CHANGES IN CYTOCHROME OXIDASE ACTIVITY IN RATS WITH A LOW-PROTEIN DIET

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Abstract. In an experiment on rats, the localization and activity of cytochrome oxidase were studied in the salivary glands, stomach, small intestine, liver, kidneys, adrenal gland, thyroid gland, testes, and spinal cord of rats maintained on a low-protein diet. Protein deficiency in the diet results in a decrease in cytochrome oxidase activity. However, a short-term increase in enzyme activity was detected in the testes 20 days after the start of the experiment.

Key words: experiment, low-protein diet, rats, salivary glands, stomach, small intestine, liver, kidney, adrenal gland, thyroid gland, testicle, spinal cord, cytochrome oxidase

ИЗМЕНЕНИЕ АКТИВНОСТИ ЦИТОХРОМОКСИДАЗЫ В ОРГАНАХ КРЫС ПРИ МАЛОБЕЛКОВОЙ ДИЕТЕ

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Аннотация. В эксперименте на крысах изучено локализацию и активность цитохромоксидазы в слюнных железах, желудке, тонком кишечнике, печени, почках, надпочечнике, щитовидной железе, семенниках и спинином мозгу крыс, содержавшихся на малобелковой диете. При белковой недостаточности в пищевом рационе происходит понижение активности цитохромоксидазы. Однако в семенниках через 20 суток от начала опыта обнаруживается кратковременное повышение активности фермента.

Ключевые слова: эксперимент, малобелковой диета, крысы, слюнных железы, желудка, тонкий кишечник, печень, почка, надпочечник, щитовидной железы, семенник, спинином мозг, цитохромоксидазы.

Introduction. The effectiveness of treating children in hospital conditions largely depends on the quality of their nutrition. Food for a sick child serves as a natural therapeutic factor, allowing targeted correction of disturbed metabolic processes and functions of various organs and systems [5]. To ensure the functioning of all physiological processes, the body requires an optimal amount of energy, major nutrients, and micronutrients, in particular, chemical elements [3,4]. In turn, changes in morphometric indicators underlie most pathologies of carbohydrate and lipid metabolism, serving as markers of adipose tissue dysfunction [1,2]. Numerous studies have shown that protein deficiency leads to severe disturbances in physiological and biochemical processes in the body, as well as to morphological changes in organs of humans and animals. The question of changes in the activity of oxidative enzymes during protein starvation is insufficiently covered in the literature.

Aim of the study. To investigate changes in cytochrome oxidase activity in rat organs under a low-protein diet.

Materials and methods. The task of the present study was to examine the localization and activity of cytochrome oxidase in the salivary glands, stomach, small intestine, liver, kidneys, adrenal gland, thyroid gland, testes, and spinal cord of rats maintained on a low-protein diet (72% protein deficiency). Both control and experimental animals were euthanized by decapitation at 5, 10, 15, 20, 25, and 30 days from the start of the experiment. Sections from pieces of the studied organs were prepared on a freezing microtome with a thickness of up to 30 μm. Cytochrome oxidase was detected using the Nadi method. The activity of cytochrome oxidase was assessed on a six-point scale: absent — 0, negligible — 1, low — 2, moderate — 3, high — 4, maximum — 5.

Results. Examination of the cytochrome oxidase reaction in the parotid gland of control animals revealed the presence of blue granularity of indophenol blue (3) in the basal parts of the acinar protein cells. The cytoplasm of these cells was stained pale blue. In some protein cells, granules were distributed throughout the cytoplasm. By 20 days of protein deficiency, fewer and smaller granules of indophenol blue (1 and 2) were found in the acinar cells. Starting from day 25 of the experiment, the cytoplasm of the acinar protein cells had a pale blue color, with no granules of indophenol blue observed. The Nadi reaction in sections of the gastric fundus in control rats revealed maximum (5) and high (4) activity of the respiratory enzyme in parietal cells of the glands; it was less pronounced in chief and mucous neck cells (4 and 3). Negligible cytochrome oxidase activity (1) was noted in the surface epithelium of the stomach and in the neck cells of the glands. By 10 days from the start of the experiment, a regular decrease in the number of indophenol blue granules was observed in all cells. By the end of the experiment (30 days), the cells of the surface epithelium of the mucous membrane, gastric pits, and necks of fundic glands became colorless (0). In the cells of the gland body, single blue granules were found against a blue cytoplasmic background (1); in some parietal cells, there were more (2). In the small intestine of control rats, a large number of blue granules were found at the apical ends of epithelial cells (4). In the epithelium at the base of the villi and in crypt epithelium, there were fewer (3 and 2). By 15 days of the experiment, a decrease in cytochrome oxidase activity was noted, most pronounced by 30 days of protein starvation. At this time point, a negligible amount of indophenol blue granules (1 and 2) was found in the epithelium of villi and crypts. In the liver cells of control rats, blue granules were detected against a blue cytoplasmic background (3). In the center of lobules, around the central vein, there were few (1). Starting from day 15 of the experiment, the activity of the oxidative enzyme in the liver decreased; by 20 days of protein starvation, single blue granules were found in the cytoplasm of hepatocytes (1); by 30 days, the cytoplasm of liver cells was weakly stained pale blue, with no

indophenol blue granules detected. In the kidneys of control animals, maximum and high cytochrome oxidase activity was noted in the cells of the main segments of nephrons (5 and 4). In the cells of intercalated segments, it was high and moderate (4 and 3). Most renal corpuscles were colorless (0); in some, single blue granules were detected against a pale blue background (1). In the cells of most straight urinary tubules of the medulla, moderate (3) and low (2) activity of the oxidative enzyme was observed; in cells of some straight tubules — maximum (5) and negligible (1). During protein deficiency, a decrease in cytochrome oxidase activity was noted, detected in the cells of straight tubules already by 10 days from the start of the experiment, and in convoluted tubules by 15 days. By the end of the experiment, activity in the cells of main and intercalated segments of urinary tubules was low (2) and moderate (3); in cells of some straight tubules of the medulla — negligible (1). The cytoplasm of most straight urinary tubule cells was diffusely stained pale blue by indophenol blue, with no granules noted. In the adrenal gland of control rats, the Nadi reaction revealed moderate cytochrome oxidase activity in cells of the glomerular zone (3), and negligible to low in cells of the fascicular zone (2) and reticular zone of the medulla (1). In experimental animals, enzyme activity in adrenal cells decreased by 30 days from the start of the experiment; indophenol blue granules were not detected in cells of the cortex and medulla, and the cytoplasm of the cells was colorless (0). In the thyroid gland of experimental rats compared to controls, no consistent pattern in changes of respiratory enzyme activity could be noted. In some animals, negligible and low cytochrome oxidase activity was observed in follicular epithelium (1 and 2); in others, it was absent (0). However, in all experimental rats by 30 days of protein deficiency in the diet, the follicular epithelium was colorless (0). In the testes of control animals, moderate (3), low (2), and in some high (4) activity of the oxidative enzyme was present in spermatogenic epithelium cells throughout the thickness of the walls of convoluted tubules. In experimental animals, enzyme activity decreased by 10 days. However, by 20 days from the start of the

experiment, an increase in the number of indophenol blue granules was observed, especially at the periphery of tubules in the cytoplasm of spermatogonia (4); closer to the tubule lumen (in spermatids and spermatozoa), there were fewer (3). By 30 days from the start of the experiment, cytochrome oxidase activity decreased again: in spermatogonia, blue granules were not detected (0); in spermatogenic epithelium cells closer to the tubule lumen, negligible activity of the respiratory enzyme was noted (1). In the spinal cord of control and experimental animals, white matter was colorless (0). In gray matter, diffuse blue staining and the presence of blue granularity in neuroglia (2) were observed. In control rats, neurons showed maximum and high activity of the oxidative enzyme (5 and 4). During protein deficiency, cytochrome oxidase activity in nerve cells slightly decreased (from 5 to 2).

Conclusion. Thus, protein deficiency in the diet leads to a decrease in cytochrome oxidase activity. However, in the testes, by 20 days from the start of the experiment, a short-term increase in enzyme activity is detected. By the end of the experiment, this activity declines, as in other organs.

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