The American Journal of Medical Sciences and Pharmaceutical Research ISSN 2689-1026 Volume 08 - 2026

Morphological Changes in Neuroimmunoendorinee Cells Off the Small Intestine in The Early Postnatal Period of Life

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Received: 24 Apr 2026 | Received Revised Version: 10 May 2026 | Accepted: 22 May 2026 | Published: 17 June 2026

Volume 08 Issue 06 2026 | Crossref DOI: 10.37547/tajmspr/Volume08Issue06-09

Abstract

This article is devoted to studying the features of the absorption process and the regulation of homeostasis in the early postnatal period. The material of the study was outbred white rats, which were on different types of feeding. The small intestine with normal microflora affects the adequate adaptation of functional systems of various levels of organization, metabolism, normal structure and function of all organs and systems, the body as a whole.

Keywords: Homeostasis, adaptation, microbiocinosis of the small intestine, neuroimmunoendocrine system.

Cite This Article: M.K. Gulyamova, & Z.T. Makhmudova. (2026). Morphological Changes in Neuroimmunoendorinee Cells Off the Small Intestine in The Early Postnatal Period of Life. The American Journal of Medical Sciences and Pharmaceutical Research, 8(06), 65–68. https://doi.org/10.37547/tajmspr/Volume08Issue06-09

1. Introduction

It is known that natural, mixed, or artificial definitive nutrition involves the entry of nutrients and a vast number of diverse microorganisms from the external environment into the intestine. As a result, the formation of a normal intestinal microbiome ensures the genetically determined harmonious development of the individual. The formation of intestinal microbiome is significantly influenced by childbirth (natural or cesarean section), the microbiome of the birth canal, the environment, medications (especially antibiotics), hospital infections, feeding type, and other factors [2, 3, 10]. However, to date, existing ideas about the role and importance of intestinal microflora in the formation of the small intestine, its neuroimmunoendocrine formations, the functional system of the external environment - intestinal microbiocenosis - internal environment of the macroorganism, adaptation and regulation of homeostasis in the process of digestion and absorption are fragmented and contradictory.

2. Methods

White mongrel rats aged 1, 3, 7, and 14 days after birth were breastfed. Animals were sacrificed and a sample of the initial section of the jejunum was collected in accordance with the International Convention for the Protection of Animals Used for Scientific Purposes (2003). After appropriate fixation and handling, ultrathin sections were obtained and examined under an IEM-100S electron microscope. The activity of hydrolytic enzymes in the jejunal mucosal homogenate was determined over time using standard biochemical methods.

3. Results

In neonatal rats, as in human subjects [6,9,11], before feeding, the small intestinal mucosa is not separated from the submucosa, forming villi of various generations and short, sparse crypts between them. The formed finger-shaped villi are lined with highly prismatic epithelium, have homogeneous cytoplasm, and a wide, up to 1.0 µm, brush border on the apical surface. Goblet cells between them are rare, have a characteristic ultrastructure, and contain moderate-density secretory granules in the supranuclear region. Endocrine and neuroreceptor cells are rarely detected and are in the differentiation stage. Lymphocytes or other leukocytes are not detected between the enterocytes of the villi or crypts. In the lamina propria of the mucosa, isolated small groups of cells consisting of clusters of lymphoblasts are detected under the epithelium.

In newborn rats (1-3 days) kept under natural vivarium conditions, due to minimal development and differentiation of the cells of the fundic glands of the stomach, acini of the pancreas, and the low hydrolytic-transport function of the columnar epithelial cells of the villi of the small intestine [9], digestion is autolytic and symbiotic, carried out in the intestinal lumen. Insufficient mucus production by goblet cells and developing Brunner's glands in the duodenum practically does not allow perimembranous and membrane digestion in newborn children and rats [9]. Absorption from the jejunal lumen into the cytoplasm of villous enterocytes occurs heterochronically via receptor-mediated endocytosis. This is a perfect mechanism for mammalian adaptation to breastfeeding, which occurs 0.5-1.0 hours after birth, naturally following the cessation of amniotic and placental nutrition via the same receptor-mediated pathway.

After feeding, regulatory, protective, and other biologically active ingredients in human milk become part of the intestinal chyme within 3-5 minutes and begin to interact with the columnar bordered enterocytes of the villi and the receptors of the plasma membranes between the bases of the microvilli that form the tubulovesicular structure. As a result, using receptor-mediated endocytosis, the most advanced method for maintaining homeostasis in the newborn's internal environment, the plastic, protective, and biologically active ingredients contained in human milk are bound in a matter of seconds. Transport of plastic, protective and biologically active ingredients from the lumen of the organ to the cytoplasm, to the supranuclear zone, to the structures of the Golgi complex.

In humans, the transition from the sterile conditions of symbiotic development in the womb to antigenital ones occurs against the background of a continuing close relationship with the mother. Over the course of 1-2 years, its adaptation consists of the formation of neuroimmunoendocrine and other functional systems [1,8] in close connection with ecology, the properties of numerous microorganisms, dynamic symbiotic relationships with the external environment, a characteristic type of nutrition, digestion, trophology, which have been evolutionarily fixed in the form of a harmonious integration of the normal intestinal microbiocenosis and internal environments, structural and functional adaptation of the neuroimmunoendocrine and other body systems, and regulation of homeostasis of the internal environment.

Between days 1 and 3 after birth, the lamina propria of the small intestinal mucosa primarily contains mesenchymal cells, rarely monocyte-like cells, and fibroblasts. Blood and lymphatic capillaries are in the formation and growth stage. Nervous elements and clusters of lymphoblasts and reticular cells are rarely detected. In the caudal portion of the duodenum and ileum, round or oval formations consisting of diffusely distributed lymphoblasts and reticular cells are detected beneath the epithelium. Mitotically dividing cells are often observed among these.

In 7-day-old rats, the proportion of formed villi and growing crypts, as well as the number and density of endocrine cells within them, increases significantly along the small intestinal mucosa with normal microflora. Concurrently, the degree of lymphocyte infiltration into the epithelial layer of the villi and crypts increases. In the lamina propria, the density of nerve fibers, differentiated leukocytes, connective tissue cells, and blood capillaries increases. As the submucosa and muscularis thicken, the nerve ganglia become larger, and the density and differentiation of the various nerve cells within them increases. Monocytes are detected within the progressively increasing clusters of lymphoblasts and reticular cells, and a network of blood and lymphatic capillaries is formed.

Seven days after birth, rats with normal microflora show an increase in both the number and volume of lymphoid formations along the organ. Individual follicles or nodules are indistinguishable. With a diffuse distribution of lymphoblasts and reticular cells within each lymphoid tissue cluster, the absolute cell count within them increases by an average of twofold. Macrophages, which are moderately active and contain polymorphic lysosomes, are the first to be detected.

Two weeks after birth, in rats with normal microflora, the proximo-distal gradient of the linear parameters of villi and crypts becomes more pronounced in the small intestine mucosa, and the incidence of their neoplasms decreases significantly. Within the small intestinal wall, the number of Peyer's patches reaches 10.8±1.6. In each lymphoid tissue cluster, a rapid increase in cell number and density leads to their protrusion into the intestinal lumen, displacing villi and crypts to the periphery. Their luminal surface is lined with a single-layered columnar epithelium, containing bordered, M, and neuroepithelial cells, with occasional goblet cells. The epithelium is infiltrated with lymphocytes at various levels. In the lamina propria of the mucosa and submucosa of the small intestine, and in lymphoid tissue clusters in the proximal small intestine, the germinal zone and follicular zone are more common than in the distal small intestine. Other structural and functional zones are not distinguished.

Structural and functional development of the intestine in rats occurs between 3 and 4 weeks after birth, when they transition to definitive feeding. In rats, as in sexually mature animals aged 3 to 4 months with normal intestinal microbiocenosis, the small intestinal mucosa, composed of connective tissue epithelium and muscularis propria, has a characteristic relief due to the presence of folds, crypts, and villi. The structural and functional unit of the small intestinal mucosa is the crypt-villus system. Within it, specific dynamic relationships are established between proliferating, functioning, and extruding epithelial cells. Epithelial cell proliferation occurs in the lower half of the crypts. The life cycle of border and goblet cells averages 72 hours. The functioning of border and goblet cells throughout the villi lasts 24-48 hours. The extrusion process can be observed at any level of the villi due to their heterochronic functioning.

Based on the study of the mucous membrane of the small intestine, the formation after birth of symbiotic relationships between macro- and microorganisms, the regular introduction of nutrients and biologically active substrates into the body for the purpose of harmonious development of the individual, adaptation and homeostasis of the internal environment of the normal structure and function of internal organs and systems naturally formed in the evolution of the functional system of the internal environment of the macroorganism - intestinal microbiocenosis - external environment. Feedback between the peripheral (in the small intestine) and central neuroimmune systems (hypothalamic-pituitary system), symbiotic relationships between peri-membrane dominant and associations of cavity microsymbionts, optimal coupling of symbiotic cavity and peri-membrane, sterile membrane digestion, coupled with absorption into enterocytes of the villi provide the most important thing - homeostasis of the internal environment of the macroorganism, adequate adaptation of functional systems of various levels of organization, metabolism, normal structure and function of all organs and systems of the organism as a whole.

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