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CHANGES IN DENDRITES OF CORTICAL NEURONS IN EXPERIMENTAL ALCOHOL INTOXICATION

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Dendrites of cortical neurons were studied in rats in the different stages of alcohol intoxication. Two categories of changes in the dendrites develop under these circumstances: destructive and compensatory. The dynamics of these changes depends on the periods of alcohol intoxication and individual differences in the central nervous system of the animals.

KEY WORDS: cerebral cortex; action of alcohol; dendrites.

Many clinical and experimental investigations have shown that prolonged alcohol intoxication leads to disturbances of higher nervous activity, changes in autonomic, somatic, emotional, and mental functions, depression of cortical excitability, phasic changes in the EEG, and so on [1, 3, 9, 12].

Changes in nerve cells, fibers, glia, and blood vessels during prolonged alcohol intoxication in man and experimental animals have been studied in detail by the methods of light microscopy. An initial lesion of cortical structures followed by the spread of the process to the subcortex, brain stem, and spinal cord is generally accepted. Some investigators have stated that the changes in the nerve cells are reversible during the first 20 days of chronic alcohol poisoning [4, 11]. It has recently been shown that the structure not only of nerve and glial cells, but also of interneuronal connections, is changed in alcohol intoxication [2, 11].

Considering the important role of dendrites in the mechanisms of brain activity and the absence of data of the dynamics of changes in the dendritic apparatus of neurons in alcohol intoxication, the investigation described below was undertaken in order to study changes in the dendrites and their spines – the specific postsynaptic receptor structures – at different times during experimental alcohol intoxication.

EXPERIMENTAL METHOD

Experiments were carried out on albino rats aged 3 months which were given a 35% solution of ethyl alcohol instead of water. In the initial period (10-20 days) they were given 2-3 ml alcohol daily, for 2-2.5 months the mean daily dose of alcohol was increased to 8-10 ml, and starting from the third month the dose given was 14-17 ml. The animals were killed 10 and 20 days and 2, 4, 8, and 12-15 months after the beginning of the experiment. Golgi's silver impregnation method was used.

EXPERIMENTAL RESULTS

After the first 10-20 days of the experiment neurons whose dendrites, especially the basal, contained few spines and sometimes had irregular outlines and no spines whatsoever, were found in the lower layers of the cortex. The dendrites of most neurons of the upper layers of the cortex, on the other hand, were covered by many spines. Whether there were few or many spines, some of them showed hypertrophy. Contacts of varicose type between processes of the swollen oligodendrocytes and the main trunks and the infrequent spines of the dendrites could be seen (Fig. 1).

After 2 months of alcohol intoxication the irregularity of the outlines of the dendrites of many small and medium-sized neurons in the lower layers of the cortex increased. In most cells the basal dendrites had no

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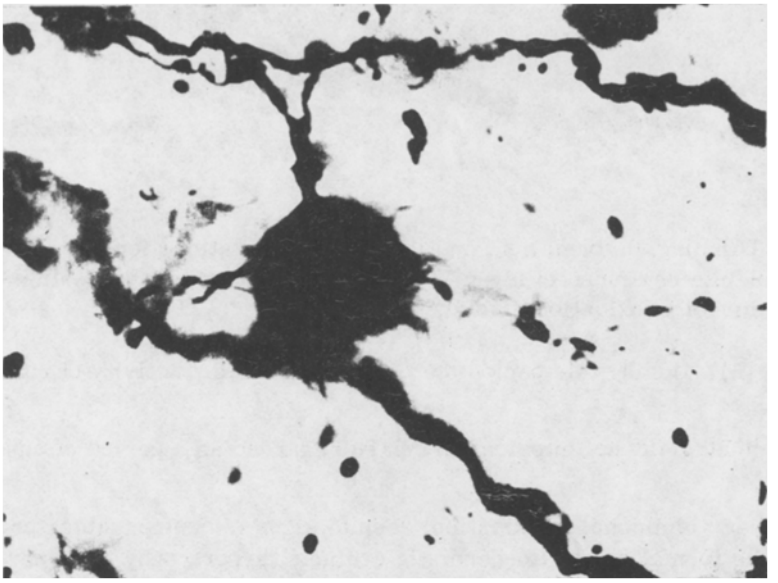

Fig. 1. Reduction in number of dendritic spines, irregularity of outlines of apical dendrites, and glio-dendritic contacts in layer V of sensomotor cortex of rats 20 days after beginning of alcohol intoxication. Golgi, 900×.

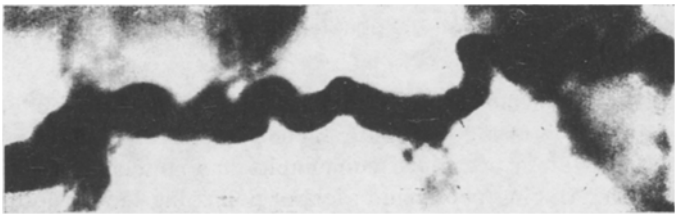

Fig. 2. Corkscrew-like appearance of apical dendrite of large neuron in layer V of sensomotor cortex 4 months after beginning of alcohol intoxication. Golgi, 900×.

spines and some of them showed varicose changes; the number of spines on the apical dendrites was sharply reduced. In the upper layers of the cortex, besides neurons whose dendrites were covered by numerous hypertrophied spines, there were others whose dendrites had very few spines or none whatsoever.

After 4 months of alcohol intoxication a sharp decrease in the number of spines on the dendrites was observed and wave-like undulations formed along the course of the dendrites (Fig. 2).

At the eighth month of alcohol intoxication "spineless" neurons, neurons with few spines, and neurons densely covered with spines were observed in the cortex, but after 12-15 months the branches of the dendrites became thinner, their power of impregnation was reduced, and they developed local vacuolation (Fig. 3). In the upper layers of the cortex, neurons with a dense covering of spines could still be seen. Some of the spines were hypertrophied or showed projections resembling cones of growth. Proliferation of drainage forms of oligodendrocytes was well-marked, and the processes of some of them, like those of oligodendrocytes with the typical structure of the intact animal, formed glio-dendritic contacts in different parts of the apical dendrites of the neurons.

In the early stages of alcohol intoxication the dominant changes in the cerebral cortex of the rats were thus functional (reversible) changes in the dendrites. Changes of a compensatory character also were seen: an increase in number and hypertrophy of the dendritic spines, possibly due to hypertrophy of the spinous apparatus, to which great importance is attached in the integrative activity of the neuron [5, 7]. The disturbance of the structure of the dendrites, reflecting the slower conduction of nervous impulses to the cell body [8, 13, 14], was evidently compensated by hyperplasia of the glial cells and the formation of glio-dendritic contacts, maintaining the functions of the damaged nerve cells. The changes described above can be regarded as a phase of formation of compensatory mechanisms in accordance with the classification of phases of a

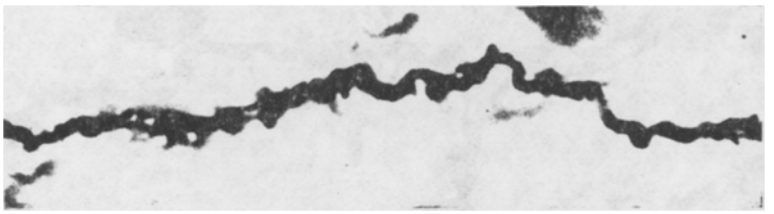

Fig. 3. Thinning, deformation, and localized vacuolation along the course of basal dendrite of neuron in layer V of sensomotor cortex 1 year after beginning of alcohol intoxication. Golgi, 900×.

compensatory character [6]. During this period the conditioned-reflex activity of rats is not significantly disturbed [10].

The period of 2-4 months alcohol intoxication can be regarded as a period of unstable compensation, in Lapin's classification [6].

After more than a year of alcohol intoxication, despite signs of compensatory processes (hyperplasia and hypertrophy of the glia, the formation of glio-dendritic contacts, hypertrophy of spines and the formation of projections resembling cones of growth), degenerative changes in the dendrites of the cortical neurons became the dominant feature.

According to physiological data, the learning process in rats is significantly changed after the 8th month of alcohol intoxication: the formation of conditioned-reflex chains of movements is greatly retarded on account of the greater intensity of the passive-defensive response and the weak character of orienting-investigative activity. The conditioned-reflex activity becomes purposeless in character. Rats can be trained only by a passive method [10].

While the special susceptibility of the cerebral cortex to the action of alcohol will be noted, the greater vulnerability of the dendritic apparatus of the efferent neurons of the lower layers must be emphasized, i.e., neurons of the cortical projection system are more vulnerable than neurons of the upper layers, which are predominantly associative in function. During prolonged alcohol poisoning the structure of the dendrites is disturbed and the working capacity of the neuronal ensembles in the upper layers of the cortex is correspondingly reduced. Preservation of the functions of the CNS in alcohol poisoning can be attributed to compensatory and adaptive changes which make up for the deficit of nerve cells.

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