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ORIGINAL ARTICLE

Effect of Individualized Versus Standardized Parenteral Nutrition on Nutrient Intake and Postnatal Growth in Premature Infants

A Retrospective Clinical Study

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This single-center, retrospective, observational study compared standardized parenteral nutrition (SPN) with traditional individualized parenteral nutrition (IPN) on nutrient intake in 82 low-birth-weight preterm infants. Nutrient intake and available growth records collected during the first 21 postnatal days were reviewed. Compared with the IPN group, the SPN group exhibited a significantly higher body weight gain during the first, second, and third postnatal weeks. Parenteral nutrition duration was significantly shorter in the SPN group than in the IPN group (25.59 ± 7.48 vs 30.34 ± 8.26 days, P = .008), suggesting that SPN is an appropriate alternative to IPN to support weight gain and provide adequate energy and protein during the first 3 weeks of life alongside partial enteral feeding. **Key words:** *individualized parenteral nutrition, low birth weight, preterm infants, standardized parenteral nutrition, total parenteral nutrition*

Low birth weight (LBW), caused by intrauterine growth restriction, prematurity, or both, has major implications for neonatal health. The World Health Organization defines LBW as a birth weight <2500 g.[1] LBW is a key factor contributing to neonatal death.[2,3] The risk of mortality in neonates with LBW is more than 20 times higher than

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The study was conducted according to the guidelines of the Declaration of Helsinki, and all procedures involving human patients and patient recruitment were approved by the Ethical Committee of the Medicine Faculty at Chung Shan Medical University Hospital (CSMUH No.: CS1-21018).

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that in neonates with a birth weight of >2500 g.[4] Additionally, neonates with LBW have a substantially higher risk of developing long-term disabilities or impairments compared with neonates with a birth weight of >2500 g.[5,6]

Nutrition is crucial for normal cell growth, and numerous nutrients are essential for brain development.[7,8] Considering the specific physiological status of infants with LBW, approaches to nutrition intervention and optimization during their early life merit further attention. In addition to an appropriate nutrition formulation, an adequate nutrition protocol, especially for the early days of life, is essential.[9,10] This is particularly true for preterm infants, for whom early nutrition support plays a critical role in sustaining extrauterine growth and development, ultimately contributing to long-term health and well-being.[11,12] Providing the appropriate amount, quality, and composition of nutrients during sensitive periods is critical to achieving the normal growth and development of organ systems.[13,14]

Feeding infants with LBW can be challenging, and their food intake generally fails to reach recommended levels.[15,16] This challenge is compounded by the fact that these infants, unlike their term counterparts, lack adequate nutrient reserves and have greater nutrient expenditure owing to prematurity-associated complications such as respiratory distress and hypothermia. Preterm infants have an immature gastrointestinal tract that cannot absorb sufficient energy and nutrients to meet the infants' nutrient requirements; parenteral nutrition (PN) is critical for the care of such infants[17,18] and provides a relatively safe means of meeting their nutrient intake goals.[19] PN is recommended to be started either immediately after birth or within the first 24 hours of life[20] and be continued until full enteral nutrition (EN) is possible. The general aim of nutritional management for preterm infants is to achieve a postnatal growth rate and body composition approximating those of a fetus of the same gestational age and a functional outcome comparable to that of term infants.[21]

PN should be introduced promptly after the birth of infants with LBW to prevent their malnutrition and growth failure during the early postnatal period.[22] No consensus exists on whether individualized PN (IPN) formulations are superior to standardized formulations in achieving total PN (TPN) goals although it is possible that SPN is comparable to IPN and better than IPN at reducing prescribing errors, compounding errors, infection risk, and lowering costs.[23] The present observational study compared the clinical effects of standardized PN (SPN) with those of IPN on nutrient intake in preterm infants with LBW.

Available strategies for nutrition interventions and optimization of infants with LBW, including patterns of nutrition supply, macronutrient proportion, and amino acid supplementation, were compared to provide new insights into the advancements made in IPN and SPN.

METHODS

Study design

This single-center, retrospective, observational study used data from clinical dietetic reports. Figure 1 presents the patient selection process. The study compared nutrient intake between infants with LBW receiving IPN and those receiving SPN. Apgar scores were measured. Current guidelines define "normal" Apgar scores to be ≥7 at 1 minute and ≥8 at 5 minutes; the neonate does not require assistance if its scores are within these ranges.[24] Small for gestational age (SGA) infants are defined as those with a birth weight that is more than 2 standard deviations below the mean or lower than the 10th percentile for their gestational age.[25] The Neonatal Therapeutic Intervention Scoring System (NTISS)[26] is used to assess disease severity in neonates requiring intensive care. The total NTISS score ranges from 0 to 99. Higher scores indicate

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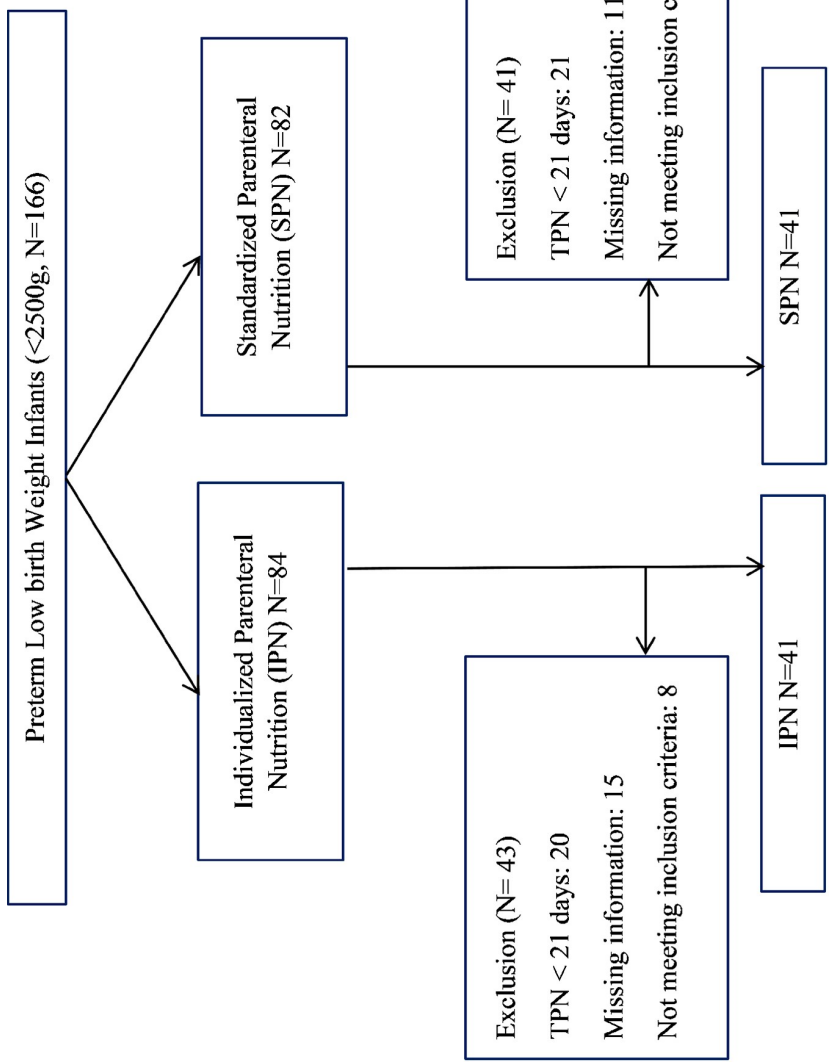

Figure 1. Flowchart of the Procedure for Screening Infants with LBW for Eligibility, along with Reasons for Exclusion.

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higher disease severity and hence a less favorable prognosis.

Participants

The study population consisted of 82 preterm infants in our neonatal intensive care unit (NICU) in the Department of Pediatrics, Chung Shan Medical University Hospital, Taiwan. The NICU has 29 beds with a bed occupancy rate of about 70%. The enrolled patients were divided into 2 groups: patients who received SPN (a ready to use product, Numeta (G13%E; Baxter Medical AB, Stockholm, Sweden) and those who received IPN (prepared at our hospital). Very preterm infants (born at 28 to 32 weeks) who received PN from September 2019 to September 2021 were considered eligible. SPN was used for preterm infants with a birth weight of <1500 g. Data on NICU stay during hospitalization and details regarding admission for PN support were obtained from medical records. The study was conducted in accordance with the guidelines of the Declaration of Helsinki, and all procedures involving human patients and patient recruitment were approved by the Ethical Committee of the Medicine Faculty at Chung Shan Medical University Hospital (No.: CS1-21018).

Inclusion criteria

Preterm infants who received PN for >21 days were included. In total, 166 infants were born at 28 to 32 weeks, and infants with birth weight <2500 g were included in this observational study. The enrolled infants were divided into 2 groups—the IPN group, consisting of 84 patients, and the SPN group, consisting of 82 patients—and their nutritional status was compared.

Exclusion criteria

Infants whose PN lasted <21 days (IPN group: n = 20; SPN group: n = 21) and those with missing nutrition records (IPN group: n = 15; SPN group: n = 11) were excluded from the study. Infants for whom IPN was switched to SPN (or vice versa) midway through the TPN intervention were also excluded (IPN group: n = 8; SPN group: n = 9). Consequently, the study ultimately included 41 infants in the IPN group and 41 infants in the SPN group (Figure 1).

IPN and SPN

Clinicians have the discretion to decide whether to use IPN or SPN (Numeta) as part of routine care in our NICU. For the enrolled patients, a clinical dietitian provided medical nutrition therapy and recorded energy and dietary intake. Notably, the PN regimen selection was based on a patient's estimated nutrient volume, protein needs, and enteral intake. However, the IPN and SPN groups both received a basic PN formula (CSP1330P, dispensed by our pharmacist) containing amino acids (2 g/100 mL) and glucose (10%) within 24 hours of birth.

At 24 hours after birth, the patients in the SPN group received standard 3CB PN (Numeta G13%E) containing amino acids (3.1 g/100 mL), glucose (13%), and fatty acids (2.5 g/100 mL, refined olive oil [approximately 80%] and refined soybean oil [approximately 20%]). Vitamins and minerals were added to the bag as needed by the newborns requiring intensive care. In the SPN group, all nutrient concentrations (glucose, proteins, and lipids) were fixed.

In addition, 24 hours after birth in the IPN group, CSP1740P containing amino acids (3 g/100 mL) and glucose (10%) were initially administered. Afterward, clinicians adjusted the PN prescription on a case-by-case basis. This modification involved adjusting the concentrations of electrolytes, protein, carbohydrate, and intravenously infused fat (SMOFlipid 20% emulsion for infusion; the daily dose did not exceed 3.0 g fat/kg body weight/day [equivalent to 15 mL of SMOFlipid/kg body weight/day]). Table 1 presents the concentrations in the PN formulations.

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Table 1. Composition of Parenteral Nutrition Regimens

Nutrients	IPN: CSP1740P	SPN: Numeta G13%E 3C
Main bag (Macronutrients)		
Glucose (g/100 mL)	10 (Variable)	13.3 (Fixed)
Amino acids (g/100 mL)	3 (Variable)	3.1 (Fixed)
Lipids (g/100 mL)	No	2.5 (Fixed)[a]
Minerals	Yes[b] (Variable)	Yes[b] (Variable)
Vitamins	Yes[c] (Variable)	Yes[c] (Variable)
Additional bag	Lipid bag (SMOF)[d] (Variable)	No

Abbreviations: IPN, individualized parenteral nutrition; SMOF, based on soybean oil, medium chain triglycerides, olive oil, and fish oil; SPN, standardized parenteral nutrition.
[a]Refined olive oil (approximately 80%) + refined soybean oil (approximately 20%).
[b]Contains sodium, potassium, calcium, phosphate, magnesium, chloride, and the individually adjusted minerals of zinc, copper, manganese, selenium, fluoride, and iodine.
[c]Routine vitamins, namely vitamin A, vitamin D, vitamin E, vitamin K, thiamin, riboflavin, niacin, vitamin B6, folic acid, vitamin B12, biotin pantothenic acid, and vitamin C.
[d]SMOFlipid 20% emulsion for infusion, daily dose did not exceed 3.0 g fat/kg body weight/day (equivalent to 15 mL SMOFlipid/kg body weight/day).

Enteral nutrition

For the vast majority of infants, EN consists exclusively of mothers' own breast milk or donor breast milk and was initiated as soon as possible after birth. Although the milk of mothers giving birth before term contains more protein and energy than does the milk of mothers giving birth at term, the milk's content of these macronutrients is still less than the recommended needs.[27] Consequently, preterm infants require additional protein, energy, fatty acids, minerals, and micronutrients, suggesting a need for human milk fortification. In accordance with clinical guidelines, breast milk was fortified with a human milk fortifier (Enfamil Liquid Human Milk Fortifier Standard Protein, Mead Johnson & company, USA) when the enteral intake of fluids was approximately 70–100 mL/kg/d. This fortifier provided 3.4 g of protein per 100 calories when mixed with preterm human milk at a 24-calorie per fluid ounce concentration.

Data collection and analysis

The nutritional status of preterm infants with LBW was evaluated by analyzing specific parameters. Nutrient intake was assessed by analyzing parenteral and enteral calories and protein and fluid intake. The clinical outcomes included nil per os (NPO) days, ICU length of stay (in days), hospital length of stay (LOS), duration of PN (in days), and NTISS score. Additionally, changes in body weight and weight-for-age z scores were measured.

Statistical analyses

Data are presented as means and standard deviations and, for categorical variables, as percentages. The IPN and SPN groups were compared using independent-sample *t* tests (for continuous variables) and Fisher's exact probability test (for categorical variables). Moreover, within-group comparisons were made using the paired Student *t* test. Data were analyzed using IBM SPSS version 25 (IBM Corp, Armonk, NY, USA), and $p < .05$ was defined as significant.

RESULTS

Patient characteristics

Of the 166 patients initially enrolled in this study, 84 were excluded on the basis of the exclusion criteria. The remaining 82 patients were included in the final analysis (Figure 1). These patients were divided into IPN and

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SPN groups. The 2 groups did not differ significantly in terms of gestational age, sex, head circumference at birth, Apgar score at 1 min, Apgar score at 5 min, SGA, 24-h NTISS score, or 48-h NTISS score. However, the SPN group had significantly lower average birth weight (1376.15 ± 230.93 vs 1522.2 9 ± 239.25 g, P = .006), smaller birth length (39.40 ± 3.44 vs 41.28 ± 2.99 cm, P = .01), and smaller chest circumference (24.78 ± 1.69 vs 25.64 ± 1.83 cm, P = .03) compared with the IPN group (Table 2).

Effects of SPN and IPN on nutrition intake

PN was the primary energy source for the enrolled preterm infants during the days after their birth (Table 3). During the first postnatal week, the SPN group had significantly higher parenteral energy intake and total energy intake than did the IPN group (parenteral energy intake: 102.97 ± 16.78 vs 82.39 ± 26.58 kcal/kg/d, P < .001; total energy intake: 111.74 ± 18.43 vs 98.95 ± 23.81 kcal/kg/d, P = .008). By contrast, the IPN group had higher enteral protein intake and total protein intake compared with the SPN group (enteral protein intake: 0.49 ± 0.52 vs 0.24 ± 0.23 g/kg/d, P = .007; total protein intake: 4.22 ± 0.85 vs 3.82 ± 0.58 g/kg/d, P = .014). Additionally, the IPN group had higher enteral fluid intake and total fluid intake than did the SPN group (enteral fluid intake: 23.10 ± 24.49 vs 12.14 ± 13.28 mL/kg/d, P = .014; total fluid intake: 140.32 ± 21.01 vs 129.78 ± 16.07 mL/kg/d, P = .013).

In the first, second, and third weeks after birth, the SPN group's daily parenteral energy intake was 25%, 19%, and 24% higher than that of the IPN group, respectively (postnatal week 1: 102.97 ± 16.78 vs 82.39 ± 26.58 kcal/kg/d, P < .001; postnatal week 3: 76.16 ± 31.84 vs 61.65 ± 29.24 kcal / kg/d, P = .035). Moreover, the SPN group's daily total energy intake in the first and second postnatal weeks was 13% and 2.3% higher than that of the IPN group, respectively (postnatal week 1: 111.74 ± 18.43 vs 98.95 ± 23.81 kcal/kg/d, P = .008).

The daily enteral protein intake of the IPN group in the first, second, and third postnatal weeks was 104%, 66%, and 44% higher than that of the SPN group, respectively (postnatal week 1: 0.49 ± 0.52 vs 0.24 ± 0.23 g/kg/d, P = .007; postnatal week 2: 0.93 ± 0.51 vs 0.56 ± 0.53 g/kg/d, P = .002; postnatal week 3: 1.53 ± 0.73 vs 1.06 ± 0.80 g/kg/d, P = .007). Additionally,

Table 2. Baseline Characteristics of Infants with LBW Receiving IPN or SPN in the NICU (N = 82)

Characteristics	IPN (N = 41)	SPN (N = 41)	*P*-value
Gestational age, weeks	30.95 ± 1.95	30.41 ± 2.21	.247[a]
Sex, male (n%)	23 (56.09)	19 (46.34)	.377[b]
Birth weight, g	1522.2 9 ± 239.25	1376.15 ± 230.93	.006[a*]
Birth length, cm	41.28 ± 2.99	39.40 ± 3.44	.010[a*]
Birth head circumference, cm	28.39 ± 1.44	28.58 ± 3.11	.721[a]
Chest circumference, cm	25.64 ± 1.83	24.78 ± 1.69	.030[a*]
Apgar at 1 minute	6.83 ± 1.55	6.44 ± 1.48	.247[a]
Apgar at 5 minutes	8.41 ± 1.09	8.27 ± 1.09	.547[a]
Small for gestational age (n%)	4 (9.76)	10 (24.39)	.078[b]
24 h NTISS	16.27 ± 3.93	16.34 ± 5.68	.946[a]
48 h NTISS	14.80 ± 4.42	14.78 ± 6.09	.983[a]

Data are presented as n or means ± SD; SD: standard deviation.
[a]Independent-samples *t* test.
[b]Fisher's exact probability test.
Abbreviations: NICU, neonatal intensive care unit; NTISS, neonatal therapeutic intervention scoring system.
[*]P < .05.

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Table 3. Average Daily Total, Parenteral, and Enteral Intakes of Macronutrients and Fluids in Postnatal Weeks 1, 2, and 3 for Infants with LBW Receiving IPN (N = 41) or SPN (N = 41)

Postnatal period PN regime	Energy kcal/kg/d Mean ± SD	Protein g/kg/d Mean ± SD	Fluid mL/kg/d Mean ± SD
Postnatal week 1			
Total intake			
IPN	98.95 ± 23.81	4.22 ± 0.85	140.32 ± 21.01
SPN	111.74 ± 18.43	3.82 ± 0.58	129.78 ± 16.07
P-value	.008*	.014*	.013*
Parenteral intake			
IPN	82.39 ± 26.58	3.73 ± 1.05	117.22 ± 25.46
SPN	102.97 ± 16.78	3.58 ± 0.55	117.64 ± 14.29
P-value	<.001*	.409	.927
Enteral intake			
IPN	16.56 ± 16.99	0.49 ± 0.52	23.10 ± 24.49
SPN	8.77 ± 9.31	0.24 ± 0.23	12.14 ± 13.28
P-value	.012*	.007*	.014*
Postnatal week 2			
Total intake			
IPN	122.36 ± 92.18	4.39 ± 0.82	152.84 ± 13.42
SPN	125.19 ± 16.02	4.32 ± 0.75	145.99 ± 16.75
P-value	.847	.687	.044*
Parenteral intake			
IPN	88.83 ± 92.27	3.46 ± 1.12	106.49 ± 29.87
SPN	105.96 ± 20.32	3.76 ± 0.87	118.70 ± 24.13
P-value	.249	.179	.045*
Enteral intake			
IPN	33.53 ± 18.56	0.93 ± 0.51	46.35 ± 26.89
SPN	19.23 ± 16.39	0.56 ± 0.53	27.29 ± 22.77
P-value	<.001*	.002*	.001*
Postnatal week 3			
Total intake			
IPN	117.41 ± 24.61	4.15 ± 0.82	156.47 ± 16.54
SPN	111.07 ± 26.50	4.06 ± 0.65	150.86 ± 18.93
P-value	.265	.595	.157
Parenteral intake			
IPN	61.65 ± 29.24	2.62 ± 1.14	81.77 ± 31.69
SPN	76.16 ± 31.84	3.00 ± 1.07	100.37 ± 36.84
P-value	.035*	.121	.016*
Enteral intake			
IPN	55.76 ± 26.59	1.53 ± 0.73	74.70 ± 33.93
SPN	34.91 ± 25.44	1.06 ± 0.80	50.49 ± 37.20
P-value	.001*	.007*	.003*

Independent-samples *t* test. Data are presented as means ± SD. Abbreviations: IPN, individualized parenteral nutrition; SD, standard deviation; SPN, standardized parenteral nutrition.
*$P < .05$; IPN versus SPN.

the daily total protein intake of the IPN group in the first, second, and third postnatal weeks was 10%, 1.6%, and 2.2% higher than that of the SPN group, respectively (postnatal week 1: 4.22 ± 0.85 vs 3.82 ± 0.58 g/kg/d, $P = .014$).

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In the third postnatal week, the 2 groups did not differ significantly in terms of their daily total energy, total protein, or total fluid intake. However, the SPN group had significantly lower enteral energy, protein, and fluid intake compared with the IPN group (energy: 34.91 ± 25.44 vs 55.76 ± 26.59 kcal/kg/d, P = .001; protein: 1.06 ± 0.80 vs 1.53 ± 0.73 g/kg/d, P = .007; fluid: 50.49 ± 37.20 vs 74.70 ± 33.93 mL/kg/d, P = .003). By contrast, the SPN group had significantly higher parenteral energy, protein, and fluid intake than did the IPN group (energy: 76.16 ± 31.84 vs 61.65 ± 29.24 kcal/kg/d, P = .035; protein: 3.00 ± 1.07 vs 2.62 ± 1.14 g/kg/d, P = .121; fluid: 100.37 ± 36.84 vs 81.77 ± 31.69 mL/kg/d, P = .016).

Clinical outcomes

The 2 groups did not differ significantly in terms of their NPO days, LOS, weight (at the time of transfer from the NICU to the general ward, weight at discharge, or NTISS score at the time of transfer from the NICU to the general ward (Table 4). However, the IPN group had a significantly longer PN duration than did the SPN group (30.34 ± 8.26 vs 25.59 ± 7.48 days, P = .008).

Postnatal growth

Both groups exhibited positive changes in weight from birth to postnatal days 7–21 (Table 5). However, the SPN group gained significantly more weight than did the IPN group in the first, second, and third postnatal weeks (postnatal week 1: mean [95% CI] = 90.20 [57.12-123.27] vs 35.61 [0.81-70.40], P = .024; postnatal week 2: mean [95% CI] = 355.68 [299.53-411.83] vs 241.22 [204.10-278.34], P = .001; postnatal week 3: mean [95% CI] = 564.32 [505.95–622.69] vs 471.12 [471.12–517.95], P = .014). The weight-for-age z-scores were not significantly different between the 2 groups.

DISCUSSION

Ensuring adequate nutrition is essential for promoting weight gain during the early days of life,[28] particularly for preterm babies who need proper nutrition to grow at a rate comparable to that of babies still in utero. Nevertheless, no consensus exists on whether standardized formulations are superior to individualized formulations in achieving PN goals. The present study compared the effects of SPN and IPN on clinical outcomes in infants with LBW. The findings suggest that using an SPN regimen rather

Table 4. Clinical Outcomes Observed for Infants with LBW Receiving IPN or SPN in the NICU (N = 82)

Intervention period	IPN (N = 41)	SPN (N = 41)	*P*-value
Clinical outcomes			
NPO, days	1.90 ± 1.53	1.63 ± 1.18	.376
ICU stay, days	44.56 ± 14.47	49.02 ± 16.01	.189
LOS, days	53.46 ± 15.62	55.49 ± 17.77	.585
PN duration, days	30.34 ± 8.26	25.59 ± 7.48	.008*
Weight, g	2814.66 ± 395.73	2863.54 ± 490.44	.621
Transfer from the ICU to the ward			
Weight, g	3150.17 ± 475.58	3118.12 ± 591.20	.788
Discharged from the hospital			
NTISS transfer from the ICU to the ward	4.88 ± 3.26	3.54 ± 2.88	.052

Independent-samples *t* test. Data are presented as means ± SD. Abbreviations: ICU, intensive care unit; LOS, length of stay; NICU, neonatal intensive care unit; NPO, nothing by mouth; NTISS, neonatal therapeutic intervention scoring system; PN, parenteral nutrition; SD, standard deviation.
*P < .05.

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Table 5. Postnatal Growth of Infants with LBW Receiving IPN or SPN in the NICU (N = 82)

Growth parameter	IPN (N = 41)	SPN (N = 41)	*P*-value
Gain body weight (g) (compared with birth weight)	Mean [95% CI]	Mean [95% CI]	
Day 7	35.61 [0.81 to 70.40]	90.20 [57.12 to 123.27]	.024*
Day 14	241.22 [204.10 to 278.34]	355.68 [299.53 to 411.83]	.001*
Day 21	471.12 [471.12 to 517.95]	564.32 [505.95 to 622.69]	.014*
Weight-for-age z score			
Day 7	−0.56	−0.55	.954
Day 14	−0.55	−0.38	.406
Day 21	−0.52	−0.41	.554

*$P < .05$. IPN vs SPN, independent-samples *t* test between periods.

than an IPN regimen can similarly improve PN duration and postnatal growth in infants with LBW without adversely affecting NPO days, LOS, or NTISS score. No significant associations were observed with laboratory data; a reasonable explanation for this is that the biochemical markers were monitored daily, allowing for immediate correction.

PN is commonly administered to preterm infants. However, whether the same level of nutrition control is assured with SPN as with IPN remains uncertain. The optimal PN management, SPN or IPN, remains controversial. IPN has generally been considered superior to SPN in achieving nutritional goals because it is tailored to an individual's needs. For example, Smolkin et al.[29] reported greater weight gain in a population receiving IPN compared with a population receiving SPN attributing the greater weight gain to the higher caloric intake associated with IPN. By contrast, Iacobelli et al.[30] reported less weight loss and greater subsequent weight gain during the first week of life in a preterm population receiving SPN compared with a population receiving IPN. In September 2019, an SPN regimen was introduced in our NICU for routine use. Concerning nutrition intake, PN needs to be adequately prescribed and requires the involvement of well-trained physicians. SPN is used by physicians in our ICU on infants with significantly low birth weight and small birth length (Table 2). Consequently, the EN intake was significantly different between the 2 groups in postnatal weeks 1–3 (Table 3).

Nevertheless, the weight of the SPN group at the time of an infant's transfer from the NICU to the general ward and at discharge were the same as those for the IPN group (Table 4). In addition, the infants in the SPN group gained significantly more weight than did those in the IPN group in the first, second, and third postnatal weeks (Table 5). The SPN group also had greater caloric intake in the first postnatal week (Table 3). Our study is consistent with previous findings, confirming that SPN is associated with higher caloric intake, contributing to the greater and earlier mean daily weight gain observed in the SPN group—an outcome that is deemed beneficial.[23]

Given that birth weight and length in the IPN group were greater than those in the SPN group, we concluded that IPN outperformed SPN in all postnatal weeks for the early initiation of enteral feeding (Table 3). However, in the second and third postnatal weeks, no difference in total caloric intake between the IPN and SPN groups was discovered, suggesting that PN in the SPN group provided sufficient calories. Furthermore, the duration of TPN administration

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(days) for infants receiving SPN was significantly shortened (Table 4), possibly because the SPN group received more calories through PN alone than did the IPN group in the first, second, and third postnatal weeks. Moreover, the catch-up in birth weight was quicker and the duration of PN was shorter in this study compared with those in previous research.[31] SPN (Numeta) is a three-in-one type of PN (glucose, lipids, and amino acids). PN with SPN is discontinued when 70% of the total protein and energy requirements are met enterally. However, with IPN, when the amount of enteral nutrition reaches 70% of the total protein and energy requirements, the lipids are discontinued first, and amino acids are then discontinued when 75% of the total protein and energy requirements are reached. Notably, the 2 groups in this study did not differ significantly in BW at the time of transfer from the NICU to the general ward or at discharge (Table 4). Thus, there is an association of SPN with a shortened duration of PN administration.

The findings of the present study are consistent with those of a before-and-after study conducted by Mihatsch et al.,[32] who included infants born at <32 weeks of gestation with a birth weight of <2000 g. Specifically, Mihatsch et al. administered SPN or IPN to infants during the transition phase which involved the provision of EN at a volume of 20 mL/kg until complete feeding was achieved (ie, 160 mL/kg). They reported that the SPN group had a significantly higher parenteral energy intake and protein intake during the transition phase than did the IPN group. Similarly, the SPN group of the present study had significantly higher parenteral intake in the first and third postnatal weeks than did the IPN group (Table 3). Additionally, the IPN group had a higher daily total fluid intake than the SPN group in the first and second postnatal weeks, possibly due to the provision of enteral nutrition (Table 3).

Several studies have reported favorable outcomes of SPN compared with IPN. Weight gain corresponding to intrauterine weight accretion was achieved in 1 study, and SPN had advantages in terms of safety, availability, and lower production costs.[30] These findings are consistent with those of Simmer et al.,[33] who reported that SPN may have advantages over IPN in terms of higher nutrient intake and weight gain. Our study obtained the same favorable outcomes for SPN; SPN resulted in significantly greater weight gain than did IPN in the first, second, and third postnatal weeks (Table 5). Because relatively small differences in nutrient intake over the early days of life may have significant impacts on short and long-term outcomes, the significance of these findings should not be underestimated. Additionally, SPN has advantages in terms of rapid availability, fewer prescription errors, decreased risk of infection, and cost savings.[34]

Despite the majority of research on SPN focusing on extremely LBW and very LBW (VLBW) preterm infants,[35,36] our study involved patients with a mean weight of 1376 g (VLBW) in the SPN group and 1522 g (borderline VLBW/LBW) in the IPN group. The clinical importance of our findings lies in the indication of emerging evidence from the use of optimized nutrition, resulting in a significant change in nutrition intakes and weight development up to postnatal day 21. However, there are some limitations to our study. The sample size was small; the design of the investigation was retrospective rather than prospective and randomized, so inclusions were not blinded, and the 2 cohorts were not completely homogeneous. Because our study was purely observational, other advantages and disadvantages of IPN and SPN, such as PN bags being wasted and prescription errors, were not addressed. Although SPN has a clinical role, especially in allowing PN to begin immediately after birth, SPN protocols must be regularly audited to assess the need for modifications.

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CONCLUSIONS

Clinician judgment and adequate monitoring are still necessary before the provision of PN prescriptions, as recommended in the 2018 European guidelines.[18] Eliminating growth failure in NICUs is a major challenge for medical teams. Our findings are of clinical importance suggesting that SPN (Numeta) may be an alternative to IPN for patients with LBW during a period of stable growth. In this study, it was observed that the use of SPN was associated with a shortened number of days of PN use and greater weight gain than did the use of IPN.

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