

Original

Nutritional assessment of very low birth weight infants: relationships between anthropometric and biochemical parameters

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Abstract

Objective: Analyze the importance of biochemical data and their relationship with anthropometric data in the longitudinal nutritional assessment of very low birth weight infants.

Methods: A prospective cohort study was performed on 55 very low birth weight preterm infants (birth weight < 1,500 g and < 37 weeks of gestational age). Measurements of weight, length, head and mid-arm circumferences, mid-arm circumference: head circumference ratio, ponderal index, and body mass index. Serum prealbumin and retinol-binding protein were studied as biochemical parameters. All variables were collected at birth and days 14 and 28 of life.

Results: The infants presented a mean birth weight of $1,076.7 \pm 286$ g and mean gestational age of 30.7 ± 2.1 weeks. At birth, the mean serum prealbumin was 7.0 ± 1.7 mg/dl and mean retinol-binding protein was 1.3 ± 0.4 mg/dl. There was a significant increase in all variables studied from birth to day 28. According to nutritional adequacy, there were no differences between appropriate and small for gestational age infants neither in the anthropometric nor in the biochemical data. The anthropometric measurements did not correlate with biochemical parameters. The serum protein concentrations were converted to serum protein mass (SPM) as follows: $SPM = \text{serum protein concentration} \times (100 \times \text{weight}) \times (1 - \text{hematocrit})$ since the studied proteins are largely intravascular and the protein mass would be a more accurate index of nutritional status. The SPM of both protein and anthropometric parameters were correlated, except for the ponderal index.

Conclusions: The serum protein mass of the prealbumin and the retinol-binding protein were better nutritio-

EVALUACIÓN NUTRITIVAL DE LACTANTES DE MUY BAJO PESO AL NACIMIENTO: RELACIONES ENTRE LOS PARÁMETROS ANTROPOMÉTRICOS Y BIOQUÍMICOS

Resumen

Objetivo: Analizar la importancia de los datos bioquímicos y su relación con los datos antropométricos en la evaluación nutricional longitudinal de los lactantes de muy bajo peso al nacimiento.

Métodos: Se realizó un estudio de cohortes prospectivo en 55 lactantes prematuros de muy bajo peso al nacimiento (peso al nacer < 1,500 g y < 37 semanas de edad gestacional). Se realizaron mediciones del peso, longitud, las circunferencias cefálica y de la mitad del brazo, el cociente circunferencia de la mitad del brazo: circunferencia cefálica, índice ponderal y el índice de masa corporal. Como parámetros bioquímicos se midieron la prealbúmina sérica y la proteína fijadora de retinol. Todas las variables se recogieron al nacimiento y a los 14 y 28 días de vida.

Resultados: El peso medio al nacimiento de los lactantes fue de $1,076,7 \pm 286$ g y la edad gestacional media de $30,7 \pm 2,1$ semanas. Al nacimiento, el promedio de la prealbúmina sérica fue de $7,0 \pm 1,7$ mg/dl y de la proteína fijadora de retinol fue de $1,3 \pm 0,4$ mg/dl. Hubo una elevación significativa de todas las variables estudiadas desde el nacimiento hasta el día 28. De acuerdo con la idoneidad nutricional, no hubo diferencias entre los lactantes con edad gestacional adecuada y aquellos con edad gestacional pequeña ni en los parámetros antropométricos ni en los bioquímicos. Las medidas antropométricas no se correlacionaban con las medidas bioquímicas. Las concentraciones de proteínas séricas se convirtieron a masa de proteína sérica (MPS) como sigue: $MPS = \text{concentración de proteína sérica} \times (100 \times \text{peso}) \times (1 - \text{hematocrito})$, puesto que las proteínas estudiadas son principalmente intravasculares y el índice de masa proteica sería un índice más preciso del estado nutritivo. La MPS tanto de las proteínas como de los parámetros antropométricos se correlacionó, excepto para el índice ponderal.

Conclusiones: La masa de proteína sérica de la prealbúmina y de la proteína fijadora de retinol fue un marcador nutricional mejor en la valoración nutricional se-

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nal markers in the serial nutritional assessment of very low birth weight infants during neonatal period than the serum protein levels.

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Key words: *Prealbumin. Retinol-binding protein. Nutritional assessment. Anthropometric parameters. Very low birth weight infants.*

Introduction

Appropriate nutritional status of the fetus can significantly influence the morbidity and mortality of the newborn.¹ The well-being of the fetus depends on a sufficient supply of nutrients from an appropriately functioning placenta, as well as the absence of factors that could retard its growth². It is important for the neonatologist to identify newborns at risk of complications resulting from an inadequate intrauterine growth rate and to prevent sequelae by anticipating eventual complications³.

According to the Committee of Nutrition of the American Academy of Pediatrics,⁴ the nutritional goal in the management of very low weight newborn is to achieve a postnatal growth that approximates the in utero growth of a normal fetus at the same postconception age, without producing nutritional deficiencies, undesirable metabolic effects or toxicity resulting from an exaggerated nutritional supply.

Traditionally, the assessment of the nutritional status of the newborns begins with the plotting of anthropometric measurements on standard intrauterine growth curves.^{5,6} But premature birth is not a natural phenomenon and therefore the anthropometric data thus obtained does not necessarily correspond to the pattern of growth of the fetus had it remained in the intrauterine environment. This fact interferes with a correct interpretation of the nutritional assessment.

However, the adaptations necessary to extrauterine life and the consequent initial weight loss, whether or not related to a disease factor, modify the growth rate.⁶ There are curves of postnatal growth for premature infants⁷⁻¹¹, that take into account the weight loss in the first week of life and compensate for the lower rate of weight gain observed during the first weeks in the extrauterine environment. Each curve reflects different clinical conditions and different nutritional approaches.

Among the anthropometric parameters, the most used are the body weight, the length and the mid-arm and head circumferences, though each with its particular limitations.

In addition to these anthropometric measurements, some relationships between anthropometric parameters have been described as methods of nutritional assessment of newborns.¹²⁻¹⁴ The objective of these is to underscore the proportionality of the intrauterine and

riada de los lactantes con muy bajo peso al nacimiento que la concentración sérica de proteínas.

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Palabras clave: *Prealbúmina. Proteína fijadora de retinol. Valoración nutricional. Parámetros antropométricos. Lactante de muy bajo peso al nacimiento.*

postnatal growth. These methods include: the ponderal index, the the mid arm: head circumferences ratios and the body mass index.

Besides the anthropometric parameters, the assessment of the nutritional status of the infant can be accomplished through biochemical parameters.³ It includes the evaluation of macronutrients, measuring the adaptation of the protein-calorie supply, as well as micronutrients status (vitamins and minerals).

Among the biochemical tests, the most sensitive are those that use the measurement of the protein pool of the organism. The serum short-term proteins such as prealbumin, retinol-binding protein and transferrin can reflect the recent protein status and the balance between synthesis and degradation⁶. It is important to point out that several of these proteins are produced in the liver and so can be influenced by physiological and pathological factors that may be independent of the nutritional variables.¹⁵⁻¹⁷

It is essential to have methods that are rapid, simple and inexpensive, that permit the longitudinal assessment of the nutritional status of the preterm newborn. These criteria could be met by the anthropometric parameters and/or the anthropometric relationships but it would be ideal if we could proceed to the assessment with only one, provided it is directly related to the biochemical parameters, especially with the serum rapid turnover proteins.

The present study had the objective of analyzing the importance of the biochemical parameters and their relationship to the anthropometric parameters in the nutritional assessment of very low weight preterm infants.

Methods

A prospective study was conducted on a cohort of very low weight preterm infants (birth weight < 1.500 g and gestational age < 37 weeks), after approval by the Commission of Research and Ethics and parents' written informed consent.

Excluded from the study were very low weight preterm infants that presented conditions that might have altered the fetal growth or situations that might interfere in the anthropometric measurements and/or in the parameters to be studied in the laboratory such as: major malformations, chromosomopathies, hydrocephaly, fetal hydrops, congenital infections, drug abuse by the mother or maternal use of corticoids.

Upon the birth of a very low weight infant, after performing the necessary routine measures of reanimation, a 2 ml sample of blood was drawn from the umbilical cord for determination of the levels of serum prealbumin and retinol-binding protein (RBP).

The weight was obtained in grams, discounting the weight of any utensils that might have been attached to the newborn during the reanimation maneuvers. During the first 24 hours of life, the measurements of the length were accomplished, as well as head and mid-arm circumferences.

The length, in centimeters, was obtained with the newborn in the dorsal decubitus position, on a rigid surface, using a length board (in gradations of 0.1 cm) with a fixed terminal (at the head) and other terminal movable (at the feet). The measurement was accomplished with the aid of another person to hold the infant. The mean of three consecutive measurements was then noted.

The head circumference, in centimeters, was obtained with a non-stretch plastic measuring tape (with gradations of 0.1 cm), the largest diameter being considered the occipital-frontal. The mean of 3 consecutive measurements was noted.

The mid arm circumference, in centimeters, was obtained at the midpoint between the acromion and the olecranon, of the right arm, with a measuring tape (with gradations of 0.1 cm), the mean of 3 consecutive measurements was considered.

The classification of the newborns was based on the weight reference curves for gestational age described by Alexander *et al.*¹⁸ The newborns were considered appropriate for gestational age when placed between the 10th and 90th percentiles on the curve; large for gestational age when above 90th percentile and small for gestational age when below 10th percentile.

On days 14 and 28 of life, those newborns that had been receiving na adequate energy and protein intake, including enteral and parenteral intake, were maintained in the study. Newborn were excluded if they presented bacteremia, pneumonia, renal insufficiency, cholestatic disease or were receiving corticotherapy or had received hemoderivatives in the previous four days, since those conditions could affect the serum levels of prealbumin and RBP.¹⁵⁻¹⁷ On days 14 and 28, the anthropometric measurements were taken again as described above and 2 ml of blood was collected from a peripheral vein, for determination of prealbumin and RBP.

The dosage of prealbumin and of RBP were done by nephelometry as this is the best method currently available for such quantification.

Considering that the serum volume in the newborn is related to weight, the great weight variation in the population of the study resulted in major differences in serum volume, modifying by the dilutional effect of the volemia on the concentrations of serum proteins. And also considering that prealbumin and RBP are predominantly intravascular, it was postulated that the

use of serum protein mass might be a more reliable method for assessment of the nutritional status.¹⁹ Thus, calculations of the serum protein masses of prealbumin and retinol-binding protein were made for purposes of comparative analyses. The formula adopted was as follows:

$$\text{SPM (mg)} = \text{SP (mg/dl)} \times \text{V (ml)} \times (1 - \text{Ht}), \text{ where:}$$

SPM = serum protein mass

SP = serum protein

V = volume = weight (kg) x 100 ml

Ht = hematocrit

Volume = 100 ml X weight (kg).

For the statistical analysis, the mean and standard deviation were calculated for the anthropometric variables and for the biochemical variables of each infant in the three periods of the study. For the analysis of variance the t test was used when the variable had a normal distribution or if not by Mann-Whitney. The relationships between the anthropometric and biochemical parameters were calculated through the coefficient of Pearson. For all of the analyses significant differences were considered when $p < 0.05$.

The population was also analyzed newborns with a subdivision of the appropriate and small for gestational age.

Results

The data obtained were collected between may 2001 and oct 2002. A total of 55 very low weight preterm infants were studied (table I).

Tables II and III summarize the anthropometric and biochemistry characteristics of the newborn in the three periods (at birth and at days 14 and 28 of life).

Following the collection of data, the analyses were accomplished using anthropometric parameters, anthropometric relationships and biochemical parameters in conjunction with the nutritional adaptation (table IV).

Table V and IV present the correlations between the anthropometric parameters and anthropometric relationships with prealbumin and RBP, respectively, in terms of both serum concentration and serum protein mass.

Table I
Characteristics of the very low weight preterm infants

Sample size	55
Birth weight (g)	1,076.7 ± 286.7 [#]
Gestational age (weeks)	30.7 ± 2.1 [#]
Appropriate for gestational age	17 (31%)
Small for gestational age	38 (69%)
Male	25 (45.5%)
Female	30 (54.5%)

- mean ± standard deviation.

Table II
Anthropometric characteristics of the very low weight preterm infants in the three study periods

	<i>Birth</i>	<i>14 days</i>	<i>28 days</i>
Weight (g)	1.076.7± 286.7 (500 - 1480)	1.095.0 ± 309.8 (600 - 1670)	1.359.0 ± 366.7* (750 - 2070)
Length (cm)	35.8 ± 3.2* (28.0 – 41.0)	37.6 ± 3.2 * (30.5 - 42.5)	39.4 ± 2.4 (32.0 - 44.5)
Head circumference (HC) (cm)	26.0 ± 2.3 (21.0 – 30.0)	26.9 ± 2.4 (22.0 - 31.5)	28.5 ± 2.1 * (24.5 - 33.0)
Mid-arm circumference (MAC) (cm)	5.5 ± 0.7 (4.0 - 7.3)	5.5 ± 0.9 (3.8 - 7.0)	6.1 ± 0.9* (4.6 - 7.7)
MAC: HC	0.21 ± 0.02 (0.16 - 0.25)	0.19 ± 0.02* (0.16 - 0.23)	0.21 ± 0.02 (0.17 - 0.24)
Ponderal index (g/cm ³)	2.28 ± 0.20* (1.6 - 3.0)	2.00 ± 0.20* (1.6 - 2.3)	2.17 ± 0.20 (1.7 - 2.6)
Body mass index (kg/m ²)	8.2 ± 1.1 (5.7 - 10.2)	7.6 ± 1.0* (5.8 - 9.6)	8.6 ± 1.2 (6.5 - 11.4)

* statistically significant difference in relation to other columns (p < 0.05)
mean ± standard deviation;
(variation)

Table III
Biochemical characteristics of the preterm very low weight infants in the three study periods

	<i>At birth n = 53</i>	<i>Day 14 n = 44</i>	<i>Day 28 n = 40</i>
Prealbumin (mg/dl)	7.0 ± 1.7* (3.9-11.9)	9.5 ± 3.3 (5.2-22.8)	8.7 ± 2.3 (4.9-15.3)
SPM of prealbumin (mg)	4.2 ± 1.5* (1.4-8.2)	6.8 ± 2.6 (2.8-11.5)	8.5 ± 3.4 (2.6-16.2)
RBP (mg/dl)	1.3 ± 0.4* (0.6-2.8)	1.9 ± 1.0 (0.7-5.4)	1.6 ± 0.8 (0.1-4.6)
SPM of RBP (mg)	0.8 ± 0.3* (0.20-2.30)	1.3 ± 0.7 (0.40-4.10)	1.5 ± 0.8 (0.08-4.00)
Hematocrit (g/dl)	45.5 ± 6.0* (33.7-59.1)	33.9 ± 7.5* (22.6-56.7)	29.1 ± 4.8 (21.2-39.3)

* statistically significant difference in relation to other columns (p < 0.05)
mean ± standard deviation;
(variation)
RBP – Retinol-binding protein
SPM – Serum protein mass.

Discussion

The nutritional assessment of the newborn is a difficult, but necessary task in a neonatal intensive care unit, especially when dealing with premature infants, since they are born before the period of greater somatic growth with its deposits of nutrients, such as glycogen, proteins, fats, vitamins, microelements and minerals.³

The use of anthropometric parameters in this assessment¹¹ is a relatively simple method, that is readily available and inexpensive. However, these pa-

rameters need a precise means of comparison in order to be valid, which is often difficult to achieve in a population of preterm newborns and especially among very low birth weight infants. Besides this, in the first days of life, major modifications occur in the body composition, with a significant reduction of the extracellular space and a consequent weight loss that can reach 20% in an extremely premature newborn.³ Also, the fluid retention and the presence of malformations, with the increase or reduction of the dimensions of parts of the body, can affect the weight in a relevant manner, independent of nutri-

Table IV
Anthropometric parameters, anthropometric ratios and biochemical parameters at birth, according to nutritional status

	AGA Mean ± SD	SGA Mean ± SD
Sample size (%)	17 (31)	38 (69)
Gestational age (weeks)	29.0 ± 1.4 (27.0 - 31.4)	31.4 ± 1.4* (27.4 - 35.0)
Weight (g)	1,143.5 ± 239.7 (780 - 1,480)	1,046.8 ± 303.5 (500 = 1,470)
Length (cm)	36.6 ± 2.4 (32.0 - 40.5)	35.5 ± 3.4 (28.0 - 41.0)
Head circumference (cm)	26.4 ± 2.1 (22.5 - 29.5)	25.8 ± 2.4 (21.0 - 30.0)
Mid-arm circumference (cm)	5.7 ± 0.5 (4.5 - 6.5)	5.4 ± 0.8 (4.0 - 7.3)
MAC: HC	0.21 ± 0.01 (0.20 - 0.23)	0.21 ± 0.01 (0.16 - 0.25)
PI (g/cm ³)	2.3 ± 0.2 (1.9 - 2.6)	2.2 ± 0.2 (1.6 - 3.0)
BMI (kg/m ²)	8.4 ± 0.9 (6.7 - 9.8)	8.0 ± 1.1 (5.7 - 10.2)
Prealbumin (mg/dl)	7.5 ± 1.7 (5.2 - 11.9)	6.8 ± 1.7 (3.9 - 10.9)
SPM of prealbumin (mg)	4.7 ± 1.4 (2.3 - 8.2)	3.9 ± 1.6 (1.4 - 7.5)
Retinol-binding protein (mg/dl)	1.4 ± 0.5 (0.6 - 2.6)	1.2 ± 0.4 (0.6 = 2.8)
SPM of RBP (mg)	0.8 ± 0.3 (0.4 - 1.8)	0.7 ± 0.3 (0.2 - 2.3)

*p < 0.001 between the two groups.

AGA: appropriate for gestational age. SGA: samll for gestatiional age.

SD: standard deviation. MAC/HC: mid-arm: head circumference.

PI: ponderal index. BMI: body mass index.

RBP: Retinol-binding protein.

Mean ± Standard deviation (variation).

SPM: Serum protein mass.

tional aspects. For this reason, the weight should not be considered alone during the nutritional assessment in the first weeks of life in ill or immature newborns.

The use of anthropometric relationships in the nutritional assessment of very low weight infants was described.¹²⁻¹⁴ It involves the ponderal index and the mid-arm and head circumferences ratio.¹² In the last few years, some studies included the body mass index in the assessment of newborn, however there is still no reference standard.^{20,21}

Another method for evaluating the nutrition of very low weight infants is through analysis of biochemical parameters. Among the various somatic proteins, serum prealbumin has been described as one of the best nutritional markers, as it is directly related to the nutritional status of the newborn.²²⁻²⁷ However, for such an evaluation, the need for blood sample should be underscored as this might injure a very immature newborn. Furthermore, there is a cost involved with this procedure, a lack of correlation with the anthropometric parameters³ and the possibility that the findings have been altered by factors other than nutritional aspects, such as sepsis or hepatic disease.³

The option of including only very low weight infants meant that the study population is one of high nutritional risk. The possibility of the presence of pathologies that compromise the well-being is high and these create various degrees of nutritional disturbances in almost all infants. Being born prematurely already places the neonate outside the normal patterns and as such applying normal growth references to these infants is clearly speculative.

The anthropometric parameters selected for this study are described in table II. The mean birth weight of 1,076.7 ± 286.7 g was compatible with 27 to 28 weeks of gestation for an appropriate intrauterine

Table V
Correlation between prealbumin and the anthropometric parameters in the three periods studied

	Age	W	L	PC	MAC	MAC/HC	PI	BMI	
Prealbumin (mg/dl)	0	r	0.15	0.19	0.07	0.16	0.18	-0.11	0.11
		p	0.27	0.15	0.60	0.24	0.19	0.90	0.40
	14	r	-0.14	-0.08	-0.25	-0.10	0.06	-0.26	-0.22
		p	0.34	0.57	0.09	0.40	0.60	0.07	0.13
	28	r	0.16	0.06	0.13	0.21	0.24	0.25	0.21
		p	0.31	0.67	0.40	0.17	0.12	0.12	0.17
SPM of prealbumin (mg)	0	r	0.76	0.72	0.66	0.69	0.40	0.22	0.65
		p	< 0.001	< 0.001	< 0.001	< 0.001	0.002	0.11	< 0.001
	14	r	0.64	0.65	0.52	0.61	0.56	0.16	0.52
		p	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.27	< 0.001
	28	r	0.81	0.69	0.66	0.80	0.68	0.57	0.79
		p	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001

P: Weight

L: length

HC: head circumference

r: Pearson coefficient of correlation

p: level of significance

AC: Mid arm circumference

PI: ponderal index

BMI: body mass index

SPM – Serum protein mass

Table VI
Correlation between the retinol binding protein (RBP) and the anthropometric parameters in the three periods studied

	Age	W	L	PC	AC	AC/HC	PI	BMI	
RBP (mg/dl)	0	r	0.06	0.05	0.01	0.02	0.01	0.09	0.10
		p	0.64	0.67	0.90	0.88	0.90	0.50	0.44
	14	r	-0.24	-0.23	-0.29	-0.22	-0.09	-0.20	-0.26
		p	0.10	0.12	0.05	0.15	0.55	0.18	0.07
	28	r	-0.04	-0.04	-0.02	-0.01	-0.01	-0.02	-0.04
		p	0.78	0.78	0.89	0.90	0.94	0.86	0.78
SPM of RBP (mg)	0	r	0.53	0.48	0.47	0.44	0.20	0.23	0.49
		p	< 0.001	< 0.001	< 0.001	< 0.001	0.13	0.09	< 0.001
	14	r	0.33	0.3	0.26	0.3	0.26	0.11	0.28
		p	0.02	0.04	0.08	0.04	0.07	0.44	0.06
	28	r	0.49	0.49	0.46	0.48	0.39	0.29	0.45
		p	0.001	0.001	0.002	0.001	0.01	0.06	0.003

P : Weight
 HC: head circumference
 AC: Mid arm circumference
 r: Pearson coefficient of correlation
 p: level of significance

L: length
 PI: ponderal index
 BMI: body mass index
 SPM: Serum protein mass

growth.¹⁸ Considering the mean gestational age of 30.7 ± 2.1 weeks found in the sampling (table I), the presence of serious intrauterine nutritional deficiency is demonstrated in the newborns studied. Thus, 69% of the population of the study were small for gestational age infants.

This finding may be explained by the characteristics of the population of pregnant women attended at the our institution where the study was undertaken, as the region is characterized by high-risk gestations.

Analysis of the anthropometric relationships revealed that up to 28 days of life, body proportions remained similar to those at birth, except the ponderal index. The use of weight in calculations of the ponderal index and body mass index causes a decline in these indices in the first weeks, since they reflect the weight profile. The same effect is to be expected in the ratio between the mid arm and head circumferences, albeit with the possible maintenance of head growth. In fact, the ideal function of the anthropometric relationships in the neonatal period of very low weight infants has yet to be fully established.

All of the anthropometric parameters analyzed proved to be similar between the appropriate and small for gestational age newborns (table IV). This result may be explained by the small number of infants in the appropriate for gestational age group (17/55), as well as by the difficulty in reaching a nutritional classification of this population, as has already been emphasized.

Since prealbumin is one of the transport proteins of thyroxin, great care was taken in verifying the results of the neonatal screenings to identify congenital hypothyroidism, thus avoiding a distortion in the analy-

sis of the results.²⁵ Those cases that certainly would have altered the prealbumin levels, such as sepsis and renal or hepatic disease were also excluded. Besides this, although zinc and vitamin A supplementation is a normal part of the nutritional routine for very low birth weight infants, those with serious deficiencies of these nutrients were not included, as the condition could reduce the synthesis of RBP.³

A sample of umbilical cord blood was used for the initial analyses in order to avoid causing trauma to the newborn, since the values provided by umbilical cord blood are similar to those of other blood on the first day of life.²⁶

Table III presents the biochemical characteristics of the study population. A significant increase in the levels of serum prealbumin was observed: (7.0 ± 1.7 mg/dl) at birth, compared to (9.5 ± 3.3 mg/dl) at 14 days and (8.8 ± 2.3 mg/dl) at 28 days of life. However there was no statistically significant difference between the values at 14 and 28 days of life. These findings are in agreement with the study by Giacoia et al.²⁷

The serum prealbumin level from umbilical cord blood (7.0 ± 1.7 mg/dl) was lower than that reported by Sasanow et al.¹⁹, (8.8 ± 2.3 mg/dl) for preterm newborns. However, the prealbumin levels found at 14 days (9.5 ± 3.3 mg/dl) and 28 days of life (8.7 ± 2.3 mg/dl) were similar to those described by these authors. On the other hand, the levels from the umbilical cord blood found in this study corroborated the values obtained by Socha et al.²⁸, (7.0 ± 2.9 mg/dl).

The interpretation of these results is extremely important, because there are few reports describing the serum prealbumin levels at birth in preterm newborns.

One of the merits of this study is the determination of mean levels of prealbumin in a homogeneous population of very low weight infants at three different times during the neonatal period; at birth, at 14 and at 28 days of life. In addition, the results showed a gradual increase in the serum prealbumin levels between birth and day 28 of life (table III), demonstrating a capacity for synthesis on the part of these newborns and, by extrapolation, they are also capable of incorporating protein into the muscular mass, thereby inducing growth, as demonstrated by the anthropometry.

The serum prealbumin masses were calculated in the three periods of the study, as described in the methodology. The objective of this calculation was to reduce the effect of dilution, because there is a great fluctuation in the volume of fluid in preterm newborns during the first weeks of life. Thus, this protein mass could represent the synthesis of this visceral protein with greater accuracy.²⁶

The serum prealbumin masses (table III) increased significantly from birth (4.2 ± 1.5 mg) to 14 days (6.8 ± 2.6 mg) and to 28 days of life (8.5 ± 3.4 mg), showing proteic synthesis.

The serum levels of RBP increased in a significant way from birth (1.3 ± 0.4 mg/dl) to 14 days of life (1.9 ± 1.0 mg/dl) and to 28 days of life (1.6 ± 0.8 mg/dl) (table III).

The serum levels of RBP of the umbilical cord (1.3 ± 0.4 mg/dl) were lower than those described by Sasanow et al.¹⁹ (1.8 ± 0.5 mg/dl) for premature newborns. The values at 14 days of life (1.9 ± 1.0 mg/dl) and at 28 days of life (1.6 ± 0.8 mg/dl) were similar to those authors' findings.

With regard to RBP, the protein masses were also calculated from the values obtained in the three periods (table III). From these data, a significant increase was observed from birth (0.8 ± 0.3 mg) at 14 days (1.3 ± 0.7 mg) and at 28 days (1.5 ± 0.8 mg) of life.

The biochemical parameters analyzed (prealbumin and RBP) were shown to be similar between the adequate and the small for gestational age.

Socha et al.²⁸ also did not find differences in the prealbumin levels of preterm newborns of appropriate size (8.1 ± 3.4 mg/dl) and small for gestational age (7.0 ± 2.9 mg/dl), suggesting that the great variations observed could be explained by individual differences within the study groups.

These results conflict with the findings of Pittard et al.²⁹, who reported that small for gestational age newborns have lower levels of serum prealbumin than those with appropriate weight, whether premature or not.

The variation of RBP from period to period was similar between appropriate and small for gestational age newborns, when their serum levels were considered. Analysis of the serum mass of RBP revealed that from 0 to 28 days of life, small for gestational age newborns gained more mass of RBP (0.9 ± 0.8 g) than those appropriate for gestational age (0.4 ± 0.4 g), this difference was statistically significant ($p = 0.04$).

Table V shows the correlations between the prealbumin and anthropometric parameters. The values of the Pearson coefficients of correlation are presented, together with the corresponding p values. When the serum protein mass was considered, high correlations were observed, in all three periods, between prealbumin and each of the anthropometric parameters, except for the ponderal index.

Table VI presents the data of the correlations between RBP and the anthropometric variables. It shows that there was no correlation between the serum levels of RBP and the anthropometric parameters in the three periods studied. Besides this, only weak correlations were noticed when the serum protein mass was used and there was no correlation between RBP and the ponderal index in any of the three periods studied.

In short, the analyses of the correlations between the anthropometric and biochemical parameters revealed that the prealbumin correlated closely with all the anthropometric variables only when the serum protein mass was considered. This confirms the results described by Raubenstine et al.⁶ Likewise, previous studies also found no correlations between the levels of serum prealbumin and the anthropometric parameters.^{23,30} It should also be emphasized that RBP proved to be a less sensitive marker in the nutritional assessment of these patients, probably because of the lower rate of synthesis in lower gestational ages or because of the presence of other as yet unidentified aspects that might have altered their serum levels.

It is still not known what repercussions nutritional deficiencies in the initial stages of life may have in the future, not only in terms of physical aspects, but also in the behavioral and intellectual development. Assessment and nutritional therapy on an individual basis, would probably be the most appropriate means of promoting appropriate growth among very low weight infants. However, further studies should be undertaken with a view to identifying the various aspects capable of achieving this goal.

At the present time, it is necessary to combine the anthropometric assessment with biochemistry for a better nutritional diagnosis of these infants and, certainly, the testing for prealbumin and the body mass index will contribute to a much more precise nutritional analysis.

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Referencias

1. Lubchenco LO, Searls DT, Brazie JV: Neonatal mortality rate: relationship to birth weight and gestational age. *J Pediatrics* 1972; 81:814.
2. Ehrenkranz R: Growth outcomes of very low-birth weight infants in the newborn intensive care unit. *Clin Perinatol* 2000; 27(2):325-45.

3. Georgieff MK, Sasanow SR: Nutritional assessment of the neonate. *Clin Perinatol* 1986; 13:73-90.
4. Committee on Nutrition, AAP: Nutritional needs of the low-birth-weight infant. *Pediatrics* 1985; 75(5):976-984.
5. Lubchenco LO, Hansman, C, Dressler M et al.: Intrauterine growth as estimated from liveborn birth weight data at 24 to 42 weeks of gestation. *J Pediatr* 1963; 32:793-800.
6. Falcão MC, Cardoso LEMB: Avaliação e monitorização nutricional. In: Feferbaum, R; Falcão, MC, ed. *Nutrição do recém-nascido*. São Paulo, Editora Atheneu, 2003. pp. 55-66.
7. Dancis J, O'Connell JR, Holt LE Jr. A grid for recording the weight of premature infants. *J Pediatr* 1948; 33:570-2.
8. Brosius KK, Ritter DA, Kenny JD: Postnatal growth curve of the infant with extremely low birth weight who was fed enterally. *Pediatrics* 1984; 74:778-782.
9. Gill A, Yu VYH; Bajuk B, Astbury J: Postnatal growth in infants born before 30 weeks' gestation. *Arch Dis Child* 1986; 61:549-553.
10. Wright K, Dawson JP, Fallis D et al.: New postnatal growth grids for very low birth weight infants. *Pediatrics* 1993; 91:922-6.
11. Ehrenkranz RA, Younes N, Lemons JA et al. Longitudinal growth of hospitalized very low birth weight infants. *Pediatrics* 1999; 104(2):280-9.
12. Georgieff MK, Amarnath UM, Sasanow SR et al.: Mid-Arm Circumference and Mid-Arm Circumference: Head Circumference ratio for assessing longitudinal growth in hospitalized preterm infants. *J Am Coll Nutr* 1989; 8(6):477-483.
13. Kramer MS, McLean FH, Oliver M, Willis DM, Usher RH: Body proportionality and head and length 'sparing' in growth-retarded neonates: a critical reappraisal. *Pediatrics* 1989; 84(4):717-23.
14. Guo SS, Wu W, Chumlea WC, Roche AF: Predicting overweight and obesity in adulthood from body mass index values in childhood and adolescence. *Am J Clin Nutr* 2002 Sep; 76(3):653-8.
15. Gofferje H, Maintz E: Behavior of prealbumin, retinol-binding protein, transferrin and haptoglobin in the postoperative and post-traumatic phase. *Infusionsther Klin Ernahr* 1978; 5(5):268-72.
16. Oppenheimer JH, Werner S: Effect of prednisone on thyroxine-binding proteins. *J Clin Endocrinol* 1966; 26:715.
17. Sann L, Bienvenu F, Bienvenu J et al.: Evolution of serum prealbumin, C-reactive protein and orosomucoid in neonates with bacterial infection. *J Pediatr* 1984; 105:977-81.
18. Alexander GR, Himes JH, Kaufman RB, Mor J, Kogan M: A United States National Reference for Fetal Growth. *Obst & Gynecol* 1996; 87(2):163-168.
19. Raubenstine DA, Ballantine TVN, Greecher CP, Webb SL: Neonatal serum protein levels as indicators of nutritional status: normal values and correlation with anthropometric data. *J Pediatr Gastroenterol Nutr* 1990; 10(1):53-61.
20. Dietz WH, Bellizzi MC: Introduction: the use of body mass index to assess obesity in children. *Am J Clin Nutr* 1990; 70(Supl.): 123S-5S.
21. Abrantes MM, Lamounier JA, Colosimo EA: Recommendations for the use of body mass index for the classification of overweight and obese children. *Food Nutr Bull* 2002 Sep; 23(3):262-6
22. Moskowitz SR, Pereira GR, Spitzer A et al.: Prealbumin as a biochemical marker of nutritional adequacy in premature infants. *J Pediatr* 1983; 102:749-753.
23. Ingenbleek Y: Prealbumin and the nutritional status of the newborn infant. *Pediatric* 1984 Jul-Aug; 39(5):399-403.
24. Giacoia GP, Watson S, West K: Rapid turnover transport proteins, plasma albumin, and growth in low birth weight infants. *JPEN* 1984; 8:367-70.
25. Socha J, Eggermont E, Carchon H, Devlieger H, Eeckels R: Plasma prealbumin in low birthweight infants. *Acta Paediatr Belg* 1977; 30:171.
26. Pittard WB, Anderson DM, Gregory D, Rothstein FC: Cord blood prealbumin concentrations in neonates of 22 to 44 weeks' gestation. *J Pediatr* 1985; 107(6):959-961.
27. Thomas MR, Massoudi M, Byrne J, Mitchell MA et al.: Evaluation of transthyretin as a monitor of protein-energy intake in preterm and sick neonatal infants. *JPEN* 1988; 12(2):162-6.