NEURONAL ULTRASTRUCTURAL REORGANIZATION IN SOME BRAIN FORMATIONS DURING PARADOXICAL SLEEP DEPRIVATION

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KEY WORDS: neuronal ultrastructure; paradoxical sleep; deprivation

Selective deprivation of paradoxical sleep has been shown to have an adverse effect on brain function [8, 10] and to lead to disturbance of biosynthetic processes in the brain [1, 2]. However, data on brain morphometry during deprivation of paradoxical sleep are very limited and were obtained by methods of light microscopy [4].

The aim of this investigation was to study neuronal ultrastructure in the dorsal hippocampus, lateral hypothalamic nucleus, and reticular formation of the pons in rats during paradoxical sleep deprivation.

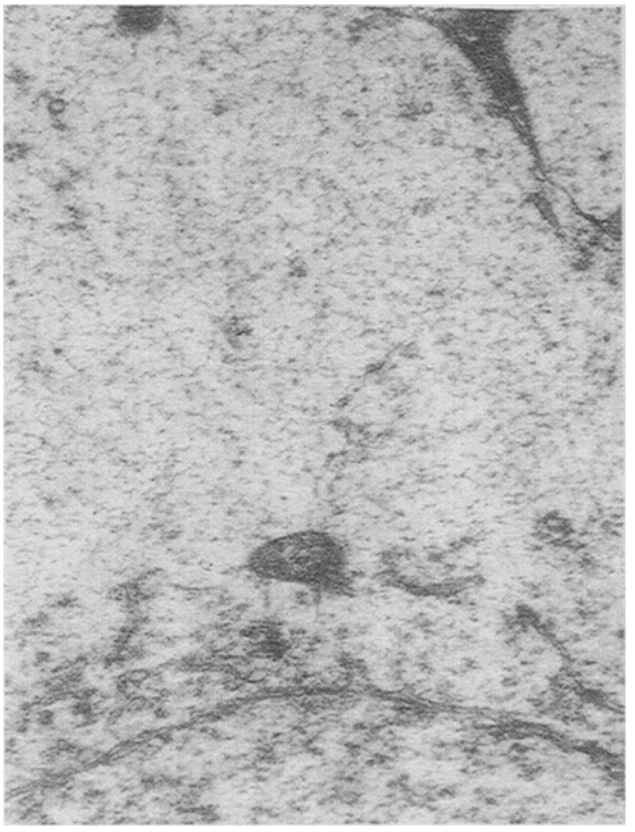

Fig. 1. Total chromatolysis in pyramidal neuron of dorsal hippocampus of rat after paradoxical sleep deprivation for 96 h. 15,900×.

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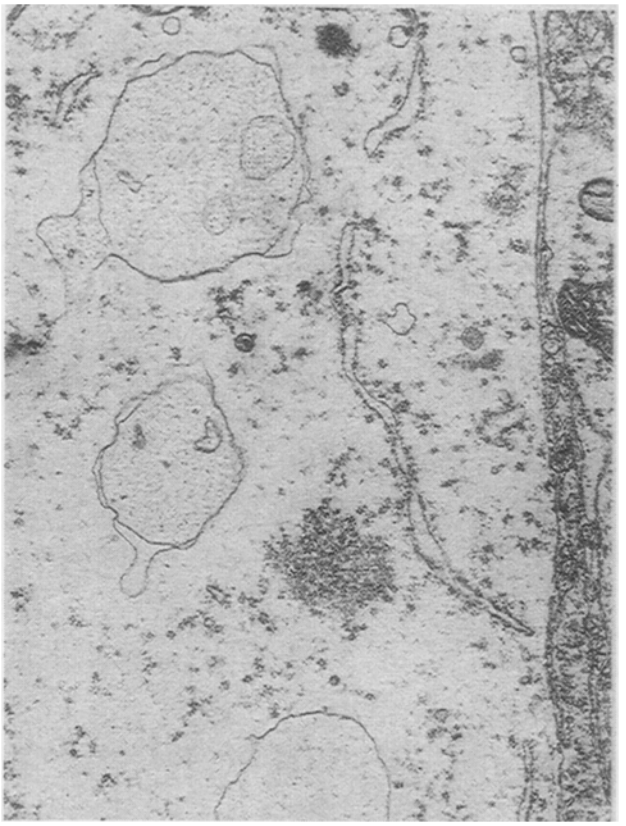

Fig. 2. Vacuolation of cytoplasm of a neuron of reticular formation of rat pons after paradoxical sleep deprivation for 96 h. 20,400×.

EXPERIMENTAL METHOD

Experiments were carried cut on 15 male Wistar albino rats weighing initially 220-230 g. The experimental animals (five rats) were taken for investigation after paradoxical sleep deprivation for 96 h. Paradoxical sleep deprivation was produced by the method in [9]. The control group consisted of 10 animals kept under normal conditions of waking and sleep. The brain of the animals, anesthetized with ether, was perfused with 2.5% glutaraldehyde. Material for electron-microscopy was processed by the standard method.

EXPERIMENTAL RESULTS

After deprivation of paradoxical sleep for 96 h, polymorphic submicroscopic changes were observed in neurons of all the brain formations studied. In some neurons, for instance, signs of destructive changes were observed, namely swelling of the nucleus, reduction of the nuclear chromatin and its accumulation near the inner karyolemma, and a sharp decrease in the number of cytoplasmic organelles. Neurons in a state of total chromatolysis could be seen (Fig. 1). The rough endoplasmic reticulum (RER) underwent significant changes, with a decrease in the number of cisterns, and the remaining cisterns were shortened and unevenly widened. The degree of widening of the cisterns of RER varied within wide limits. Some cisterns were converted into vacuoles, distinguished by the great diversity of their shape, size, and internal contents. Vacuolelike formations in the cytoplasm were electron-translucent or they could be filled with finely granular material and contain smaller vacuoles. Occasionally focal accumulations of

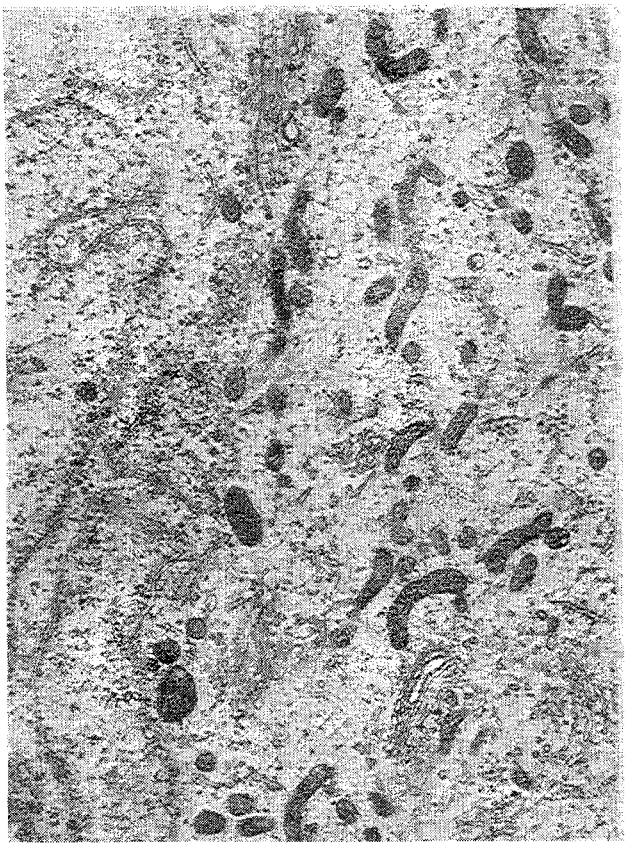

Fig. 3. Compensatory-adaptive processes in pontine neurons of rats after paradoxical sleep deprivation for 96 h. 18,700×.

electron-dense material were seen in the cytoplasm (Fig. 2). In addition, disorganization of the components of the Golgi complex was found in some nerve cells with swelling and vacuolation of individual cisterns. Mitochondria were much fewer in number. As a rule they were swollen, with partial reduction of their cristae, and often with disturbed integrity of their inner membranes. Meanwhile compensatory hypertrophy of individual mitochondria could be observed.

Neurons with signs of compensatory and adaptive processes also were present. These changes took the form of an increase in size of the nucleoli, their displacement toward the periphery of the nucleus, and in the dorsal hippocampus there was the occasional appearance of binucleolar cells. The nuclei were sometimes elongated in shape. In many cases ectopia of the nucleus was observed, with an increase in the amount of nuclear chromatin. The folds of the karyolemma became deeper and their number was increased to five or six in the experimental animals compared with two or three in the control rats. Besides activation of the nucleolar apparatus, hyperplasia of the cytoplasmic organelles could be seen: the mitochondria, cisterns of RER, components of the Golgi complex, and lysosomes. The mitochondria varied considerable in size, and among them there were some hypertrophied organelles (Fig. 3). Destructive changes were most marked in neurons of the pontine reticular formation, and compensatory and adaptive processes in neurons of the dorsal hippocampus.

Besides altered neurons, in all brain formations studied some nerve cells still preserved their normal ultrastructure.

Thus paradoxical sleep deprivation for 96 h is a powerful extremal factor leading to disturbance of metabolism and of intraneuronal homeostasis. Destructive changes which we observed in the majority of organelles of some nerve cells were reversible [5-7] and evidently arose as a result of functional overstrain during paradoxical sleep deprivation for 96 h. Signs of damage to the protein-synthesizing apparatus (nucleus, nucleolus, RER, and ribosomes) discovered in the neurons are evidence of a disturbance of protein biosynthesis. Our electron-microscopic findings are in agreement with the results of numerous neurochemical investigations, which showed that paradoxical

sleep deprivation in animals leads to a sharp decrease in concentrations of proteins and RNA in nerve cells of the brain [2, 3, 11].

The presence of neurons with signs of compensatory and adaptive structural changes in the brain formations studied is evidence of the still adequate powers of adaptation of the brain even after paradoxical sleep deprivation for 96 h.

Differences in the intensity of destructive and compensatory and adaptive processes in individual brain formations may be due to their functional heterogeneity.

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