NEW METHODS

TWO METHODS OF ISOLATED BILATERAL DESTRUCTION OF SUBCORTICAL STRUCTURES NUCLEUS CAUDATUS AND PUTAMEN

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A model of bilateral isolated destruction of the nuclei of the striate system may be essential for the study of their function which to this day has not been fully clarified. Without such a model it is quite impossible to know the character of the interrelationships existing between the cerebral hemispheres and the nearest subcortical structures – the striate system.

Cases in which the striate nuclei become involved in pathological processes terminating fatally are not of value in answering the question put above. The subcortical nuclei and especially the striate system have wide compensating capacities: the functions of the excluded nucleus of the one side of the brain can be replaced by the action of the same nucleus of the other side. To determine the function of these nuclei one must have complete bilateral ablation by the pathological process. This pathological process has to either destroy them fully or else destroy their function by way of stimulation.

Clinically one sees destruction of either a portion of one or the other striate nucleus or else, when they are completely destroyed, there is also involvement of adjacent tracts and nuclei including also cerebral hemisphere damage.

Disease of one of striate nuclei – globus pallidus – is associated with appearance of compulsive movements – hyperkineses, thus there is ascribed to this nucleus a participation in the function of movement. Two other nuclei of the striate system: nucleus caudatus and putamen – are thought to exert an inhibitory effect upon the globus pallidus.

I. P. Pavlov indicated how important the "near subcortex", as he called it, was for the proper functioning of the cerebral hemispheres. However, it is not clear to this day precisely what role these nuclei play in the processes of the highest nervous activity.

To the present there has not existed a method for having a model in animals where the subcortical structures would be ablated without simultaneous damage to the cerebral cortex.

We were able to develop two methods based on different principles. These methods permit total ablation of the nucleus caudatus bilaterally without damaging the substance of the cerebral hemispheres.

One method depends on surgical extirpation of the nucleus caudatus. The other method permits the removal of the nucleus caudatus or the putamen by means of clipping or coagulating the blood vessels supplying these structures.

EXPERIMENTAL METHODS

1. Bilateral extirpation of the nucleus caudatus surgically*

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Puppies ages 2 to 5 months or dogs ages 6 to 7 months were placed as a preliminary on a dry diet. The animals were subjected to morphine-Barbamyl narcosis. The incision was made through the skin of the head in the midline from the frontal notch to the occiput. In the posterior frontal and anterior parietal region the periosteum was scraped and rongeur forceps used in the indicated region to make a trephine opening 2.5 x 2.5 cm in size. Bone bleeding was checked by use of surgical wax.

The special nature of this operation is that the bone of the skull is removed above the longitudinal venous sinus by crossing our midline incision for 3-4 mm. The greater part of the trephine opening 2.5 x 2 cm is on the side where the operation is to be performed (in our procedures, the right).

The dura mater was incised in such a manner that the base of the flap was at the longitudinal sinus. On the two parietal veins, as they entered the longitudinal sinus or a couple millimeters prior to that, in the dura mater there were placed ligatures with subsequent coagulation with the tip of an electrocautery. Then, a broad retractor was used to push the left cerebral hemisphere to the left until the corpus callosum came into view along with the vein of the corpus callosum which traverses it. The corpus callosum was then incised longitudinally, somewhat to the right of the midline. Such an incision gives entry to the right ventricle. A curved spatula was used to elevate the upper wall of the ventricle, this permitting the sight of the head and body of the caudate nucleus.

Fig. 1. Frontal section of puppy brain. Both caudate bodies have been removed by means of this operation.

The substance of the caudate body was scooped out by use of a bone spoon, the depth of the ventricle being lighted by a special lamp. The experimenter removing the caudate nucleus used a lens magnifying 2.5x during this stage of operation. By using care, the fibers of the internal capsule were left undamaged. The slight bleeding occurring during the scooping out operation was readily checked by means of pledgets of cotton soaked in warm saline solution. Having removed the caudate nucleus from the right side, the left caudate nucleus was extirpated by an analogous procedure. At the end of the operation the portion of the brain exposed by the trephine opening was covered by a fibrin sheet, this minimizing scar formation. The flap of the dura mater was then sewed over this sheet. The animals survived this operation well, and could then be followed for years later as a long-term experiment.

Figure 1 shows the total ablation of the caudate nuclei with preservation of the fibers of the internal capsule resulting from this operation.

2. Removal of nucleus caudatus or putamen by means of application of clips or coagulation of arteries supplying these structures *.

In order to coagulate the basal arteries supplying the nucleus caudatus and putamen we used the route introduced into experimental animal surgery where the side (temple) approach is utilized in the dog. The skin incision is made half way between the eye and ear of the dog, along the temporal muscle. This muscle is incised on a slant down to the bone. The skull arch and coronary process of the upper jaw were removed. The edges of the temporal muscle were spread with a Jansen retractor, thus exposing the temporal surface of the skull. In this region the bone was trephined, baring the parietal frontal region of the brain above the Sylvian fissure. The dura mater was then opened. The brain was elevated with a spatula exposing the olfactory tract with the sulcus endorhinalis which served as an orientation marked during further surgery. Our investigations have established that the arteries supplying the nucleus caudatus, putamen and internal capsule enter the brain in this sulcus endorhinalis (branches of cerebri mediae) or just below it (branches cerebri anterior). When this part of the brain was exposed as described, either group of arteries or both could be coagulated, a magnifying lens being used.

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Fig. 2a. Basal area of the surface of the large dog brain. The dotted lines enclose the area where the striate arteries were coagulated as they entered the brain substance.

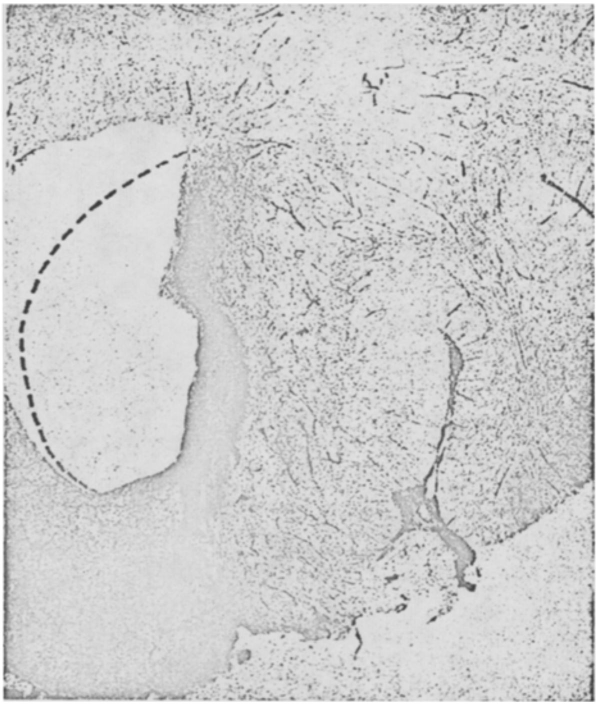

Fig. 2b. Frontal section through puppy brain in animal subjected to coagulation of the striate group of arteries. The caudate nucleus underwent necrosis. The blood vessels of the brain were injected with India ink. The dotted line outlines the disappearance of the necrotized nucleus caudatus.

When the appropriate arteries were surgically electrocoagulated the nucleus caudatus and the putamen underwent necrosis. This fact we established by numerous studies made histologically employing the Nissl stain and injecting the brain vessels with India ink. In the latter instance one could observe an alteration in the character of the filling of the subcortical structures being studied as compared with adjacent brain structures (white substance of the frontal region and the corpus callosum). In the caudate and lenticular nuclei were found areas of the vessel net which did not fill.

Figures 2a and 2b outline the location at the base of the brain of the arteries supplying the subcortical nuclei in the region of the olfactory cortex which were subjected to obliteration and coagulation. The sections demonstrate quite well the degeneration of the nucleus caudatus that ensues following the shutting off of the arteries feeding it.

SUMMARY

The authors described two procedures for ablation of the nucleus caudatus and putamen in such a manner as not to injure any of the surrounding structures.

One method involves surgical removal. The other procedure employs destruction of the blood supply of these nuclei.