CERTAIN CONSEQUENCES OF DESTROYING THE CAUDATE NUCLEI IN RABBITS AND DOGS

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One of the main tasks of physiology is to investigate the role of the basal ganglia. There is a mass of literature on this subject. Scientists are especially interested in the function of the striate body [1-7 and others], and particularly, in the function of one of its nuclei (nucleus caudatus).

In recent years, a series of authors have discovered new facts indicating that the caudate nuclei evidently send inhibitory and stimulating impulses to the cerebral cortex [8, 9, 10]. There are indications in the literature that the caudate nuclei are related to conditioned reflex activity [11, 12]. Nevertheless, the physiological role played by the separate nuclei of the striate body has not yet been clearly established. This prompted us to investigate the functional importance of the caudate bodies. For this purpose, we chemically caused unilateral and bilateral destruction of the caudate nuclei in rabbits and dogs and examined the consequences of our intervention.

EXPERIMENTAL METHODS

In our experiments, we first used an injection of alcohol, to which colophony was added to increase the viscosity, to destroy the subcortical nuclei. However, even the addition of the colophony did not completely prevent the alcohol from spreading and diffusing through the brain matter, which could cause an undesirable stimulating effect. Therefore, we used melted paraffin for this purpose in later experiments. With the localized destruction of the subcortical nuclei by such a method, conditions were created which were somewhat analogous to those attending a brain tumor (as, for example, pressure on the adjoining tissue).

Paraffin, at a temperature of 80-100°, was taken up into a hypodermic and injected in small amounts into the region of the caudate bodies (about 0.03 ml was injected into the rabbits, from 0.05 to 0.2 ml into the dogs). In the dogs, the injection was done through a puncture in the cerebral cortex at the level of gyrus cruciatus posterior. After this method had been developed in short experiments, we went on to study the consequences of destroying the caudate nuclei in long experiments. The operation was done on the dogs under morphine-ether-chloroform anesthesia, in the rabbits, under a local novocain anesthetic. The animals were observed for different periods of time (from 2 weeks to 3-6 months), depending on the conditions of the experiment, and then killed; their brains were examined pathoanatomically and, in some cases, histologically.

EXPERIMENTAL RESULTS

Experiments on rabbits. The caudate nuclei were unilaterally destroyed in 6 rabbits, bilaterally, in 7 rabbits. A control operation was done on three rabbits (cranial trepanation and two symmetrical punctures of the cerebral cortex). A total of 16 animals were observed. After the operation (Fig. 1), in the rabbits with bilaterally destroyed caudate nuclei, one could detect slight locomotor disturbances manifested by the "falling to pieces" of the paws in a jump and rather clumsy movements, which, 1-2 weeks after the operation could only be observed when the rabbits were on a slippery floor. A certain decrease in the tonicity of the leg muscles

was observed in the animals. The thresholds of the flexor reflex to an induced current were raised, but only during the first few days after the operation. There were no definite changes in the respiration and arterial blood pressure. Certain peculiarities in the general behavior of the animals appeared after bilateral destruction of the caudate nuclei. During the first days after the operation, the orientation reaction to the environment either became very weak or disappeared entirely in the rabbits. They sat passively in one place; if they were moved from this position, the animals often dashed off wildly (especially when tactile stimulation was employed) and hid in a corner.

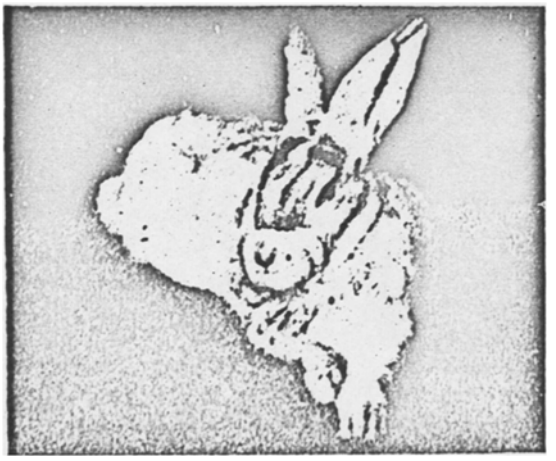

Fig. 1. Rabbit with caudate nucleus on right side destroyed shown the 5th day after the operation.

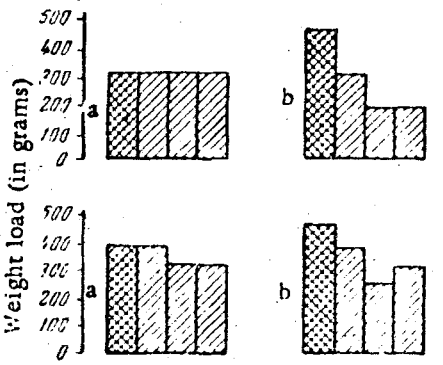

Fig. 2. Change in extensor tonicity of the muscles in Ace after destruction of the caudate nucleus on the left side.
I) anterior paws; II) posterior paws; a) left; b) right. Crosshatch) measurement before operation; slanting lines) measurement after operation; on the day of the operation and 7 and 14 days after it.

After unilateral destruction of the caudate nuclei, we often observed asymmetrical positions of the rabbits' head and body (bent towards injured side). Their movements were selectively orientated towards the injured side. On the opposite side of the body, the paws (especially the anterior one) were often in a semi-extended position, although the rabbits could easily pull them back into the normal position. The flexor reflex thresholds of these extremities were usually raised immediately following the operation, but returned to the preoperation level by the 2nd-3rd day.

Experiments on dogs. Five dogs were experimented upon; one dog was used as a control and, of the other four, two had unilateral destruction of the caudate nuclei and two, bilateral while the control dog received only cranial trepanation and surface punctures of the cerebral cortex.

No sharp locomotor disturbances were observed in the dogs Ace and Little Yellow (February 18, 1954 and April 13, 1954) after unilateral damage to the caudate nuclei (0.05 of melted paraffin injected). They walked and ran well. We noted a decrease in the extensor tonicity of the leg muscles on the side opposite the operation which was evident both visually and when the tonicity was measured with Shpigel's apparatus Fig. 2). The flexor reflex thresholds of these extremities to an induced current were raised during the first 2 days after the operation. The deep sensibility of these extremities was disturbed.

The dogs were observed for two weeks after the operation. After this period, the disturbances described had still not yet been fully compensated, but were considerably less expressed. The animals were killed $2\frac{1}{2}$ months after the trauma. Histological examination of the brain showed that a considerable part of their caudate nuclei had been destroyed and that there was cell degeneration in the remaining part (Fig. 3).

In the other two dogs, Gypsy and Mushroom, the caudate nuclei were bilaterally destroyed.

The animals were observed for a long period before the operation, but only one was systematically examined (Mushroom), as the second dog was extremely excitable. Clear conditioned reflexes to light were developed in both dogs, and, in Mushroom, a differentiation was also developed. We used an electric current as an unconditioned reinforcement. Mushroom was operated upon on July 24, 1954 and Gypsy, August 18, 1954.

After the operation, we observed a certain decrease in tonicity and change in the deep and cutaneous sensibility in Mushroom. In Gypsy, stiffness of movement was observed 1-2 weeks after the operation.

The conditioned reflexes were retained in both dogs, although their magnitude decreased somewhat, particularly during the later periods after the operation.

For example, in Mushroom, 2-3 months after the operation, the conditioned reflex was often delayed, sometimes there was no reaction to either the conditioned or unconditioned stimuli; the motions were slow, the paw being raised "in stages" (Fig. 4).

Fig. 3. Frontal section of the left cerebral hemisphere in Ace.

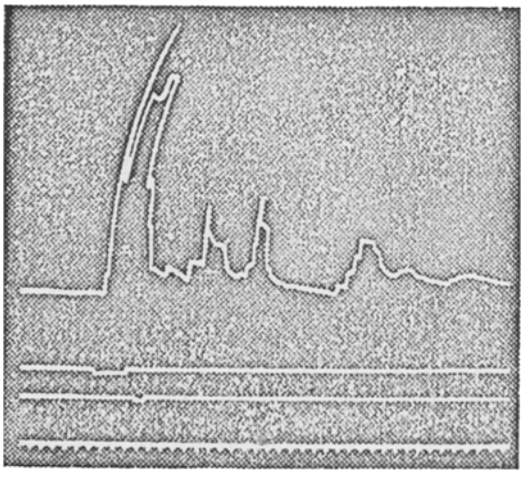

Fig. 4. Graduated character of conditioned motor reaction in Mushroom. Curves from top to bottom show: paw movement, indication of conditioned stimulation, indication of unconditioned stimulation, indication of time (in 1 second marks).

Hyperesthesia to tactile stimulation developed in both animals. No changes were observed in general behavior and locomotion in the control dog (with the cranial trepanation and punctures of the cerebral cortex).

Gypsy was killed 2½ months and Mushroom 7 months after the operation. Pathologicoanatomical and histological examinations of the brain showed that the paraffin had destroyed most of the caudate nucleus in Gypsy's left hemisphere; there was less damage to the caudate nucleus in the right hemisphere, but the remnant of the caudate nucleus was degenerating due to hydrocephalus of the ventricle. In Mushroom, there was pronounced bilateral degeneration of the cellular elements of the caudate nucleus.

We consider the above experimental data obtained from rabbits and dogs to be preliminary. One can nevertheless make certain conclusions from these data with a view to outlining the course of further study. The consequences described which result from the destruction of the caudate nuclei should apparently be considered both as symptoms of disassociation and as symptoms of stimulation – a combination which is often clinically found in various diseases (usually with tumors) of the subcortical ganglia.

SUMMARY

The consequences of destruction of the caudate nucleus were studied in rabbits and in dogs. Injections of molten paraffin into the above subcortical formation were used for that purpose (the puncture was performed through the brain cortex). It was considered that this may bring about disturbances similar to those which appear in brain tumors.

It was demonstrated by the results of these experiments that the delicate function of motor coordination was disturbed in local destruction of the larger portion of the caudate nucleus. Sensitivity, both cutaneous and

proprioceptive was, likewise, disturbed. Characteristic changes appeared in the animals' behavior. Conditioned reflexes were disturbed in rabbits, as well as in dogs.

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