the plasma cell. The latter is not inferior to the neuron in the quantity of protein it produces (the high degree of development of the rough endoplasmic reticulum in the plasma cell is well known), but the bulk of the protein produced by the plasma cell is of only one type, namely a concrete immunoglobulin. This narrow specialization is combined with a high degree of condensation of chromatin in the plasma cell. The opposite character of the structure of chromatin in the neuron and the intensive incorporation of ^{3}H-uridine in the zone where, as has been shown, mRNA is synthesized, are evidence of derepression of a much greater part of the genome in the neuron than in other cells of the body, and of the many different kinds of proteins produced by the neuron.

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BRAIN MORPHOLOGY AND FUNCTION IN RATS WITH VARIED DEGREE OF NEUROLOGIC RECOVERY AFTER SYSTEMIC CIRCULATORY ARREST

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The most difficult and important task in modern resuscitation practice is the full restoration of brain activity [9]. In connection with this task, the choice of the method of assessment of changes developing in the brain after clinical death assumes particular significance. We know that analysis of the morphology and function of Purkinje cells (PC) in the cerebellar cortex, which are highly sensitive to anoxia, provides a means of determining the role of changes in the general density of the population and its composition in the pathogenesis of postresuscitation brain damage, of assessing the role of different types of cells in the maintenance of population homeostasis, and of revealing some mechanisms of repair processes developing in the brain after clinical death. Investigation of the PC population is essential not only because of the important role of cerebellar injury in the formation of postanoxic encephalopathy [2], but also because the state of the PC population depends on the duration of ischemia and correlates with the degree of recovery of the neurologic status of revived animals and with changes in other brain regions [4]. In recent years a new experimental model of clinical death has been developed, namely systemic circulatory arrest caused by ligation of the vascular bundle of the heart in rats [6]. No morphological investigations of the nervous system of rats subjected to clinical death of this etiology have hitherto been undertaken.

The aim of this investigation, using an approach developed previously, was to assess the state of the brain in rats differing in their degree of neurologic recovery after systemic circulatory arrest caused by ligation of the vascular bundle of the heart.

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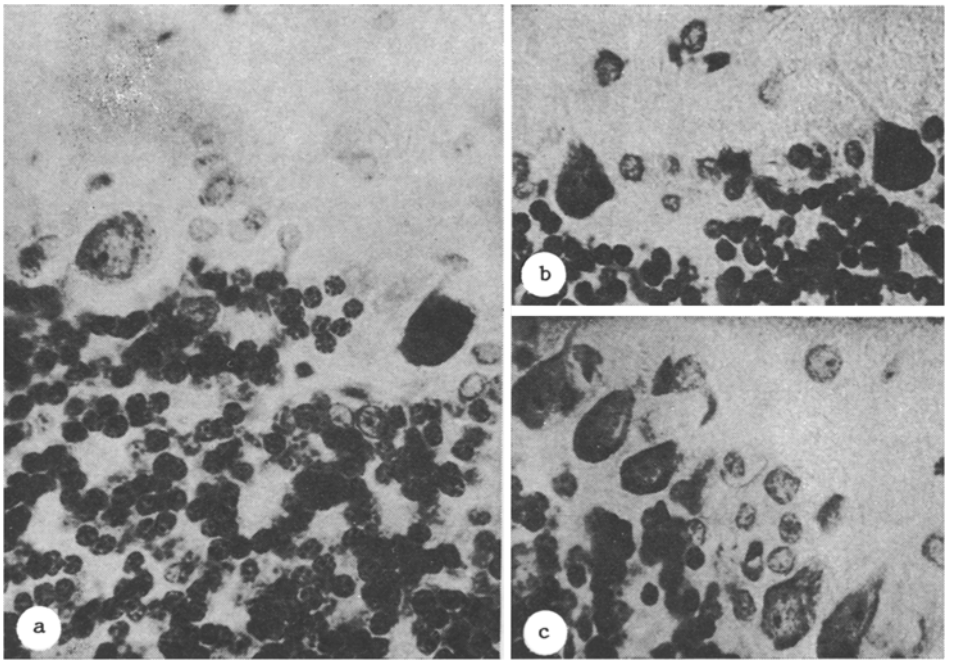

Fig. 1. Normal and morphologically changed PC. a) Pale and dark cells, b) swollen neurons, c) cells with severe degenerative changes. Nissl's stain. 60×.

EXPERIMENTAL METHOD

Under ether anesthesia circulatory arrest was induced in 10 male albino rats weighing 150-200 g by intrathoracic ligation of the vascular bundle leaving the heart [6]. Resuscitation was carried out by indirect cardiac massage combined with artificial ventilation of the lungs with air. In the course of resuscitation the times of recovery of effective cardiac activity, spontaneous respiration, and the corneal reflex were determined. The general neurologic state of the animals was assessed on a 100-point scale [7].

On the 4th day after resuscitation a morphometric analysis of the PC population was undertaken [1] on rats with complete recovery (six animals) and with residual neurologic disturbances, by comparison with intact animals [4]. During investigation of PC attention was paid to their heterogeneity, and the presence of morphologically demonstrable pale and dark neurons (Fig. 1). Two different functional regions of the cerebellum were studied, namely medial and lateral [14], which differ in their vulnerability during clinical death. Considering that the state of the protein-synthesizing apparatus plays an important role in functional and adaptive activity of the neuron [3], we investigated the nucleolus, a change in the size of which is one parameter of the intensity of ribosomal RNA synthesis [13]. The area of the nucleolus of PC [8] was determined on the 4th day after resuscitation in the medial and lateral regions of the cerebellum.

EXPERIMENTAL RESULTS

The experimental animals did not differ in the times of recovery of their cardiac activity, respiration, and corneal reflex. Depending on their final neurologic recovery two groups of resuscitated animals were distinguished: 1) rats with complete recovery [7] and 2) rats with residual neurologic disturbances. Differences in the time course of neurologic recovery of the rats were found as early as 2 h after resuscitation. Meanwhile, in the rats of group 1 the neurologic status was assessed at 35 ± 2 points (blindness, significant ataxia), but the animals still preserved their normal posture. By the 7th hour after resuscitation the ataxia was much less severe (20 ± 2 points) and the animals exhibited adequate activity. In the rats of group 2 neurological recovery was significantly delayed, and even 5 h after resuscitation it was assessed at only 36 and 42 points. The animals could not maintain a normal posture. The postural disorders and blindness persisted in these animals until the 4th day after resuscitation, whereas in the rats of group 1 they disappeared by the 1st or 2nd day.

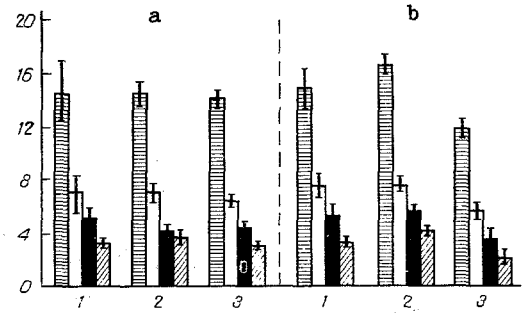

Fig. 2. General density and composition of PC population in medial (a) and lateral (b) regions of rat cerebellum 4 days after resuscitation. Ordinate, number of cells per millimeter length of the PC layer. 1) Control (intact animals), 2) rats with complete recovery, 3) rats with residual neurologic disturbances. Horizontally shaded columns) general population density, unshaded columns) pale neurons, black columns) dark neurons, obliquely shaded columns) morphologically changed cells.

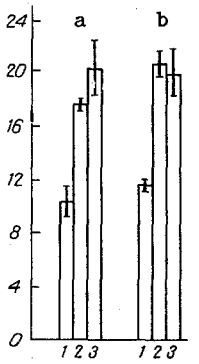

Fig. 3. Changes in size of nucleolus of PC in medial (a) and lateral (b) regions of rat cerebellum 4 days after resuscitation. Ordinate, area of nucleolus (in μ^2). Remainder of legend as to Fig. 2.

Morphometric analysis of the PC population showed that the general density of the PC population in the rats of group 1 was similar to that in intact animals in both medial and lateral regions of the cerebellum. There was likewise no change in the composition of the population, i.e., the relative proportions of pale, dark, and morphologically changed neurons (Fig. 2).

In the rats of group 2 the density and composition of the PC population in the medial region of the cerebellum were unchanged compared with those in intact animals (Fig. 2). In the lateral region, however, there was a significant decrease in the general density of the PC population (by 29.3%), i.e., loss of neurons was taking place. The numbers of both pale (by 25.0%) and dark (by 32.7%) PC were reduced (Fig. 2). Changes also took place in the composition of the morphologically changed cells. In intact animals the main type of change in PC was swelling (Fig. 1), an indication of active working of the neuron [10]. The proportion of these PC among all morphologically changed neurons was 48.8%. In rats with neurologic disturbances the proportion of PC with swelling was reduced to 20.8%, and the principal type of change was now Nissl's "severe disease", evidence of significant brain damage [5]. The proportion of these PC among all morphologically changed cells was 77.6%.

Thus in rats with residual neurologic disturbances, by contrast with animals with complete external recovery, there were significant changes in the density and composition of the PC population, and severe degenerative changes developed in the neurons. The most vul-

nerable region was the lateral region of the cerebellum – this is also the most vulnerable region of the cerebellum in the case of clinical death of other etiology (blood loss, electric shock).

Investigation of the size of the nucleolus of PC showed that in rats with complete recovery, compared with intact animals, the area of the nucleolus increased in both the medial (by 68.9%) and lateral (by 76.7%) regions of the cerebellum (Fig. 3). Significant changes in size of the nucleolus also were found in the animals with residual neurologic disturbances: in the medial region of the cerebellum the area of the nucleolus was increased by 95.1% and in the lateral region by 69.8%.

It was shown previously [8] that an increase in area of the nucleolus of PC, correlating with the duration of ischemia, also takes place in dogs surviving after clinical death due to electric shock or blood loss. The changes in size of the nucleolus of PC revealed in the postresuscitation period cannot be interpreted unambiguously, because there are various factors which may cause the appearance of the changes found. The answer to the question of which factor leads to a change in the size of the nucleolus of PC after clinical death can perhaps be given by autoradiograph studies. However, the results of the present investigation, together with earlier data showing an increase in size of the nucleus and cytoplasm of PC and in their dry weight in the postresuscitation period, allow certain suggestions to be made regarding the nature of the changes observed. It may be that changes in size of the nucleolus of PC revealed in different animals after clinical death of varied etiology are one of the ways by which neurons adapt themselves to anoxia and reflect the process of intracellular reparative regeneration, a universal mechanism of compensation of disturbed functions of the CNS [11, 12].

Analysis of the morphology and function of the PC population thus enables the severity of the degenerative changes and the intensity of reparative changes developing in the rat brain after systemic circulatory arrest caused by ligation of the vascular bundle of the heart to be adequately assessed and it showed that these changes correlate directly with the degree of recovery of the neurologic status of the revived animals.

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