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Morphological aspects of cerebral cortex plasticity in alcohol intoxication

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Abstract

The paper covers the experimental study of the morphofunctional organization of the CA_1 hippocampal field and the piriform region of a rat's brain cortex in alcohol intoxication, cuased by an intraperitoneal introduction of a 15% solution of alcohol. The results showed the morphogenetic mechanisms of nerve cells plasticity developing by the 600th min of alcohol intoxication. They manifest in the formation of hypochromic reparative regeneration, characterized by the increase of the volume of hypochromic neurons, containing two nucleoli and regenerative hypertrophy, characterized by intracellular hyperplasia of the organelles and nuclei.

Key words: cerebral cortex, plasticity, alcohol, neurons.

Морфологические аспекты пластичности коры головного мозга в состоянии алкогольного опьянения

В работе рассматриваются экспериментальные исследования морфофункциональной организации участка CA1 гиппокампа и грушевидной области коры головного мозга крыс при алкогольной интоксикации, вызванной внутрибрюшинным введением 15% раствора спирта. Результаты показали, что морфогенетические механизмы пластичности нервных клеток развиваются к 600-й минуте алкогольного опьянения. Они проявляются в формировании гипохромной репаративной регенерации, характеризуются увеличением объема гипохромных нейронов, содержащих два ядрышка и регенерационной гипертрофией, характеризующейся гиперплазией внутриклеточных органелл и ядра.

Ключевые слова: кора головного мозга, пластичность, алкоголь, нейроны.

Introduction

The use of ethyl alcohol is widespread among the population in the world. According to the Federal State Statistics Service, in Russia, from 1991 to the present time there is a tendency to an increase in populationabusing alcohol [7].

Alcohol as a neurotropic agent causing a variety of functional and morphological changes is poorly understood in terms of mechanisms for its effects on the brain.

A lot of research is devoted to study the influence of alcohol, both on the body as a whole, as well as directly on the brain. Analysis of the literature provides an extensive view of the direction of research in addressing both acute and chronic alcoholism. Among them are the studies of neurophysiological patterns [6], neurochemical and pharmacological manifestations of alcoholism [1] and biochemical abnormalities [10], chronobiological changes [3], and neurological symptoms [4, 15]. It should be noted that great importance is attached to the analysis of morphological and biochemical changes that develop in the organism in chronic alcoholism. Less studied in terms of metabolic manifestations, the question of the influence of acute alcohol intoxication on behavior and conditioned reflex activity remains unanswered.

It has been shown that ethanol at a dose of 0.3 g/kg body weight affects the risk of accidents, while the visible and pronounced signs of conscious motor activity occur at concentrations in the 0.5-0.6 g/kg [9]. Numerous medical and statistical studies have revealed a correlation of high concentrations of alcohol (> 1-2‰) in the blood with mortality in road traffic accidents, fires, falls from heights, and with the risk of injury at plants and factories [13, 14].

Following the adoption of large amounts of alcohol, the alcoholdehydrogenase reaction shifts toward the oxidation of ethanol for acetaldehyde [2]. The metabolism of ethanol in subcellular fractions (nuclear, mitochondrial, microsomal, etc.) of the brain is significantly lower than in the liver [10]. Only a small portion of alcohol is exposed to catalase in peroxisomes of the liver. Formed during the oxidation of ethanol, acetaldehyde is further oxidized in aldehydedehydrogenase reaction. Its small part under the action of PAD-dependent aldehyde oxidase and xanthine oxidase is oxidized to form acetic acid and the active radicals (H_2O^- and $O^{\cdot -}$), which can stimulate free radical processes, including lipid peroxidation [2].

However, several studies have shown in the development in cerebral cortex cells the presence of reversible changes, even when exposed to large doses of alcohol, i.e., the plasticity of the cerebral structures. The study of structural and functional mechanisms of reactivity and plasticity of the central nervous system is one of the most important problems of modern neuroscience. Plasticity of biological structures is based on their ability to adaptation – protective physiological process which occurs in the organism under the influence of environmental factors, or their cancellation [8]. Morphogenetic mechanisms of plasticity of nervous tissue elements in CNS are provided by the development of various standard forms of morphofunctional variability, based on the set of reactions that cause the complex of structural, functional and metabolic changes in neurons and glia that contribute to the preservation and maintenance of homeostasis at different levels of structural organization of the nervous tissue in the changing conditions of existence. We carried out a comparative histomorphological characteristics of the reactions of archicortex and paleocortex for alcohol intoxication.

Material and methods

The experiment was conducted on 120 inbred albino male rats weighing 180-200 g. Animal care and experiments were carried out in accordance with the recommendations of the Russian Ministry of Health Committee for experimental work with animals, the WHO recommendations, as well as the recommendations of the European Convention for the Protection of Vertebrate Animals used for experimental and other purposes [12]. Two groups of animals were formed for research. The first group consisted of intact rats. The animals of the second group were injected with a solution of 15% ethanol once, intraperitoneally, with a dose of 2.25 g/kg in aseptic conditions. Euthanasia of animals was carried out under general anesthesia using thiopental in winter time in 60 and 600 minutes after ethanol injection. The object of the research were CA_1 hippocampal field and cortex piriformis, dissected on the cytoarchitecture maps of Paxinos [16]. Fragments of the brain were fixed in 10% buffered formalin solution, pH 7.4, embedded in paraffin. Sections 5 micron thick were stained with toluidine blue according to Nissl.

In studied parts of the hippocampus and the piriform region, the volume of neurocytes and the number of different forms of morphological variability of nerve cells were determined in each animal. In the description of the observed structural and functional changes, the classification of standard forms of morphological variability of CNS under the influence of anthropogenic factors was used [4].

Results and discussion

Sixty minutes after an ethanol injection of a dose of 2.25 g/kg, cortex redistribution of cellular forms of neurocytes was observed in the studied regions of the rat's brain . In CA1 hippocampal field the nerve cells with signs of focal chromatolysis dominated. The number of hypochromic, hyperchromic and pyknotic neurocytes, as well as cells-shadows increased moderately, and the number of normochromic cells decreased, compared with controls. However, we observed unaltered neurons. Nerve cells responding increased in the volume of the body and the nucleus. In the piriform region hyperchromic neurons dominated with an increased volume in body and nucleus; a decrease in the number of normochromic and hypochromic nerve cells was observed, but the number of cells-shadows increased (fig. 1, a-c).

Up to the 600th minute of alcohol intoxication, histomorphological structure of archicortex and paleocortex was highly polymorphic. The number of normochromic and hypochromic neurons decreased as compared with the 60th minute of observation. The number of pyknotic neurons and cells-shadows increased. The content of hyperchromic nerve cells remained practically unchanged. Thus, normochromic neurocytes in part with chromatolysis and cells-shadows were predominant (fig. 1, d-f). The reaction of normochromic and hyperchromic nerve cells was characterized with the decrease of body and nucleus volume, compared with the control. The volume of hypochromic neurons was increased. In the piriform region we observed the following changes: The number of normochromic, hypochromic cells, pyknotic neurons and cells-shadows increased; the amount of hyperchromic nerve cells was significantly less than in the control; the cells reacted by the increase of body

and nucleus volume. Focal and peripheral chromatolysis was observed in the cytoplasm of most normochromic nerve cells. In rare cases, we met vacuole. The volume of bodies and nuclei increased. It should be noted that 600 minutes after ethanol injection in a dose of 2.25 g/kg, in some hippocampal neurons, hyperplasia of the nucleolus was observed. The number of binucleolar neurons in CA_1 was about 22,6 ± 0,57%. Nerve cells with two nucleoli were also observed in the piriform region but much less than in the archicortex. Besides this, the so-called "paired-neurons" previously described in the literature [2] were also observed.

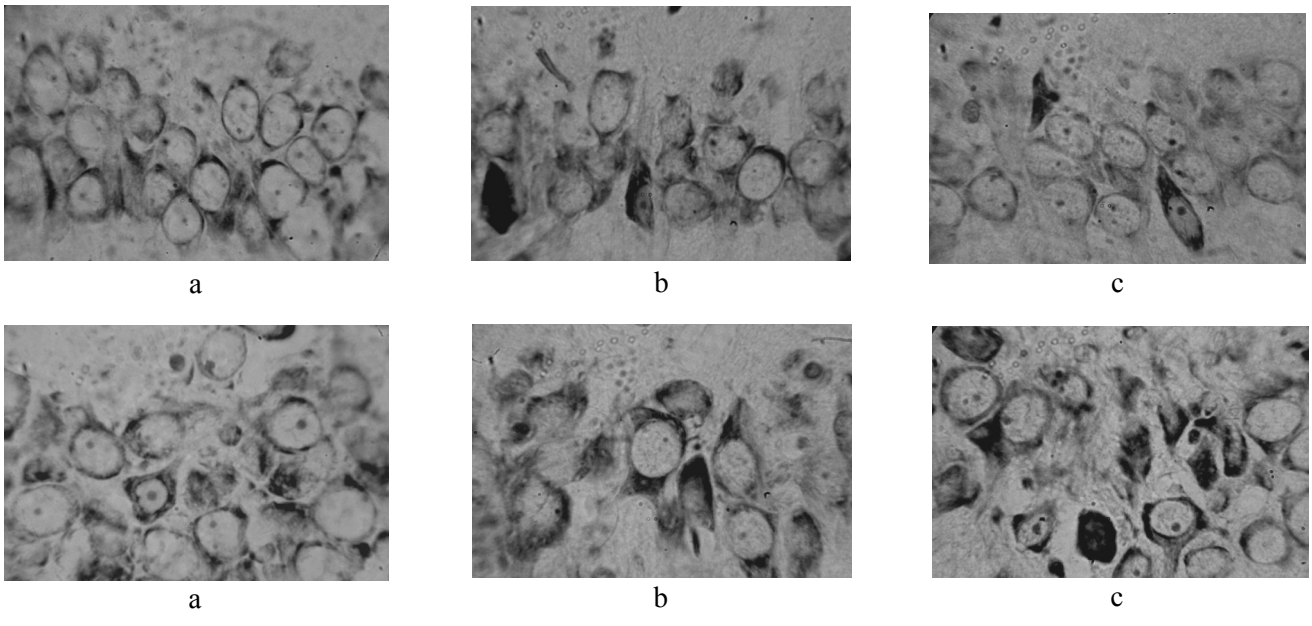

Fig. 1. Morphological organization of archicortex and paleocortex in alcohol intoxication.

Signature: the top row – CA_1 hippocampal field; bottom row – piriform region; a, d – control groups; b, e – 60 minutes after ethanol injection, c, f – 600 minutes after ethanol injection. Nissl's staining; 100 × 20.

Conclusion

Intraperitoneal administration of ethanol in a dose of 2.25 g/kg produces a set of typical non-specific changes in the archicortex and paleocortex of rats for the duration of the experiment.

The increase of the number of normochromic neurons with chromatolysis, observed in archicortex in the 60th minute is a sign of growing neuronal dystrophy and is reversible. The increase of the number of pycnotic neurons and cells-shadows confirms the presence of necrobiotic processes and indicates a decline in the functional activity of the hippocampus. In the piriform region, the signs of neuronal dystrophy were also observed, however, in this case, it has a hypochromic type. Thus, in the early period after administration of ethanol in the studied regions of the rat's cerebral cortex, alterative changes dominated.

With the increasing of hypo- and hyperchromic forms of cellular destruction in CA1 in the 600th minute of alcohol intoxication, adaptation changes are observed. They proceed according to the type of hypochromic reparative regeneration, characterized by the increase of volume of hypochromic neurons, containing two nucleoli. The morphologic equivalent of adaptation reaction in paleocortex is the presence of hyperchromic neurons without the signs of dystrophy and with increased volume in the body and nucleus. Such changes are indicative of the processes of regenerative hypertrophy, characterized by intracellular hyperplasia of organelles and nuclei. Presumably, the presence of "paired neurons" is also a manifestation of the adaptation process, because there is evidence proving that the convergence and contacting of neighboring neurons caused by increased intracellular movement of cytoplasm is due to a change in cell metabolism by the splitting of phosphates energy [2].

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Caracteristica morfofuncțională a elemenetelor complexului funiculotesticular care influențează hemodinamica glandei genitale masculine

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The morphofunctional characteristics of elements in the funiculotesticular complex that regulate haemodynamics in the male genital gland

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Using macromicroscopic and microscopic methods of investigation, we have determined numerous extra- and intravascular morphological elements. These elements play an important role in the regulation of blood supply to the testis, such as; the formation of the muscular system by striped and smooth muscle fascicles, the spiral and reticular basic principle of structure of the cremaster muscle and conjunctive tissue formations, and para- and perivassal formations, which adhere to the adventitia of the blood and lymph vessels oriented according to the action of the extension forces in the muscular fascicles, different endothelial prominences, sphincters, and anastomoses.

The capacity of adaptation of the vascular and lymphatic systems depends on the degree of development of the muscular system and paravassal elements.

Key words: testis, spermatic cord, cremaster muscle, funiculotesticular complex.

Actualitatea temei

Este cunoscută sensibilitatea ridicată a epiteliului canaliculelor seminifere în caz de dereglare a circulației sângelui, ceea ce reprezintă unul din factorii patogeniei sterilității masculine [3, 5, 8, 6, 7, 10].

Astfel de dereglări pot avea loc în efectuarea diferitelor intervenții chirurgicale asupra testicului sau a