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ELECTROPHYSIOGICAL STUDY OF VISUAL SYSTEM STRUCTURES FUNCTION IN EXPERIMENTAL RETINA DYSTROPHY

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Abstract. The study is devoted to the neurophysiological study of the visual analyzer function. The work was carried out on rabbits. The electrical activity of the visual system structures was recorded by electroencephalography. Electroencephalogram spectral analysis was performed in the central and subcortical visual analyzer structures (vizual cortex, colliculus superior, lateral genuculate body) in the norm, as well as against the background of the development of retinal dystrophy (35 and 90 days after injection of monoiodoacetic acid) followed by recovery. The similarity of changes in the spectral background, observed in the visual cortex and lateral genuculate body at retinitis pigmentosa. In contrast, changes in the opposite direction were observed in colliculus superior. Comparative analysis of the obtained results revealed that magno and parvocellular pathways transmission of visual information to the cerebral cortex are in reciprocal opponent relations.

Keywords: *Visual cortex, retina, lateral geniculate body, superior colliculus.*

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1. Introduction

The retina, which has microscopic dimensions, consists of 10 layers of different cells. Each layer performs its own functions in the visual process of perception. Due to a number of negative reasons, thinning of the retina is observed, resulting in serious problems in the function of vision. Dystrophy and other degenerative diseases of the retina are characterized by clinical and genetic heterogeneity (Agnese *et al*., 2019). The main symptoms of these disorders include night or color blindness, tunnel vision and late progression to total blindness (Benjamin *et al*., 2015). Dysfunction of the peripheral part of the visual system is also reflected in the central structures. Negative changes observed in the amplitude-time parameters of the electroretinogram (ERG) are reflected in the amplitude-time parameters of evoked potentials in the central structures of the visual system. This, in turn, affects the function of these centers (Panakhova *et al*., 2022; Miryusifova *et al*., 2022). Consequently, the suppression and reduction of retinal function not only affects the central structures, but also causes a change in the relationship between them (Lennartsson *et al*., 2021).

The visual system is represented by a set of neural systems - channels specific to the perception of a certain spectrum of spatial frequencies. It is known that information

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is transmitted from the retina to the visual cortex in several ways. The centers located on these paths, in turn, have mutual functional connections with each other. Most of the fibers leading from the retina to the primary visual cortex (field 17) pass through the lateral genuculate body (LGB). For people diagnosed with blind vision due to damage to the primary visual cortex, LGB plays an important role in conveying visually meaningful information, which is below the level of conscious perception (Schmid *et al*., 2021)

In the analysis of spatial visual information at the lower hierarchical levels, starting from the retina two parallel transmission channels of qualitatively different information are involved. The magnocellular pathway is stimulated by low contrast, low spatial frequency, images, small stimulus size and movement. The parvocellular pathway, in contrast, is stimulated by high-contrast images with high spatial frequency, large stimulus size and color. These paths are most clearly distinguishable at the level of the lateral geniculate body, where they pass through different layers of cells - large and small, forming two tracts. Magnocellular and parvocellular pathways, which are in opposition to each other, originating in the retina with projections through the lateral geniculate nucleus of the thalamus into different layers of the visual cortex, are the main channels providing primary filtering of visual information, which is then used by neurons in the dorsal and ventral pathways (Shoshina *et al*., 2014). These data are Shoshina İ. and Shelepin Yu. 2014, 2016. Information provided does not match previous submissions about the transmission of information to the visual cortex of the brain (Livingstone *et al*., 1988).

From this point of view, the study of electrical processes in the centers of vision in the regulation of the functional state of the retina in retinal dysfunction is of great interest from an experimental point of view. In our animal studies, we discovered, that 3 months after mild retinal dystrophy spectral composition of the EEG in the central and subcortical structures of the visual analyzer approaches the background.

Such a mechanism of self-healing of visual function after dystrophic changes is of significant interest. It was important to understand the mechanisms providing functional restoration of retinal cells after their damage and disruption of trophic supply.

It is known that a number of degenerative diseases of the retina are characterized by the decay of the outer part of the retina and photoreceptors, leading to progressive loss of vision. In the interior of the retina including retinal neurons of the second and third order, aberrant structural changes are also found at all stages of degeneration.

In such a situation, recovery processes can be explained in terms of neuroplasticity and adaptation. It is known from modern literature that stem cells have a rehabilitation effect. Activation of Mullerian and glial cells providing hemostasis in various brain structures (hippocampus, olfactory bulbs, basolateral amygdala) and retina leads to retinal remodeling and restoration of its function by establishing new connections based on the mechanisms of neuroplasticity (Henri *et al*., 2023).

The main goal of our experiments was a study of the spectral composition of the electrical activity of the visual centers and retina in the process of establishing new connections.

2. Objects and research methodogy

Experiments were carried out on Chincilla rabbits weighing 2.5-3 kg. Nichrome electrodes were applied to the structures of the brain colliculus superior (CS), lateral geniculate body (LGB), visual cortex (VC) in accordance with the coordinates of the stereotexic atlas (Blinkov *et al*., 1973). Diameter of electrodes for cortical structures were 0.5 mm, subcortical structures - 0.1-0.15 mm. Exsperimental retinal dystrophy was caused by the introducing of monoiodoacetic acid (MIAA) into the ear vein (18-22 mg/kg). The electroencephalogram was recorded and analyzed in the "Neuron-Spectrum-5" software package. Activities of various rhythms in the brain allows you to evaluate the spectral analysis of the EEG.

3. Results and discussion

The purpose of our experimental studies was to conduct a comparative analysis of the spectral composition of the electrical activity of the central and subcortical structures of the visual system in the formation and subsequent recovery of mild experimental retinal dystrophy. At the initial stage of our study, background EEG activity was recorded in the central and subcortical structures of the visual system and their spectral analysis was performed.

As can be seen from the picture in the norm no special differences are observed. the maximum levels of spectral features in all three structures are observed in the delta and theta rhythms. The similarity of changes in LGB and VC was revealed. In CS, the maximum levels of spectral features are located at a relatively high frequency (Figure 1).

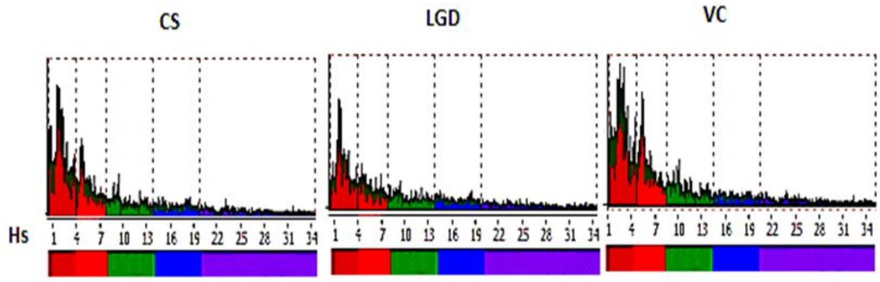

Figure 1. Spectral analysis of the EEG structures of the visual system

At the next stage of research, an experimental model of retinal dystrophy was created. The time spent on the creation of this model coincided with the time indicated in the literature and was 33-35 days. Interesting results were obtained from a comparative analysis of the spectral composition of the EEG dystrophic activity with the background (Figure 2).

In the process of development of retinal dystrophy, a powerful decrease in the maximum level of the main peak of the EEG spectral characteristics is observed. at the level of the visual cortex and LGB in the delta and theta frequency ranges. The same pronounced changes but the opposite direction is observed in relation to the increase in the amplitude peaks of CS at all frequencies. In particular, the maximum level of the main peak in this structure increases in the delta and theta frequency ranges. It is known that in many neurological and other disorders, delta waves are markedly enhanced. An excess of amplified delta waves practically guarantees the presence of cognitive impairment. In general, there is a shift in the EEG to a higher frequency range. This indicates the development of pathology.

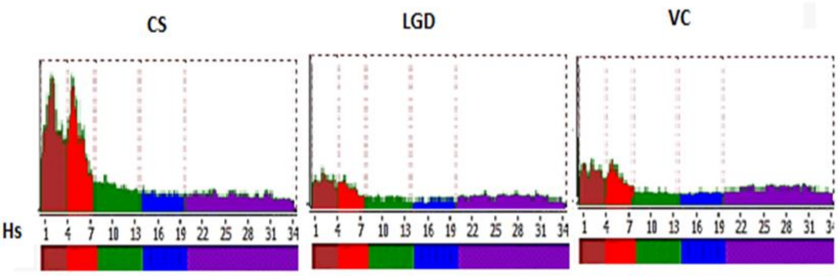

Figure 2. Spectral analysis of the EEG structures of the visual system in retinal dystrophy (35 days after MIAA injection)

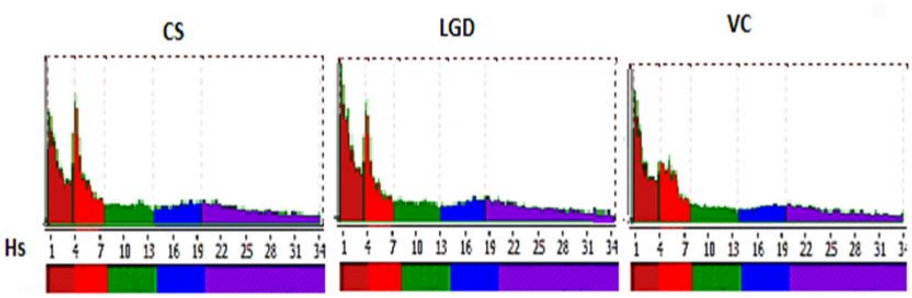

Figure 3. Spectral analysis of the EEG structures of the visual system (3 months after MIAA injection)

Registration of the EEG of these structures and spectral analysis were carried out daily for three months. When considering the spectral pattern of electrical activity in animals after 3 months the pattern at delta and theta frequencies in all three structures is relatively similar to the background (Figure 3). Unlike LGB and CS the frequency of VC beta waves was restored to the background level. The focus of these studies is on observing a different pattern in the structures with retinal dystrophy and recovery. So, against the background of dystrophy, there is a change in the opposite direction in CS, compared to the same direction of change in LGB and VC (magno- and parvocellular pathways used in visual signal transmission).

4. Conclusion

Analysis of the obtained results revealed that the spectral background of the EEG is formed in antiphases in magno-(CS) and parvocellular (VC, LGB) visual system structures on the background of experimental retinal dystrophy. It has been proved that these channels of carrying information are not independent and parallel: they are in reciprocal, opposing relations.

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