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Effect of hospital nutrition support on growth velocity and nutritional status of low birth weight infants

Firas S. Azzeh[1], Awfa Y. Alazzeh[2], Ibrahim R. Dabbour[1], Abdelelah S. Jazar[1] and Ahmed A. Obeidat[3]

[1]Department of Clinical Nutrition, Faculty of Applied Medical Sciences, Umm Al-Qura University, Makkah, Saudi Arabia. [2]Department of Clinical Nutrition, Faculty of Applied Medical Sciences, University of Ha'il, Ha'il, Saudi Arabia. [3]Department of Clinical Nutrition, Faculty of Applied Medical Sciences, Taibah University, Yanbu, Saudi Arabia.

Abstract

Introduction: **Infants with low birth weights are provided with hospital nutrition support to enhance their survivability and body weights. However, different hospitals have different nutrition support formulas. Therefore, the effectiveness of these nutrition support formulas should be investigated.**

Objective: **To assess the effect of hospital nutrition support on growth velocity and nutritional status of low birth weight infants at Al-Noor hospital, Saudi Arabia.**

Methods: **A cross-sectional study was conducted between October, 2010 and December, 2012. Three hundred newborns were recruited from Al-Noor Hospital in Makkah city, Saudi Arabia. Infants were selected according to their birth weights and were divided equally into three groups; (i) Low Birth Weight (LBW) infants (1501-2500 g birth weight), (ii) Very Low Birth Weight (VLBW) infants (1001-1500 g birth weight) and (iii) Extremely Low Birth Weight (ELBW) infants (< 1000 g birth weight). Data were collected at birth and at discharged. Infants' weights were recorded and growth velocity was calculated. Some biochemical tests and mineral levels were measured.**

Results: **Body mass index values of VLBW and ELBW groups were lower ($p < 0.05$) than LBW group. The growth velocity of infants in all groups ranged between 8.7 to 10.2 g/kg/d with no differences ($p > 0.05$) were observed among groups. Serum calcium, phosphorus and potassium levels at discharge were higher ($p < 0.05$) than that at birth for ELBW and VLBW groups; while sodium level decreased in ELBW group to be within normal ranges. Albumin level was improved ($p < 0.05$) in ELBW group.**

Conclusion: **Health care management for low birth weight infants in Al-Noor Hospital was not sufficient to achieve normal growth rate for low birth weight infants, while biochemical indicators were remarkably improved in all groups.**

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Keywords: *Low birth weight, Hospital nutrition support, Growth velocity, Biochemical tests.*

Correspondence: Firas S. Azzeh, PhD.
Associate Professor of Clinical Nutrition,
Department of Clinical Nutrition,
Faculty of Applied Medical Sciences, Umm Al-Qura University.
P.O. Box: 7067, Makkah (21955), Saudi Arabia.
E-mail: fsazzeh@uqu.edu.sa

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EFECTO DE LA ASISTENCIA NUTRICIONAL HOSPITALARIA SOBRE LA VELOCIDAD DE CRECIMIENTO Y EL ESTADO NUTRICIONAL DE BEBÉS CON BAJO PESO AL NACER

Resumen

Introducción: **Los bebés con bajo peso al nacer reciben asistencia nutricional hospitalaria para reforzar su supervivencia y peso corporal. Sin embargo, cada hospital tiene su propia fórmula de asistencia nutricional. Por lo tanto, la efectividad de esta asistencia nutricional debería ser investigada.**

Objetivo: **Evaluar el efecto de la asistencia nutricional hospitalaria sobre la velocidad del crecimiento velocidad del crecimiento y el estado nutricional de bebés con bajo peso al nacer en el hospital Al-Noor, Arabia Saudita.**

Métodos: **Se llevó a cabo un estudio interseccional entre octubre de 2010 y diciembre de 2012. Se seleccionó a trescientos recién nacidos del hospital Al-Noor de la ciudad de Makkah, Arabia Saudita. Los bebés fueron seleccionados según su peso al nacer y fueron separados en tres grupos iguales: (i) Bajo peso al nacer (BPN) (peso de nacimiento 1501- 2500 g), (ii) Muy Bajo peso al nacer (MBPN) (peso de nacimiento 1001-1500 g) y (iii) Peso extremadamente bajo al nacer (PEBN) (peso de nacimiento < 1000 g). Los datos fueron recopilados en el momento del nacimiento y en el momento del alta. Los pesos fueron registrados y se calculó la velocidad del crecimiento. Se hizo la medición de algunos tests bioquímicos y niveles minerales.**

Resultados: **los valores de índice de masa corporal del VBPN y EBPN fueron menores ($p < 0.05$) que los del grupo BPN. La velocidad de crecimiento de los niños de todos los grupos osciló entre 8.7 y 10.2 g/kg/d sin diferencias ($p > 0.05$) observadas entre grupos. Los niveles de suero, calcio, fósforo y potasio en el momento del alta fueron superiores ($p < 0.05$) que los del momento del nacimiento para los grupos de EBPN y VBPN, mientras que los niveles de sodio descendieron en el grupo de EBPN hasta un rango normal. El nivel de albúmina mejoró ($p < 0.05$) en el grupo de EBPN.**

Conclusión: **La gestión de la atención sanitaria para bebés con bajo peso al nacer en el hospital Al-Noor no fue suficiente para alcanzar un índice normal de crecimiento para bebés con bajo peso al nacer, mientras que los indicadores bioquímicos mejoraron notablemente en todos los grupos.**

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Palabras clave: *Bajo peso al nacer, Asistencia nutricional hospitalaria, Velocidad del crecimiento, Tests bioquímicos.*

Abbreviations

BMI: Body mass index.
ELBW: Extremely low birth weight infants.
GV: Growth velocity.
LBW: Low birth weight infants.
RBS: Random blood sugar.
VLBW: Very low birth weight infants.

Introduction

Infants whose birth weight is less than 2500 g (5 ½ Ib) are classified as having a low birth weight[1]. Those infants are more likely to experience complications during delivery than normal weight babies and their nutritional status would deteriorate more quickly along with having possible physical and mental birth defects, contracting diseases and dying early in life[2]. It was reported that about 67% of infants who die before their first birthdays were having low birth weights[2]. There are several reports indicating the prevalence of low birth weight infants in Saudi Arabia[3-5]. The risk factors associated with delivering low birth weight in western Saudi Arabia were probably related to multiple births, smoking and lower fruits intake than the nutritional recommendations[5].

Energy and protein intakes are the most critical factors in nutrition support for low birth weight infants. Low energy and protein intakes for low birth weight infants would result in low weight gain. Adding to that the head circumference and the lean body mass would inappropriately increase[6]. Average daily nutrition requirements of low birth weight infants was reported by Anderson[1] to be 90–150 kcal/kg/d of energy, 3.5 g/kg/d of optimal amino acid mixture, and 80-105 ml/kg/d of fluid at the first day of life then increased gradually; while, 3-8 g/kg/d of lipids, and about 10-20 g/kg/d of carbohydrates can be used.

The Nutrition Committee of the American Academy of Pediatrics reported that with most select care and nutritional support management, the growth velocity (GV) and health indicators of low birth weight infants should be similar to those of full-term newborns[7]. However, some hospitals in western Saudi Arabia have adopted different nutrition support formulas based on the recommendations of their pediatricians. Some of these hospitals have had distinguishably, on average, low birth weight infants at time of discharge, even after hospital nutrition support. Therefore, the objective of this study was to assess the effect of the nutrition support at Al-Noor Hospital (Makkah region- western Saudi Arabia) on the GV, biochemical indicators and some mineral levels of low birth weight infants.

Methods

Study design, setting and participants

A cross-sectional study was conducted to investigate the effect of hospital nutrition support on GV and biochemical tests of low birth weight infants. Infants were recruited from Al-Noor Specialty Hospital in Makkah, Saudi Arabia, during the period of October, 2010 to December, 2012. Three hundred (48.1% males), vaginal birth and appropriate-for-gestational age infants, were selected according to their birth weights and divided equally into three groups; (i) Low Birth Weight (LBW) infants (1501-2500 g birth weight), (ii) Very Low Birth Weight (VLBW) infants (1001-1500 g birth weight), and (iii) Extremely Low Birth Weight (ELBW) infants (< 1000 g birth weight). Infants who died during the study were excluded. Infants selected for the study were delivered by mothers who were healthy from any chronic disease, non-smokers and who did not have any known infections.

Nutritional support

As infants were introduced into the neonatal unit, parenteral feeding was maintained, while enteral feeding started when the infant's gut became mature. Both methods had similar feeding components and concentrations regarding protein, dextrose, fat and micronutrients (table I). Infants were discharged from the hospital when their weight reached 2500 g.

Anthropometric measurements

Measurements of infants' weight and length were taken by professional pediatric nurses using a pan-type pediatric electronic scale for weight with a stationary headboard and moveable footboard for length. Infant weights were recorded at birth and at discharge from the hospital. Body Mass Index (BMI in kg/m^2) was also calculated. The growth velocity of infants was calculated using the following equation[8].

Table I
Contents of nutritional support additive[1] for low birth weight infants during hospital stay

Nutrient	*Level*
Amino acid mixture	6.5 %
Dextrose	50 %
Lipids	20 %
Sodium chloride	0.5 mmol/mL
Calcium phosphate	3 mmol/mL
Potassium chloride	2 mmol/mL
Magnesium sulphate	0.4 mmol/mL
Multivitamins	1.5 ml

[1]Heparin used in parenteral feeding by 5 units/mL.

GV = [1000 × ln(*Wn*/*W*1)]/(*Dn* _ *D*1), where:

Wn: The weight of the infant at the day of discharge.

W1: The weight of the infant after delivery at the first day.

Dn: The day of infant discharge.

D1: The delivery day.

This exponential model equation is extremely accurate with mean absolute errors of 0.02% to 0.10% [8].

Laboratory tests

Some minerals and biochemical indicators of infants were assayed at birth and at discharge from the hospital. Serum Calcium (Ca), Phosphorus (P), Sodium (Na), Potassium (K), glucose, total bilirubin, albumin, urea and creatinine were measured using Dimension instrument (Siemens Dimension RxL, Siemens, Munich, Germany). Reference ranges for all previous tests were taken from Nelson Textbook of Pediatrics[9].

Statistical analysis

Analysis of Variance (ANOVA) was performed with SAS software (version 9.1.3 SAS Institute Inc., Cary, NC, USA). Two-way ANOVA was performed to determine statistical significances of each parameter and test among and within groups. Data are presented in tables and figures as means and standard errors. P-value less than 0.05 was considered statistically significant according to Least Significant Differences (LSD) test.

Ethical consideration

This study was approved by the Umm Al-Qura University Institutional Review Board, Makkah, Saudi Arabia. All mothers provided informed written consent after delivery.

Results

Gestational age for LBW (36.1 weeks) was higher ($p < 0.05$) than that of ELBW (29.5 weeks; table II). However, there were no differences ($p > 0.05$) in gestational age between VLBW and either of ELBW and LBW groups. Weight at birth had a significant ($p < 0.05$) effect on anthropometric measures (weight, height, and BMI). Thereof, as the weight at birth decreased, the anthropometric measures decreased. Length of stay at the hospital for ELBW (36.8 days) was higher ($p < 0.05$) than that for LBW infants (8.5 days). However, there were no differences ($p > 0.05$) in length of stay at the hospital between VLBW and either of LBW and ELBW groups. Meanwhile, there were no differences ($p > 0.05$) in GV among groups (fig. 1).

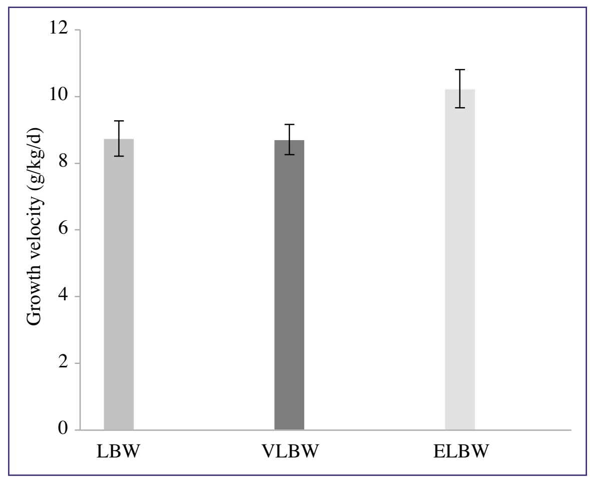

Fig. 1.—Estimated Average growth velocity (g/kg/d) for low birth weight infants during stay at Al-Noor hospital, Makkah, Saudi Arabia
Bars indicating standard error of means.
Abbreviations: LBW: low birth weight; VLBW: very low birth weight; ELBW: extremely low birth weight.

Table II
Characteristics and anthropometric measurements[1] of low birth weight infants at Al-Noor hospital, Makkah, Saudi Arabia

Parameter	*Birth Weight*		
	LBW	*VLBW*	*ELBW*
Male% (Female %)	48.3% (51.7%)	36.8% (63.2%)	59.2% (40.8%)
Gestational age (weeks)	$36.1^{a}\pm0.3$[2]	$32.8^{ab}\pm0.4$	$29.5^{b}\pm0.3$
Weight (kg)[3]	$2.1^{a}\pm0.0$	$1.3^{b}\pm0.02$	$0.9^{c}\pm0.0$
Height (cm)[3]	$47.5^{a}\pm0.3$	$42.5^{b}\pm0.5$	$35.3^{c}\pm0.2$
BMI (kg/m^2)[3]	$9.3^{a}\pm0.1$	$7.2^{b}\pm0.3$	$7.2^{b}\pm0.2$
Length of stay (days)	$8.5^{b}\pm0.8$	$25.0^{ab}\pm1.8$	$36.8^{a}\pm1.1$

[1]Results are shown as Means±SEM.
[2]Means, within the same row, with different superscripts are significantly ($p < 0.05$) different.
[3]Weight, height and BMI were measured at birth.
Abbreviations: BMI: Body Mass Index; LBW: low birth weight; VLBW: very low birth weight; ELBW: extremely low birth weight.

Numerically, ELBW group showed the highest GV, which was about 10.2 g/kg/d, while the GV for LBW and VLBW were found to be 8.7 and 8.7 g/kg/d, respectively.

Calcium levels at birth for all groups were lower than normal range (8.6-10.2 mg/dL); however, at discharge, Ca levels for all groups were in the normal range (table III). Calcium levels at discharge for VLBW and ELBW groups were higher ($p < 0.05$) than that at birth; while for LBW, there were no differences ($p > 0.05$) between Ca levels at birth and at discharge. Phosphorus and K levels were within the normal range at birth and at the end of study. However, Na level at birth for ELBW was higher ($p < 0.05$) than that of the other groups; as well as higher than the normal range. At the end of study, Na levels for ELBW was lower ($p < 0.05$) than that at birth, to fall within the normal range of Na.

Glucose levels for all groups were within the normal range (50-90 mg/dL; table IV). Total bilirubin levels for all groups were extremely higher than the

Table III
Minerals levels[1] of birth weight infants during stay at Al-Noor hospital, Makkah, Saudi Arabia

Mineral Level	*Normal Range[2]*	*Sample Date*	*Birth Weight*		
			LBW	*VLBW*	*ELBW*
Ca (mg/dL)	8.6 – 10.2[2]	Birth date	8.0±0.2[3,4]	$_{b}$7.5 ±0.2	$_{b}$8.2±0.1
		Discharge	8.6±0.2	$_{a}$9.3±0.1	$_{a}$10.1±0.1
P (mg/dL)	4.8 – 8.2	Birth date	5.5±0.2	6.7±0.2	5.5±0.2
		Discharge	6.2±0.2	7.0±0.1	5.7 ±0.0
Na (mmol/L)	135- 145	Birth date	137.8^{b}±0.5	139.8^{b}±0.6	$_{a}$157.3^{a}±3.3
		Discharge	141.2±0.4	138.2±0.5	$_{b}$132.4±1.2
K (mmol/L)	3.5- 7.0	Birth date	5.5±0.1	5.3±0.1	4.4±0.1
		Discharge	5.6±0.1	5.7±0.1	4.6±0.1

[1]Results are shown as Means±SEM.
[2]Numbers are reference ranges for infants from Kliegman et al.[7]
[3]Means with different superscripts in the same row are significantly ($p < 0.05$) different.
[4]Means with different subscripts in the same column are significantly ($p < 0.05$) different.
Abbreviations: LBW: low birth weight; VLBW: very low birth weight; ELBW: extremely low birth weight; Ca: calcium; P: phosphorus; Na: sodium; K: potassium.

Table IV
Biochemical tests[1] of low birth weight infants during stay at Al-Noor hospital, Makkah, Saudi Arabia

Mineral Level	*Normal Range*	*Sample Date*	*Birth Weight*		
			LBW	*VLBW*	*ELBW*
Glucose (RBS; mg/dL)	50-90	Birth date	75.6±2.6	88.1±1.8	85.5±2.0
		Discharge	61.3±1.0	71.7±1.2	69.6±1.8
Total bilirubin (mg/dL)	0-1	Birth date	$_{a}$4.4±0.2	$_{a}$4.4±0.3	$_{a}$4.7±0.1
		Discharge	$_{b}$1.9±0.0	$_{b}$2.1±0.1	$_{b}$2.0±0.2
Albumin (g/dL)	1.8-3.4	Birth date	3.4 ^{a}±0.1	2.4 ^{ab}±0.0	$_{a}$1.7 ^{b}±0.0
		Discharge	3.4 ^{a}±0.1	2.9 ^{a}±0.1	$_{b}$2.6 ^{b}±0.0
Urea (mg/dL)	3-25	Birth date	21.1±0.9	26.7±1.5	26.1±1.2
		Discharge	17.7±1.0	19.1±1.1	18.9±1.0
Creatinine (mg/dL)	0.3-1.0	Birth date	0.8±0.0	$_{a}$1.0±0.0	$_{a}$0.9±0.0
		Discharge	0.6 ^{a} ±0.0	$_{b}$0.4 ^{b}±0.0	$_{b}$0.5 ^{b}±0.0

[1]Results are shown as Means±SEM.
[2]Numbers are reference ranges for infants from Kliegman et al.[7]
[3]Means with different superscripts in the same row are significantly ($p < 0.05$) different.
[4]Means with different subscripts in the same column are significantly ($p < 0.05$) different.
Abbreviations: LBW: low birth weight; VLBW: very low birth weight; ELBW: extremely low birth weight; RBS random blood sugar.

normal range (0-1 mg/dL), which indicated the presence of jaundice disease. Total bilirubin level at discharge was reduced ($p < 0.05$) from that at birth, for all groups, but still higher than the normal range (table IV). Albumin level of ELBW at discharge, with nutrition support, was higher ($p < 0.05$) than that at birth; however albumin level of ELBW at discharge, was lower ($p < 0.05$) than that of LBW and VLBW groups. Urea concentration, at the end of study, decreased insignificantly for all groups. Creatinine levels for all groups were in the normal range (0.3-1.0 mg/dL); however, at discharge, with hospital care, creatinine levels were lowered ($p < 0.05$) for VLBW and ELBW compared to its levels at birth, but not for LBW ($p > 0.05$).

Discussion

This formula contained low protein and calorie intakes from parenteral or enteral feeding. Average energy intake for low birth weight infants of this study was 105 kcal/kg/d, while protein intake was 1.5 g/kg/d. Therefore, energy and protein intakes should be increased to 150 kcal/kg/d and 3.5 g/kg/d of protein to acquire normal growth rates for low birth weight infants[1] as The ones found in the study of Costa-Orvay et al.[6] The low energy and protein intake by low birth weight infants of this study might explain the low GV found (8.7 to 10.2 g/kg/d). These results could be attributed to using similar low protein and low calorie nutrition formula for all infants in the premature neonatal unit in the hospital, irrespective of their birth weights. Our GV results were in contrast to the study by Ehrenkranze et al[10], who reported that the GV for very low birth weight infants were about 15.2-16.0 g/kg/d. However, other studies[2, 12, 13] concluded that the weight rate of low birth weight infants increased between 14.8 to 15.0 g/kg/d.

Results of gestational age of infants ranging (29.5 -36.1 weeks; table II) were partially in accordance with the results of Ehrenkranze et al[10], who reported that gestational age for low birth weight infants was between 24.8-30.9 weeks. The study results showed that length of stay at the hospital for low birth weight infants increased as the birth weight decreased, which is in agreement with Ghadimi et al[11]. Length of stay at the hospital for ELBW group (37 days) might indicate that they required extra hospital care for recovery to have normal health and weight. Previous studies concluded that the length of stay at the hospital for low birth weight infants is related to the type and duration of parenteral nutrition, which are in turn mainly affected by both calorie and protein intakes[3, 11, 12]. Anthropometric measurements, in terms of weight, height, and BMI, were reduced as birth weight decreased. These results were in line with results of many previous studies[2, 10, 12, 13].

To our knowledge, this is the first study to investigate the effect of hospital nutrition support on mineral levels and some biochemical parameters in low birth weight infants during hospital stay. As expected, mineral levels of low birth weight infants improved after nutrition support. Calcium level increased while Na level decreased to be within the normal ranges. This could be due to the minerals mixture in infants' formula that contained low Na and desirable levels of Ca and K, which would help infants to enhance the mineral levels in the blood serum of low birth weight infants to attain normal ranges. In addition, glucose level improved after enteral or parenteral feeding because of desirable content of dextrose (10 g/kg/d) admitted to infants. Porter et al[14] reported that one of the common risk factors associated with hyperbilirubinemia is prematurity. Hyperbilirubinemia was detected in infants of this study at birth and at discharge, which indicates that nutrition support at hospital for low birth weight infants did not lead to full improvement in total bilirubin levels at the end of study. Wood et al[15] showed significant association between poor weight gain and jaundice, which could explain why direct bilirubin level was still high during their hospital stay. Albumin is measured to determine the nutritional status of infants[16] and is often found to be low in low birth weight infants[17, 18]. Albumin is also important to preterm infants by its transport and binding capacity in the neonate, which binds to possibly toxic products such as bilirubin and antibiotics[18]. Albumin status improved ($p < 0.05$) in ELBW and VLBW infants, but this was not sufficient to achieve normal values for both groups. A study found that in premature neonate, endogenous albumin synthesis was stimulated by adequate nutritional support when receiving 2.4 g amino acid/kg/d[19]. Therefore, using low protein concentration for low birth weight infants did not improve albumin levels. Urea and creatinine levels, as indicators of kidney function[16], were improved during hospital care. Low protein levels in nutritional support decreased urea levels and therefore enhanced kidney function by decreasing nitrogenous wastes. Costa-Orvay et al.[6] concluded that protein intakes more than 4.2 g protein/kg/d for low birth weight infants may increase serum urea ($p < 0.05$) and ammonia ($p > 0.05$) levels, which could be life-threatening to infants.

Our study showed that it is crucial to provide a balanced nutrition support of low birth weight infants that contains adequate energy and protein contents. We recommend performing other studies to determine the optimal protein and caloric content in the nutritional formula for the different low birth weight groups to achieve the best GV for each group.

Conclusions

Low birth weight infants are at high nutritional and health risk. Inadequate health care and nutrition support for low birth weight infants in hospital could be detrimental. From study results, it was concluded that parenteral or enteral nutrition and health care procedures for low birth weight infants at Al-Noor Hospital, Makkah, Saudi Arabia, were not sufficient to maintain good growth rates for infants. Growth velocity for low birth weight infants was not improved. In addition, bilirubin and albumin levels were not improved even after hospital nutrition support. This conclusion should focus on improving health care processes in the hospital and change the nutrition feeding program, regarding infants' nutrition requirements.

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Conflict of Interests

The authors declare that they have no conflict of interests.

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