QUANTITATIVE ESTIMATION OF MORPHOLOGICAL CHANGES IN THE CENTRAL NERVOUS SYSTEM

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A quantitative method of estimating the degree of morphological changes in neurons of the CNS is suggested. The following groups of altered neurons are distinguished: a swollen neuron with initial signs of breaking up of tigroid masses, a swollen neuron with marked evidence of breaking up of tigroid masses and initial signs of hypochromatosis, a swollen neuron with total tigrolysis and with hyper- and hypochromatosis, a dehydrated hyperchromic neuron, a vacuolated neuron, a shrunken, atrophic neuron, and a dying neuron. For a more precise and objective assessment of the observed changes, each of these groups is given a certain number of points characterizing the degree of the morphological changes. A formula is suggested for evaluating the degree of morphological changes for different formations and zones of the CNS.

KEY WORDS: CNS; neurons; point scale.

Methods of quantitative investigation are becoming increasingly important at the present time in biology and pathology. Quantitative analysis gives a fuller and more objective assessment of morphological changes in structures in different pathological and physiological states [1].

This paper describes an attempt to use quantitative methods to characterize the state of individual formations of the CNS.

The method described by Chibunidze [5] was used as the basis. This worker gives a formula for calculating the volume, severity, and degree of a CNS lesion by distinguishing four groups of altered neurons: the "unchanged neuron (UN), the slightly changed neuron (SN), the grossly changed neuron (GN), and the absent neuron (AN)."

The formulas given by Chibunidze for calculating the volume of the lesion (VL), the degree of the lesion (DL), and its severity (SL) reflect the character of the pathological changes sufficiently objectively. However, when gross changes in neurons are absent, these formulas do not give a sufficiently accurate estimate of the character of the changes observed. By distinguishing only three groups of affected neurons (AN, GN, SN), Chibunidze attaches importance primarily to grossly altered and absent neurons when estimating SL, as is clear from the formula he gives for determining DL:

$$DL = \frac{(2AN + 2GN + SN) \times 100\%}{2(UN + AN + GN + SN)}.$$

This approach is perfectly justified whenever severe destructive processes take place in the CNS. In other cases, when mainly reversible states of the nerve cells are present, a more accurate quantitative evaluation of the morphological changes is necessary.

For this purpose the writer proposes increasing the number of groups of altered neurons by giving each of them an empirically determined coefficient of the degree of change

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TABLE 1. Quantitative Characteristics of Neurons, in Points

Characteristics of neuron	Score (in points)	No. of neurons in groups
Normal neuron	1	*a*
Initial signs of swelling and tigrolysis	2	b
Marked signs of swelling and tigrolysis	3	c
Severe swelling, total tigrolysis	4	d
Dehydrated neuron	5	e
Vacuolated neuron	5	f
Atrophic neuron	6	g
Dying neuron	6	h

(a point rating).

Using Beletskii's classification [2-4], the writer distinguishes the following groups of altered neurons: a swollen neuron with initial signs of breaking up of the tigroid masses; a swollen neuron with marked signs of breaking up of the tigroid and initial signs of hypochromatosis; a swollen neuron with total trigolysis and with hyper- and hypochromatosis; a dehydrated hyperchromic neuron; a vacuolated neuron; a shrunken atrophic neuron, and a dying neuron (i.e., with remnants of its body or with a residual nodule).

Coefficients reflecting the degree of change in a neuron for each of the groups named above are given in Table 1.

It is accordingly possible to deduce a general formula expressing the degree of morphological changes in a formation or zone of the CNS as a whole:

$$DC = \frac{(2b + 3c + 4d + 5e + 5f + 6g + 6h) \times 100\%}{a + 2b + 3c + 4d + 5e + 5f + 6g + 6h},$$

where DC is the degree of the morphological changes, and the letters "a, b, c,..., h" represent the number of neurons of the corresponding groups as given in Table 1.

This formula can be written in a simplified form:

$$DC = \frac{C \times 100\%}{A},$$

where C = 2b + 3c + 4c + . . . + 6h, and A = C + *a*.

A concrete example of the use of this formula is given by the morphological analysis of the action of chlorpromazine on the CNS. The changes thus arising in the neurons are mainly reversible in character.

After administration of chlorpromazine in a single daily dose of 10 mg/kg the following values for the named groups of neurons were found in the sensomotor cortex of albino rats: *a* = 68, b = 55, c = 33, d = 12, e = 0, f = 1, g = 0, and h = 0. Substituting these values in the formula we obtain:

$$DC = \frac{(110 + 99 + 48 + 5) \times 100\%}{68 + 110 + 48 + 5} = 78\%.$$

If the same daily dose was spread out over 3 days, the following values were obtained for the corresponding groups of neurons: *a* = 30, b = 35, c = 43, d = 22, e = 0, f = 1, g = 0, and h = 0; hence

$$DC = \frac{(70 + 129 + 88 + 5) \times 100\%}{30 + 70 + 129 + 88 + 5} = 93\%.$$

In this case the degree of the morphological changes was 15% higher than in the previous case.

Experience with the use of this formula shows that it is suitable for case when mainly reversible morphological changes in the CNS are under consideration.

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