CLINICAL STUDY

Exact determination of optimal nutritional composition for at-risk newborns tolerating enteral intake–breast milk analysis as a routine future standard in neonatal care

Macakova I[1], Letenayova I[2], Tulejova J[2], Brucknerova J[1], Dobos D[2], Brucknerova I[2]

Faculty of Medicine, Comenius University in Bratislava, Slovakia. **ingrid.brucknerova@fmed.uniba.sk**

ABSTRACT

AIM: To analyse the dynamics of macronutrients in breast milk in Slovakian women and compare the dynamics between mothers of hospitalized newborns and donors of human breast milk relative to the gestational age of their babies.

METHODS: Human milk samples were collected from 101 breastfeeding women and analysed once or repeatedly from September 2017 to August 2018. Group A consisted of 79 mothers of newborns hospitalized at the Neonatal Department of Intensive Medicine (NDIM) of whom 69 were mothers of premature newborns (subgroup A1) and 10 were mothers of term babies (subgroup A2). Group B consisted of 22 breast milk donors registered at the Human Milk Bank at National Institute of Children's Diseases (NICHD). Of these, 4 were mothers of premature newborns (subgroup B1) and 18 were mothers of term newborns (subgroup B2). From subgroup A1, we chose two mothers, one with a hypotrophic newborn and another with a eutrophic newborn. The results were obtained by using the MIRIS breast-milk analyzer.

RESULTS: The overall dynamics of macronutrients correspond with other studies, however, we demonstrated that the level of macronutrients in individual cases were different.

CONCLUSION: The determination of macronutrients in human milk is essential in neonatal care. It provides information about the nutritional value of breast milk and helps to optimise nutrition according to the individual needs of newborns *(Fig. 10, Ref. 16)*. Text in PDF *www.elis.sk*.

KEYWORDS: breast milk, macronutrients, newborn.

Introduction

Breastfeeding is the most natural way of feeding a newborn. The trends in breastfeeding have changed throughout history, depending on cultural, social and economic conditions in the world. If breastfeeding is contraindicated or mother does not have enough of her own milk, the breast milk for hospitalised patients is provided by the Human Milk Bank. It deals with selection of donors, collection, processing, storage, analysis and distribution of breast milk (1).

Proteins, lipids and carbohydrates as well as other bioactive and nutritive components are important for proper infant development and growth (2). The estimated composition of macronutrients in mature breast milk is 0.9–1.2 g/dl of protein (P), 6.7–7.8 g/dl of carbohydrates (C) and 3.2–3.6 g/dl of fat (F). The amount of energy best correlates with fat content and averages 65–70 kcal/dl (3).

Human milk is a constantly changing, dynamic, biological fluid (4). The composition of breast milk varies depending on many factors such as the lactation phase, frequency and routine of breastfeeding, number of previous pregnancies, age of the mother, and diet taken by the mother during the lactation period (3).

Lactation is divided into three basic phases. The first milk is called colostrum and its excretion occurs during approximately the first 5 days after delivery. Colostrum is produced in a small volume, gradually increasing during the first week. Compared to mature milk, colostrum is rich in protein, but has a relatively lower concentration of fat and sugar. As a result, its caloric value is low. The colostrum production period is followed by a phase of transition milk, which is excreted approximately up to 15 days after delivery. The last type of milk is mature milk which is produced from day 15 until the end of lactation. It contains less protein and more sugar and fat than the colostrum (5).

Even in high-risk newborns, the optimal diet is enteral. Since the newborns of mothers without optimal metabolic compensation during pregnancy are at risk of postnatal hypoglycaemia, the initiation of enteral nutrition is desirable also for babies of mothers with diabetes mellitus, (6). By analysing the breast milk, we are able to optimize newborn enteral nutrition with fortifiers. Apart from the macronutrients, fortifiers contain other components such as folic acid (7). In addition to the determination of macronu-

[1]Faculty of Medicine, Comenius University in Bratislava, Slovakia, and [2]Neonatal Department of Intensive Medicine Faculty of Medicine, Comenius University in Bratislava, National Institute of Children´s Diseases, Bratislava, Slovakia

Address for correspondence: I. Brucknerova, MD, PhD, MPH, Neonatal Department of Intensive Medicine Faculty of Medicine, Comenius University in Bratislava, National Institute of Children´s Diseases, Limbova 1, SK-833 01 Bratislava, Slovakia.
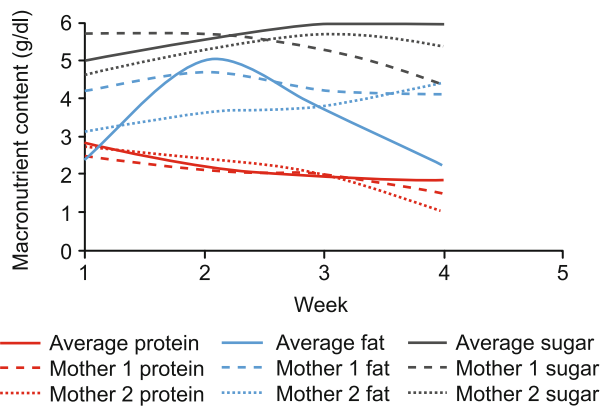
Fig. 1. Macronutrient content in the first month after delivery. Mother 1: mother of hypotrophic newborn. Mother 2: mother of eutrophic newborn.
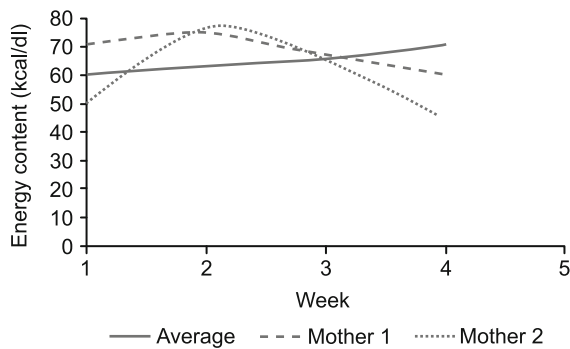

Fig. 4. Fat content in milk from mothers of hospitalised preterm (n = 69) and term (n = 10) newborns.

Fig. 2. Energy content in the first month after delivery. Mother 1: mother of hypotrophic newborn. Mother 2: mother of eutrophic newborn.
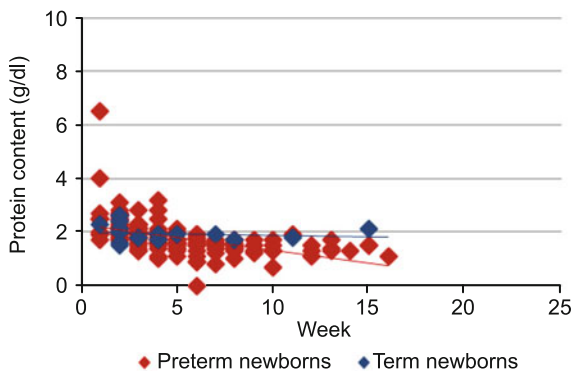

Fig. 5. Sugar content in milk from mothers of hospitalised preterm (n = 69) and term (n = 10) newborns.
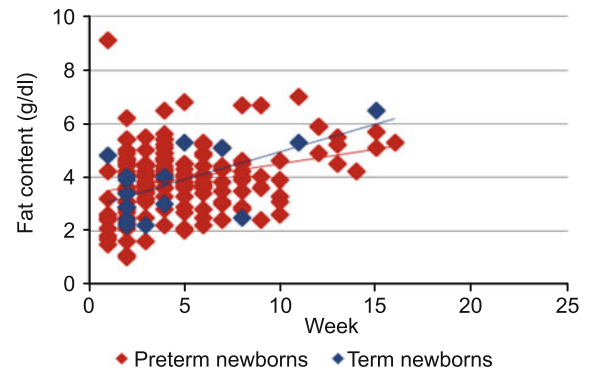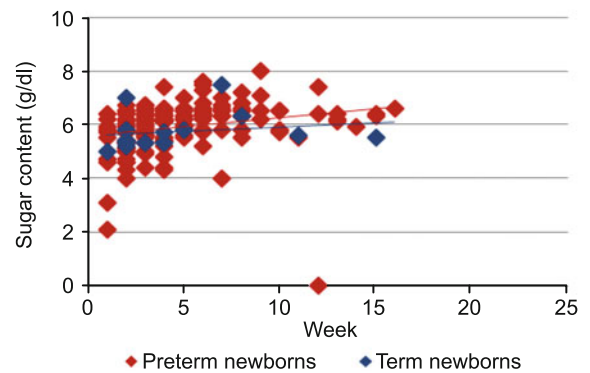

Fig. 3. Protein content in milk from mothers of hospitalised preterm (n = 69) and term newborns (n = 10).
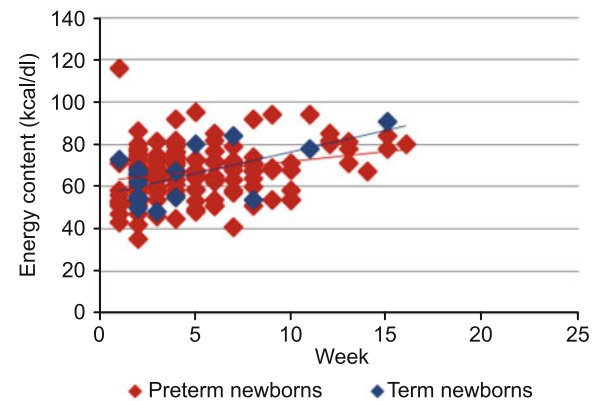

Fig. 6. Energy content in milk from mothers of hospitalised preterm (n = 69) and term (n = 10) hospitalised newborns.

trients in human milk, clinical practice would benefit also from the detection of micronutrients (trace elements and vitamins) in human milk. Since breast milk is ideally the best source of nourishment for the baby during the first 6 months of his/her life and serves as a dietary supplement up to the age of 2 years (8), it is essential to know its composition in order to ensure optimal nu-

trition for high-risk newborns. Administration of milk containing suboptimal levels of macronutrients may lead to reduced growth after birth (9).

The determination of various components in serum is an irreplaceable part in modern health care and is often easily performed by commercially available kits based on routine methods (10).
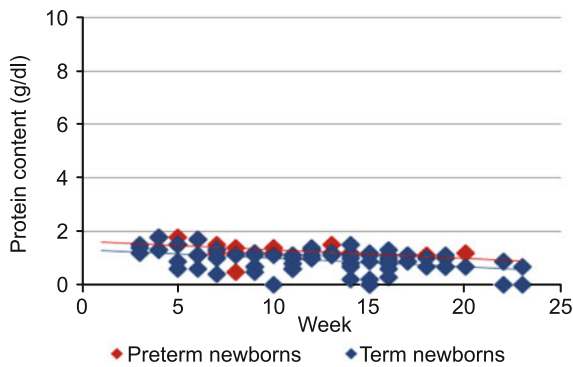
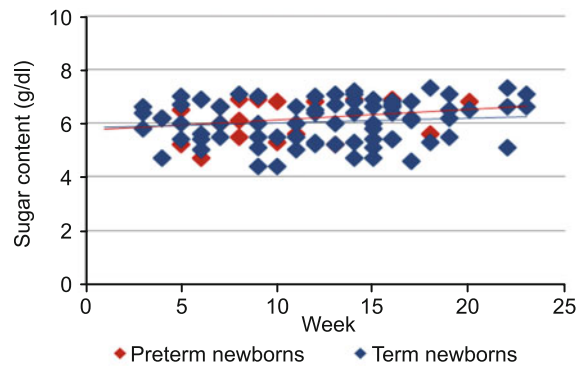**Fig. 7. Protein content in milk from donors who gave birth to preterm (n = 4) or term (n = 18) newborns.**

Fig. 9. Sugar content in milk from donors who gave birth to preterm (n = 4) or term (n = 18) newborns.
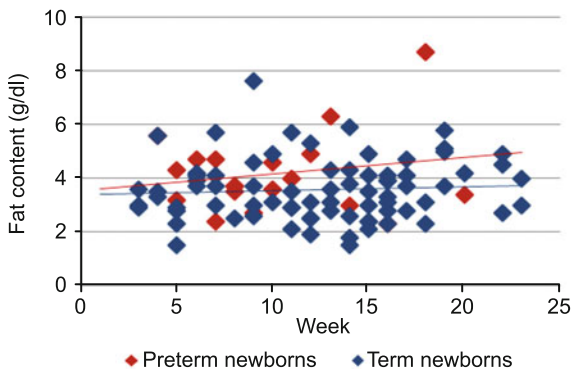

Fig. 8. Fat content in milk from donors who gave birth to preterm (n = 4) or term (n = 18) newborns.
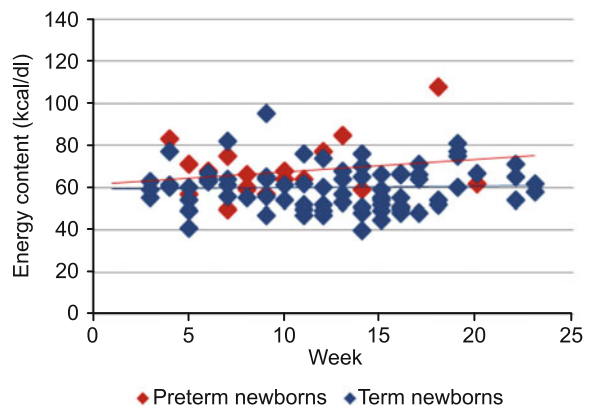

Fig. 10. Energy content in milk from donors who gave birth to preterm (n = 4) or term (n = 18) newborns.

Measurement of breast milk composition should be a standard in special intensive neonatal health care. Most of the modern analysers used for determination of macronutrients in breast milk work on the principle of the middle infrared spectroscopy. This method can be considered sufficiently reliable (11).

Objective

We analysed the composition of breast milk of mothers of hospitalized newborns at NDIM in Bratislava and donors of breast milk over a period of 12 months and evaluated the dynamics of changes in protein, fat, sugar and energy content. We also analysed the timeline dynamics of changes in values of monitored parameters in breast milk of two newborns at 1 month of age due to their birth weight.

Materials and methods

Human milk samples were collected from 101 breastfeeding women whose breast milk was analysed once or repeatedly in a period of 12 months from September 2017 to August 2018. These women were divided into two groups. Group A consisted of 79

mothers of hospitalized newborns at NDIM. Of these, 69 mothers of premature newborns (born at gestational age < 37 weeks) formed the subgroup A1, and 10 mothers of term babies (born at gestational age ≥ 37 weeks) formed the subgroup A2. Group B was formed by 22 breast-milk donors registered at Human Milk Bank in NICHD. Of these, 4 mothers of premature newborns (born at gestational age < 36 weeks) formed the subgroup B1 and 18 mothers of term newborns formed subgroup B2.

We chose two mothers from subgroup A1. Mother 1 gave birth to a prenatally hypotrophic newborn (delivered in the 29th gestational week; 1st child from the 1st risk pregnancy; delivery in head position; birth weight 1,440 grams; birth length 39 cm; Apgar score 7/7; amniotic fluid pure; problems during postnatal period included adnate infection, respiratory insufficiency, and ABO isoimmunisation; maximum weight loss balanced on the 17th day of age). Mother 2 gave birth in 32nd gestational week (2nd pregnancy; Caesarean section; birth weight 1,842 grams; birth length 42 cm; premature rupture of amniotic membranes 13.5 hours before delivery; amniotic fluid pure; Apgar score 9/9; problems during postnatal period included adnate infection, respiratory insufficiency, and ABO isoimmunisation; maximum weight loss on 6th day of life 13 %; birth weight regained by

the 16th day of life).The nutritional status of both mothers was optimal.

The results of milk analysis were obtained by using the MIRIS breast-milk analyser and 2-ml breast-milk samples in each measurement.

Results

We determined the overall values of macronutrients (P, C, F) in all study samples taken in first week after delivery. Then we analysed the macronutrient (P, C, F) content in breast milk taken during first week after delivery from Mother 1 and Mother 2. Dynamic changes of protein, fat and sugar content are shown in Figure 1.

The overall dynamics of energy content during the first month after delivery and specific dynamics for Mother 1 and Mother 2 are shown in Figure 2.

In Figures 3, 4, 5 and 6, we demonstrate the measurements of P, C, F and energy content, respectively, in breast milk for preterm and term newborns hospitalized at NDIM.

In Figures 7, 8, 9 and 10, we present amounts of P, C, F and energy content in breast milk from donors registered at Human Milk Bank at NDIM.

Discussion

In our analysis of macronutrients (P, C, F) in breast milk samples obtained during the first month after delivery, we observed a decline in protein levels in time. Our findings corresponded with the dynamics presented in other studies (12). Mature milk usually contains 0.9–1.2 g/dl of protein (2). Our overall values were 1.92 g/dl and 1.84 g/dl in mature milk. Levels of fat content tend to increase during lactation in the 1st month. In samples from Mother 1, the changes in the amount of fat was minimal. The fat content was above 4 g/dl in the first month after delivery. In samples from Mother 2, the fat content gradually rose from week 1, reached maximum of 5 g/dl in the 2nd week, and then decreased up to the 4th week. This finding does not correlate with the dynamics shown in other studies (12). In line with the study of Bauer and Gerss, 2011 (13), our study shows that the levels of carbohydrates in the samples from Mother 2 gradually increased. However, the levels of carbohydrates in Mother 1 decreased progressively. The dynamics of the energy content corresponded with the dynamics of fat since fat content represents 40–50 % of the energy intake (14).

We confirmed that when comparing colostrum to mature milk, the former was higher in protein, and lower in energy, fat, and lactose (15). Mothers 1 and 2 represent the individual differences that we need to focus on. The calculation of nutritional status from estimated content of macronutrients in breast milk may not guarantee the optimal intake and coverage of nutritional needs in individual risk newborns.

The mean total content of macronutrients in human milk for populations in the United States and Canada (1980-2017) in the period of 1-6 months *post partum* ranges from 0.79 g/dl to 1.29 g/dl for proteins, from 3.04 g/dl to 4.53 g/dl for lipids, from 6.51 g/dl to 7.56 g/dl for lactose, and from 55.87 kcal/dl to 75.43 kcal/dl for the energy content (4).

In our group of mothers of hospitalised newborns (group A), the protein level tended to decrease in the subgroup with term newborns, however in preterm newborns the decrease in proteins is negligible while its level is maintained at around 2 g/dl, which is higher than the overall values for mature milk (3). We confirmed that the protein levels in colostrum in preterm milk were higher than in term milk. However, in our study, the protein levels in mature milk from mothers of preterm newborns were lower than in the mature milk from mothers with term newborns (15). Fat level in group A tended to increase, however, in mothers of term newborns the increase was more significant. The fat content in preterm colostrum is higher than in term colostrum (15). As expected, the carbohydrate content in group A was slightly increased in both subgroups (3). The increase in carbohydrates in the milk of mothers of preterm newborns is almost negligeable. Total energy intake is proportional to the contents of fat and carbohydrates. Fat and carbohydrate represent almost 90 % of total energy content of breast milk (14).

In the group of donors of breast milk (group B), the protein levels slightly decrease in time in both subgroups. The trend of decline is less pronounced because the number of samples of mature milk obtained from donors was larger than that obtained from the group of mothers of hospitalised newborns. In the group B, we also confirmed that both colostrum and milk from mothers of premature newborns were higher in protein than those from mothers of term newborns. The fat levels in colostrum in mothers of premature newborns are higher than in mothers of term newborns (13, 15) and increase more significantly than in mothers of mature newborns. The increase in the latter subgroup was shown to be very slight. Carbohydrate levels also increase slightly, however the increase is more visible in preterm newborns. The trend line for the energy content in term milk is horizontal, whereas in preterm milk, it grows in time, albeit not as significantly as in other studies (15).

The trends in the dynamics of macronutrients and energy could be affected by the number of analysed samples in ach subgroup and many factors such as diet. From donors of breast milk, we collected more samples of mature milk while in the group of mothers of hospitalised newborns we analysed more samples in the first weeks after delivery. The key factors influencing the results of our study could include lactation stage, diurnal variation, sample handling and storage (4).

Conclusion

Breast milk analysis is important for optimizing the nutrition of premature infants and those with low birth weight, for whom adequate growth is essential (16).

By analysing the composition of breast milk, we are able to determine the amount of proteins, fats, carbohydrates and energy present in breast milk. It has a great irreplaceable value in neonatal care. Based on the analysis of breast milk, we can assess whether milk covers the nutritional needs of the baby. In the case of insufficient nutrient content, the milk is individually fortified.

With the ability to determine macronutrients in breast milk, infant nutrition can be optimized to cover the individual needs and inter-individual differences among newborns. We believe breast milk analysis for proteins, carbohydrates, fats and energy will become a routine standard in the investigation of neonatal care at all neo-natal centres with neonatal intensive care units, as well as part of standards for the management of at-risk newborns.

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