Ranney (A. L.)

THE INTERNAL CAPSULE OF THE CEREBRUM AND THE DIAGNOSIS OF LESIONS AFFECTING IT

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THE INTERNAL CAPSULE OF THE CEREBRUM AND THE DIAGNOSIS OF LESIONS AFFECTING IT.*

By AMBROSE L. RANNEY, M.D.

IN connection with the description of the so-called basal ganglia (the "corpus striatum" and "optic thalamus" of each hemisphere), I have mentioned a tract of fibres, called the "internal capsule of the cerebrum." This bundle has an anatomical peculiarity, which has brought it into prominence with both physiologists and neurologists, viz., that it seems to traverse the substance of the basal ganglia without any apparent structural relation with the nerve-cells found within them. It is by no means certain that the nerve-cells referred to may not, in some indirect manner, be yet proven to modify or govern the impulses which travel along the fibres of the internal capsule (as we have every reason to believe they do in the case of other fibres which pass from the cortex to the crus, pons Varolii, and spinal cord); but, at present, we are compelled to admit that this bundle appears to afford the only *direct communication* between the convolutions and parts below the cerebrum,[1] because any intervention on the part of the corpus striatum

*A lecture delivered before the class of the Medical Department of the University of the City of New York, during the session of 1882-83.

[1] The fibres of the "external capsule of the cerebrum" may be an exception. (Fig. 1.)

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or the optic thalamus has not been conclusively demonstrated.

This tract seems to be a continuation of both the *motor* and *sensory* portions of the crus (the "basis cruris," and "tegmentum cruris," of Meynert—see Fig. 3) into the white substance of the cerebral hemisphere of either side, where its fibres diverge and pass to the convolutions. It forms the greater part of the so-called "corona radiata," which was described in a previous lecture.[1] If we trace the anterior fibres of this bundle from below upward, we shall see that it divides the corpus striatum of each hemisphere into its two portions, the caudate and lenticular nuclei. Its posterior fibres separate the lenticular nucleus from the optic thalamus of the corresponding side. The diagram, to which I now direct your attention, will make the relations

FIG. 1.—A DIAGRAM DESIGNED TO SHOW THE RELATIONS OF THE INTERNAL CAPSULE OF THE CEREBRUM TO ADJACENT STRUCTURES VIEWED FROM ABOVE. The section of the brain has been made *horizontally* in a plane to intersect the basal ganglia C. N., caudate nucleus of corpus striatum; L. N., lenticular nucleus of same with its three parts (*a*, *b*, *c*); O. T., optic thalamus; S, fossa of Sylvius; C, claustrum; E. C., external capsule of cerebrum; *i*, *i*, *i*, convolutions of the island of Reil; *a*, *b*, *c*, the inner, middle, and external member of the lenticular nucleus; 1, anterior limit of the internal capsule; 2, "knee" or bend of same; 3, posterior limit of same; F, crura of fornix, the fifth ventricle lying in front, and the third ventricle behind it; *s. l.*, septum lucidum, showing its two layers with fifth ventricle between them; *m. c.*, middle commissure of the thalamus; *p*, pineal gland and its peduncles; *n*, nates cerebri; *t*, testes cerebri.

[1] *N. Y. Med. Jour.*, April 16 and 24, 1883.

of this bundle apparent, while it will also show the peculiar angle or bend which the internal capsule exhibits in all horizontal sections of the brain which intersect the basal ganglia.

Now, if a cross vertical section of the cerebral hemispheres be so made (see Fig. 2) as to include the substance of the thalamus and the lenticular nucleus, it will be perceived that the peripheral outline of these two masses of gray matter may be compared to a square; and that a diagonal band running from the outer and upper corner to the lower and inner corner of this square corresponds to the situation of the compressed portion of the "internal capsule," which is included between these ganglia. Above the level of the basal ganglia, the fibres of the internal capsule radiate to join certain convolutions or "gyri" which will be enumerated later. Thus it is that the fibres of the internal capsule appear in most of the cross-sections of the middle zone of the cerebrum to bear a resemblance to the handle and sticks of a Japanese fan; the handle being the constricted portion between the corpus striatum and the optic thalamus, and the diverging fibres being located within the medullary centre of the cerebral hemisphere.

The extension of *sensory fibres* from the tegmentum cruris upward within the internal capsule of the cerebrum is not so clearly proven as is the continuity of the *motor tract*, anteriorly. The course of the former has been studied by dissection, embryological investigation, physiological experiment, and, finally, by the examinations of pathological processes. It has been shown by Türck[1] that, when certain convolutions of the brain (chiefly those which are motor in function) have suffered partial or complete destruction, that a *descending degeneration* follows the course of the nerves

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[1] This author first made known his great discovery to the Academy of Sciences of Vienna, in 1851.

which are connected with the cells of the injured part. This degenerative process extends along the nerves, from the cells of the cortex, to their peripheral terminations, in the cells of the spinal gray matter; thus enabling a careful observer to trace the paths of the fibres with even greater

FIG. 2.—SECTION ACROSS THE OPTIC THALAMUS AND CORPUS STRIATUM IN THE REGION OF THE MIDDLE COMMISSURE. (Schäfer after a preparation by Mr. S. G. Shattuck.) Natural size. *th.*, thalamus; *a*, *e*, *i*, its anterior, external, and internal nuclei respectively; *w*, its latticed layer; *m. c.*, middle commissure; above and below it is the cavity of the third ventricle; *c. c.*, corpus callosum; *f*, fornix, separated from the third ventricle and thalamus by the velum interpositum. In the middle of this are seen the two veins of Galen and the choroid plexuses of the third ventricle; and at its edges the choroid plexuses of the lateral ventricles; *t. s.*, tænia semicircularis; *cr*, forward prolongation of the crusta passing laterally into the internal capsule, *i. c.*; *s. t. r.*, subthalmic prolongation of the tegmentum, consisting of (1) the dorsal layer, (2) the zona incerta, and (3) the corpus subthalamicum; *s. n.*, substantia nigra; *n. c.*, nucleus caudatus of the corpus striatum; *n. l.*, nucleus lenticularis; *e. c.*, external capsule; *cl*, claustrum; *I*, Island of Reil.

accuracy and positiveness than the most skilful dissector could possibly hope to attain. By means of this fact,[1] amplified somewhat by Waller, physiologists have been enabled to solve many problems regarding the origin and course of special nerves, as well as of certain nerve-tracts within the spinal cord and brain, which could not otherwise have been determined.

Although the remarkable observations of Türck were given to the profession some years before Waller was awarded the honor of meriting recognition as the recipient of the Moynton prize for Experimental Physiology, his

[1] The reader is referred to a lecture upon the "Wallerian Method of Research," by Prof. Dalton. *Med. Record*, Feb. 11, 1882.

paper remained comparatively unknown for some years, when its great value at last became recognized. The difference between the discoveries of Waller and Türck lie in the fact that the observations of the former were confined to the results of artificial section of spinal nerves, made for the purpose of studying the effects of such injuries, while those of Türck were of a purely pathological character, in which the results of old morbid deposits within the substance of the brain were studied by the aid of successive sections of the brain and spinal cord at different levels, which could be contrasted with each other. Both of these observers arrived at the same fundamental law, viz., that injuries of nerves or of nerve-tracts cause a degenerative process which extends along the separate nerve-fibres to their ultimate ramifications.[1] Waller's experiments were confined exclusively to the spinal nerves, and resulted in the following deductions: 1, That if the nerve was divided at its exit from the vertebral canal, *all of its ultimate fibres degenerated* for its entire length ; 2, that if the anterior root of the nerve was alone divided, only the *motor fibres* degenerated ; 3, that if the posterior root of the nerve was severed outside of its ganglion, the *sensory fibres* of the nerve degenerated and the motor fibres remained unaffected ; 4, that if the posterior root was divided *internal to its ganglion*, the nerve outside of the ganglion did not degenerate, but the portion which was still attached to the spinal cord, but separated from the ganglion, suffered complete degeneration. From these data, this observer was enabled to lay down the general law that *the motor fibres of the spinal nerves are dependent for their structural*

[1] Nerve-fibres degenerate only when severed from their connection with some special nerve-centre. When once cut off, the degenerative process extends throughout the entire length of the nerve ; unless it meets another nerve-centre (some ganglionic mass of gray substance) interposed in its course. It seldom, therefore, extends from spinal nerve-tracts into the spinal nerves, or *vice versâ*.

integrity upon their connection with the spinal cord, while the sensory nerve-fibres depend upon their connection with the spinal ganglia.

The degenerative process which was recognized by both Türck and Waller consists in the production of granular cells along the course of the affected nerve-fibres. The unaffected fibres retain their normal appearance, and thus define the diseased bundles so that they can be traced along the spinal cord and peripheral nerves with great accuracy. Türck was enabled by this means to demonstrate for the first time a distinction between the anterior and posterior segments of the lateral column of the spinal cord, which no ordinary dissection could possibly have established. The observations of Türck have been supplemented by those of Goltz, Gull, Flechsig, Meynert, Bourdon, Charcot, and others, who have added much to our knowledge of the situation and functions of the various spinal nerve-tracts.

This digression will enable you to appreciate the grounds which now enable us to speak with a certain degree of positiveness concerning the course of motor nerve-tracts, comprised within the anterior two thirds of the internal capsule of the cerebrum. I designate the limits of the motor fibres of this bundle somewhat definitely, because it is now generally accepted among neurologists that the *posterior one third* of the internal capsule contains *sensory bundles*, while the *remaining two thirds* has a purely *motor* function.

Now, because motor fibres carry centrifugal impulses, it is logical to describe the motor bundles of the internal capsule from the above downward, beginning with an enumeration of the convolutions from which the motor fibres are believed to spring, and tracing the course of these fibres to their connection with the cells of the anterior horns of the spinal gray matter, while it is customary to reverse the method, in case the sensory fibres, which carry centripetal impulses, are under consideration.

The diagram to which I shall first call your attention was designed by its author to rudely represent the general features of the internal capsule. It is impossible to properly portray all of the more important facts, to which I shall call attention, by any form of schematic drawing; so that the diagram offered, which is most excellent of its kind, cannot

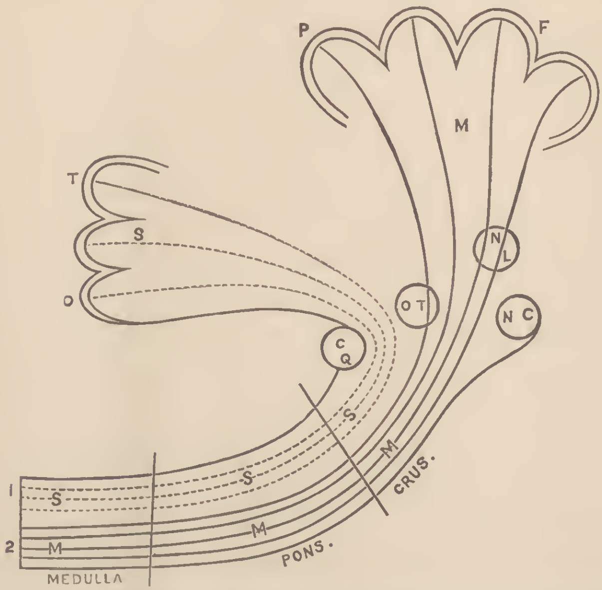

FIG. 3.—DIAGRAM OF THE COURSE OF SENSORY AND MOTOR TRACTS IN THE MESOCEPHALON AND HEMISPHERES. (Seguin.) S, sensory tract in posterior region of mesocephalon, extending to O and T, occipital, and temporal lobes of hemispheres; M, motor tract in basis cruris, extending to P and F parietal and (part of) frontal lobes of hemispheres; C. Q., corpus quadrigeminum; O. T., optic thalamus; N. L., nucleus lenticularis; N. C., nucleus caudatus; 1, the fibres forming the "tegmentum cruris" (Meynert); 2, the fibres forming the "basis cruris" (Meynert).

more than afford general hints of value, and should be used as a guide only in contrast with more elaborate cuts found in standard anatomical works.

The *motor bundles* arise from the cells of the cerebral cortex comprised within the convolutions of the middle region of the brain. This region—the so-called "motor district"—includes the *ascending frontal gyrus*, the *basis of the first*, *second*, and *third frontal gyri*, the *ascending parietal gyrus*, the *paracentral lobule*, and the *supra-marginal gyrus*.[1] Some of these bundles pass directly into the substance of the caudate nucleus, some into the lenticular nucleus, and possibly a few into the optic thalamus of the corresponding hemisphere, after traversing the medullary centre of the cerebrum; but the majority appear to be directly continuous with the constricted portion of the internal capsule.

The *sensory fibres* which are comprised within the internal capsule are probably prolonged upward from the posterior parts of the crus (tegmentum cruris cerebri—Fig. 3) to the convolutions of the occipital, temporo-sphenoidal, and parietal lobes. It is believed, however, that the posterior third or (sensory portion) of the internal capsule has connections also, by means of the optic, olfactory, gustatory, and acoustic nerves, with the peripheral organs of special sense. Physiological experiment has shown that, when certain convolutions of the sensory regions of the cerebral cortex have been destroyed in animals, the senses of sight, smell, hearing, and taste have been either temporarily or permanently impaired. We know also that total hemi-anæsthesia results from lesions, both in man as well as animals, which involve the posterior third of the internal capsule. The impairment of special senses from cortical lesions, moreover, appears to be confined to the side opposite to the seat of injury, in case of unilateral destruction of the cerebral convolutions—phenomena which point strongly to a decussation of these fibres, in which respect they bear an analogy to the common sensory tracts. Future consideration will be given to these points. Some

[1] The late work of the author "The Applied Anatomy of the Nervous System," D. Appleton & Co., New York, contains numerous diagrams which illustrate these parts. The term "gyrus" is synonymous with "convolution."

of them, particularly bearing upon the location of an olfactory, optic, and acoustic centre, within the substance of the thalamus, have already been discussed at some length in a previous lecture.[1]

When we discussed the corpus striatum, I constructed for you a diagram which represented the afferent and efferent fibres of that ganglion, in which the motor fibres of the internal capsule were shown. I stated, at that time, that the functions of the caudate and lenticular nuclei were still unsettled, but that anatomical grounds could be advanced to sustain the belief that the cells of both halves of that ganglion exercised a modifying and controlling influence upon motor phenomena, and were probably the seat of automatic action, irrespective of the cells of the cerebral cortex. I stated, also, that it was demonstrable that the cerebellum had a direct connection with the cells of the caudate nucleus, and that physiological experiment pointed strongly to cerebellar innervation of motor acts, because disturbance in coördination of movement are produced by disease of the cerebellum, and motor acts appear to be weakened. Now, because experiments made upon the caudate and lenticular nuclei can hardly be said to have afforded results which can be made the basis for positive deductions respecting the functions of each, it seems highly probable that the cerebellar fibres are in some way connected with those of the internal capsule, which are unquestionably associated with motor phenomena.

Among the afferent fibres of the corpus striatum, in addition to the cerebellar fasciculus (fibres of the *processus cerebelli ad cerebrum*), may be mentioned the "corona radiata," the "stria cornea," fibres from the cortex of the olfactory lobe, and fibres from the septum lucidum.[2] If it

[1] The reader is referred to a late article by the author upon "The Optic Thalamus," *Journal of Nervous and Mental Disease*, April, 1883.

[2] *Journal of Nervous and Mental Disease*, Jan., 1883.

can be shown that these five sets of afferent nerves become associated with those of the internal capsule, it will help us

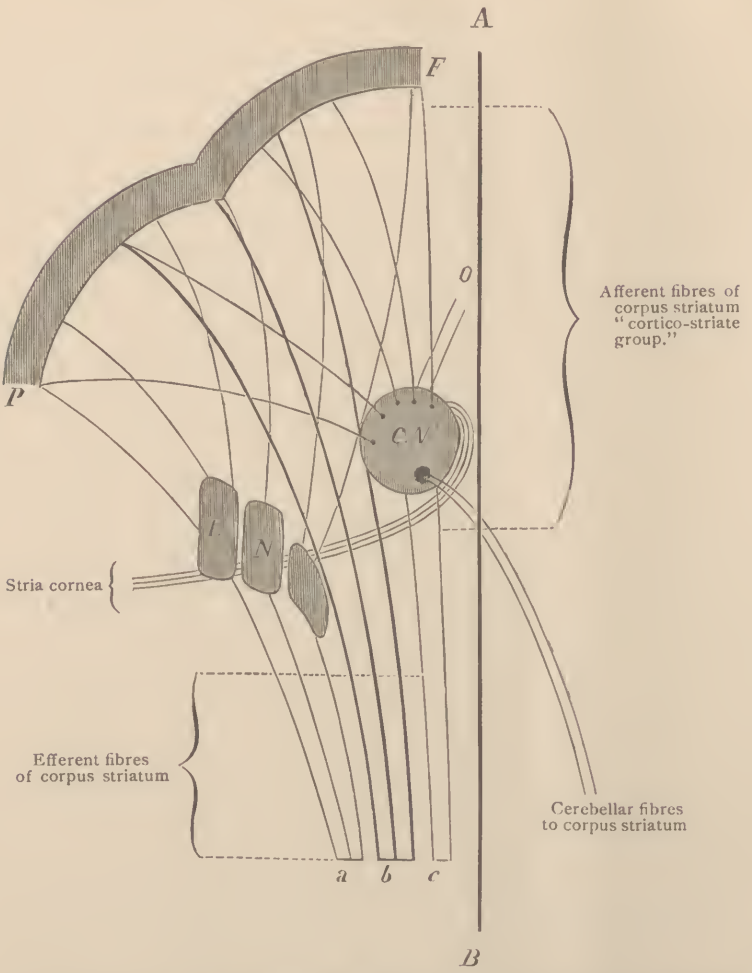

FIG 4.—A DIAGRAM DESIGNED TO SHOW THE AFFERENT AND EFFERENT FIBRES OF THE CORPUS STRIATUM. *C. N.*, "caudate nucleus," or ventricular portion of corpus striatum; *L. N.*, "lenticular nucleus," or extra-ventricular portion of corpus striatum; *A—B*, median line, separating cerebral hemispheres; *P—F*, psycho-motor regions of the cortex; *a*, peduncular fibres connected with *L. N.*; *b*, fibres of the so-called "internal capsule"; *c*, fibres connected with *C. N.*; *O*, olfactory fibres.

to better interpret the functions of the parts. The time has passed when any single experiment can be advanced to prove the existence of isolated functions within ganglionic masses. Anatomical research has demonstrated that nerve-tracts frequently traverse these masses (without any apparent association with the cells embedded within them) in order to terminate in remote parts. It has been conclusively proven also that special centres are sometimes interspersed between these nerve-bundles, so that it is illogical to attribute every phenomenon caused by an intra-cranial experiment to a disturbance in the activity of any special centre. The physiology of many parts of the brain is far from satisfactorily marked out. Many glaring contradictions are apparently proven by the experiments of different investigators, and the statements previously made will help, to some extent, to explain them. I pointed out, when discussing the structural anatomy of the thalamus,[1] that, until the existence of the special centres, which are believed to exist by some authorities within that ganglion, could be positively demonstrated, it will be maintained by others that many phenomena which accompany lesions of the thalamus are due entirely to *pressure* exerted upon the adjacent internal capsule. This view is held also by many neurologists, when phenomena provoked by any experiment upon the corpus striatum[2] are adduced to prove a special function as located within that ganglion. Pathological research has, in some instances, seemed to oppose the view that the lenticular nucleus possesses any important motor functions. The French experimenters, Franck and Pitres, published in 1878 a most brilliant attempt to demonstrate conclusively that the anterior fibres of the internal capsule were continuous with the motor convolutions of the cerebrum and conducted motor impulses. These physiologists

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[1] See *Journal of Nervous and Mental Disease*, April, 1883.

[2] It is possible that the *caudate nucleus*, when seriously impaired by lesions, may cause hemiplegia and secondary degeneration. Charcot claims, however, that the effects of hemorrhage of the corpus striatum are to be attributed entirely to pressure upon the motor fibres of the internal capsule.

found that when the white substance of the cerebral hemisphere, which underlies the motor convolutions, was faradized, muscular movements were created on the opposite side of the body in definite regions corresponding to the supposed action of the so-called "motor centres" of the cortex. It must be confessed by all that these observations, which are considered by many as a final proof of the distribution and function of this bundle of fibres, are among the most satisfactory which have been as yet recorded.

Before we pass to the consideration of the internal capsule in its practical aspects, let us speak a little more definitely in regard to its exact situation and limits. This bundle, as was stated before, lies between the lenticular nucleus on the one side, and the caudate nucleus and the optic thalamus, on the other. Transverse vertical sections of the cerebrum show that the lenticular nucleus lies external to and below it, while the caudate nucleus and thalamus lie internal to and above it (Fig. 2). In the region of the base of the cerebrum, the head of the caudate nucleus becomes fused with the lenticular nucleus, so that the internal capsule does not extend to the extreme anterior limits of these ganglionic masses. The posterior limit of the internal capsule is defined by the termination of the lenticular nucleus; the thalamus being prolonged beyond it into the substance of the cerebral hemisphere. Above the level of the basal ganglia, the fibres of this bundle radiate into the different lobes of the cerebrum (Fig. 3); the anterior part of the frontal lobe, and some portions of the occipital and temporo-sphenoidal lobes, being possibly exempt.

To the naked eye, the fibres of the internal capsule, which pass between the ganglionic masses at the base of the hemisphere, appear to be continuous with the corona radiata above, and the fibres of the crus cerebri below. There is a general belief among anatomists, however, that successive loops will probably be demonstrated by more extended research—the fibres of the crus leaving the internal capsule to join the cells of the basal ganglia, while others leave the ganglia to pass, by means of the internal capsule, to the cerebral convolutions. The results lately obtained by Franck and Pitres (mentioned on a preceding page), seem, however, to be rather opposed to this view, although they do not positively controvert it.

Effects of Lesions of the Internal Capsule.

The situation of this bundle of nerve-fibres renders it liable to become directly involved when hemorrhage, softening, or tumors of the *central portions* of the hemisphere exist; or, indirectly, when these conditions affect the *caudate nucleus*, the *lenticular nucleus*, or the *optic thalamus*. The most frequent seat of cerebral apoplexy is the corpus striatum; because that ganglion is extremely friable and very vascular. The optic thalamus probably ranks next in the order of comparative frequency. The blood-vessels which enter these bodies[1] through the anterior and posterior perforated spaces at the base of the cerebrum seem to be frequently affected with atheromatous degeneration and miliary aneurisms, and are often ruptured when subjected to any unnatural strain. Nature has given to the carotid and the vertebral arteries a remarkable tortuosity before their entrance into the cavity of the cranium, in order, as it were, to diminish the liability to rupture of blood-vessels by decreasing the velocity of the flow when the heart's action is excessive; but even this mechanical safeguard is not always sufficient to protect the intracranial vessels from rupture when extensively diseased.

[1] The motor regions of the cortex are supplied by the *middle cerebral* artery; the nucleus caudatus by branches of the *anterior cerebral* and *anterior* communicating arteries; the lenticular nucleus by the *middle cerebral;* and the optic thalamus by branches of the *middle* and *posterior cerebral* vessels.

Again, the condition of softening may result from embolic obstruction to some branches of the carotid (usually of the left side)[1] because the nutrition of the parts supplied by the occluded vessel is thus arrested either entirely or in part. The same result may also follow an attack of cerebritis or a previous extravasation of blood into the substance of the brain, both of which tend often to create impairment of the blood-supply to adjacent regions.

Finally, tumors sometimes develop within the cerebral hemispheres, and create pressure upon, as well as destruction of important nerve-tracts. Time will not permit us to enter into detail respecting all the diagnostic points by which the existence of each of these conditions may be recognized during life. I direct your attention, therefore, only to such points as are of importance in the diagnosis of disturbance of the supposed functions of the internal capsule.

It may be stated with some degree of positiveness that, if the anterior two thirds of the internal capsule be affected, a *hemiplegia* of the opposite side is developed.[2] This is more or less complete, according to the seat and extent of the lesion which causes it. The exciting cause may possibly be situated within the anterior or middle portions of the white centre of the cerebral hemisphere, above the level of the basal ganglia, in which case it interferes with the normal action of certain bundles of the internal capsule which spring from the motor convolutions of the cortex previously enumerated. Again, it may be situated within the constricted portion of the capsule, in which case bundles of nerve-fibres, functionally associated with widely diffused

[1] The reasons for this fact can be found in a late work by the author—"Practical Medical Anatomy." Wm. Wood & Co., 1882.

[2] Exceptions to this rule are occasionally observed. The hemiplegia, in rare cases, exists on the same side as the lesion. The explanation of this fact has been shown, by the researches of Flechsig, to lie in the varying proportions of the direct and decussating fibres which pass from the cerebrum to the spinal cord.

areas of the cortex may be affected by a lesion of small size. Finally, it may be apparently confined to the subtance of one of the two nuclei of the corpus striatum (Fig. 5), or the optic thalamus, and still exert sufficient pressure upon the constricted part of the internal capsule to produce more or less extensive and complete paralysis of the opposite lateral half of the body. The hemiplegia of intracerebral lesions forms, as a rule, a striking contrast with the various types of *monoplegia*, which are produced by circumscribed lesions of the cortex. The latter are often of the greatest aid to the neurologist in localizing the seat of the exciting cause.[1]

FIG. 5.—A DIAGRAM OF THE BRAIN IN TRANSVERSE VERTICAL SECTION (MODIFIED SLIGHTLY FROM DALTON). 1, crus cerebri; 2, internal capsule; 3, optic thalamus; 4, caudate nucleus; *C. C.*, corpus callosum; *L. N.*, lenticular nucleus; *S*, fissure of Sylvius; *Fo*, gyrus fornicatus; *F'*, *F''*, *F'''*, first, second, and third frontal convolutions; *T'*, *T''*, *T'''*, temporal convolutions; *H*, gyrus hippocampi.

The second symptom which may indicate a lesion of the internal capsule is *hemi-anæsthesia*. By this, I mean a loss of sensation, more or less complete, which is confined to the lateral half of the body. It exists on the side opposite to

[1] The subject of *monoplegia* has been discussed, in all of its clinical aspects, by the author in his work previously referred to. The term covers many forms of paralysis where *special groups* of muscles are alone affected.

the seat of the lesion. This may occur when fibres of the *posterior third* of the internal capsule are destroyed or impaired by diseased conditions directly affecting them, as noted by Charcot, Raymond, Rendu, Ferrier, and others, or by the pressure exerted by lesions situated in parts adjacent to them. It is usually accompanied with a slight form of motor paralysis; probably because a few of the motor fibres of the internal capsule are, as a rule, simultaneously interfered with. The tests by which this condition may be recognized are, doubtless, familiar to you all. They were given you in detail in a previous lecture. No examination is ever complete unless sensation, as well as muscular power, is carefully tested, before a diagnosis is made.

A third symptom of lesions of the internal capsule includes a variety of manifestations of *impairment of the special senses.* In connection with the discussion of the optic thalamus, you will recall the views which I advanced respecting the possibility of existence of special centres of smell, sight, hearing, and sensation within the substance of that ganglion. I have also stated that some clinical facts point strongly to a relationship between nerve-fibres related to certain special-sense perceptions and the internal capsule. It is impossible, with our present knowledge, to definitely place the situation of the cortical centres which preside over the various special senses, or the course of separate fibres which seem to be associated with them, but we are forced to admit that some of the fibres of the posterior part of the internal capsule have a direct or an indirect association with smell, sight, hearing, sensation, and perhaps of taste also. During the last winter's course, I mentioned many interesting facts in physiology, which showed the value of abnormal phenomena in smell, sight, speech, hearing, taste, etc., upon the diagnosis of intracranial lesions.[1] Many of these might be repeated here with advantage, if time would permit. One peculiar fact cannot be omitted, however, which Charcot has endeavored to explain, viz., that hemianopsia[2] never (?) occurs in connection with lesions of the internal capsule, but an amblyopia is developed on the same side as the cutaneous anæsthesia, with a remarkable contraction of the field of vision and difficulty in discrimination of color. The explanation which this author makes of this fact is, that a second decussation of the fibres of the optic nerve takes place somewhere between the optic chiasm and the internal capsule, probably in the tubercula quadrigemina.

When the radiating fibres of the internal capsule are involved in a lesion which creates a gradually increasing pressure (as in the case of tumors which grow slowly) the *fundus of the eye* exhibits morbid changes in the region of entrance of the optic nerve which are of value in diagnosis. The condition so produced is commonly known as the "choked disc." It is nearly always bilateral, but often most marked in one eye. It may be considered as one of the most positive signs of an extensive intra-cerebral lesion, and especially of tumors of the brain. When the eye is examined with an ophthalmoscope, this condition is characterized by a swollen appearance of the optic nerves, which project appreciably above the level of the surrounding retina; the margin of the disc is either obscured or entirely lost; the arteries appear small, and the veins large and tortuous; finally, small hemorrhagic spots may often be detected in the retina near the margins of the disc. In spite of this condition, the power of vision may be little impaired;

[1] See "Applied Anatomy of the Nervous System." D. Appleton & Co., N.Y., 1881.

[2] The term "hemiopia" signifies half sight; hemianopsia means a blindness of one half of the retina. The latter is, therefore, the preferable term in this connection.

so that the existence of " choked disc " may be unsuspected unless the ophthalmoscope be used before the diagnosis is considered final. After a number of weeks, and very much longer if a tumor is the exciting cause of the condition, the appearance of the disc changes. An unnatural bluish white color, which denotes atrophic changes, develops; the outline of the disc becomes sharply defined; the retinal vessels become small; and vision becomes markedly interfered with.

In exceptional cases of destruction of the internal capsule, the *sense of smell* has been abolished on the side opposite to the seat of the lesion. This fact requires special consideration, as it has been shown that the centre proper for olfactory perceptions seems to be in the hemisphere of the same side. Meynert claims, however, to have demonstrated the existence of an olfactory chiasm in the region of the anterior commissure, in animals where the bulbs are largely developed; and fibres have been traced in the region of the " subiculum cornu Ammonis," or the tip of the temporo-sphenoidal lobe, which connect the olfactory centres with each other. The experiments of Ferrier tend to disprove the decussation of the olfactory paths in the anterior commissure; so that the question still remains unsettled. The sense of smell is more commonly affected in the nostril of the side which corresponds to the seat of the lesion.[1]

Among the fibres of the internal capsule which are distributed to the temporo-sphenoidal lobe some appear to have some association with the *sense of hearing;* but experimentation upon animals to determine the exact seat of the centres of hearing and the effects of their destruction are exceedingly difficult, because the evidences of impairment of this sense are more or less vague. Ferrier thinks,

[1] Ferrier reports a case where smell and taste were simultaneously abolished by a blow upon the top of the head. Ogle records a similar instance.

however, that the superior temporal convolution is unquestionably connected with acoustic perceptions. The area which he maps out as acoustic in function is quite extensive.

The region of the hippocampus seems to be chiefly connected with *tactile sensibility*, because its destruction has been found to create a total loss of that sense on the opposite side of the body (Ferrier).

As regards *taste*, the results of experimentation upon the monkey tribe seem to point to the lower portion of the middle temporal convolution as the probable seat of the centres which are related to that sense.[1] When this region is subjected to irritation, certain reflex movements of the lips, cheek, and tongue are observed, which seem to point to an excitation of the gustatory sense. Its destruction causes abolition of taste.

We have now considered three of the more prominent symptoms which are produced by lesions of the internal capsule, and I pass to a fourth, which I believe to be of great value in aiding the recognition during life of an extensive and rapidly developing lesion of the white centre of the cerebral hemisphere, viz., *conjugate deviation of the eyes and head.*

When, in connection with rapid softening or an extravasation of blood into the substance of the cerebrum above the level of the basal ganglia, this peculiar symptom is developed (either simultaneously with or following paralysis and coma), the patient's head and eyes will be observed to be turned constantly away from the paralyzed side and toward the side which is the seat of the lesion. Various attempts have been made by late authors to throw discredit upon the clinical significance of this symptom as particu-

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[1] This may help to explain the fact that injuries received upon the vertex and occipital protuberance cause, in some instances, an abolition of taste. The temporal lobe being injured by concussion against the adjacent bone.

larly indicative of a lesion of the cerebral hemisphere, but I am convinced that it is a valuable differential sign. Ferrier has demonstrated that a cortical centre, which he locates in the first and second frontal gyri near to their bases, presides over conjugate movements of the head and eyes, and causes dilatation of the pupils. He attributes this symptom, when occurring in connection with hemiplegia of cortical or ganglionic origin, to the unantagonized action of the corresponding centre of the uninjured hemisphere, thus explaining the fact that the distortion is toward the side of the lesion. Clinical evidence of the correctness of this view has been brought forward by Hughlings-Jackson, Priestly Smith, Chouppe, Landouzy, Carroll, and others; and, in some cases reported, the situation of the lesion has been verified by pathological observation. The opportunity to record pathological observations upon cases where this symptom was well marked during life is, unfortunately for science, a comparatively rare one. It is impossible, therefore, to speak positively concerning the diagnostic value of this symptom, although the weight of clinical evidence seems to be strongly in its favor.

A fifth symptom, which points strongly to an existing lesion of the internal capsule, is *choreiform movements* following hemiplegia or hemianæsthesia. These movements vary in type and degree. In some cases, the movements exhibit the peculiarities of athetosis, the fingers or toes being thrown into active motions which cannot be controlled by the patient; in others, true ataxia may be developed; again, the spasmodic movements partake of the character of genuine chorea; finally, a tremor, more or less marked, may be detected.

It is not uncommon to find that both hemiplegia and hemianæsthesia may co-exist with these post-paralytic forms of spasmodic disease; but one usually overshadows the other, the hemiplegia being, as a rule, the more marked. How we are to explain these late phenomena, is not definitely settled. They are probably to be classed with other morbid manifestations which paralyzed muscles sometimes exhibit, chiefly that of "late rigidity" so often seen, concerning the cause of which many conjectures have been advanced but nothing of a positive nature demonstrated.

Finally, it has been observed that lesions of the internal capsule, if very extensive, are often followed by a very marked *rise in the temperature* of the body. We have yet much to learn concerning the vaso-motor centres which are variously disposed within the substance of the brain and spinal cord.

The fact has been mentioned that the fibres of the internal capsule probably terminate, anteriorly, in the *motor convolutions* of the cerebral cortex. Although there are still some neurologists of note who deny the value of the late attempts of Fritsch, Hitzig, Broca, Ferrier, Charcot, Hughlings-Jackson, Pitres, Landouzy, Exner, Chouppe, and a host of others, to locate special centres within the convolutions of the cortex, clinical and pathological observations are constantly being brought forward in support of the more generally accepted views. The region which embraces these motor centres appears, however, to be somewhat limited. A critical review of recorded cases shows, I think, beyond cavil, that the white centre of each hemisphere of the cerebrum, as well as the cortex, may in some instances, be extensively diseased or injured without any motor or sensory results which can be determined. Pathological evidence seems to demonstrate, however, that the region so impaired must not be situated where the fibres of the internal capsule suffer destruction or pressure if we expect to meet with negative results. Abscesses of immense size have been found in the anterior part of the frontal lobe, as well as in certain portions of the occipital and temporo-sphenoidal lobes without any sensory or motor paralysis during life to indicate the existence of such a lesion. Tumors, softenings, and the most severe types of traumatism have likewise occurred without creating serious effects.

In case of the occipital and temporo-sphenoidal lobes, to which some of the posterior fibres of the internal capsule are probably distributed, sensory and psychical symptoms have been observed by some to follow circumscribed lesions. A more careful consideration of such cases will perhaps demonstrate the functions of these convolutions more clearly, but at present they are somewhat conjectural. Some forcible arguments have been advanced of late to prove a relationship between the occipital lobes and the mental faculties in opposition to the more commonly accepted doctrine that the frontal lobes were those of intelligence. The temporal lobes seem to exert an influence upon the special senses of touch, smell, and hearing. The angular gyrus of the parietal lobe is probably associated in some way with vision. An apparent connection of the optic and auditory functions with the cerebellum and optic thalamus has been mentioned in previous lectures. The bearing of morbid phenomena of these special senses [1] upon diagnosis will be considered in detail later in the course.

In closing this important subject, let me suggest, that it is by no means certain that lesions, which primarily affect the constricted portion of the internal capsule, may not, in themselves, create sufficient pressure upon the corpus striatum and the optic thalamus to cause interference with the free action of some of the *special centres* which are believed to exist within those bodies. If this be the case, many of the interesting phenomena described during our

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[1] The reader is referred to the author's treatise upon nervous anatomy for information respecting these phenomena.

discussion of lesions of the optic thalamus, would *co-exist* with those symptoms of disease within the internal capsule already mentioned. Ritti's views respecting the relations of the optic thalamus to hallucinations, and those of Luys pertaining to its olfactory, optic, and acoustic functions[1] have a special interest in this connection.

[1] *Journal of Nervous and Mental Disease*, April, 1883.

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