CONDITION OF THE CEREBELLAR NUCEI AFTER EXTIRPATION OF THE CORTEX AND THE TOTAL REMOVAL OF ONE OF THE CEREBRAL HEMISPHERES

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Destruction or removal of parts of the cerebral cortex influences the condition of various parts of the central nervous system and gives information concerning the connections of these parts with the corresponding cortical regions.

We have set out to find to what extent removal of parts of the cerebral cortex or total removal of one hemisphere affects the condition of the cerebellar nuclei; we have also used this method to determine the connection between the cerebral cortex and the cerebellar nuclei.

It has been reported that the vermis develops earlier than the cerebellar hemispheres, which, according to Edinger [6], represent a comparatively recent addition–the "neocerebellum." The cerebellar hemispheres are quite well developed in monkeys, but achieve their greatest development in man.

I. O. Klimov [2] has shown that the central white matter of the cerebellum is formed from fibers which enter it from all parts of the cerebellar cortex and from the three cerebellar peduncles. Also, in the white matter of the cerebellum, there are isolated groups of nerve cells known as the cerebellar nuclei. The structure has been described in this way in the works of Ingvar [9] and Jakob [10]. Demole [5], studying the dentate nucleus of man, the chimpanzee, and the macaque monkey, has found that the dentate nucleus was connected to the cerebrum through the red nucleus and corpora quadrigemina.

There are various opinions on the decussation of the superior cerebellar peduncles. Some authors [13, 14] maintain that the decussation is complete, whereas others [12] consider it partial and maintain that, after the decussation, the fibers terminate in the opposite red nucleus.

Some authors [1, 7, 13] have pointed out that the fibers of the superior cerebellar peduncle terminate in the thalami. Held [8] supposed that these fibers proceed further and terminate in the subcortical ganglia and ultimately in the cerebral cortex. Meynert [11] showed that the connection between the cerebellar cortex and the cerebral hemispheres was crossed, and demonstrated a connection between the superior peduncles and the gray matter of the dentate nucleus.

After removal of the cerebellum from cats, Brodal and Gogstad [3] found retrograde degeneration of the neurones in the red nucleus. After destruction of the dentate nucleus, they found the same number of degenerating cells in the red nucleus as when the whole cerebellum had been removed. These degenerative changes were found chiefly on the opposite side. Cooke and Snider [4] stimulated various regions of the cerebellum in cats and found a change in the electrical activity of both the motor and sensory cerebral cortices.

However, these authors left unsolved the question of the connection between the cerebellar nuclei and the cerebral cortex. They made no histological studies of the cerebellar nuclei after extirpation of the cerebral cortex or after total removal of one hemisphere, so that no information concerning the condition of the cerebellar nuclei was available.

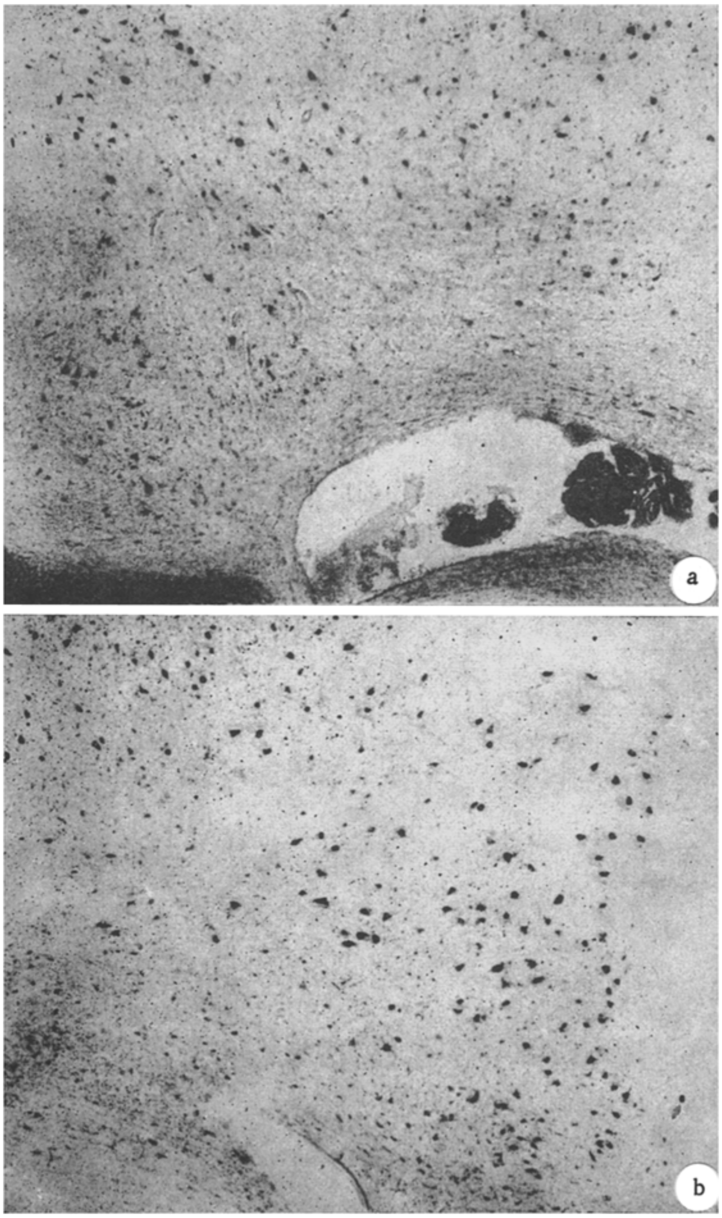

Fig. 1. Dentate and emboliform cerebellar nuclei after removal of the left cerebral hemisphere. a) Right cerebellar hemisphere. Considerable rarefaction of the dentate nucleus; b) left hemi - sphere. No rarefaction. 2 cm micro-Summar lens. Extension of bellows 40 cm.

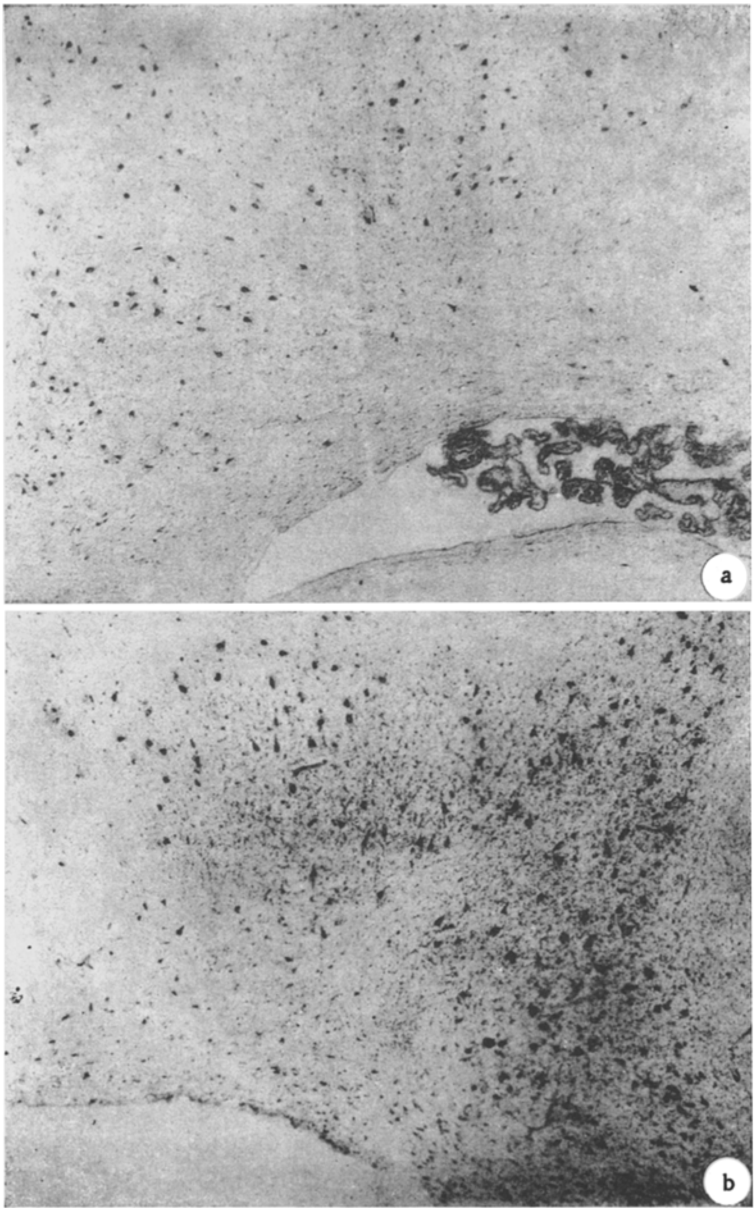

Fig. 3. Cerebellar dentate and emboliform nuclei after total removal of the left cerebral hemisphere. a) Right cerebellar hemisphere. Considerable rarefaction of the dentate and emboliform nuclei; b) left hemisphere. No rarefaction. Photography as in Fig. 1.

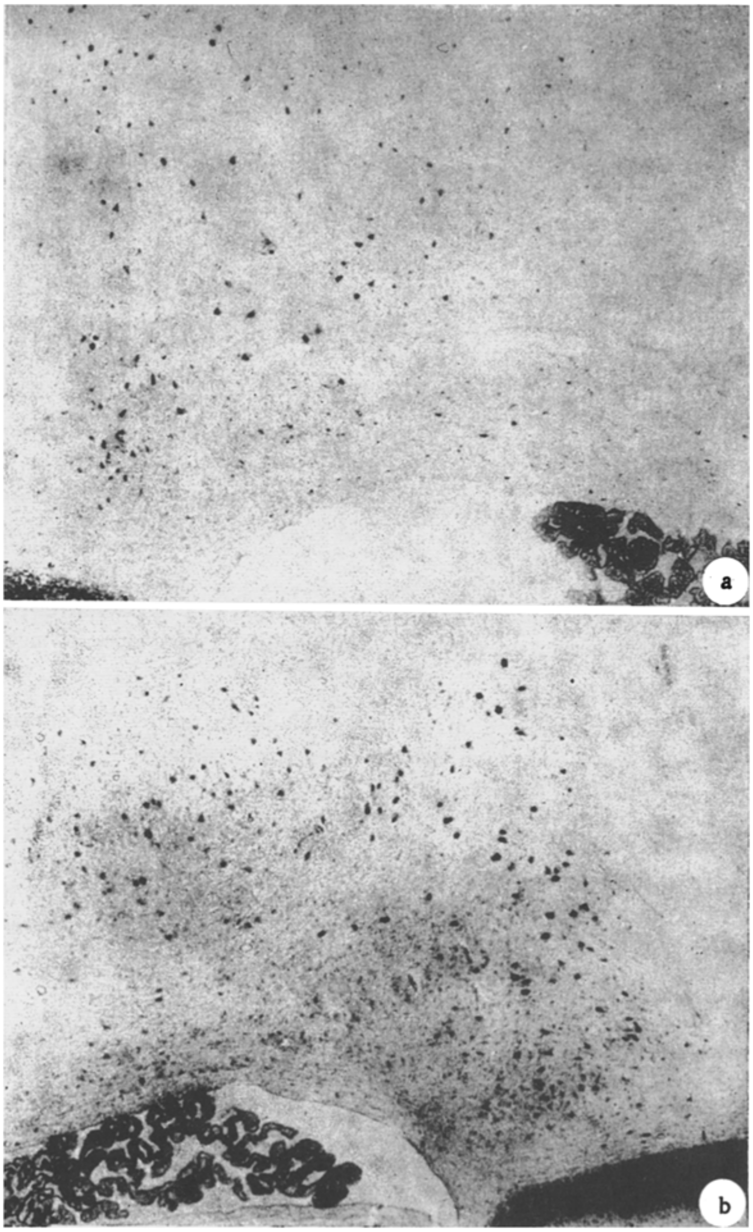

Fig. 2. Dentate nucleus and emboliform nucleus of the cerebellum after removal of the cortex first from the right and then from the left cerebral hemisphere. a) Right, b) left cerebellar hemisphere. On both sides the dentate nucleus is reduced, though there is a greater loss of cells from the right side. Photography as in Fig. 1.

EXPERIMENTAL METHOD

The experiments were carried out on cats. Because of the extent of the trauma and the complexity of the operation on the brain, only 13 animals out of a large number survived. Normal cerebellar nuclei were studied in four cats.

The operation consisted essentially in the removal of various regions of the cortex either from one or from both cerebral hemispheres; the total removal of one hemisphere entailed extirpation of the whole cortex, the underlying white matter, the corpus striatum, and the thalamus.

We carried out three series of experiments: in the first, the left or right hemisphere was removed from 5 cats; in the second, initially one hemisphere was removed from each of 2 cats, then the second was removed from one of them after 71 days, and from the other after 95 days; in the third set of experiments on 6 animals, one hemisphere was extirpated entirely.

The cats were killed with large doses of chloroform at various times from 7 to 527 days after the experiment. In the post mortem examination the cerebellum was removed intact and fixed in alcohols of increasing strength. It was embedded in celloidin, sections 15-20μ thick were cut, and every fifth section was stained in Nissl, van Gieson, or in hematoxylineosin. Retrograde degeneration of the neurones in the cerebellar nuclei was studied.

EXPERIMENTAL RESULTS

Between 20 and 30 days after the operation, in cats of the first group no cytoarchitectonic changes could be observed in the cerebellar nuclei. However, after 135 days, there was some loss of tissue from the dentate nucleus on the side opposite the operation. Later, after 298 days and even more so after 528 days, there was still further loss of nerve cells from the dorsomedial part of the dentate nucleus, and glial cells had increased in this region on the side opposite the operation (Fig. 1).

In the second set of experiments, 85 days after the first operation and 14 days after the second, it was found that the nerve cells had become more sparse in the dentate nucleus both sides, though the effect was more marked on the left.

This change had become more pronounced on both sides 526 days after the first operation and 431 days after the second operation. The loss of nerve cells from the right dentate nucleus on the side opposite the site of the second operation was the more marked (Fig. 2).

In the third set of experiments, no cytoarchitectonic changes of the cerebellar nuclei were observed seven days after the removal of the cerebral hemisphere. However, 215, 237, and 246 days after removal of the one hemisphere, on the opposite side there was a considerable loss of nerve cells, not only from the dorsomedial part of the dentate nucleus also from its ventrolateral regions. In the emboliform nucleus on the side opposite to the operation, there was also a loss of nerve cells. Rarefaction of the dentate and emboliform nuclei was observed at periods as long as 448 and 490 days after the operation (Fig. 3).

These experiments showed that after removal of cerebral cortex there was a loss of nerve cells from the dorsomedial part of the dentate nucleus when the whole of one hemisphere was removed, there was a loss in the ventrolateral region of this nucleus. In animals from which the whole of one cerebral hemisphere had been removed, there was a loss, not only from the dentate nucleus, but also from the emboliform nuclei.

These results show that there is a direct connection between the nuclei and the cerebral cortex. Probably the connection of the dentate and emboliform nuclei is made by several neurones (indirect connection), and runs to the cerebral cortex of the opposite side.

It should be noticed that no changes were found in the nucleus globosus, which, in cats, consists of a small number of nerve cells lying close to the emboliform nucleus. In the fastigial nucleus, no changes were found in any of the experiments.

Thus, microscopical study of sections of the cerebellar nuclei of cats has allowed us to establish that no disturbances occur on the operated side. Nevertheless, on the opposite side there is a loss of cells due to retrograde degeneration of neurones causing cytoarchitectonic changes in the cerebellar nuclei.

Changes in the nerve cells of the cerebellar nuclei were studied at various times after damage inflicted at operation. The most marked changes did not occur until long after the extirpation. The conclusion is that there may be a direct connection between the cerebral cortex and the dentate and emboliform cerebellar nuclei.

SUMMARY

Comparatively little work has been done on the relationship of the cerebral hemispheres and cerebral cortex to the cerebellar nuclei, and we have contributed to this study. After extirpation of various portions of the cerebral cortex, or of one of the cerebral hemispheres, microscopic examination of cerebellar sections demonstrated a disturbance in the cerebellar nuclei occuring at various times. There was a loss of nerve cells from the dentate nucleus on the side opposite the extirpated cortex or extirpated hemisphere.

Loss of nerve cells from the emboliform nucleus occurred only when the whole of one cerebral hemisphere had been removed, and again the change was on the contralateral side. These results indicate an indirect connection between the cerebral cortex and the dentate and emboliform nuclei

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