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A DESCRIPTION OF SOME DISSECTIONS OF THE INTERNAL CAPSULE, THE CORONA RADIATA AND THE THALAMIC RADIATION TO THE TEMPORAL LOBE*

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In the early years of the nineteenth century, dissection of the brain was practiced with great success by such men as Burdach and Reil, who were able to trace some of the larger fiber tracts in alcohol-hardened brains. But with the introduction of more refined methods, attention was diverted to the study of serial sections under the microscope, and for many years no effort was made to trace fiber bundles by mechanical dissociation. Recently there has been a revival of interest in this method of study. It has been found that in formaldehyd-hardened material bundles of fibers can be followed with ease and the outline of nuclear masses readily determined. Johnston¹ and Hoeve² advocated fiber tract dissection as a part of the laboratory course in neuro-anatomy, and in 1909 Curran,³ using this method, discovered a bundle of association fibers in the cerebrum, extending from the frontal into the occipital lobe along the inferior border of the lateral surface of the lentiform nucleus. To this tract he gave the name fasciculus occipitofrontalis inferior.

In making the dissections here described, the technic advocated by Curran has been followed. In removing nuclear masses to display fiber tracts which run through or beneath them, it is desirable to let a stream of water play over the specimen while the dissection is in progress. This serves to wash away the nuclear material as it is broken up and makes it much easier to display the fiber bundles.

The shape of the internal capsule and its relation to the basal ganglions can be studied to particular advantage in dissections prepared for this purpose. It is very difficult to form, from a study of serial sections, a clear cut mental picture of these structures in their entirety, and for

* Contribution 82, from the Anatomical Laboratory of Northwestern University Medical School, Jan. 6, 1918.

1. Johnston, J. B.: *Anat. Record* **2**:344, 1908.

2. Hoeve, H. J. H.: *Anat. Record* **3**:247, 1909.

3. Curran, E. J.: *J. Comp. Neur.* **19**:645, 1909.

this reason preparations which show their true form and relations are particularly instructive. A reconsideration of the anatomy of the internal capsule seems desirable because no articles dealing with this subject have appeared in the last twenty years, and the descriptions found in most textbooks are very unsatisfactory. A good account was given by Dejerine,⁴ but this is difficult to follow because it is based entirely on the study of sections and gives no view of the internal capsule as a whole.

DESCRIPTION OF DISSECTIONS

By removing the insula, along with the more lateral portions of the frontal, temporal and occipital lobes, one can readily expose the corona radiata, external capsule, fasciculus occipitofrontalis inferior and the fasciculus uncinatus as shown by Figure 2 in another article in this issue.⁵ The outline of the lentiform nucleus is clearly visible beneath

Fig. 1.—Lateral view of the lentiform nucleus and the corona radiata dissected free from the left cerebral hemisphere (from Ranson's *Anatomy of the Nervous System*).

the external capsule. There is a very definite plane of cleavage between the fiber bundles shown in this figure and those more superficially placed. This makes the dissection easy except in that part of the corona radiata which lies above and anterior to the lentiform nucleus. Here the fibers intersect with those from the corpus callosum and are not easily followed. The bed of fibers exposed in the dissection below and behind the lentiform nucleus is quite sharply separated from the more superficial white substance and includes both the internal and external sagittal strata of the occipital lobe.

When the uncinatus and inferior occipitofrontal fasciculi have been removed and the external capsule stripped away, the lentiform nucleus is

4. Dejerine, J.: *Anatomie des Centres Nerveux* 2:19, 1901.

5. Davis, L. E.: *Anatomical Study of Inferior Longitudinal Fasciculus*, this issue, p. 370).

exposed. Its shape is well shown in Figure 1. The corona radiata is seen emerging from the internal capsule which lies medial to this nucleus. It is a broad band of radiating fibers and forms three-fourths of an ellipse surrounding the nucleus except for a short distance below and in front.

If now the lentiform nucleus is scraped away, the internal capsule will be exposed (Fig. 2). It presents an evenly concave lateral surface

Fig. 2.—Lateral view of brain stem and internal capsule (from Ranson's Anatomy of the Nervous System).

within which the lentiform nucleus is received. There is no sharp bend in this surface to correspond to the genu, the position of which cannot be identified on this side of the internal capsule. There is, however, a rather sharp curved ridge around the border of the concave lenticular impression, and this ridge marks the transition of the internal capsule into the corona radiata. The majority of the fibers of the corona radiate forward, upward and backward in a nearly vertical plane to intersect with the radiation of the corpus callosum beyond the convex border of

the caudate nucleus; but the lowermost coronal fibers are directed lateral into the temporal lobe (Fig. 1).

The corona radiata has been partly cut away in Figure 2, so as to show the convex border of the caudate nucleus. This nucleus is for the most part hidden behind the internal capsule and the remains of the corona radiata. The outline of the hidden part is indicated by a dotted line. As this dotted line curves upward and backward over the lenticular surface of the internal capsule, it marks the position of the genu which appears as a curved ridge when the capsule is viewed from the medial surface (Fig. 3). Between this dotted line and the curved ridge marking the edge of the lenticular impression is the lenticulocaudate portion or anterior limb of the internal capsule (Fig. 2). Behind the

Fig. 3.—Dissection of cerebral hemisphere, showing the internal capsule exposed from the medial side. The caudate nucleus and thalamus have been removed (from Ranson's *Anatomy of the Nervous System*).

dotted line is the posterior limb of the internal capsule which has been subdivided by Déjerine⁴ into lenticulothalamic, retrolenticular and sublenticular portions. The figure shows very well the direct continuity of the internal capsule with the basis pedunculi on the one hand and the corona radiata on the other.

An instructive view of the internal capsule can be obtained from the medial side by opening up the lateral ventricle and scraping away the thalamus and caudate nucleus. Each of these nuclear masses makes a distinct impression on the medial surface of the capsule, and between the two is a prominent curved ridge (Fig. 3). In horizontal sections through the brain at appropriate levels, this ridge appears as a sharp angle between the anterior and posterior limbs of the internal capsule

and is known as the genu. This genual ridge follows the line of the sulcus which separates the thalamus from the caudate nucleus in the floor of the lateral ventricle and which contains the stria terminalis. Figure 3 shows why the shape of the internal capsule and the position and prominence of the genu vary as they do in horizontal sections taken at different levels through the basal ganglions.

The caudate impression corresponds in outline to the shape of the nucleus which produces it. Where the head of the nucleus rests on the capsule, the impression is large, and as the nucleus tapers to form the long curved tail, the caudate impression also becomes narrow.

The thalamic impression is markedly concave and belongs entirely to the posterior limb of the capsule. Below, it goes over without sharp line of demarcation into the posteromedial surface of the basis pedunculi at about the level of the optic tract. Above, it is limited by the curved ridge of the genu. The width of this portion of the capsule increases steadily from below upward. Its anterior border is continuous with the anteromedial border of the basis pedunculi. At its upper extremity a short distance behind the anterior commissure, this border bends forward at a rather sharp angle to become continuous with the inferior border of the anterior limb. The entire thalamic surface of the internal capsule as seen after removal of the thalamus and subthalamus is shaggy in appearance, due to the presence of innumerable fibers of the thalamic radiation which were broken off when the thalamus was removed.

The anterior limb, pars frontalis, or lenticulocaudate portion of the internal capsule, consists in part of fibers from the medial portion of the basis pedunculi (frontopontine tract) which curve forward over the anterior commissure and run a more or less horizontal course toward the frontal lobe. But the majority of the fibers belong to the frontal stalk of the thalamus which is also directed horizontally forward. This segment of the internal capsule has a sickle-shaped outline and presents a distinct lower border beneath which the caudate and lentiform nuclei are fused together (Fig. 2). Its other two borders are curved with convexity forward and upward. Of these the anterosuperior border presents the greater curvature and corresponds to the anterior part of the ridge between the internal capsule and corona radiata. The posterior inferior border is indicated in Figure 2 by a dotted line which corresponds to the position of the genual ridge. These two borders meet in an acute angle which points toward occiput.

Horizontal sections through the internal capsule above the level of the anterior commissure cut through the thalamus as well as the genu and both limbs of the internal capsule. Such sections pass through what Déjerine⁴ has called the thalamic region of the internal capsule.

Sections through the anterior commissure or immediately below it pass through both the thalamus and subthalamus, since the latter is situated in front of, as well as below, the former. Such sections are said to pass through the subthalamic region of the internal capsule. They do not include either the genu or the anterior limb.

The posterior limb of the internal capsule is more complex than the anterior and, as has already been said, consists of three parts: lenticulothalamic, retrolenticular and sublenticular. The lenticulothalamic portion includes that part of the lenticular surface which lies behind the curved line of the genual ridge (Fig. 2). Its fibers have for the most part a vertical direction. They belong to the corticobulbar, corticospinal, and corticorubral tracts and to the parietal stalk of the thalamus; and to these there are added in the subthalamic region the frontopontine tract from the anterior segment and the temporopontine fibers from the sublenticular segment. It is usually said that the fibers of the corticobulbar tract pass through the genu of the internal capsule. But since the genu is a curved ridge of considerable extent, it will be obvious that this statement can apply only to the genu as it is seen in horizontal sections through a particular region. According to Déjerine the corticobulbar tract passes through the genu in the inferior one-third of the thalamic region.

The retrolenticular segment of the internal capsule lies behind the lentiform nucleus on the lateral surface of the thalamus. It consists of fibers from the pulvinar, which are at first directed horizontally outward behind the lentiform nucleus and then turn sharply backward to run over the lateral surface of the tail of the caudate nucleus toward the occipital lobe. They form the optic radiation.

The sublenticular part of the internal capsule extends laterad beneath the lentiform nucleus (Figs. 1 and 2), and helps to form the roof of the inferior horn of the lateral ventricle. It is composed of fibers which enter it from the lateral part of the basis pedunculi (the temporopontine tract) and of fibers uniting the thalamus with the temporal lobe. The latter group of fibers had been dissected away in the preparation from which Figure 2 was drawn, and only the temporopontine fibers are illustrated. They spread out on the upper surface of the sublenticular segment immediately beneath the lentiform nucleus and are directed nearly horizontally laterad into the temporal lobe. Traced in the other direction in the dissected specimen, they can be seen to turn downward and backward into the lateral part of the basis pedunculi.

Beneath this layer of temporopontine fibers is another composed of fibers joining the thalamus with the temporal lobe. These fibers sweep forward and laterad under cover of the temporopontine tract which has been removed in Figure 1, in order to display them. There are

thus two distinct strata in the sublenticular segment, the upper of which is composed of laterally directed temporopontine fibers while the lower belongs to the thalamic radiation to the temporal lobe and has its fibers directed forward and laterad.

In this article, we are especially concerned with those portions of the thalamic radiation which go to the temporal lobe. The ventral stalk or inferior peduncle of the thalamus, also known as the *ansa peduncularis* (Fig. 1) springs from the basal aspect of the anterior part of the thalamus and runs behind the anterior commissure under the posterior end of the anterior limb of the internal capsule and then laterad beneath the lentiform nucleus to the insula and temporal lobe. In addition to this well known bundle, there are other fibers connecting the thalamus with the temporal lobe. Degenerations resulting from experimental lesions in the brains of monkeys have shown, according to Probst,⁶ that thalamotemporal fibers run through the posterior part of the internal capsule to the cortex of the superior temporal gyrus. Some of these fibers are said by him to leave the internal capsule above the lentiform nucleus and run through the external and extreme capsules to the superior temporal gyrus.

But by far the largest bundle of fibers joining the thalamus with the temporal lobe is the temporothalamic fasciculus of Arnold,⁷ which we have already encountered in the sublenticular segment of the internal capsule (Fig. 1). This bundle emerges from the ventrolateral part of the posterior extremity of the thalamus under cover of the external geniculate body. The fibers form a large strand directed forward in the inferior of the two layers of the sublenticular segment of the internal capsule along the roof of the inferior horn of the lateral ventricle. Here a few at a time they curve outward and then somewhat backward into the white matter of the temporal lobe. Thus as they spread out toward their distribution, the fibers describe broad curves with convexity forward. The most medial of these fibers extend farthest forward reaching the anterior extremity of the roof of the inferior horn before they curve outward and backward toward their distribution (Fig. 4). The fasciculus of Arnold must not be confused with the fibers from the medial geniculate body, which constitute the auditory radiation and which are mingled with the temporopontine tract in the sublenticular segment of the internal capsule.

Another bundle of thalamotemporal fibers seems to have been overlooked by nearly all previous investigators. The constituent fibers of this fascicula can be traced from the stratum zonale on the dorsal sur-

6. Probst, M.: *Sitzungsab. d. k. Akad. d. Wissensch. Math.-natur. w. Wien.* **114**:173, 1905.

7. Arnold, A.: *Handbuch der Anatomie des Menschen* **2**: 1851.

face of the posterior part of the thalamus. They are gathered into a compact bundle along the medial side of the stria terminalis. The bundle arches backward, then downward, and finally forward around the posterior extremity of the thalamus following the tail of the caudate nucleus into the roof of the inferior horn of the lateral ventricle (Fig. 4). In its arched course around the thalamus it lies on the medial side and partly under cover of the stria terminalis. Passing through the sublenticular portion of the internal capsule, the bundle flattens out in the roof of the inferior horn of the lateral ventricle under cover of the ependymal lining and can be traced forward to the anterior part of the temporal lobe. It lies on the ventricular surface of the temporothalamic fasciculus of Arnold between that bundle and the epen-

Fig. 4.—Dissection of the temporal lobe from below. The mesencephalon has been cut across at the level of the superior colliculus. The medial and inferior portion of the temporal lobe has been removed and the fibers of the corona radiata and sublenticular part of the internal capsule exposed: *C. G. L.*, corpus geniculatum laterale; *F. T. A.*, fasciculus temporothalamicus of Arnold and fasciculus thalamotemporalis arcuatus; *F. T. Arc.*, fasciculus thalamotemporalis arcuatus; *F. G. C.*, fasciculus geniculocalcarinus; *P. T.*, polus temporalis and *Pul.*, pulvinar.

dyma of the ventricle. In order to differentiate this bundle from that described by Arnold, it may be designated as the fasciculus thalamotemporalis arcuatus.

After these fibers from the stratum zonale had come to view in our dissections, a careful review of the literature was made to see if they had been described before. The only mention of them seems to be by Probst⁶ in 1905. He traced them in the brain of a monkey after an

experimental lesion in the thalamus and internal capsule and regarded them as constituting an hitherto undescribed bundle which he designated in his drawings by the letter *y*. His description of this bundle corresponds exactly with that given herewith for the fasciculus thalamotemporalis arcuatus. The degeneration which he found in this fascicle resulting from a lesion in the thalamus indicates that at least a large part of these fibres are corticopetal. Probst states that he has also been able to demonstrate these fibers in the brains of microcephalic idiots where for some reason they stand out with special clearness.

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