
| Pancreatitis | 6.2 | 4.6 | 5.4 |
| Mucositis | 4.8 | 4.0 | 4.4 |
| Fistula | 4.1 | 1.3 | 2.7 |
| Others | 14.5 | 8.6 | 11.5 |
| ICU admission (%) | 49.0 | 48.3 | 48.6 |
| Death (%) | 20.0 | 12.6 | 16.2 |

Values are expressed as mean ± SD, or %.
*$p < 0.05$.

the PN therapy, and therefore the lack of clear clinical differences between the two periods studied. We ran the cost model under two scenarios studied depending on the percentage of individualized PN obtained.

The patients were identified from the pharmacy records of all patients to whom PN was dispensed. Anthropometric and clinical parameters, as well as indication, duration and amounts of PN, were collected from the pharmacy, medical and nursing records. Results were expressed as number and percentage, mean ± standard deviation (SD). The data were analyzed by T-test for continuous variables in both groups and by Mann Whitney test in the event of an abnormal distribution. Quality variables were analyzed using a Chi-square test. All statistical analyses were performed with Stata software, release 11.0 (Stata Corporation, College Station, Texas); and statistical significance is reported for $p < 0.05$.

## Results

During the two periods studied, a total of 3167 PN solutions were made for 296 adult patients; 145 in the IPN period before standardization implementation and 151 in the SPN period after the implementation. Three patients previously on home PN treatment were excluded. Of the total number of PN performed, 1129 (35.6%) were hospital or subcontractor compounded and 2038 (64.4%) were as standard commercial three-compartment bags. Overall, 85.7% of the PN used within the SPN were commercial MCB, significantly higher compared with 47.5% in the IPN period (table II).

Differences in amounts of nutrient and volume of the PN between the two periods were found although not energy intake (table II). No significant differences were seen between groups among demographic parameters. Nevertheless, higher percentage of male patients was found within the first period. Details of PN utilisation are shown in table II. More than a third of patients were started on PN for postoperative ileus or postoperative complications.

No significant differences were found between the percentage of compliance in the 10 quality criteria compared (table III). No difference was observed in the incidence of hepatic complication between the two periods studied. None of the patients met the criteria of hepatic complication when excluding patients with any baseline liver function test altered. A small decrease in the percentage of patients who met criteria of CRI was observed. However, this decrease was not statistically significant. The overall line sepsis rate was 4.4 and 1.8 per 1000 PN days within the IPN and SPN period, respectively.

**Table III**
*Quality criteria results*

| | *IPN period* | *SPN period* |
|---|---|---|
| 1. PN indication | | |
| a) PN no administered | 0.8 | 0.6 |
| 2. Adequacy of the PN & monitoring | | |
| a) Energy intake 20-35 Kcal/kg | 70.8 | 73.7 |
| b) Insufficient protein intake as nitrogen balance | 4.5 | 5.1 |
| 3. Safety & complications | | |
| a) Days of hyperglycemia | 19.5 | 20.5 |
| b) b. ii. Hepatic complications | 12.4 | 8.1 |
| c) Hypertriglyceridema | 10.8 | 7.7 |
| d) Catheter-related infection | 6.2 | 2.0 |
| 4. Global efficacy | | |
| a) Albumin maintain | 44.0 | 44.7 |
| b) Albumin improvement | 30.0 | 31.6 |

Values are expressed as %.

Overall, clinical conditions associated with customized PN use (hospital compounded or by subcontractor) on univariate analysis were: renal impairment, long-term PN, critical illness, and hypertriglyceridemia. However, before the standardization was enacted, long-term PN was not related to customized PN use (Odds Ratio [OR]: 1.04 [CI: 0.86-1.25]). Pre-standardization period was significantly associated with utilisation of individualized PN (table IV).

The mean cost of individualized PN formulations produced by the pharmacy department or subcontractor was €63.1 ± 6.1 per bag, compared to €39.5 ± 6.1 per bag of MCB. Based on the utilisation of each formulation, the mean cost of PN bag administered for the first period was significantly higher than the mean cost during the SPN period (52.4 ± 13.2 *vs.* 42.2 ± 9.8, $p < 0.05$). Meanwhile, the cost for all PN formulations during the IPN period was estimated at €92,773.1, compared to €59,058.9 for the SPN period.

According to the cost accounting model used, the standardization of PN was associated with cost savings of €10.2 (19.5%) per patient per day compared with the previous period. Therefore, a total saving of €18,054 would be obtained within the first period. Consequently, in a large facility such as our hospital, savings for a mean of 8,500 PN bags per year would be €86,700.

## Discussion

In this study we analyzed the changes in PN support after implementation of standardization for the adult patients in our hospital. In support of the primary hypothesis, this study found that after standardization, using commercial MCB as standard PN, cost of PN dropped significantly without negative effects on PN care quality.

The standard solutions in this study were manufactured as MCB solutions. Five commercial MCB were chosen as standard solutions. The formula selection was made based on similarities to those most frequently employed and those previously used. Therefore, costs were calculated for each commercial MCB used. Costs used for calculation were based on our own

**Table IV**
*Use of costumized PN regarding clinical condition and period studied*

| *Clinical condition* | *IPN period* | | *SPN period* | | *All* | |
|---|---|---|---|---|---|---|
| | *Customized* | *OR (CI 95%)* | *Customized* | *OR (CI 95%)* | *Customized* | *OR (CI 95%)* |
| Renal impairment | 364 (73.7) | 3.51 (2.79-4.42)* | 74 (18.1) | 1.51 (1.11-2.07)* | 438 (48.5) | 2.14 (1.83-2.51)* |
| Long-term PN | 402 (53.0) | 1.04 (0.86-1.25) | 95 (19.5) | 1.86 (1.38-2.52)* | 497 (39.9) | 1.35 (1.17-1.57)* |
| Hepatic impairment | 338 (52.6) | 0.99 (0.83-1.22) | 68 (15.0) | 1.09 (0.79-1.49) | 406 (37.0) | 1.10 (0.94-1.28) |
| Critical illness | 507 (73.9) | 4.43 (3.59-5.46)* | 128 (23.8) | 5.59 (4.00-7.80)* | 635 (51.9) | 3.16 (2.72-3.68)* |
| Hypertriglyceridemia | 149 (68.7) | 2.17 (1.60-2.93)* | 83 (38.1) | 3.43 (2.51-4.69)* | 232 (53.3) | 2.34 (1.90-2.87)* |
| Period | 929 (52.5) | – | 200 (14.3) | – | 1130 (35.7) | 6.63 (5.57-7.91)* |

Values are expressed as number of customized PN (%).
OR: Odds ratio; CI: confidence Interval.
*$p < 0.05$.

**Table V**
*Overall costs, per period and per PN bag, in Euros*

| | *Pre-Standardization* | *Post-Standardization* | *Total* |
|---|---|---|---|
| *MCB standard* | 40.1 ± 6.7 | 39.1 ± 5.6 | 39.5 ± 6.1 |
| Manpower | 5.1 | 5.1 | 5.1 |
| Material | 35.0 ± 6.7 | 34.0 ± 5.6 | 34.4 ± 6.1 |
| Estimated total cost | 33667.5 | 48689.8 | 80537.3 |
| *Hospital & subcontractor-compounded* | 63.6 ± 5.4 | 60.9 ± 8.4 | 63.1 ± 6.1 |
| Manpower | 4.0 ± 1.4 | 4.6 ± 2.2 | 4.1 ± 1.6 |
| Material | 59.6 ± 6.7 | 56.3 ± 10.6 | 59.0 ± 7.7 |
| Estimated total cost | 59105.6 | 12189.1 | 66671.2 |
| All PN bags | 52.4 ± 13.2 | 42.2 ± 9.8* | 47.9 ± 12.8 |
| Estimated total cost | 92773.1 | 59058.9 | 136814.7 |

Values are expressed as mean ± SD, or %.
*$p < 0.05$.

data previously obtained.[10] Moreover, we added costs of customized PN prepared by an outsourced center. The mean difference of € 10.2 per bag gives the possibility of a cost reduction near to 20% related to PN costs. Overall, there was an important decrease in cost of PN after standardization with a total saving of € 86,700 per year.

Apart from the analysis of costs, we assessed the impact of standardization on PN care quality. In the evaluation of the intervention program, the indicator should be chosen to establish the effectiveness, efficiency, and efficacy rate of the program.[11] Ten criteria were selected to evaluate our work on standardization of PN. There are several quality criteria related to PN support;[5-7,11] however, we assessed the quality criteria clearly related to the intervention described. Therefore, quality indicators assessed were related to PN administration; nutrition assessment, nutritional requirements, patient monitoring, safety, and outcomes evaluation of the PN regimen. Although indicators regarding PN administration might not be affected by the change of practice, we selected the percentage of PN bags not administered and returned to the Pharmacy Service, since standardization has a better use of PN bags. Standardization could lead to re-utilization of the PN bags returned. Thus, 1% of returned standard PN bags for a mean of 8,500 PN bags per year might obtain a savings of € 3,587 per year. The economic impact of clinical interventions to optimize PN care should be considered to achieve quality improvement.[11]

This quality control study shows that after standardization of PN formula no modification was found with regard to quality indicators assessed. Indeed, most of the indicators assessed showed a slight improvement. However, this might be due to an initial effect of the standardization training. Therefore, in order to avoid this effect, the second study period started 3 months after implementation of the standardization. The available evidence comparing commercial standardized with customized PN with regard to patient safety is limited.[12,13] According to our results, the use of commercial MCBs do not modify the PN quality care and therefore do not increase the risk of complications related to PN. Nevertheless, standard PN formulations have been related to metabolic complications[7] although the definition of metabolic complications by the authors included electrolyte disturbances, hypo- and hyperglycemia, and not hepatic complications. Furthermore, some of the commercial standard MCBs used in our study were without electrolytes; thus, electrolytes would be added according to the compatibility of the admixture and the patient's clinical condition. In contrast, more recently Turpin et al. reported an association between the use of MCB and lower rate of CRI compared to the rate associated with the use of pharmacy-compounded PN.[14,15] As infusate contamination is a rare cause of CRI, we believe that most of the CRI are related to errors and catheter care, rather than due to the type of PN formulation. In addition, the compounding of PN admixtures must be made under strict aseptic conditions. Therefore, more studies should explore this issue in the future. However, no differences were found related to CRI in our study.

The use of commercial MCB is widespread in Europe. According to surveys performed in Switzerland and Spain, most PN for hospitalized adults were administered as commercial MCB.[16,17] Furthermore, it seems that compounding of customized PN solutions takes place in medium to large facilities. Most hospitals offer between one to four different PN formulas, and two- and three-compartment bags were used. In the past, the potential disadvantage to MCB appeared to be the limited range of formula available. However, there are currently a large variety of standard MCB solutions on the market. A two-compartment system has been used as standard PN; it means that the addition of lipids to the bag is needed in order to deliver a total PN. Besides, electrolytes and nutrients such as glutamine might be added to the standardized bag because these criteria have been considered in the development of the

formulation. In this way, standardization of PN has been developed to a new way called "modular".[18] That means that from adding different macro- or micronutrients to standard formulations, a customized PN can be obtained. In addition to cost savings, the use of standard solutions might lead to reduce calculation errors as well as the risk of microbiological contamination, since there is a reduction in the handling of the constituents of the PN solution.[13,19,20]

We evaluated the current PN practice, which includes a variety of prescribing and compounding methods, including customized PN based on the patient's clinical condition. The use of customized PN was related to the following clinical conditions: long-term, renal impairment, hypertriglyceridemia and critical illness; similar to previously reported.[21] Our study showed that after the intervention, the use of standard PN was 85%. This finding is in keeping with the results of other authors who suggested that three standard PN formulations might cover the macronutrient needs of 82% of patients.[22] It is suggested that patients for whom standardized PN might be difficult to use include those with renal, hepatic or other organ compromise, critical illness and home PN.[13] Long-term PN patients are more likely to receive customized PN formulations in order to avoid metabolism associated with long-term PN therapy. Critical illness is typically associated with a catabolic stress state in which patients commonly demonstrate a systemic inflammatory response. This response is coupled with complications such as multi-organ dysfunction, leading to alterations in electrolyte balance as well as in macronutrient metabolism. Renal impairment affects water, electrolyte and acid-base metabolism; but also induces alterations in protein, carbohydrate and lipid metabolisms. In addition, renal impairment has been related to episodes of hypertriglyceridemia and hyperglycemia in patients receiving PN.[23,24] Therefore, it appears that patients with renal impairment should receive customized PN. In contrast, European guidelines suggest that standard PN formulation should be used in chronic kidney disease patients when PN is indicated.[25] However, European guidelines on PN and surgery indicate that standardized nutritional support cannot be applied to patients with chronic renal failure.[26] Therefore, standard PN solutions should be assessed in each facility to know how they might be used.

In comparison to the first period, the glucose and protein content of PN admixtures were on average lower within the standardization period. But the mean lipid content was significantly higher during this second period. However, on percentage, the differences found in macronutrients were less than 8%. This represents a mean difference of 0.8 g of nitrogen, 7.8 g of glucose and 3.3 g of lipids. We assume that standard PN solutions might be used in an even larger proportion of patients than observed in our evaluation, since we did not detect an increase of complications. Besides, little differences in macronutrient amounts were found.

The authors acknowledge that this was a retrospective study; thus, the data limit us to identifying potential associations. However, our findings may contribute to an open discussion regarding the use of MCB and customized formulations. Current PN practice includes prescribe and compound PN methods, including customized PN formulations based on the patient's clinical condition. In fact, the two periods compared included both those patients who received PN compounded in the hospital pharmacy or by an outsourced centralized compounding center and patients receiving commercial MCB. The decision regarding PN choice can be complex; it would be influenced by the number and type of patients requiring PN within a specific clinical situation.

In conclusion, the use of both kinds of PN, customized or commercial MCB, has shown to be efficient and flexible to the specific demands. However, greater use of customized PN was significantly more expensive. Our study has demonstrated that PN standardization can bring about cost-containment without compromising PN quality care.

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