mRNA, is a characteristic feature. For cells of the satellite oligodendroglia, whose activity depends on that of the accompanying neurons, the quantity of reserve RNA ought to be low, as was in fact observed in these cells. Endothelial cells with a very low rate of protein synthesis [2] generally speaking contain only solitary ICG. These facts agree with the results of a study of hyperchromic neurons. Activity of metabolic processes is known to be depressed in the cytoplasm of cells of this type, but RNA accumulates in their nuclei [1]. That is why in hyperchromic neurons during the first few hours after administration of chlorpromazine the newly synthesized RNA, unable to escape into the cytoplasm, must accumulate in the nuclei in its reserve form, namely ICG. The facts examined above thus confirm the hypothesis that ICG has a functional role as the reserve form of mRNA.

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MATHEMATICAL MODEL OF PATHOMORPHOLOGICAL CHANGES IN THE SPINAL CORD DURING PROLONGED COOLING

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No special morphometric investigations or mathematical modeling of the dynamics of adaptive changes in structures of the CNS under the influence of cold could be found in the accessible relevant literature. An important role in adaptation of the body to unfavorable extremal external environmental factors is played by the temperature-sensitive spinal centers [13, 14].

The aim of this investigation was to study and give a mathematical description of pathomorphological changes taking place in structural units (capillary, perineuronal gliocyte, neuron) of the spinal cord of experimental animals during acclimatization to cold.

EXPERIMENTAL METHOD

Altogether 72 experiments were carried out on rabbits weighing 2.5-3 kg. All the animals were divided into two groups (A and B), each of which contained six intact and 30 experimental rabbits. The animals were exposed to cold in a specially equipped chamber at a temperature of between −3 and −5°C and with a relative air humidity of 70-90% for 10-12 h daily for 1, 2, 4, 8, and 12 weeks. At the end of cooling the animals were killed by intravenous air embolism.

After sacrifice of the rabbits of group B their arterial system was injected with a solution of black ink with gelatin [4] in a dose of 50 ml/kg body weight. Autopsy material (segments of the spinal cord) of the experimental and control animals were fixed in 10% neutral formalin solution, and then embedded in paraffin wax in accordance with a unified scheme.

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The spinal cord of rabbits of group A was processed for microspectrophotometry in the usual way [1, 3]. Sections 5 μ thick were stained in a freshly prepared solution of gallocyanin and chrome alum by Einarson's method, experimental and control tissue samples being processed simultaneously and mounted under the same coverslip. Cytophotometry of total nucleoproteins was carried out by the frame method [9] on a scanning cytophotometer in the Laboratory of Light-Optical Methods of Investigation, Research Institute of Human Morphology, Academy of Medical Sciences of the USSR. The mean optical density of the substance was determined in the neuroplasm of 31 motoneurons and the same number of autonomic neurons of the intermediate zone of gray matter of the spinal cord. The results of the measurements were analyzed by the Nairi-K computer, using Student's t test.

Segments of the spinal cord of rabbits of group B were used for histiometric calculations. Neurocellular structures of the gray matter were stained with gallocyanin and chrome alum by Einarson's method in sections 10 μ thick. The circulation in the spinal cord at different stages of whole-body cooling was assessed by calculating the length of the capillary system in 1 mm^2 of tissue in the ventral horns of gray matter (LCSGM) [5] and the analogous index for the fiber systems of the anterior white columns (LCSWC), and also by calculating the area of capillaries per 1 μ^2 area of cross section of neurons in the ventral horns (the MCV index). At the same time the glial index (GI) was determined as in [6] and the perineuronal index (PNI), showing the number of gliocytes per 1000 μ^2 surface area of motoneurons was calculated. Gliocytes located not more than 5 μ away from the motoneuron bodies were classed as perineuronal [8]. The measurements were made with an ocular planimetric grid, consisting of 16 squares with a total number of points of 960.

Each index was measured in 32 fields of vision in the cervical, thoracic, and lumbosacral segments of the spinal cord of each experimental and control animal. Statistical analysis of the numerical results was carried out on the Minsk-32 computer. Empirical series, the individual values of which were equalized by the weighted sliding mean method [10] were constructed from the results of the calculations. On the basis of the equalized data, graphs were plotted and empirical equations determined [2, 7] for the dependence of the morphometric criterion (the function Y) on the duration of total cooling (argument X). Empirical and theoretical series were approximated by calculating coefficients of the equations by the method of least squares on the Promin'-2 digital computer. The equation thus found was regarded as the mathematical model of the systems under analysis provided that values of the empirical series corresponded to the calculated values, and this was verified by calculating the normalized deviation (t), the nonparametric maximum criterion, and the Wilcoxon two-sample criterion (T). Deviation of values of the theoretical and calculated curve was considered to be normal provided that $t < \pm 1\sigma$ and $T > T_{05}$ [2, 11].

EXPERIMENTAL RESULTS

Mathematical models of all the indices studied were represented by a second degree polynomial:

$$Y = A_0 + A_1X + A_2X^2.$$

The dynamics of the acclimatization changes in mean optical density of total nucleoproteins in bodies of motoneurons of the cervical, thoracic, and lumbosacral segments corresponded to equations (1), (2), and (3):

$$Y = 34.172 - 2.40X + 0.22X^2, \quad (1)$$

$$Y = 37.360 - 1.568X + 0.067X^2, \quad (2)$$

$$Y = 28.935 + 1.40X - 0.21X^2. \quad (3)$$

Changes in the analogous index for the autonomic neurons of the intermediate zone of gray matter in the cervical, thoracic, and lumbosacral segments obeyed equations (4), (5), and (6):

$$Y = 34.155 - 2.9X + 0.24X^2, \quad (4)$$

$$Y = 32.782 + 1.014X - 0.125X^2, \quad (5)$$

$$Y = 30.293 + 0.451X - 0.104X^2. \quad (6)$$

Lengthening the period of total cooling (argument X > 12 weeks) will help to maintain the nucleoprotein content in motoneurons of the cervical segment at a higher level than in

the control and to restore normal metabolism in the thoracic segment, whereas in the lumber segment the mean optical density of nucleic acids will fall progressively.

Changes in the intramedullary circulation in the cervical portion of the spinal cord took place in agreement with equations (7) (the LCSGM index), (8) (the LCSWC index), and (9) (the NCV index).

$$Y = 489{,}44 + 16{,}18X - 2{,}60X^2, \tag{7}$$

$$Y = 160{,}68 + 9{,}03X - 0{,}79X^2, \tag{8}$$

$$Y = 0{,}696 - 0{,}0039X - 0{,}0025X^2. \tag{9}$$

According to the relationships obtained, lengthening the period of total cooling leads to a significant decrease in length of the functioning capillaries in the gray matter of the spinal cord.

Mathematical models of the dynamics of LCSGM, LCSWC, and the NCV index in the thoracic portion of the spinal cord are given by equations (10), (11), and (12):

$$Y = 580{,}12 - 20{,}26X + 0{,}80X^2, \tag{10}$$

$$Y = 163{,}77 - 2{,}449X + 0{,}13X^2, \tag{11}$$

$$Y = 0{,}983 - 0{,}064X + 0{,}003X^2. \tag{12}$$

Mathematical models of the dynamics of LCSGM, LCSWC, and the NCV index for the lumbosacral portion of the spinal cord corresponded to equations (13), (14), and (15):

$$Y = 577{,}53 - 32{,}87X + 1{,}71X^2, \tag{13}$$

$$Y = 151{,}42 - 1{,}30X - 0{,}315X^2, \tag{14}$$

$$Y = 0{,}521 - 0{,}0158X + 0{,}0004X^2. \tag{15}$$

In the thoracic and lumbosacral segments of the spinal cord, by contrast with the cervical segments, changes in the intramedullary circulation, as shown by interpolation, were within the limits of the adaptive norm, and no significant circulatory disturbance will subsequently be recorded.

It would be incomplete to estimate the morphological status of units of the spinal cord in the course of prolonged total cooling without making allowance for changes in the glial cells of the gray matter. PNI of the cervical, thoracic, and lumbosacral segments change in accordance with equations (16), (17), and (18):

$$Y = 1{,}86 + 3{,}69X - 0{,}28X^2, \tag{16}$$

$$Y = 5{,}87 + 0{,}96X - 0{,}091X^2, \tag{17}$$

$$Y = 6{,}23 + 0{,}51X - 0{,}062X^2. \tag{18}$$

Active involvement of neurons of the cervical portion in a process of acclimatization to cold led to a sharp increase in the number of perineuronal gliocytes. Fluctuations in the value of PNI in the thoracic and lumbar segments of the spinal cord were within the limits of the compensation zone.

The value of GI changed in the same direction in all parts of the spinal cord. The mathematical description of the changes discovered is given by equations (19), (20), and (21):

$$Y = 4{.}55 + 0{,}685X - 0{,}066X^2, \tag{19}$$

$$Y = 4{.}63 + 0{,}688X - 0{.}067X^2, \tag{20}$$

$$Y = 6{,}90 - 0{,}320X + 0{.}016X^2. \tag{21}$$

Starting with the 4th week of whole-body cooling the number of glial cells falls progressively; the standardized deviation of the parameters of this system becomes less than $-4\ \sigma$, possible evidence of predominance of pathological shifts in the system under analysis [2].

On the basis of this investigation the cervical segments of the spinal cord can be classed as a zone of "increased risk" of development of unfavorable metabolic and circulatory disturbances in this part of the CNS under the influence of cold. Accumulation of nucleoprotein in an increased amount in the bodies of neurons in the cervical portion of the

spinal cord confirms at the micromorphological level the presence of secondary temperature-sensitive centers in this region [13] and also is evidence of the development of lasting cold adaptation and the formation of an "autonomic memory" [12, 15] in some of the preserved neurons.

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