EDITORIAL

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LIPOLYSIS IN LACTO TROPHY OF NEWBORN AND 1-YEAR INFANT

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Lipolysis is accomplished sequentially and simultaneously by lipase in saliva and gastric juice in the infant's stomach as inductors in autolytic digestion by bile-dependent lipase in breast milk and colipase-dependent pancreatic lipase in the ileum. Lipase was determined in blood serum of women in labor, in umbilical cord blood, in water, and in infant gastric content. According to the data obtained, the initial lipolysis potential of newborns is significantly lower than that of the mothers. It is developed during the first half of pregnancy so gestation period does not have a significant effect on it. Over a year of lactation period, the breast milk steatolytic activity decreases, with a lower rate compared with other breast hydrolytic activities. If the steatolytic activity is low during the first month of lactation, it increases during the succeeding 4–5 months. In cases when steatolytic activity is high initially, it decreased during the following months. This indicates that the lipase content level has an effect on lipolysis at lactotrophy. Additional food and specifically bottle feeding strongly increased the steatolytic activity of duodenal content because of lipase exosecretion stimulation in the pancreas. In contrast, the steatolytic activity is decreased when mixed feeding is introduced. Assessment of lipolysis potential is important in choosing the feeding type for newborns and infants.

Keywords: full-term pregnancy; lactotrophy; lipase; lipolysis; breast milk feeding; incomplete pregnancy; newborn; blood serum.

О ЛИПОЛИЗЕ В ЛАКТОТРОФИИ НОВОРОЖДЕННЫХ И ДЕТЕЙ ПЕРВОГО ГОДА ЖИЗНИ

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Липиды грудного молока имеют в естественной лактотрофии ребенка энергетическое и трофогенное значение, которое реализуется после их липолиза. Липолиз последовательно и одновременно совершается липазами слюны, желудочного сока в желудке грудного ребенка по типу собственного пищеварения и в роли индукторов в аутолитическом пищеварении желчезависимой липазой грудного молока и колипазозависимой панкреатической липазы в тонкой кишке. Определены липазы сыворотки крови родильниц, крови пуповины, околоплодных вод и содержимого желудка новорожденных. По результатам анализа стартовый липолитический потенциал новорожденного младенца существенно ниже материнского, формируется у плода в первой половине беременности, и потому срок гестации на него существенно не влияет. Липолитическая активность грудного молока на протяжении годовой лактации снижается медленнее других гидролитических активностей молока. При низкой липолитической активности молока в первый месяц лактации в последующие 4–5 месяцев она нарастает, а при начальной высокой активности в последующие месяцы лактации она снижается. Это свидетельствует о значении уровня содержания липазы в молоке в варьировании липолиза при лактотрофии. Прикорм и особенно перевод младенца на искусственное вскармливание многократно повышают липолитическую активность дуоденального содержимого за счет стимуляции экзосекреции липазы поджелудочной железой с одновременным снижением липолитической активности грудного молока при смешанном вскармливании ребенка. Определение липолитического потенциала новорожденного и грудного ребенка имеет значение в выборе технологии его вскармливания.

Ключевые слова: доношенная беременность; лактотрофия; липаза; липолиз; молочное вскармливание; недоношенная беременность; новорожденные; сыворотка крови.

INTRODUCTION

Natural breastfeeding is an acknowledged "gold standard" of infant nutrition since birth owing to the high caloric value and unique trophic properties of breast milk. Studies on the properties of breast milk have been increasing because of the need to create infant formulas with similar composition and properties as those of breast milk. Attention is drawn not only to its nutrients but also to minor components with relevant and unique physiological properties [2, 3, 8, 17, 19]. At the same time, the digestion of most of these components requires structural enzymatic degradation. Enzymatic degradation, as is known, is performed by hydrolases of digestive glands and small intestine of the baby since the neonatal period during lactotrophy, mixed feeding and finally lifelong definitive nutrition of the macroorganism according to the type of its own digestion [11]. During lactotrophy, hydrolases of the breast milk itself are also involved in autolytic digestion. An induced autolytic digestion was observed in the laboratory of Ugolev A.M. [13], and it was concluded that autolytic digestion is involved in digestion in the early stage of human ontogenesis during lactotrophy. We recently described the technology of its implementation in relation to lipolysis and proteolysis [10]. In general, lipolysis occurs in the digestive tract of an infant during natural feeding by two types of digestion: intrinsic and autolytic. It is essential that milk lipids, mainly triglycerides, are contained in phospholipid granules. Their complexly organized shell [5, 7] is inaccessible to the lytic action of milk lipase, which is crucial for the preservation of granular triglycerides in gastric and duodenal cavities. The hydrophobic shell of granules acts as an inducer of lipases of saliva and gastric secretion; these lipases diffuse into granules through their shells, thereby causing their partial disintegration and initiating lipolysis. Lipolysis is subsequently actualized in the duodenum by lipase of breast milk itself with the aid of bile salts (bile-dependent lipase) by induced autolytic digestion and also by colipase-dependent lipase of pancreatic secretions by intrinsic digestion. Thus, lactotrophy occurs through a complex pathway of intrinsic and induced autolytic digestions, for which lipases of salivary, gastric, and pancreatic glands are required.

MATERIAL, SCOPE, METHODS

The morphofunctional initial state and consequently the lipolytic potential of a newborn can be assessed by determining the lipolytic activity of gastric contents, cord blood serum, and amniotic fluid. This concept is the basis of the study of the lipolytic potential of newborns with normal and short gestation periods. According to our data, with a short gestation period, the levels of amylase, alkaline phosphatase, and pepsinogens I and II are reduced in the cord blood serum of a newborn as well as in the gastric contents and amniotic fluid.

In this study, lipase levels in the umbilical cord venous blood, stomach contents and amniotic fluid of newborns were measured. The samples were obtained from the women in labor and from their newborns at normal delivery (47) and at cesarean section (29), and written consent of parents was obtained in accordance with the current law[1] and the decision of the ethics committee.

Among the examined women, 36 had full-term and 40 had premature deliveries. Lipase levels in biofluids were measured using standard branded reagent kits (L1PC: CAN8731 Cobas Roche). Biochemical analysis was performed on a modular platform with Cobas-8000 (module 702) using a colorimetric method.

Lipase levels in biofluids studied varied and did not follow a normal distribution. Hence, lipid levels are presented as median, maximum, and minimum values; as upper and lower quartiles; and as the mean. To analyze differences between two independent data groups, the nonparametric Wald–Wolflowitz, Kolmogorov–Smirnov, and Mann–Whitney tests were used. Statistical analysis of the data was performed using the package Statistica 6 [15].

RESULTS AND THEIR DISCUSSION

It is generally recognized that concentrations of enzymes in blood plasma and serum and of zymogens in digestive glands characterize their enzymatic potential; that is, the number and activity of glandulocytes that produce the corresponding enzymes and zymogens [9].

As shown in Table 1, lipase level in umbilical cord blood serum of a newborn is, on an average, three times lower than that in the blood serum of women in labor. This indicates the initial stage of the formation of the enzyme potential for the synthesis of lipase by glandular cells of salivary, gastric and pancreatic glands, a certain initial maturity of the morphofunctional potential of digestive glands of a newborn. At that, it has different terms for different glands and enzymes [4, 6].

Gastric contents in newborns had relatively high lipase levels, which come from three sources: swallowed saliva, gastric juice, and regurgitated duo-

[1] Federal Law on Protection of Health of Citizens of 11/21/2011 No. 323-FZ.

Table 1

Lipase (U/l) of blood serum, gastric contents, and amniotic fluid of full-term (numerator) and premature (denominator) newborns and of puerperal serum

Таблица 1

Липаза (Ед/л) сыворотки крови, желудочного содержимого и околоплодных вод доношенных (числитель) и недоношенных (знаменатель) новорожденных, сыворотки крови родильницы

Parameter	Serum of women in labor	Umbilical cord blood serum	Gastric contents of a newborn	Amniotic fluid
Mean	28.79 30.30	10.79 10.49	43.68 40.47	2.01 4.64
Median	27.29 30.0	10.12 10.00	10.65 20.50	1.90 4.05
Maximum	7.10 8.40	5.70 5.40	0.30 0.10	0.90 0.90
Minimum	63.50 51.90	21.30 18.80	270.00 244.10	4.90 33.40
Lower quartile	22.35 23.35	8.30 8.30	2.50 4.45	1.45 2.10
Upper quartile	31.10 35.20	12.10 12.60	48.75 41.94	2.35 4.64
p	>0.10	>0.10	>0.10	↑<0.01

denal contents, which we have not differentiated. Amniotic fluid had much lower lipase contents than gastric contents of the newborns, blood serum of women in labor, and umbilical cord blood.

The low initial potential for lipolysis is one of the reasons for the difficulty with natural breastfeeding of newborns. During this period, the rate of hydrolysis of milk triglycerides is low because of low lipase levels secreted by digestive glands of the infant [8]. Low lipolytic activity of gastric contents is sustained for a fairly long time – from 25 to 34 weeks of gestation [4, 6, 12].

According to previous studies [3], a low and qualitatively altered production of pepsinogens by gastric glands is noted in premature newborns, but the activity of salivary amylase may be increased. Malabsorption of lipids in premature newborns has been described previously [2, 17]. In 40 premature newborns, we observed low lipase levels in the umbilical cord blood, which did not differ from those in full-term newborns. A similar trend was noted in gastric contents. Lipase level was also low in the amniotic fluid, although it was higher than that in full-term newborns, the reason for which remains unclear. In general, these findings enable us to conclude that the early lipolytic potential of digestive glands of newborns is almost equally low in full-term and premature infants. This distinguishes the state of the marked decrease in the concentration of hydrolases (amylase, alkaline phosphatase, and pepsinogenes I and II) in the umbilical cord blood serum, gastric contents, and amniotic fluid in premature gestation, as noted above.

The low lipolytic potential of the digestive tract of newborns explains the disorders in the hydrolysis of milk fat (triglycerides) and necessitates its replacement in nutritional formulas for mixed or bottle feeding with other lipids (particularly plant lipids) [8, 12, 17]. Several studies addressing this issue are currently being conducted in several countries. This was also the focus of long-standing research on the lipolytic activity of milk, on its special shape in the form of globules, on the secretion of fat by lactocytes of mammary glands [5, 7], and on the postulate of autolytic hydrolysis of milk nutrients as stated at the beginning of this article.

We found that in the annual dynamics of lactation, lipase content of milk decreases from month to month slower than other hydrolases, which, at the end of the lactation year, is only 1.5 times lower than that at the initial months when it was maximal (Table 2). It can have compensatory and adaptive values in optimizing autolytic lipolysis during lactotrophy of a breastfed baby.

Finally, R.M. Kharkova [16] showed that mixed feeding, and particularly bottle feeding, induces the secretion of lipase (and other hydrolases) by pancreas of the nursing mother because in duodenal con-

Table 2

Enzymatic activity of breast milk by months (1–12) of women lactation ($M \pm m$, $n = 62$)

Таблица 2

Ферментативная активность грудного молока по месяцам (1–12) лактации женщин ($M \pm m$, $n = 62$)

Months	Pepsinogen (U/ml)	Amylase (U/ml)	Lipase (U/ml)
1	21.0 ± 1.2	98.1 ± 6.5	3.4 ± 0.2
2	19.2 ± 1.2	86.1 ± 5.1	3.4 ± 0.2
3	18.6 ± 1.0	83.4 ± 4.1	3.4 ± 0.2
4	24.3 ± 1.5	70.9 ± 5.5	3.0 ± 0.2
5	19.4 ± 1.3	62.4 ± 3.1	4.1 ± 0.2
6	18.8 ± 0.9	62.3 ± 3.1	4.1 ± 0.2
7	20.7 ± 1.2	62.1 ± 2.9	3.3 ± 0.2
8	18.0 ± 0.8	54.8 ± 3.1	3.3 ± 0.1
9	15.0 ± 0.7	55.6 ± 3.6	3.3 ± 0.1
10	10.0 ± 0.5	45.2 ± 2.6	3.2 ± 0.1
11	10.7 ± 0.6	39.8 ± 2.6	3.0 ± 0.1
12	7.8 ± 0.8	26.1 ± 0.5	2.4 ± 0.1

Примечание. Методы определения: трипсиноген и ингибитор трипсина по методу Эрлангенра в модификации В.А. Шатерникова, субстрат-бензол-D1-аргининпаранитроанилид [18]; пепсиноген — модифицированный метод B.J. Hirschowitz, субстрат — сухая плазма крови [20]; амилаза — амилокластический метод в модификации А.М. Уголева, субстрат — растворимый крахмал [14]; липаза — трибутиразный метод в модификации Ф.А. Абдуллаева [1].
Note. Methods of determination: trypsinogen and trypsin inhibitor by the Erlangenr method in the modification of A.A. Shaternikov, substrate-benzene-D1-argininеparanitroanilide [18]; pepsinogen: modified method of B.J. Hirschowitz, substrate, dry plasma of blood [20]; amylase: amyloclastic method in the modification of Ugolev A.M., substrate, soluble starch [14]; lipase: tributylase method in the modification of Abdullaev F.A. [1]

tents, lipase level increases several times from the preserved daily lactation volume (Fig. 1).

CONCLUSION

The hydrolysis of lipids in breast milk in the small intestine with natural lactotrophy is performed by lipases of saliva, gastric juice, milk, and pancreatic juice. The hydrolysis of lipids simultaneously proceeds by intrinsic and induced autolytic digestions. This is because of differences in the properties of lipases, substrates they hydrolyze, and environment in which they are degraded. These processes depend on their location within the digestive tract, into different series of postnatal morphofunctional development of the digestive system of a nursing infant and its enzymatic potential.

Determination of the enzymatic potential, primarily the lipolytic potential of newborns, particularly premature newborns, deserves not only scientific and cognitive interests but also its introduction as a method for the characterization of a newborn's own digestion during lactotrophy. Based on the results of such study, a reasonable choice of nutritional formulas and supplemental feeding techniques for newborns can be made. Further research of this problem is promising.

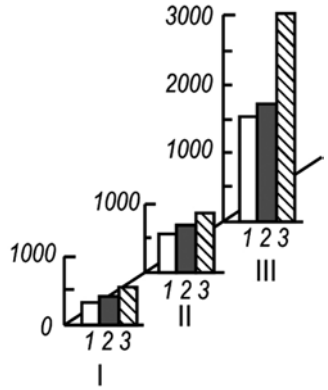

Fig. 1. Activity of lipase (U/ml) of duodenal contents in infants during the first year of life with different types of feeding (according to R.M. Kharkova [16]): 1) on an empty stomach; 2) on stimulation of pancreatic secretion by introducing 0.2% solution of HCl into the duodenum; and 3) on stimulation of secretion by the introduction of sunflower oil into the bowel. Types of feeding: I) breastfeeding; II) mixed; III) bottle feeding

Рис. 1. Активность липазы (Ед/мл) дуоденального содержимого у детей первого года жизни при различных видах вскармливания (по данным Р.М. Харьковой [16]): 1 — натощак; 2 — при стимуляции панкреатической секреции введением в двенадцатиперстную кишку 0,2 % раствора HCl; 3 — при стимуляции секреции введением в кишку подсолнечного масла; виды вскармливания: I — грудное; II — смешанное; III — искусственное

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