per cent.; no motor symptoms, 13 = 29 per cent. Total spasm, 17 = 38 per cent.

Other lesions of cortex (100 cases): Spasm, 1 = .09 per cent.; spasm and paralysis, 13 = 11.5 per cent.; paralysis, 62 = 56 per cent.; no motor symptoms, 36 = 32 per cent. Total spasm, 14 = 12 per cent.

Thus, in more than one-third of all cases of brain tumor, localized spasms or contractures exist at some period of the disease. When present, they indicate a greater probability of localization in the cortex than in any other part of the brain; and after that, in the region of the corpus striatum and thalamus opticus. In the table, the highest percentage falls to tumors of the peduncle; but this fact is offset by the great rarity of tumors in this region.

TABLE V.—PROPORTION OF CASES OF SPASM WITH TUMORS.

Seat.	Number of cases.	Spasm.	Spasms and paralysis.	Paralysis.	Total spasm.	Percentage.	No motor symptoms (except ataxia).
Cortex—							
Central gyri	39	4	24	10	28	71	2
Parietal lobe (motor)	11	..	7	1	7	63	3
Total motor zone	50	4	31	11	35	70	5
Frontal gyri	14	2	1	4	3	21	7
Other latent parts	13	1	2	2	3	23	8
							Per cent.
Total cortex	77	7	34	17	41	53	20 = 25
Centrum ovale	124	12	22	45	34	27	45 = 36
Basal ganglia	41	9	10	14	19	46	8 = 19
Peduncle	10	1	5	3	6	60	2 = 20
Corpora quadrigemina	13	1	3	2	4	30	7 = 53
Pons	56	3	7	38	10	17	8 = 14
Cerebellum	165	20	12	26	32	19	107 = 64.5
Medulla	30	8	2	15	10	33	5 = 16
Total	516	..	..	..	156	30	202 = 37.5

It is evident that spasmodic contractions of muscles may be caused by irritation either of the nerve elements of a motor centre, or of the fibres of a motor tract descending from it, but that the first condition is more favorable. A continuous fibrillary twitching is frequent in cortical tumors. But tumors of the pons and medulla are rarely accompanied by spasm; it seems that the liability to irritation increases higher up in the tract, and also when the latter is more incompletely invaded. Irritation of the skin over the affected muscles will often throw them into spasm.

Paralyses of Motility.—These are especially characterized, as a rule, by their gradual development, a circumstance which is most useful in distinguishing brain tumors from hemorrhage. It does not, however, serve to differentiate tumors from softening, for in the latter the paralysis is also gradually developed.

To a certain extent the paralyses of tumors share the peculiarities of those caused by other lesions of the same locality. As already stated, however, in the case of tumors, the paralyses are rarely purely typical throughout the whole course of the disease, because they constantly tend to encroach upon other regions than that in which they originated; and because their influence, by transmitted pressure and nutritive irritation, is apt at all times to diffuse itself considerably beyond the region which they visibly occupy. A paralysis which may seem at a given stage to be entirely atypical may, however, exhibit in the history of its development peculiarities which point out the true nature of the disease. The local diagnosis is best assured when a localized spasm has passed gradually into a localized paralysis. The paralysis has been preceded by a slowly progressing paresis, or by tremor or spasm in the affected muscles, or has existed in one set of muscles, or in one limb, or in one or more cranial nerves; or there has been a combination of paralyses of such nerves with others of the extremities, before the disease reached its complete evolution. Or, further, the very first appearance of paralysis may have been preceded by one or more diffused symptoms; or it may have been ushered in by an epileptiform convulsion or an apoplectic attack, remarkable for its brevity and incompleteness. Or a paralysis may declare itself at once, in a fully developed form, but isolated, as in one facial nerve, and after prolonged headache, attacks of vomiting, and change of mind or character of the patient. The typical characteristics of the paralyses, according to locality, are as follows:

Cortex.—The paralysis, at the outset at least, is "dissociated," monoplegic. One arm or one side of the face is affected, or the two together are affected on the same side. It is extremely rare that paralysis begins in the leg; but this extremity often becomes involved later, and then the patient suffers from a complete hemiplegia, difficult to distinguish at first from the common hemiplegia due to hemorrhage into the internal capsule. It is very rare, however, that the paralyzed limbs become rigid. It is with tumors in this region that clonic spasms are most frequent, either before or during the paralysis. Symptoms of tumors of different regions of the cortex follow, approximately, the rules which have been laid down for other lesions, according as they occupy the "latent" or the motor zones. The latent regions are those parts of the brain in which, with rare exceptions, lesions produce no motor symptoms. The motor zones are those whose lesions are always followed by spasm or paralysis, except in a very few cases, in which the absence of symptoms is explained by the extremely slow growth of the tumor, which allows nerve tissue to accommodate itself to increased pressure. When an "absolute field" exists it will be found that, in all cases in which motor symptoms are absent, this field is entirely free from lesion. In the regions adjacent to these, lesions sometimes do and sometimes do not produce symptoms. This fact, as already stated, has been explained in two ways —by the theory of transmitted pressure, and by the theory of a "relative field," which contains motor mechanisms of less degree of intensity and concentration than those belonging to the "absolute field." The absolute motor zones are:

First, for the upper extremity, the anterior central convolutions, especially the lower two-thirds, the upper half of the posterior central convolution, the paracentral lobule, and, in the left hemisphere, the greatest part of the superior parietal lobe, and possibly a few points on the occipital.

Second, for the lower extremity, it is the upper third of both central convolutions and the paracentral lobule, and in the left hemisphere again the greater part of the superior parietal lobe. This "absolute field" is, according to Exner, surrounded by a relative field which occupies the posterior half of the superior frontal gyrus, almost the entire convex surface of the other two frontal gyri, both parietal lobes, and the upper part of the occipital lobe. This field belongs to both extremities.

The centres for the muscles of the trunk have been placed by Horsley and Schäfer in the gyrus marginalis.

Third, there is no absolute field for either facial muscles or tongue, the mechanisms for both seeming to be diffused over the greatest part of the hemispheres. But the seat of greatest concentration, for the facial nerve, exists at the lower half of the anterior central gyrus and the lower third of the posterior central; while a relative field extends over the posterior half of both lower frontal gyri and the anterior part of the supramarginal gyrus. The principal centre for the hypoglossal nerve is the lower part of the anterior central gyrus and adjacent part of the middle and inferior frontal gyri.

Fourth, no definite cortical field has been outlined for either the motor-oculi nerve or the trigeminus. In regard to the first, however, it seems certain that all the branches of both nerves are influenced by the centres of a single hemisphere.

The zone for common sensibility coincides with the motor zone as above defined.

Fifth, the zones latent in regard to motor or sensory symptoms include all the frontal lobes, the temporo-sphenoidal lobes, the parietal lobe of the right hemisphere, and the occipital lobes. Lesions of these lobes may remain absolutely latent, and did so in 13 of Exner's 44 cases of tumors, that is, in 29 per cent. But, even when unattended by paralysis or spasm, lesions of these latent zones are liable to be followed by such disorders of speech, of vision, or of hearing as lead to the localization, within their boundaries, of the centres for these important functions.* In Table V. it will be seen that there were 9 cases of paralysis, with or without spasm, occasioned by tumors in the non-motor regions; the percentage of paralysis to whole number of such tumors being 37 per cent. Out of the whole number of cases of paralysis from 77 tumors of the cortex (51 cases), the percentage belonging to tumors of non-motor regions was 17.5 per cent.; that of those belonging to motor regions (42 cases) was 54 per cent. of the whole, and 84 per cent. of the tumors of that region; while, finally, the probability that a tumor situated in the cortex would occasion some form or degree of paralysis is indicated by the relation of 51 to 77, or 66 per cent.

Centrum Ovale.—A much larger percentage of tumors remain latent in this region than in the cortex, as, for example, 36 per cent., instead of 25 per cent. (see Table V.). The absence of symptoms is to be expected when the tumor neither occupies nor affects bundles of fibres coming from the motor regions of the cortex. In the following table Ladame's and Bernhardt's cases are combined, and show to what extent tumors situated in non-motor regions may yet inhibit the mechanisms of the motor regions.

TABLE VI.—PARALYSIS WITH TUMORS OF CENTRUM OVALE.

Motor Regions.			Non-Motor Regions.		
Seat.	Paralysis.	No paralysis.	Seat.	Paralysis.	No paralysis.
Pars centralis anterior and posterior (Petres)	61	16	Pars frontalis	37	37
			Pars occipitalis	10	23
			Temporal lobe	2	3
			Other parts	..	7
Total	61	16	Total	49	70

The paralyses which are associated with tumors of this region present nearly the same characteristics as do those associated with tumors of the cortex if they are near the surface; that is, they are liable to be monoplegic; but they resemble those of tumors of the internal capsule, if they approach the basal ganglion, in which case they may become completely hemiplegic, and may be followed by rigidity. Tumors in the anterior part of the centrum are chiefly indicated by motor symptoms, spasm or paralysis; those situated posteriorly cause sensory symptoms—hemianæsthesia, or pains on one side of the body. Usually a long period of paresis precedes that of complete paralysis.

The percentage of cases of paralysis in tumors of the centrum ovale, whether calculated from the smaller number of cases in Table VI. or from the larger number in Table V., is about the same, viz., 54 per cent. in the first case, 56 per cent. in the second.

Basal Ganglia.—Tumors of the corpora striata, optic thalami, and lenticular nuclei occasion hemiplegias, which often differ from those of hemorrhage in the same region, exclusively by their gradual rate of development. The paralysis is, however, sometimes monoplegic; thus, out of 41 cases, it was confined to the facial nerve four times, to the arm once, to the arm and facial once, and to the leg once. It is extremely remarkable that large tumors may exist in this region without causing any symptoms whatever. This is the rule for tumors limited to the thalamus or to the lenticular nucleus. Acute lesions, such as hemorrhage in the latter ganglion, cause temporary hemiplegic symptoms, but these subside, probably because the function of the destroyed tissue is supplemented by that of other motor centres. But such temporary paralyses are not seen with chronic lesions, as, for example, tumors, unless these are complicated by an accidental hemorrhage.

But tumors limited to the corpus striatum will certainly cause paralysis if they involve the anterior two-thirds traversed by the motor tract of the internal capsule. It is injury to this tract which determines the phenomenon of "late rigidity"; a phenomenon depending on the descending degeneration which reaches the spinal cord, and which, though so commonly seen after cerebral hemorrhage, is not peculiar to that lesion, but only to the locality which it most frequently occupies.

If a tumor involve the posterior third of the internal capsule, whose fibres pass between the corpus striatum and the thalamus, it tends to destroy the sensory fibres which pass in this locality (Charcot, Veysière), and causes a hemianæsthesia in addition to the motor paralysis. This complication is therefore of great use in establishing the diagnosis of tumors of this region, which from their encroaching tendencies are so liable to involve all parts of the internal capsule. It is possible that a transmitted irritation to sensory fibres has something to do with the high percentage of spasms observed in tumors of the basal ganglia (46 per cent., see Table V.). There were 24 cases of paralysis, with and without spasm, which is 58 per cent. of the whole number.

Hemianopsia, or paralysis of some ocular muscles, occurs with such tumors of the thalamus as touch upon the corpus geniculatum externum. Athetoid movements and intention tremor are very characteristic of thalamic tumors. Still more so is Bechterew's symptom, namely, preservation of the innervation of facial muscles for voluntary movements, with loss of the automatic movements involved in emotional expression,—as in laughing or crying. This isolated mimetic paralysis seems to be quite peculiar to lesions of the thalamus.

Peduncle.—As might be expected, tumors of this region cause hemiplegic paralysis in almost all cases (eighty per cent.). Together with the extremities, the facial nerve and also the hypoglossus are usually involved. The most characteristic circumstance, however, is the paralysis of the motor-oculi nerve by direct pressure upon its trunk as it emerges in the interpeduncular space. The paralysis is on the same side as the tumor, that is, on the side opposite to the hemiplegia. The paralysis is usually total, in which case there will be unilateral dilatation of the pupil, ptosis from paralysis of the levator palpebræ muscle, and divergent strabismus from paralysis of the internal rectus. In other cases, one or more of these symptoms may exist alone. As the tumor grows larger it sometimes crosses the interpeduncular space, and compresses the nerve on the opposite side. This important symptom existed in seven out of the ten cases of Ladame and Bernhardt. It is not, however, absolutely pathognomonic of lesions of the peduncle; for it results, with exactly the same forms, from every tumor of the interpeduncular space; thus, from those springing from the base of the cranium.

Corpora Quadrigemina.—Tumors of these bodies lie outside of the direct cerebro-spinal motor tracts, and thus produce much less definite motor symptoms. Some degree of paralysis existed in 5 out of 13 cases: in 1, paresis of the arm and facial nerve; in 2, a unilateral facial paresis; in 1, paresis of one leg; and in 1, paresis of one-half of the body.

On the other hand, the motor-oculi nerve seems to be paralyzed as often as in the case of tumors of the peduncles; a fact which might be expected from the proximity

*The wide diffusion of the mechanisms for the motor-oculi nerve and the facial, which render their paralyses of little value in regional diagnosis, is probably correlated to the complex relations of these two nerves to the mechanisms of psychic existence, and their functions in the innumerable shades of facial expression.

of the corpora quadrigemina to the nuclei of the nerves, which lie immediately below them. In 14 cases, divergent strabismus existed in 8 (5 cases of Bernhardt, 3 related by Nothnagel). In 1 other case, the abducens was paralyzed, so that internal strabismus existed (Gowers, *Lancet*, 1879).

Cerebellum.—Absence of true motor paralysis, taken together with impairment of the power of equilibration, is highly characteristic of tumors of the cerebellum. Out of a total of 165 cases, only 38 showed any kind of paralysis (23 per cent.). This is almost the proportion in which the symptom is absent in tumors of the cerebral cortex. Excluding the cerebellum and corpora quadrigemina, the probabilities of paralysis with brain tumor are expressed by the percentage 89, while for the cerebellum and corpora quadrigemina alone the percentage is only 24.

Tumors of either lateral lobe of the cerebellum cause of themselves no motor symptoms, even ataxic, and may be completely latent. Out of the 38 cases of paralysis the tumor occupied the middle lobe of the cerebellum in 4; in 5, one of the peduncles; in 15, though mainly situated in a lateral lobe, it extended into the middle lobe, or else compressed the pons or medulla.

The facial nerve may be affected either by an isolated, or by an alternating, or by a hemiplegic paralysis, in the rare cases in which hemiplegia occurs. The lesion is never really of cerebellar origin, but always secondary to encroachment upon the pons or medulla.

Pons Varolii.—In this locality tumors produce the most extensive and also the most complex combinations of paralyses. They are occasionally paraplegic, and not infrequently they become, little by little, generalized throughout the four limbs. This creeping generalization is highly characteristic of tumors of the pons. On the other hand, only cranial nerves may be affected.

Case (Wernicke, *Archiv f. Psychiat.*, Bd. vii.): Patient aged fifty-eight years. In July, headache, diplopia; difficulty in opening and shutting mouth. By end of August, paralysis of left facial nerve, including upper branches; rigidity of left masseter; eyes persistently deviated toward the right; diminished sensibility of face and head on the *right* side, that is, on the side opposite to the facial paralysis. Death occurred in October without further motor affection. Section discovered a tumor on the floor of the fourth ventricle, on the left side of the middle line. Associate nucleus of facial and abducens completely destroyed; left facial nerve nucleus, as also part of the fibres of the right trigeminus, destroyed.

After the frequent generalization of the paralysis, the remarkable paralytic symptoms of pontine tumors are: 1. The coexistence of hemiplegic paralysis of the extremities with paralysis of one or more cranial nerves on the opposite side of the body: alternate paralyses. 2. The occurrence of a *persistent* conjugate deviation of the eyes, thus distinguished from the same symptom in lesions of the hemispheres, where it is always transitory. To these positive symptoms may be added an important negative characteristic, namely, the nearly complete absence of local irritative symptoms, and, to an even more marked degree, of general convulsions. The alternate paralyses are produced by tumors in the lower part of the pons, which injure the nerve nucleus or compress the nerve trunk on the side on which they are situated, and injure the general motor tracts of the limbs previous to their decussation, so that the resultant hemiplegia follows the usual law for cerebral paralysis, and appears on the side of the body opposite to the lesion. When the tumor occupies the upper segment of the pons, anterior to the cerebral peduncles, the facial paralysis will be on the same side as the limbs, since it depends not on a lesion of the nucleus or nerve trunk, but on one involving the central fibres after their decussation. When the tumor occupies the region of the abducens nucleus, the movements of both eyeballs to that side are paralyzed. The double nature of the paralysis proves that the nucleus common to the abducens and internal rectus has been affected.

In the most typical cases, all the branches of the facial are paralyzed, including those innervating the orbicularis palpebræ. The eye cannot be closed, and the patient presents the appearance of Bell's paralysis. The electric excitability of the nerve may then be diminished. However, neither of these last conditions is invariable, even when the paralysis is alternate.

Double facial paralysis is extremely rare. It is lesions of the pons which have furnished the explanation of the remarkable phenomenon—conjugate deviation of the eyes—which for a long time puzzled pathologists. This deviation implies paralysis of the abducens nerve of one side, supplying the external rectus, and coincident paralysis of a branch of the motor-oculi nerve supplying the internal rectus on the opposite side. The apparent remoteness from each other of the nuclei of origin of these two nerves rendered this phenomenon extremely difficult to understand, until the discovery was made, in the pons, of a common nucleus, which unites fibres of the abducens with fibres from the lower nucleus of the motor-oculi on the opposite side. Destructive lesions of this associate nucleus are followed by a permanent conjugate deviation, as in the case (Wernicke) above quoted. It becomes evident that the transitory deviations of the eye, frequently seen immediately after an attack of hemorrhage into any part of the brain, are due to a remote shock propagated to this same nucleus.

The abducens nerve is not infrequently paralyzed alone, causing a converging strabismus of the affected eye.

Isolated paralysis of the motor-oculi nerve is much more rare, and is seen only when the tumor or its influence extends above the pons into the cerebral peduncles, or above them to the nerve nuclei. Ptosis, from isolated paralysis of the levator palpebræ branch, has sometimes been observed alone, and, so far, in cases of tumors, but not in those of any other lesion. This symptom would, therefore, be useful in differential diagnosis.

Paralysis of the hypoglossus is not rare. It is indicated by an impairment of the voluntary movements of the tongue and by disturbance of speech, dysarthria. This paralysis alternates with that of the extremities. It is distinguished from progressive bulbar paralysis by absence of atrophy of the tongue.

The motor branch of the trigeminus is sometimes paralyzed, more often irritated, causing, in the latter case, spasmodic trismus or clonic convulsions of the muscles of mastication.

Difficult deglutition is also sometimes present, but does not seem to be attributable to paralysis of the pharynx muscles, but rather to be a secondary consequence of paralysis of the tongue and of certain muscles innervated by the facial nerve, the styloglossus, digastricus, and stylohyoideus (Nothnagel).

The following table exhibits the various combinations of paralyses, which have been observed with tumors of the pons.

TABLE VII.—MOTOR PARALYSES WITH TUMORS OF PONS (56 CASES).

Cranial nerves alone.		Limbs alone.		Combination of limbs and cranial nerves.		No motor symptoms.
3d nerve	2	Hemiplegia	7	*On same side.*		
7th nerve	3	Paraplegia	3	Hemiplegia and		
3d and 6th nerves	2	Four extremities	2	7th nerve	4	
6th and 7th nerves	3	Arm alone	1	*Alternate paralysis.*		
7th and 12th nerves	1			Hemiplegia and—		
3d, 7th, and 12th nerves	1			3d nerve	2	
3d, 5th, 7th, and 12th nerves	1			6th nerve	3	
				7th nerve	4	
				3d and 6th nerves	1	
				3d and 7th nerves	3	
				6th and 7th nerves	5	
				3d, 6th, and 7th nerves	1	
				3d, 5th, 7th, and 12th nerves	1	
				3d, 6th, 7th, and 12th nerves	1	
Total	13	Total	13	Total	25	4

The number of cases in which the cranial nerves or those of the limbs were paralyzed independently of each other is, in this collection of cases, exactly equal. The number of cases of combined paralyses is just double that of either of the classes of isolated paralyses. Among the cranial nerves, the liability of the facial is evidently the greatest; it was affected, alone or in combination, twenty-four times; the abducens sixteen times.

Medulla.—In this region the liability to paralysis again diminishes. Tumors of the medulla are not infrequently confined to the floor of the fourth ventricle, so that the motor tracts and nuclei are both left uninjured. In this case, the patient escapes all paralysis; indeed, he often remains with singularly few symptoms for the subject of an organic disease seated so near to vital nerve centres. Out of 30 cases, 12, or nearly half, remained free from motor symptoms. In one case, so far unique (Erichsen, *Petersb. med. Zeitschr.*, 1870), a bilateral paralysis of the vocal cords was noted, due to lesion of the accessory nerve.

TABLE VIII.—MOTOR PARALYSES WITH TUMORS OF MEDULLA (30 CASES).

Cranial nerves alone.		Extremities.		Combination.		Negative.
3d nerve	2	Hemiplegia	1	Hemiplegia and—		
7th nerve	2	Three extremities	1	6th nerve	1	
3d and 7th nerves	1	Paraplegia	2	*Same side.*		
7th and 11th nerves	1	General	2	Hemiplegia and—		
5th, 6th, and 7th nerves	1			6th nerve (alternating)	1	
				3d, 6th, and 7th nerves	1	
				3d, 7th, and 12th nerves	1	12
				7th and associated 3d and 6th nerves	1	
Total	7	Total	6	Total	5	12

The third form of motor lesion is *ataxia.*

This form of lesion is principally seen with tumors of the cerebellum and corpora quadrigemina; the latter, possibly from the connection of these bodies with the cerebellum through the superior cerebellar peduncles. In the pons and medulla, the advent of paralysis is often preceded for some time by a staggering or reeling gait "like a drunkard's." This same symptom is very conspicuous in tumors of the cerebellum, and, when associated with the negative symptoms of absence of motor or sensory paralysis, points very strongly to tumors of this region. For the development of the symptom, however, it is essential that the middle lobe be involved or indirectly affected; tumors limited to a lateral lobe are characteristically latent.

Forced movements, or inclinations of the body or head to one side or the other, are sometimes associated with tumor in a lateral peduncle on the corresponding side. A tendency to fall forward or backward has been associated with the situation of the tumor in the anterior or posterior extremity of the upper or lower processus vermiformis (middle lobe).

A combination of ataxia with ocular paralyses was pointed out by Nothnagel to be highly characteristic of tumors of the corpora quadrigemina.

Recently there has been described an ataxia in tumors of the frontal lobes closely resembling that supposed to be special to the cerebellum. It is due to paralysis of the muscles of the trunk, whose centre of cortical innervation is placed by Horsley and Schäfer in the gyrus marginalis, thus in the middle line. Hence with a unilateral tumor there will be bilateral ataxia.

LESIONS OF SENSIBILITY.—With the exception of headache, already described as a diffuse symptom, alterations of sensibility are very much less prominent in the symptomatology of tumors than alterations of motility.

It is evident from this table that, in the cortex, the seat of sensibility coincides with the seat of motility. Pain or anæsthesia rarely exists without paralysis, or except in connection with tumors situated in the motor zones. The liability to pain, other than headache, with tumors of the centrum ovale, is very slight (5 cases out of 124).*

It has already been pointed out that tumors of the basal ganglia will cause hemianæsthesia in paralyzed limbs, provided they involve the bundle of fibres which pass in the posterior third of the internal capsule; otherwise they will not be attended by lesions of sensibility. The table, therefore, expresses the probabilities of this precise situation, in giving the proportion of cases of pain or anæsthesia as eight out of thirty-nine, or twenty per cent.

The highest percentage is with tumors of the pons, and the next highest, if the few cases of tumors of the peduncles of the cerebrum be excluded, is with those of the medulla. In these places occur pain and anæsthesia in the facial range of the trigeminus. When similar symptoms are excited by tumors of the cerebellum, it is only because the pons or medulla has been compressed.

TABLE IX.—LESIONS OF SENSIBILITY WITH BRAIN TUMORS.

Seat.	With Motor Paralysis.						Without Motor Paralysis.						Negative.	No. of cases. Total percentage lesions of sensibility.
	Unilateral.		Double.		Trigeminal.		Unilateral.		Double.		Trigeminal.			
	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.	Pain.	Anæsthesia.		
Cortex (57 cases):														
Central gyri	6	7	....	....	....	....	1	....	....	....	....	....	11	14 = 56
Parietal gyri	1	3	....	....	....	....	....	1	....	....	....	....	12	5 = 29
Frontal gyri	.....	....	....	....	....	....	1	....	....	....	....	....	9	1 = 10
Temporal	.....	2	....	....	....	....	....	1	....	....	....	....	1	3 = 75
Occipital	.....	....	....	....	....	....	....	....	....	....	....	....	1	0 = 0
Entire cortex	8	15	....	....	....	....	....	....	....	....	....	....	34	23 = 40
Centrum ovale (124 cases)	5	14	....	....	....	....	....	....	....	....	....	....	105	19 = 15
Basal ganglia (39 cases)	1	5	....	....	....	....	....	2	....	....	....	....	31	8 = 25
Peduncle (10 cases)	1	3	....	....	....	....	....	....	....	....	1	....	5	5 = 50
Pons (51 cases)	Same side, 1. Opp. side, 7.	10	....	2	....	2	....	....	....	....	....	....	24	27 = 52.5
Medulla (30 cases)	4	5	....	2	1	1	....	1	....	....	....	....	16	14 = 46
Cerebellum (167 cases)	2	7	....	1	1	4	5	5	....	....	....	....	142	25 = 14.5
Corpora quad. (13 cases)	1	....	....	....	....	....	1	....	....	....	....	....	11	2 = 15
Total (491 cases)	30 = 6% of all cases.	59 = 12%	....	5 = 1%	4 = 0.8%	10 = 2%	8 = 1.2%	8 = 1.6%	....	....	1	....	368	....

Percentage of lesions of sensibility in all cases equals 25.

* The percentage of headache, however, was sixty-six, the highest after the cerebellum and rare cases of corpora quadrigemina. The liability to headache, from distention of the dura mater, is constantly seen to bear no proportion to perversions of sensibility due to lesion of sensory tracts or centres.

Trigeminal neuralgia or anæsthesia is, like cramp or paralysis of the masticatory muscles, a most important symptom for helping to localize a tumor in the posterior cranial fossa. It is noticeable (see table) that trigeminal anæsthesia has hitherto been observed on the side opposite to the paralysis, while anæsthesia of the extremities has nearly always existed on the same side.

The cerebellum and corpora quadrigemina show the same minimum liability to lesions of sensibility as they do to motor paralysis. Their precentage, almost alike for the two cases, is, however, not lower than that of the centrum ovale.

Lesions of the Special Senses.—*Vision.*—Disturbances of vision are extremely frequent as symptoms of brain tumor, and are of three kinds: First, atrophy of the optic papilla as a consequence of choked disc, and therefore as a remote consequence of increased intracranial pressure; second, deviations of the eyeball or eyelids from isolated or combined paralyses of the nerves supplying the ocular muscles, the third, sixth, and seventh; and finally, third, amblyopia or amaurosis, resulting from direct affection of the optic nerve in its course through the cranium, or at its cerebral centres, the mode of development being therefore almost precisely analogous to that of paralysis of any other nervous tract by direct compression. The first two kinds of ocular defect have been sufficiently described; the third comprises two different kinds of lesions, those affecting (by compression) the optic tract or chiasma, and those which affect the optic stations at the posterior extremity of the thalami or at the corpora quadrigemina, or else at the final visual centres of the cortex.

The optic nerve or chiasma is liable to compression from tumors arising from the base of the cranium or from the hypophysis, and also from tumors of the peduncle; an acute descending optic neuritis, with atrophy of the papilla, is usually excited. When one tract or one side of the chiasma is compressed, hemiopia results, a phenomenon dependent on the semi-decussation of nerve fibres which takes place in the human chiasma. Thus pressure on the right side beyond the chiasma, of such a nature as to injure the fibres of one tract, will abolish vision in the right half of both eyes. A tumor in front of the chiasma may cause temporal hemiopia of both eyes, since it injures fibres coming from the nasal half of both eyes. There is no way in which a double nasal hemiopia can be produced by tumors at the base of the brain.

Tumors of the thalamus might be expected to affect the sight from lesion of the corpus geniculatum, with its branch to the optic tract. As a matter of fact, however, blindness is not very common from tumors of this locality—only 5 cases out of 26 (19 per cent.) As already mentioned, hemianopsia is seen with tumors of the thalamus, when they involve the corpus geniculatum externum. Tumors of the corpora quadrigemina, however, have an immensely large portion of cases. Out of 11, 9 showed either amblyopia or amaurosis, 5 with and 4 without choked disc (81 per cent.).

Visual defects from lesions of the cortex are extremely interesting in connection with two physiological problems, viz., the question of a second decussation of optic-nerve-fibres in the cerebrum (Charcot), and that of the localization of the mental centre of vision. This centre was placed by Ferrier at the angular gyrus, as an inference from direct experiment upon the brain of monkeys. But Exner, on the authority of four cases of lesion reaching to the cortex, of which two were tumors, places the visual centre in the first and second occipital gyri—the cuneus and adjacent part of the lobulus quadratus.

Case (Gowers, *Lancet*, 1879): Visual hallucinations of a peculiar nature, associated with some degree of amblyopia, affecting both eyes, but more markedly the left. Tumor occupying first and second occipital gyri, posterior half of superior and inferior parietal lobes, the cuneus, and a part of the lobulus quadratus.

Case (Jastrowitz, *Centralbl. für prakt. Augenheilkunde*, vol. i., 1877): Paralysis of both right extremities and facialis; aphasia, with agraphia; hemianopsia dextra. Tumor of the left occipital lobe, principally in the occipital gyri and the precuneus.

Case (Pooley, *Arch. f. Augen- und Ohrenheilk.*, Bd. vi.): Together with various characteristic symptoms of brain tumor in a syphilitic man, extensive binocular hemianopsia. Tumor in posterior lobe of left hemisphere, surrounded by extensive zone of softening. Left thalamus completely softened.

A tumor of one hemisphere may thus cause double hemiopia, a single or double amblyopia or amaurosis, and visual hallucinations of various kinds. The double hemiopia from unilateral lesion, has been interpreted as a proof that, arrived at the cerebral hemispheres, optic fibres which had decussated in the chiasma, recrossed to the opposite hemisphere, thus finally arriving at the same side of the retina as that from which they started. Hemiopia is habitually unaccompanied by choked disc. Crossed homonymous hemianopsia is the characteristic local symptom of disease of the occipital lobes. The symptom occurs also with lesion of any portion of the optic tract, from the chiasma to the occipital cortex. When the lesion is in the medulla of the left occipital lobe, to the hemianopsia is added another important symptom complex, namely, alexia and optic aphasia. It is determined by injury to the association tracts running through the left occipital lobe from the occipital convolutions on both sides to the speech centre in the left superior temporal convolution. The patient recognizes objects by sight, but is unable to name them, unless he either feels, hears, smells, or tastes them. He cannot read words, but can write spontaneously and under dictation. Mind blindness indicates with certainty lesion of the occipital lobes (Bruns).

Six cases of amblyopia and amaurosis have been observed with cortical tumors, unaccompanied by choked disc. These are all to be attributed to a lesion of the visual centre; and, when located in the frontal lobe, the lesion must be regarded as indirect. The amaurosis or hemiopia, with tumors of the centrum ovale (thirty-nine cases, or thirty-one per cent.), probably always implies a transmitted lesion of the cortical visual centre. Of the two cases of hemiopia, referred to in table X., one is used by Exner and Nothnagel as documentary evidence in support of the theory of a visual centre in the cortex of the occipital lobe, but it is placed by Bernhardt among the tumors of the lobes. The total percentage of blindness is higher with tumors of the cerebellum than with those of any other locality, except the corpora quadrigemina. Out of 91 cases there are 41 with some degree of blindness (45 per cent.). Of these, 23, or nearly half, are without choked disc; the blindness being therefore due to the direct action of the tumor upon some visual centre. It seems most probable that the centre affected is that of the corpora quadrigemina; the influence being transmitted through the superior cerebellar peduncles. The high percentage of blindness in the two localities so especially liable would be shown, therefore, to have the same significance. Tumors of the pons and medulla also determine amaurosis otherwise than by choked disc, through direct upward pressure upon the corpora quadrigemina. The direction of the transmission is the same as for the upper (unassociated) nucleus of the motor-oculi nerve, which lies just below the corpora quadrigemina. Out of a total of 51 cases for medulla and pons together, there are 14 cases of amblyopia or amaurosis, or 27 per cent.

To judge from this table we should infer that the chances of amaurosis in brain tumor were exactly equal, whether choked disc existed or not; but that the chances of amblyopia were three times as great without the choked disc as with it. This probably means that if choked disc occur, the impairment of vision which may have been initiated independently of it, by the direct influence of the tumor, will rapidly increase to complete blindness: whereas, without this local complication, the visual defect may for a much longer time, or even altogether, remain partial and incomplete.

Table X.—Lesions of Vision (in 369 Cases).

Seat.	Total number of cases.	With Choked Disc.				Without Choked Disc.					Other Lesions of Vision not Noted.	
		Hemiopia.	Amblyopia.	Amaurosis.	Per cent.	Hemiopia.	Amblyopia.	Amaurosis.	Per cent.	Total per cent. lesions of vision.	Choked disc.	No choked disc.
Centralgyri	....	....	....	1	....	.....	....	....	....	....	3	20
Parietal	....	....	....	1	....	.....	3	2	....	....	....	12
Frontal	....	....	....	....	....	.....	1	....	....	....	....	8
Occipital	....	....	....	....	....	.....	....	....	....	....	....	3
Temporal	....	....	....	1	....	.....	....	....	....	....	1	....
Entire cortex	56	....	....	3	5	.....	4	2	10.5	16	4	43
Centrum ovale	124	....	4	11	12	2 {1 occipital / 1 frontal}	9	13	19	31.5	12	70
Basal ganglia	26	....	....	....	....	.....	4	1	19	19	2	18
Cerebral peduncle	10	....	1	....	....	.....	2	....	....	....	....	7
Pons	30	....	1	3	13	.....	6	....	20	33	2	18
Medulla	21	....	....	....	....	.....	1	3	....	19	2	15
Cerebellum	91	....	4	14	19.5	.....	9	14	25	45	11	39
Corpora quadrigemina	11	....	2	3	45	.....	3	1	36	81	1	1
Total	369	....	12	37	....	.....	42	36	....	....	38	254

Total lesions of vision = 127 in 369 cases = 34 per cent.

Hearing, Taste, and Smell.—All these special senses together are less frequently affected than is vision alone. Out of a total of 369 cases of brain tumor, lesions of vision existed in 127, or 34 per cent. But in a total of 561 cases (which include Ladame's), hearing, taste, and smell were altogether affected only in 67, or 12 per cent. In 46 out of these 67 cases the patient suffered from either tinnitus or deafness, the latter rarely complete. In 29 per cent., the tumor was situated in the cerebellum. This fact tends to confirm, if need be, the recent anatomical demonstration, which traces the central fibres of the acoustic nerve to the cerebellum. By far the highest percentage of disturbance of hearing is exhibited by tumors of the corpora quadrigemina. It is singular that reports of tumors of the frontal lobes so rarely mention symptoms indicating lesion of the olfactory tracts. It would seem that an indirect influence or diffused pressure is insufficient to pervert the sense of smell; this is affected only by actual disorganization of the tracts. In a few cases, anosmia, associated with frontal headache, psychic disturbance, and absence of motor or sensory paralysis, has been a valuable symptom which correctly pointed to tumor in the frontal lobes. But anosmia has also been observed with a tumor of the supramarginal convolution. The sense of taste, though controlled by two medullary nerves, usually escapes injury, even with tumors of the medulla. Unilateral paralysis of the acoustic nerve, with correlative deafness, is strikingly frequent in tumors of the cerebellum.

Table XI.—Lesions of Special Senses (561 Cases—369 for Vision).

Seat of tumor.	Hearing.	Per cent.	Taste and smell.	Per cent.	Vision.	Per cent.
Cortex (59 cases)	1	1.5	4	7	9	16.0
Centrum ovale (192 cases)	8	4	3	1	59	31.5
Basal ganglia (41 cases)	2	4	..	..	5	19
Pedincle (3 cases)	..	....	..	..	3	....
Corpora quad. (13 cases)	4	30	..	..	9	81
Cerebellum (167 cases)	26	15	2	1	41	45
Pons (56 cases)	3	5	9	16	10	33
Medulla (30 cases)	2	6	3	10	4	19
Total	46	8.0	21	3.5	120	21

Disturbances of Language.—These symptoms were formerly confounded either with symptoms of mental alienation or else with difficult articulation due to tongue paralysis. But their interest and importance have been greatly widened by the modern discoveries that a patient may retain other mental conceptions yet lose that of spoken or written speech; and that the generic aphasic defect may be resolved into several modes: motor aphasia, sensory aphasia, agraphia, alexia. The cerebral region belonging to the faculty of speech occupies an extensive area in the left hemisphere, including the third frontal convolution, the insula, the posterior end of the first temporal convolution, the adjacent parts of the gyrus angularis and occipitalis sinister, together with subcortical association tracts. Tumors in the right hemisphere may also occcasion speech disturbance, when from their considerable size they compress the left hemisphere; or when they cause a distention of the opposite lateral ventricle; or because, as Oppenheim asserts, the right hemisphere participates to a real though subordinate extent in the function of speech.

When a disorder of speech has been a very early symptom of the tumor, it constitutes a valuable means of local diagnosis. Nevertheless speech symptoms not infrequently fail though the tumor be situated in a speech centre; while, on the other hand, any form of aphasia may be caused by tumors at a distance acting on the speech regions by transmitted pressure, or encroaching on them in the course of their growth. With tumors of the central or frontal convolutions the aphasia is sometimes preceded by a bradyphasia; or the patient finds a difficulty in beginning words, or in speaking above a whisper.

When aphasia occurs with tumors of the left occipital lobe, or complicates an alexia or hemianopsia, it is always a sensory aphasia. Tumors of the third frontal convolution are liable to produce spasms of Jacksonian epilepsy in the face, tongue, jaws, and larynx.

From the foregoing analysis of the causation and especial probabilities of diffuse and focal symptoms, it is possible in a given case to answer the two questions: first, Is there a brain tumor present? second, In what part of the brain is it situated?

I. Existence of Brain Tumor.—Although a tumor of the brain may develop during either childhood or adolescence, let us suppose it to have begun its growth in an individual of middle age, who perhaps has shown a tendency to tuberculosis. In such a case we can assume that the clinical picture will be somewhat like the following: For weeks or months the patient will suffer from persistent or periodic headache, usually localized at one spot; the pain is peculiarly severe, and is increased by percussion. After a time there will be attacks of vomiting, which sometimes coincide with the most intense paroxysms of pain, and sometimes do not. These attacks, furthermore, seem to bear no relation to the character of the food taken, or to the condition of the digestive organs; they do seem, however, to be dependent upon changes in the position of the body, as, for example, from the recumbent to the upright position. As in the