CHARACTERISTICS OF HYPERCHROMIC NEURONS FROM A CORTICAL FOCUS OF LOCAL DESTRUCTION

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The problem of the nature of hyperchromic neurons appearing in response to various factors, and the reversibility of changes in them remains unsolved [2]. An important role in the elucidation of this problem can be played by methods of electron cytochemistry and, in particular, those which shed light on the degree of functional activity of the DNA-RNA-protein synthesizing system and its morphological equivalents. One such method is the electron-cytochemical detection of condensed chromatin and ribonucleoprotein (RNP) particles in the nucleus as described by Bernard [1].

The object of this investigation was to study the state of chromatin and RNP particles in the nuclei of hyperchromic neurons, chosen at different distances from a local destruction in the cerebral cortex. According to observations of Queiroz and Faria [6], in this case a whole spectrum of hyperchromic neurons can be obtained — from relatively unchanged cells (mild hyperchromia) to shrunken cells with irreversible destructive changes.

EXPERIMENTAL METHOD

The test object was the sensomotor cortex of male WAG rats weighing 160-180 g. A local focus of destruction was obtained by electrical coagulation through a small burr-hole in animals anesthetized with thiopental (0.036 mg/kg). After electrical coagulation the burr-hole was sealed with a drop of wax and the skin wound sutured with silk. To prevent infection of the animals penicillin was injected intramuscularly in a dose of 10,000 U/kg daily for 2 days.

The animals were killed by rapid decapitation 3 days after the operation. The brain was carefully removed from the cranial cavity and pieces of tissue were taken at distances of 3-5 mm from the focus of coagulation, fixed in 2.5% glutaraldehyde solution, and embedded in Epon. RNP particles were demonstrated by a modified Bernard's method [4]. Ultrathin sections were examined in the EM 201 electron microscope (Philips, The Netherlands).

EXPERIMENTAL RESULTS

The study of hyperchromic neurons at different distances from the focus of destruction showed that changes were least in nerve cells from areas of tissue more distant from the focus. In these case there was a decrease in area of the cytoplasm and an increase in density of the ribosomes and polysomes (Fig. 1a). A small quantity of condensed chromatin appeared in the nuclei of these cells, but most of the RNP particles consisted of perichromatin and interchromatin fibrils (PCF and ICF) respectively. An increase in size of the clusters of interchromatin granules (ICG) was observed, the number of perichromatin granules (PCG) was increased, but nucleoli in the nuclei of these cells were very small and contained a small quantity of condensed chromatin. No reaction of the satellite glia could be observed at this stage.

In areas of tissue closer to the focus of injury the changes described above were intensified: Nearly the whole space of the cytoplasm was filled with closely packed ribosomes and collapsed cisterns of the endoplasmic reticulum (Fig. 1b). Foci of translucency appeared in

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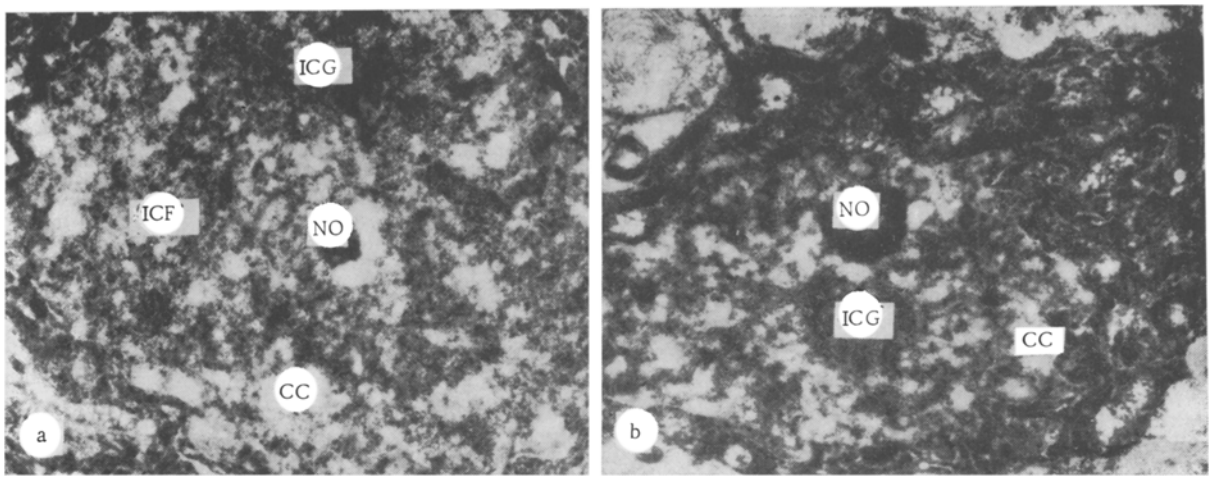

Fig. 1. Hyperchromic neurons from a focus of local destruction in the cortex with initial changes in nucleus and cytoplasm: a) areas of tissue more distant from focus of destruction; b) areas of tissue closer to focus of destruction. CC) condensed chromatin, NO) nucleolus; ICG) interchromatin granules, ICF) interchromatin fibrils. Bernhard. 11,000 ×.

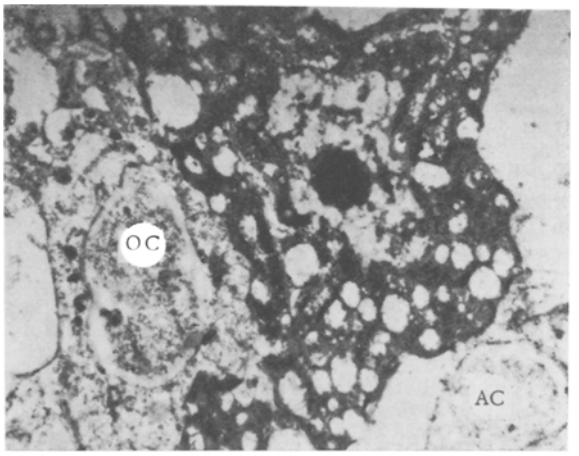

Fig. 2. Hyperchromic neuron with considerable changes in nucleus and cytoplasm and with oligodendrocyte (OC) and astrocyte (AC). Bernhard. 5000 ×.

the mitochondria as a result of partial destruction of the cristae. Condensed chromatin occupied a considerable area of section of the nucleus. Practically no PCF and ICF were seen, and ICG were found in all parts of the section of the nucleus. There were many PCG. The nucleoli were enlarged and situated eccentrically. Neurons with the changes described above often had oligodendroglial cells as satellites, which had many RNP particles in the nucleus, an enlarged cytoplasm, and many polysomes.

In the next region of tissue toward the focus of destruction changes of hyperchromic type in the neurons were more marked still: Ribosomes in the cytoplasm of these cells were so closely packed together that often they were virtually confluent, with numerous vacuoles visible among them, the remains of destroyed mitochondria and the swollen cisterns of the lamellar complex (Fig. 2).

The nucleus at this stage was almost completely filled with condensed chromatin. The few RNP particles consisted of small clusters of ICG and single PCG. The nucleolus was large. These cells were always accompanied by oligodendrocytes, whose ultrastructure corresponded to that described above. These hyperchromic neurons also were surrounded by bodies and processes of astrocytes. Finally in the immediate vicinity of the focus of destruction hyperchromic neurons in a stage of total destruction were found. Signs of neuronophagy were frequently observed. One stage of this process is illustrated in Fig. 3, in which the insinuation of a large oligodendroycte into the cytoplasm remaining from a hyperchromic neuron can be seen. Such a site was usually surrounded by astrocytic glia.

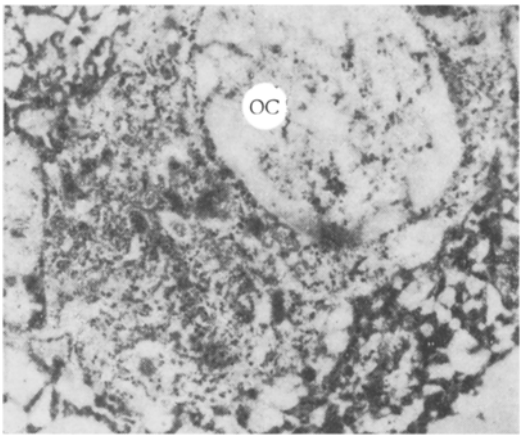

Fig. 3. Oligodendrocyte insinuating itself into cytoplasm of hyperchromic neuron. Bernhard. 12,500 ×.

On the basis of the functional role of different types of nuclear RNP particles the pattern of changes in the neurons from a focus of local destruction of the cerebral cortex of hyperchromic type can be represented as follows. In the perikarya of the nerve cells there is a sharp diminution of synthetic activity. Evidence of this is given by dissociation of polysomes into separate ribosomes, their detachment from the endoplasmic reticulum, condensation of the latter, and destruction of the mitochondrial cristae. Synthetic activity also is depressed in the nucleus. This fact is confirmed by the appearance of condensed chromatin in the nucleus and by a decrease in the number of PCF and ICF (morphological forms of newly synthesized dRNA [5]) in the nucleus. The simultaneous increase in the number of PCG and ICG, to which the role of transport and reserve forms of RNA is ascribed [3, 5], in the nucleus indicates a decrease in the outflow of RNA from the nucleus into the cytoplasm. These cells begin to be isolated from the surrounding neuropil by astrocytic glia, and the satellite oligodendroglia around them is activated.

With a decrease in synthetic activity in these neurons, processes of hydrolysis are evidently intensified: The number of ribosomes in the cytoplasm and the RNP content in the nucleus are sharply reduced. Under these circumstances the nucleus becomes almost completely filled with condensed chromatin, which is less exposed to the action of hydrolases. Isolation of dying neurons by astrocytes, meanwhile, has its own part to play. Changes in the satellite oligodendroglia are evidence of activation of these cells, which carry out lysis of fragments of hyperchromic neurons.

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