THE EFFECT OF UNILATERAL DECORTICATION ON CALCIUM METABOLISM IN THE CENTRAL NERVOUS SYSTEM

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For many years (1934-1958), in Prof. É. A. Asratyan's [1] laboratory, various reflexes were investigated in dogs after extirpation of the cerebral cortex. In these investigations studies were made of the changes in the general functions of the body after total decortication, and in the functions of symmetrical organs after unilateral decortication. There is no doubt that all the disturbances after unilateral decortication are associated with definite changes in the functional state and activity of those nervous structures which are actually responsible for controlling the work of the corresponding organs, i.e., which carry out the reflex regulation of the body functions. On the basis of much research proving beyond doubt the close relationship between physiological and biochemical processes [4, 10, 14, and others], it would be reasonable to expect some form of disturbances in the chemical activity of the nervous centers after extirpation of the cortex of one hemisphere. It would also be reasonable to postulate changes in the relationship between the nervous tissue and various neurotropic elements – calcium, in particular.

The aim of the present research was to study the changes in the calcium metabolism in different areas of the central nervous system after unilateral decortication by means of the radioactive isotope Ca^{45}. We chose this indicator of the biochemical disturbances in the nervous system after decortication in view of the undoubted importance of the calcium ion in fundamental nervous processes [7, 8, 9, 11, 18, 19].

EXPERIMENTAL METHOD

Experiments were carried out on rabbits of both sexes, weighing from 1900 to 3000 g. In each experiment three rabbits were used: one after decortication, one after trephining, and the third as a control. All the animals were taken at the same time from the nursery and kept under identical conditions. The operations of decortication and trephining in all the experiments were performed on the right side. The interval between operation and experiment was 37-43 days. Three hours before the rabbits were sacrificed, all received intravenous injections of a solution of $Ca^{45}Cl_2$. Altogether, nine experiments were performed on 27 animals. The isotope was injected in a dose of 100 μC/kg body weight. Three hours after the injection of Ca^{45} the rabbits were sacrificed by means of air embolism. Weighed samples of the right and left halves of the diencephalon, the midbrain, the medulla, the cerebellum, and the spinal cord were transferred to porcelain crucibles and incinerated in a muffle furnace at a temperature of 800°. To the dry residue after incineration was added 0.2 ml HCl (1:1), and to this solution, distilled water to a volume of 1 ml. From the solution thus obtained two targets were prepared for counting, and to each of them 0.2 ml of this solution was applied.

The activity of each target was determined twice (for 4 minutes) with an end-type counter on a "B" apparatus. The number of impulses in a weighed sample of brain was calculated per g of fresh tissue. At the same time the activity of the serum was determined, having been obtained by means of a syringe from the heart before the animals were sacrificed.

EXPERIMENTAL RESULTS

The object of the research was to ascertain the effect of the operation of unilateral decortication on the calcium metabolism in the central nervous system by comparison with that in an animal after unilateral trephining and an intact animal. This was done by comparing the level of Ca^{45} in corresponding divisions of the brain and spinal cord of the animals of all three groups; the radioactivity of the right halves of the brain structures taken for the experiment from the intact rabbit was compared only with the radioactivity of the right halves from the trephined and decorticated rabbits, and this was done in the same way with respect to the radioactivity of the left halves of the corresponding divisions. Table 1 shows how the accumulation of Ca^{45} in the structures of the nervous system on either side was altered after the operations of unilateral trephining

TABLE 1. Ca^{45} Content (in imp/min/g) in Various Divisions of the Central Nervous System of Rabbits 3 Hours after Intravenous Injection of $Ca^{45}Cl_2$

Division of the CNS	Right (operated) side			Left (unoperated side)		
	decortication	trephining	control	decortication	trephining	control
Spinal cord	2 220±113	1 930±272	1 875±151	1 960±109	2 362±349	1 800±136
Medulla oblongata	3 032±155	2 118±132	2 258±158	2 728±194	2 505±241	2 241±109
Midbrain	2 368±132	2 034±130	2 173±159	2 160±90	2 033±134	2 097±174
Diencephalon	2 350±145	1 800±124	1 845±171	2 113±218	1 807±235	1 877±112
Cerebellum	2 531±307	1 984±149	2 015±230	2 118±325	2 102±235	2 045±150

TABLE 2. Ratio of Radioactivity of the Right Side of Divisions of the Central Nervous System to Radioactivity of the Left Side in a Rabbit 3 Hours after Intravenous Injection of the Radioactive Isotope of Calcium

Division of the CNS	Decortication	Trephining	Control
Spinal cord	1.13±0.090	1.02±0.074	0.99±0.080
Medulla oblongata	1.14±0.107	0.95±0.052	1.0 ±0.054
Midbrain	1.11±0.058	1.00±0.033	1.05±0.055
Diencephalon	1.33±0.087	1.0 ±0.05	0.99±0.073
Cerebellum	1.25±0.14	1.03±0.08	1.05±0.08

and decortication, by comparison with the initial level in the intact rabbit.

It is easy to observe that after the operation of decortication the Ca^{45} content increased both on the right (operated side) and on the left (unoperated side); the increase observed on the left, however, was much more weakly expressed. The operation of trephining was not followed by any lasting changes in the calcium metabolism. It can be seen from the results in Table 1 that there was no sharp difference between the various brain formations in their Ca^{45} content, if no account be taken of the fact that the medulla showed a tendency toward an increase, and the spinal cord a tendency toward a decrease, in the content of radioactive isotope from the mean level.

By means of a different treatment of the results obtained, however, it was possible to show how there was a considerable asymmetry in the accumulation of Ca^{45} within each division between the half lying on the side of the operation, and that on the unaffected side. For this purpose the Ca^{45} content of one side of each division of the brain was taken as unity, and the ratio between the total Ca^{45} of the opposite side and this quantity was calculated. It is clear that if no asymmetry exists within the limits of the brain structure under consideration, this ratio will be equal to unity, as was observed in the control rabbits. It may be seen from Table 2 that the operation of decortication disturbed the equilibrium existing before operation: the ratio between the Ca^{45} content of the operated side and that on the unoperated side in all divisions was greater than unity – in the spinal cord it was 1.13, in the medulla 1.14, and so on. In the trephining experiments no statistically significant changes in the calcium metabolism were found. The different divisions of the central nervous system reacted differently to unilateral decortication. The most obvious changes were found in the diencephalon, followed by the cerebellum, the medulla, the spinal cord, and the midbrain.

As a result of these experiments it may be stated that unilateral extirpation of the cerebral cortex led to an increase in the accumulation of Ca^{45} in the subjacent divisions of the central nervous system, mainly concentrated on the side of operation. Changes in the calcium concentration are known to affect the working of the nervous system as a whole, both central and peripheral [12, 13, 15, and others]. Not without reason is the calcium system one of the most stable in the body [17].

In its turn, an increase in the calcium metabolism in the nervous system, in response to some influence acting upon it, is a part of the reaction of the nervous tissue to the agent concerned. The paralyzing, depressing action of the calcium ion, the properties of which have been widely employed in medical practice, and also the tendency of the nervous tissue to retain calcium in the brain during narcosis, suggest that a close relationship exists between calcium and the process of inhibition [6].

On the basis of these data and the results of our own experiments, we consider that the accumulation of Ca^{45} in the brain after unilateral decortication reflects the similarity between the process taking place during artificial or natural sleep, or depression, and the state in which the subjacent nervous centers are found after operation. The theoretical basis of this hypothesis is Pavlov's idea of protective inhibition, developed by É. A. Asratyan, who postulated that protective inhibition is a universal reaction of the nervous system in both functional and organic disorders.

The differences in the accumulation of Ca^{45} in the divisions of the central nervous system that were tested are regular, and are evidently due to their distinctive structural and biochemical features, which have developed as a result of long evolution. Only guesses may be made regarding the true role of the accumulation of Ca^{45} in inhibited structures. That this is a beneficial phenomenon is clear from the very meaning of the process accompanying the calcium ion. It is possible that the calcium ion, with its many functions, has yet another, connected in some manner with the beneficial aspect of the action of the inhibition process.

SUMMARY

The effect of unilateral decortication and trephining upon the calcium metabolism in the diencephalon, mesencephalon, medulla oblongata, cerebellum, and spinal cord was studied by a radioactive method. Experiments were conducted 40 days after the operation. The results of experiments demonstrated that decortication induces a rise of radiocalcium accumulation in these nervous formations, mainly concentrated at the site of operation. No statistically significant changes were revealed after trephining.

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