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# Peculiarities of Digestive Organs Development in Ontogenesis

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**Abstract:** The article presents the structural and functional features of the development of the digestive organs in early postnatal ontogenesis. It is shown that the digestive organs of the newborn are still unformed, therefore the baby is immature. The final formation of the organs and systems of digestion occurred in the lactotrophic and subsequently mixed periods of feeding.
**Key words:** postnatal ontogeny, intestines, pancreas, rats.

**Relevance.** At present, a sufficiently large amount of clinical and experimental material has been accumulated, which makes it possible to present a detailed structural and functional characteristic of the gastrointestinal tract in pre- and postnatal ontogenesis of mammals, including humans. No less detailed data are also presented in the literature regarding the factors regulating the development of the structure and function of the digestive organs in ontogeny. According to modern concepts, pre- and postnatal development of the digestive organs is regulated by the following four determinants: genetic program, biological clock, neurohormonal factors, and environmental factors [1, 2, 3, 5, 7, 17, 19, 28, 29]. Thanks to the integrative activity of these regulatory factors, the conformity of the structure and function of the digestive system to the changing type of nutrition and food composition during critical periods of the transition of offspring from placental-amniotrophic nutrition to lactotrophic and from the latter to definitive nutrition is ensured in the norm.

In our review, we considered it necessary to discuss in more or less detail the literature concerning the restructuring of the gastrointestinal tract during critical periods of the transition of offspring from intrauterine to extrauterine life.

Before proceeding to a review of the available information on the issue under discussion, we recall once again that the laboratory rats used by us as an object of study belong to immature-born species. Therefore, many changes in enzymatic activities that occur postnatally in them, just like in mice, are a continuation of intrauterine development. At the same time, in many other species, including humans, the development of the structure and function of the digestive system is almost completed by the end of prenatal life [7, 8, 9, 19].

Before proceeding to the coverage of the period of lactotrophic nutrition, it should be pointed out that mother's milk is not only an ideal product for a newborn [20, 21, 22], with mother's milk, through the mammary gland, the child also receives adoptive immunity, ready-made immunoglobulins adapted against environmental antigens. media [23, 24, 26, 27, 30, 31, 41, 42, 43, 44]. In addition, they have an immunomodulatory role for the immune and digestive systems, as well as enzymes that appear with mother's milk contribute to the normalization of the function of the infant's still immature digestive system [40, 43, 49, 52]. In addition, rats are considered a convenient model for conducting various experiments on the physiology and pathology of the digestive organs in a developing organism, since they have clearly limited periods of lactotrophic nutrition and transition to solid food. Withdrawal from them begins on the 17th day of life and ends by the 26th day [51, 53]. It is associated with a significant modification of the composition of food, which, in turn, leads to changes in digestive function. When taken away, not only the proportion of nutrients changes significantly, but also the consistency of food, that is, liquid is replaced by solid. In addition, the composition of essential nutrients, in particular carbohydrates, changes significantly. So, for example, carbohydrates in milk are represented by lactose, while in solid food - mainly sucrose and starch. The latter, as is known, after digestion in the intestinal cavity is split into oligo- and disaccharides. The pattern of development of withdrawal in humans should theoretically be the same as in animals (rats, mice, etc.). Specific features of this scheme are imposed by many factors, which we consider not appropriate to discuss here: we recall only one of them, which is directly related to the regulation of the activity of digestive hydrolases. This is the unequal content in the milk of women and rodents of carbohydrates (lactose) and fat.

Women's milk contains more of the first component, and less fat than in rodent milk [5, 7, 9, 13, 14]. Specialists in the field of evolutionary physiology have expressed a theoretical position, which, in our opinion, is of some interest to physicians as well. Its essence is as follows. It is known that the sucklings of some rodents (rats, mice) show significant changes in their digestive capacity during the third postnatal week and fully acquire the adult model by the end of the fourth week of life. This fact allows us to consider that in the process of natural selection, those species in which maturation of the gastrointestinal tract did not occur by the time of weaning, should have perished. On the other hand, it follows from this provision that the maturation of the gastrointestinal tract ahead of spontaneous withdrawal is a great risk for the survival of the species. We believe that any factors, including pathological ones, leading to premature maturation of the gastrointestinal function can adversely affect the digestive function of the body.

The data available in the literature allow us to provide a detailed overview of the development of the secretory activity of the salivary glands, stomach, pancreas and small intestine. In order not to go beyond the goals and objectives of the work, we will limit ourselves to discussing only those works that relate to the exocrine secretion of the pancreas, the activity of digestive enzymes, and the absorption of nutrients. In addition, here we will discuss some issues related to the structural and functional development of the gastrointestinal tract in normal conditions, as well as present literature data on possible routes of transmission of infection and the resulting toxins from mother to offspring during pre- and postnatal development.

Exocrine secretion of the pancreas

In rats during the first two weeks of postnatal life, pancreatic enzymes are almost absent in the cavity of the small intestine. The concentration of such enzymes as trypsin, chymotrypsin, lipase and amylase increases sharply by the time of withdrawal [5, 12]. The coordination between the functional maturation of the salivary, pancreatic, and gastric glands in rats has been covered in great detail in a number of reviews [7, 9]. It has now been proven that the secretory capacity of the pancreas of α-amylase is mature already on the first day of life [4]. At the same time, a low concentration of chymotrypsinogen in the early period of milk feeding is associated with inhibition of secretion in newborn animals. The ability of the gland to secrete amylase, chymotrypsinogen and lipase in response to urocholine administration increases significantly during the third postnatal week. It is assumed that the change in the concentration of pancreatic enzymes in the cavity of the small intestine is due to the combined control of both synthesis and secretion. It is believed that the low concentration of hydrochloric acid and pepsin in the gastric juice, as well as the weak activity of pancreatic proteases in the intestinal contents during the neonatal period, plays a positive role, since it creates favorable conditions for the passage of immune proteins of mother's milk through the gastrointestinal barrier intact. Unlike proteases, the basal concentration of lipase is hardly detected in newborns, and α-amylase is not detected at all. Both of these enzymes show adult activity at 2 weeks of age.

In addition, it is believed that in newborns the ability to digest triglycerides and starch is much less pronounced than that of proteins. The low lipolytic activity of pancreatic juice in newborns is compensated to some extent by the presence of lipase produced by special glands on the surface of the tongue and gastrocytes [12, 39]. All this, obviously, creates favorable conditions for the utilization of milk triglycerides by newborn children. As for the data on the digestive capacity of the gastrointestinal tract of newborns in relation to starch, they are very contradictory. It is quite possible that alternative pathways of starch digestion, namely, the presence of pancreatic α-amylase in mother's milk, may play some role here [7]. or rather pronounced activity of enteral γ-amylase [8].

Digestive enzymes of the small intestine.

At present, it has been established that the final stage of hydrolysis of nutrients is realized due to intestinal enzymes localized on the outer surface of the membranes of microvilli of epithelial cells [10, 32, 33]. Developmental studies of these membrane-bound enzymes have shown that newborn rats have a hydrolytic activity that is specific to a limited number of substrates present in mother's milk [11]. This is well seen in the example of carbohydrate digestion. Milk is relatively poor in total carbohydrates, and the carbohydrates present in it are practically not found in the diet of adult animals. The main carbohydrate in the milk of most placental mammals is lactose [16] and a high activity of the corresponding oligosaccharidase, lactase, was found in the intestinal mucosa of the offspring of mammals during breastfeeding. According to available data, in all mammals studied to date, intestinal lactase activity increases rapidly at the end of the fetal period and reaches a peak immediately or shortly after birth [13, 15]. The same pattern of development of the enzyme spectrum in mature and immature born species suggests that the development of lactase activity is somehow, possibly hormonally, associated with the birth process. Many species, including most humans, have low lactase activity in adults compared to neonates [14, 34, 35, 45, 46, 47, 48] and are therefore unable to utilize ingested lactose into adulthood.

In rats, the activity of intestinal hydrolases involved in the digestion of carbohydrate components of solid (definitive) food is absent or low at birth, then appears and/or increases [13]. Maltase has a low activity for the first two weeks of life, then it increases 5-10-fold over the next two weeks [14]. Sucrase and isomaltase are not detected in the intestine during the first two weeks of postnatal life. In rats, their activity appears approximately on the 16th postnatal day and, rapidly increasing, reaches the adult level by the end of 4 weeks [16]. These changes in the activity of intestinal oligosaccharidases have a pronounced physiological significance, since they contribute to the adaptation of a growing organism to a changing food composition during the transition from milk feeding to definitive nutrition.

It should be noted that during the transition from dairy to definitive nutrition, not only the activity of enzymes that break down carbohydrates undergoes certain changes, but also the activity of other enzymes. The developmental profile of lysosomal hydrolases, such as rat neuraminidase, is very similar to that of lactase. The activity of this enzyme is high in rats during the first two postnatal weeks and decreases during the third week. During this period of lactotrophic nutrition, other lysosomal hydrolases are also highly active: P-galactosidase, P-glucuronidase, L-sulfatase, and individual cathepsins [16, 20, 36, 37, 38]. It is believed that the high activity of, for example, cathepsins during this period creates favorable conditions for accelerating the renewal of brush-edge proteins. In addition, cathepsins are involved in the intracellular digestion of proteins when the enzyme systems for the extracellular digestion of this food component in the stomach and small intestine are not yet functioning.

All lysosomal hydrolases, which are highly active in rats during breastfeeding, are characterized by their long-term localization along the length of the small intestine, which contributes to the hydrolysis of proteins entering the cells by pinocytosis [8, 9, 21, 22].

Thus, at present there is no doubt that the elementary factor is essential in the regulation of the digestive-transport function of the digestive organs in ontogeny. So, from our brief review it is clear that the gastrointestinal tract of mammals, including humans, undergoes regular changes in the process of ontogenesis. Thanks to these changes, the developing organism acquires the ability to adapt to the changing composition of food.

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