CHAPTER VI

TUMORS OF THE INTRACRANIAL CAVITY

By FOSTER KENNEDY

Classification.—For clinical purposes all expanding lesions situated within the skull may be regarded as tumors; the symptoms of which arise by reason of their each constituting an alien mass within a rigid, almost inextensible box, already adequately filled with nervous tissue, cerebrospinal fluid, and brain membranes; such masses, no doubt, behave somewhat differently according to their different cellular constructions, but it is mainly true that, while it is most often possible, and frequently easy, to name the site of a foreign body growing within the cranium, speculation regarding its nature is usually but little more than a hazardous guess.

We know, for example, that the cerebellum and pons are affected by conglomerate tubercle in young persons, but have difficulty, in the absence of gross calcification of such granulomatous formation, capable of obstructing the passage of x-rays, in positively excluding the possibility of the lesion being gliomatous in character.

True, a chronological survey of the events of the history of the onset and progress of a case may direct the observer’s mind in a quantitative rather than a qualitative fashion towards approximate speculation regarding the nature of the process at work; gliomata are, on the whole, more malignant in character and more rapidly sinister in effect than are, for example, endotheliomata, which are encapsulated, more slowly growing and intrinsically benign, and arise from the endothelial lining of the brain membranes; such premises naturally lead an observer to believe that a fulminating, expansive process clearly deeply seated in the cerebrum is due more probably to the existence of a glioma than of an endothelioma which is likely to be leisurely in its progress and superficial in its site.

The differentiation of the granulomata from neoplasms proper is, of course, an affair of first-rate clinical importance and, as has been indicated, often of first-rate clinical difficulty. Reference has been made to tuberculous masses occurring in children, and all students are informed—and over-informed—concerning the frequency of intracranial gummatas, which appear by no means as frequently in the autopsy room as they are mentioned in the lecture hall. The family history in the possible tuberculous, the personal history in the possible syphilitic, help clinical direction; age, incidence, and topography of the lesion aid further, because gummatas affect primarily the meninges and only secondarily the brain, whereas massed tubercle is surrounded always by nervous tissue, and only, at the last stages, molest the meninges by the induction of a generalized tuberculous meningitis. Annecent considerations, such as the presence of a tuberculous or syphilitic focus elsewhere in the body, are of self-evident importance, and examination of the cerebrospinal fluid and blood serum may show definite evidences of syphilitic infection.

Incidence.—The frequency of tumor formation within the skull has been variously stated. They have been found in from 2 per cent. to 1.5 per cent. of cases in different groups of autopsy material; when one considers the difficulty of identification by the naked eye in the fresh specimen, of infiltrating tumor growth, and the often cursory examination of the brain in cases in which the...
clinical picture has pointed to a lesion in some other physiological system, one is compelled to think as probably true the higher rather than the lower figure, and to remember that Cushing, in his material at a General Hospital, found 200 of the first 2,500 surgical admissions to be suffering from this condition, though this group must have gone through some selection by reason of the reputation of the Director as a neurological surgeon. At any rate, the brain and its membranes is far from being an unusual position for tumor growth, and general practitioners of medicine do well to bear in mind the general picture occasioned by such morbid processes, for most certainly no member of our profession can escape having to care for such situations in the course of affairs.

Etiology.—The pathogenesis of tumor formation in the brain is as obscure as that governing such phenomena in other parts of the organism. The granulomata occasioned by syphilis, tuberculosis, and fungi, like actinomyces, are probably lymphogenous infections. The mode of production of cysts in the fourth ventricle by cysticercus cellulosae is sufficiently patent, as is that of metastases from other organs, but the processes determining the production of gliomata, endotheliomata, and sarcoma are as yet undetermined, though dermoid tumors, teratomata, and chordomata occur as the result of embryonic defect and are usually basal in position.

Antecedent skull injury has often been credited with the production of brain tumors, and some circumstantial support to the idea comes from the alleged greater incidence of brain tumor in the male than in the female sex. However, the statistics for this assertion include all forms of expanding lesions within the skull, and it may be pointed out that syphilis and prolonged physical exertion causing aneurysms and gummata in men oftener than in women might account for this sex incidence as reasonably as might the greater frequency of masculine head trauma.

A blow not infrequently is followed by tumor signs, due to the production by violence of a hemorrhage into the body of a very vascular and loosely cellular glioma, which up to the time of injury had not given any definite sign of its presence—post hoc, propter hoc reasoning has played too large a role in etiological medicine, and our exact knowledge regarding the causal relationship of skull injury to intracranial tumors does not permit us to go farther than the Scotch verdict of "not proven."

Probably one-half of all brain tumors are gliomata, growths of ectodermal origin, and consisting specifically of a hyperplasia of the neuroglial groundwork of the central nervous system. They are usually solitary, but may be diffuse and so may cover a large area. They are commonly infiltrating growths, and so insidious in their progression that uninjured nerve fibers often traverse their substance—a circumstance which throws some light on the difficulties encountered in subjecting some of them to focal diagnosis. In appearance they are often of the same grayish pink color as the adjacent brain tissue, though they may be seen to be more highly vascular, or their demarcation from normal cerebrum may have been made simple by a hemorrhage having taken place into their substance; but in the main, if they be not carefully searched for in the operation field and at autopsy, they may easily enough be overlooked.

Pathology.—A few such growths of lower vitality than the majority of their fellows, perhaps after growing to a great size, undergo cystic degeneration, almost the entire tumor area being found to consist of yellow gelatinous fluid (Fig. 1); unfortunately, the evacuation of this fluid seems occasionally to grant a renewed activity to the cells which go to make the false wall of the cyst. It is proper to look upon these growths as malignant in character; owing to their poor differentiation from their environment, their entire removal is difficult, and their frequently high vascularity makes attempts at separation very hemorrhagic proceedings. A
pleasanter spectacle is offered by the whorl-cell endotheliomata, and by those more fibrous growths which take origin from the sheaths of the cranial nerves,

**Fig. 1.**—Glioma which has Undergone Cystic Degeneration.

more particularly from that of the acusticus. These types are essentially benign in character. Both are encapsulated, and growing very slowly, do not infiltrate the brain tissues, but push and distort them; injury is inflicted, however, so gradually that the normal tissues are given leisure to accommodate themselves somewhat to the intruder. Under such circumstances, symptoms may be long in making their appearance and only become manifest when pressure is exerted on vascular supply, inducing a cerebral edema, or on a point of ventricular drainage inducing hydrocephalus.

Their benignity and the fact that they are so usually meningeal in position render them excellent operative risks, and their extirpation is attended with more ultimate satisfaction than is often the case in more vascular or less capsulated growths. Because of their slow advance, however, they may be immense things by the time their removal is undertaken, and may have produced extraordinary deformity in structures contiguous to them. In one of the writer's cases, without clinical evidence of pontine damage, the pons was found to be bowed in a semicircle around an acusticus tumor; it is, therefore, necessary to remove them with infinite caution and lack of haste, and the operation is probably better carried out in two stages. If such precautions be taken, however, the outlook for complete recovery is good, and offers perhaps as brilliant a result as can be obtained anywhere in clinical medicine. A cortical endothelioma of over 180 grams weight was removed some twelve years ago from one of the best known public men in our world to-day, nor has he been inconvenienced since by his old malady.

Not infrequently these neoplasms arising from the falx or other portion of the dura mater produce by irritation of the periosteum of the skull such localized thickening of the bone as to give rise to bony knobs on the cranium—knobs which invite by their appearance the diagnosis of primary osteomata of the skull (Fig. 2). Such malformation of bone often fails to be accompanied by cerebral symptoms other than headache. These excrescences are composed of very solid ivory-like bone, and should

**Fig. 2.**—Osseous Thickening Secondary to Endothelioma.
be approached by operators with great caution. It is necessary to make the line of the bone-flap in such cases clear of the bony tumor, as the violence needed to cut through the newly formed and very hard bone itself is always accompanied by profound shock to the patient.

Sarcomata of the brain are very difficult to distinguish by naked eye appearances from gliomata; they are often metastatic, as from a hypernephroma, and occasionally are pigmented as from the uveal tract. Metastatic sarcomata in the brain resemble carcinomata in the same position in being usually multiple. Infrequently, cases of diffuse primary sarcomatosis are seen affecting wide areas of the meninges; sarcomatous thickening and sarcomatous nodules being found in the membranes and spinal theca; metastasis occurs by means of the cerebrospinal fluid. In the writer’s experience, these conditions have begun in the cord membranes, and only secondarily have affected the brain. Sarcomata primarily affecting the base of the skull are not rare in young people. They damage seriatim the contiguous cranial nerves and are quite inoperable.

A type of growth to which not enough attention has been paid is the simple adenoma arising from the epithelial cells of the choroid plexus. A good instance of this interesting condition was seen by the writer at the National Hospital in London. The woman presented all the clinical characteristics of a tumor, involving the left temporoparietal lobe. The evidence of great intracranial compression was absolute. On opening the dura over the affected brain area, there was a tremendous extrusion of brain cortex which suddenly burst, emitting a fountain of cerebrospinal fluid through the thinned out and ruptured ventricular wall. Sir Victor Horsley, who performed the operation, digitally explored the interior of the ventricle and removed a tumor the size and shape of a large pea, which had been attached to the choroid plexus, and appeared had blocked interventricular communication. This tumor was epithelial in structure and had two small cystic areas on its surface; it was benign and the patient entirely recovered.

**SYMPTOMS AND DIAGNOSIS**

The basis of all clinical investigation must be a careful chronological history of the events leading up to the situation to be examined. A steady progression of symptoms over a period of a year or so may be of more importance in determining the nature of the process than is the physical examination itself; but the observer must weigh carefully the symptomatology and clinical data, and before coming to conclusions, make sure of the essential unity and balance in the morbid picture.

Naturally, not all cases of intracranial tumor growth show a gradually ingravescent symptom-complex. As has been suggested, the first sign of a large endothelioma may be occasioned by its having encroached on an important blood vessel and induced an acute edema around itself with a correspondingly acute accession of symptoms.

Evidences of Intracranial Compression.—One of our latest tumor cases in Bellevue Hospital suffered a typical apoplexy and hemiplegia some eight months before the onset of signs of any rise in general intracranial tension. In this case hemorrhage occurred in the body of a vascular loosely knit glioma of the parietal region, and by reason of the tension of the outpoured blood, induced pressure on the adjacent and traversing motor fibers, which resulted in a complete contralateral hemiplegia. The clot contracted and was partially absorbed, so that his symptoms improved for some months, that is, up to the time when cellular growth of the tumor itself overtook and passed the limits of the old hemorrhage, and by its persistent pressure raised intracranial tension to such a pitch as to reinduce his hemiplegia, and to produce also the
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evidence of general vascular and cerebrospinal compression, which were, as in most tumor cases, headache, nausea and vomiting and papilledema, often miscalled optic neuritis.

In the case just related, the symptoms which made clear the site of the lesion were, of course, the contralateral hemiplegia produced by direct injury of the motor fibers through blood effusion and tumor pressure, but the symptoms which made clear the nature of the lesion were those which showed the pressure of a general expanding pathological condition. These general symptoms are mainly the result of the physical conditions which obtain within the skull. The skull is practically rigid in the adult and forbids relief to any increase of pressure within its cavity; manifestations of such pressure must, therefore, be directed to the points of lowest resistance.

The Mechanism of Papilledema.—The cerebral pond is compressed by the growth and its contents are forced to dilate the ventricular cavities of the brain, to drag and stretch the cerebral membranes, thus inducing headache (it has been shown that the dura mater is insensitive to touch and incision, but acutely sensitive to traction); to force downward into the foraminal ring the inverted cone of the medulla, thereby unbalancing its centers and inducing nausea and vomiting and a slow vagal pulse; and finally, to force cerebrospinal fluid out of the great cerebral pond into the potential space between the optic nerve and its vaginal sheath, itself, directly continuous with the intermeningeal spaces about the brain. This latter phenomenon, therefore, causes through an excess of fluid in the intravaginal spaces, a resultant edema around the nerve heads. This distention of the vaginal sheaths may easily be demonstrated by autopsy in cases where papilledema has been seen clinically.

The occurrence or non-occurrence of papilledema in cases where intracranial pressure is raised dependent in the highest degree upon the formation of the eyeball. In hypermetropic and em-
general signs. It is indeed excellent when the diagnosis can be made in the absence of these general signs, but only occasionally can it be done. Much has been written on the advisability of forestalling the onset of general signs by focal diagnosis, but the way to achieve this good aim is not always so elaborately set forth. Without great experience in cerebral diagnosis, attempts to do without clear evidence of the nature of the lesion under inspection are likely to lead to disaster. Interlacing or reversal of the visual fields for different colors has proved to be of no value for early diagnosis.

Other signs of general increased pressure are attacks of dizziness, which may be due to irritation of the labyrinth, or other parts of the cerebellar mechanism, or they may accompany attacks of transient diplopia. The latter occur frequently in tumor histories, and may be the earhest of a paralysis of one or both external recti muscles, which occurs also as a result of intracranial compression. The mechanism of such oculor palsies has been variously described. The sixth nerves have a very long extracerebral course before they leave the cranial cavity, and it has been thought that changes in the position of the brain through compression allowed traction and consequent physiological block to occur in their fibers. Cushing, however, has pointed out that often the sixth nerves are overlain by branches of the basilar artery, and that gross arterial indentations can be seen across nerves so disadvantageously placed. However, whatever the cause, the fact is plain that transient diplopia and transient deterioration of one or the other, or both sixth nerves, are characteristic phenomena of an increasing intracranial compression. Diminution in the deep tendon reflexes in the arms and legs, prefaced by sharp pains in root areas, are quite often found where intracranial tension is high, and are apparently the result of pressure or traction on the posterior spinal roots; degeneration of these roots and in the posterior columns has been frequently demonstrated in such cases.

Drowsiness and frequent yawning, with a lowering of mental acuity, are seen in individuals with ventricular distention; generalized convulsions may occur, even though the neoplasm is not situated in either motor area. Alterations in body weight are to be regarded probably as focal signs of hypophysial change, rather than of any alteration of general conditions, and the same is probably true also for alterations in output and character of urinary secretion. Profound hebetude, with occasional generalized epileptiform convulsions, disoriented ocular movements, a slowed pulse and sighing, shallow, irregular respirations, frequent paroxysmal vomiting and hicough, alternating with feeble screaming, occasioned by agonizing bouts of headache, constitute with sphincter relaxation the general picture of the terminal stages of an unoperated case of brain tumor in which focal diagnostic signs have not appeared.

One cannot close this brief survey of the general results of brain compression by neoplasm without noticing how surprisingly rarely in the course of these conditions (often producing the gravest possible damage to all parts of the brain), one sees any sign of alienation of the personality. If the brain be regarded as the organ of the mind, whether we consider the mind as being in the brain, of the brain, or acting through the instrumentality of the brain, we would naturally expect wide defects of judgment, memory, attention, and consciousness of personal identity when the brain suffers grave injury. On the whole, such defects of personality are rarely seen. Emotional expression is interfered with in subthalamic lesions; some emotional dissipation may be seen in supratelamic lesions as in the frontal lobes; but even in those persons suffering hallucination through temporo-sphenoidal injury, the illusions are very superficial, and the awareness of the individual is alert, even during the illusion period, to discriminate between those appearances that are real and those that are not. In war, none of us saw mental alienation in even the gravest cases of head injury at all comparable to the dis-
orders of personality occurring without physical injury as the result of emotional shock.

In many cases of brain tumor focal signs and symptoms never appear; in others they are equivocal. In most it is possible to establish correct localized diagnosis if sufficient care be taken in the examination of the patient. Education has for its object nothing more nor less than the development in man of the ability nicely to appraise evidence; for happy results in the study of brain lesions there must be brought to the task, patience, clear vision, a discriminating sense of values, and that quality to boot which Johnson dubbed the highest form of intelligence—a noble curiosity concerning phenomena under observation. There is no great difficulty in explaining the mechanism of a process which imposes a succession of one-sided jacksonian fits and a slowly progressive hemiplegia on the signs of a vastly increased intracranial tension, but acumen is needed to correlate a number of small signs in such an instance as a tumor of the vermis which has begun to invade the left lateral cerebellar lobe.

The diagnosis depended in such an instance of our series, on a proper appreciation of the meaning of a nystagmus, somewhat grosser on looking to the left than to the right, a greater difficulty in standing on the left than on the right foot, a clumsiness in the performance of rhythmical acts with the left hand greater than could be explained by the physiological inaptitude of a right-handed person, a slight tendency when walking to abduct the left leg and evert the left foot to guard against a tendency to fall to that side, and on gauging correctly the significance of a moderate tilting of the head by which the occiput was ever so slightly inclined towards the left shoulder. Each of these observations was in itself of little enough account; when added together they pointed to a deterioration in the functions of the left cerebellar lobe.

In the same case there was depression of the left abdominal reflexes and a pathological left plantar response. To account for this apparent anomaly in the syndrome of a left-sided cerebellar expansion demanded a constructive visualization of the mechanical conditions involved. Pressure was clearly extreme; there were some general signs of medullary compression; it was imagined, therefore, that the brain stem might well have been forced through the foramen magnum so far as to bring the pyramidal decussation below the bony outlet of the skull—pressure then would react diagonally from the left occipital bone to the right side of the foramen, and deterioration of function in the motor pathway to the left side of the body would follow, owing to the abnormally placed pyramidal crossing. It was decided, therefore, that the slight left hemiplegia was corroborative rather than antagonistic to the diagnosis already reached, which diagnosis was later verified through exposure of the tumor by operation.

Evidences of injury to representing centers are of diagnostic value in direct proportion to the stage in the disease process at which they appear: the sooner such signs can be discovered the more valuable they are. When symptoms of brain tumor have been of long standing and much ventricular disturbance has occurred, manifestations of focal irritation or pressure, such as generalized or even jacksonian convulsions, or cranial palsies, especially those of the abducens ocular muscles, have to be subjected to a high degree of scrutiny before being accepted as of diagnostic value.

Of course, this attitude of philosophic doubt can easily be exaggerated, and briefs can be compiled without much difficulty which would go to show the comparative worthlessness of all focal evidences in diagnosis: how an unsuspected secondary growth in the left motor area has produced such irritative phenomena as entirely to obscure the existence of a larger and earlier growth in the right temporasphenoidal lobe; how medullary compression in the foraminal ring held our vision from a tumor in the midbrain, obstructing the iter and giving rise to an enormous enlargement of the ventricular cavities.
It is indeed easy to multiply cases of mistaken diagnoses—none of us is without his quota—and to expatiate from autopsy material on just how the mistakes arose and how natural, indeed how praiseworthy they were! However, the fact remains that careful and often repeated examination of the patient—and each examination must be moderately complete—will, in the great majority of cases of intracranial expanding lesions, bring us to correct diagnoses.

In the early discovery and appreciation of the meaning of quite small defects of function, correlated with the known facts of intracranial anatomy and physiology, lie the secret of success in this field. The old Latin tag, “ex pede Herculem,” might serve aptly enough for a neurologist’s motto—not only from the foot can one tell Hercules, but mayhap from the movement of an eyelid or a tired abdominal reflex. In the case of a young stenographer of our series, a correctly planned operation was carried out through the discovery of her inability to name an ordinary fountain pen which she described instead as “one of those patent pens,” a deterioration of word recollection, so unusual under the circumstances, as to direct suspicion immediately towards the left temporo-sphenoidal area.

**Tumors of the Motor Areas.**—These tumors usually produce a clearly outlined syndrome containing phenomena both irritative and paretic. The early occurrence of focal epilepsy is naturally a diagnostic sign of the greatest importance, and is in itself presumptive evidence of a lesion affecting either the meninges or cortex. The severity, frequency, and duration of attacks are no indication of the size of the irritating lesion producing them, though a constant site of inception and direction of spread may give precise information as to its position.

Such violent irritations of the motor areas are followed by exhaustion of the great Betz cells of the cortex, and by a temporary weakness of the parts of the body served by them. This deterioration of function may appear as a complete hemiplegia or hemiparesis; by a weakness or complete loss of power in a limb or one side of the face, or by difficulty in speech. Such phenomena are usually transient, at first lasting but a few minutes, later remaining for some hours and, finally, becoming constant when the growth has exerted destructive as well as irritative pressure.

When the growth is situated entirely in front of the Rolandoic fissure, it is unusual to find any objective sensory changes in the contra-lateral limbs, though focal fits caused thereby are likely to be prefaced by numbness and tingling in the fingers or toes. Should the neoplasm, however, be placed more posteriorly, there may well be much paresthesia and loss of the sense of position in even the large joints of the limbs of the opposite side, in which case astereognosis would be evident in the affected hand. Quite rarely is there found any interference in tactile sensibility from damage to the cortical zones; changes in pain and temperature appreciation from such lesions never occur.

It must always be borne in mind when dealing with brain tumors that they are of gradual development and produce their effects for the most part slowly. Deterioration of function necessarily precedes destruction of function and a slight clumsiness in the performance of a fine movement is, in these cases, a harbinger of future palsy. For the most part, also, the pressure exerted by a growth varies inversely with the distance from that growth, and exact information can usually be gathered concerning its position by a minute examination of the sequence of events. Despite recent onslaughts on the classical conception of the cerebral representations of speech and the amorphous character of these now presented to us, it will be found that lesions involving the anterior parts of the motor zones, if situated on that side of the brain on which the individual’s speech faculties are represented, will produce defects of speech emission comparable to those losses of fine movement of the fingers to which reference has just been made.
Words will come sluggishly and are slurred. Inapposite terms are unlikely to occur, but accurate descriptions are pronounced badly and with difficulty, hesitation, and effort. Appropriately sided tumors, however, placed low down on the motor zone, affecting by contact or pressure the superior temporal-sphenoidal gyrus, will produce inaccuracies of name and description rather than difficulty of emission and articulation. This is usually recognized and resented by the speaker who tries to compensate for his terminological errors by fluent circumlocution.

Left motor zone growths pressing occipitally in most right-handed persons may cause to deteriorate those highly organized areas which have been educated to subserve the function of recognizing written symbols, and a high degree of alexia may occur which may be the beginning of an inability to recognize visualized object forms. Such cases will also have defects in the contralateral visual fields, and will earlier have lost, as has been said, stereognosis in the affected hand.

**Explanation of Crossed Aphasia**—Speech defects can be more adequately dealt with, however, when examining the focal evidence of tumors involving primarily the temporoparietal lobes, but reference may be made here to the evidence explaining the puzzling cases of crossed aphasia, that is, those apparently inexplicable individuals who, though right-handed, acquire a severe aphasia through a lesion in the right brain, or who, being left-handed, remain accurately articulate through the same malady. If inquiry be made regarding the handedness of the family stock of such a patient, it will most often be found that the location of his speech areas, as regards the right or left side of the brain, has followed the idiosyncrasies of his stock rather than his own individual handedness. Anomalous cases of this character furnished many of the arguments which tried to overthrow our ideas regarding the precise localization of speech function. It is here submitted that investigation of the type of handedness prevalent in the family and forebears of the patient makes reasonable such phenomena, and gives in many cases additional information regarding the position of his lesion.

**Subcortical Growths.**—Subcortical growths of the motor areas differ from those superficially placed in either never causing focal epileptic seizures, or in causing them late in the disease, after a considerable degree of paresis has occurred in the contralateral limbs. In the first instance, the growth is probably deeply placed and may even impinge on the optic thalamus of the same side, in which event there will be diminution in the power to register emotion on the contralateral side of the face. There will also be some alteration to all forms of sensory stimulation on the opposite side of the body, which may be the seat of deep, vague, burning pains, produced especially by contact with cold or sharp objects. Athetosis in the contralateral arm and hand is occasionally seen in such persons, a result of interference with suprathalamic fibers. A subcortical growth may advance its bulk towards the brain cortex, and on attaining it may produce focal irritation. When one remembers, moreover, the great depth of the cerebral sulci it will be readily realized that the occurrence of such irritative episodes is no strong argument for the presence of a tumor in a superficial position, unless they take place quite early in the history of the illness.

**Tumors of the Frontal Lobes.**—Tumors of the frontal lobes are often difficult to diagnose because of the rather indeterminate condition of our knowledge concerning the functions of these parts of the brain. The frontal lobes have been rather generally credited with being the especial instrument of intellect, but it is disconcerting to discover how much damage, indeed ablation, can take place in these areas without much definite alteration in the memory, attention, or judgment of the individual. An inapt, purposeless jocosity is more often described than seen in persons suffering from the effects of these lesions; more commonly the reverse condition—drowsiness and a ten-
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Tendency to morbid sleep, with frequent yawning occurs; it is not possible to give topographical reasons for these contrasted pictures. There may be involuntary relaxation of the sphincters with or without hebetude. A fine tremor in the ipsilateral hand is often seen as a result of interference with frontopontine fibers, and pressure backwards on the motor areas frequently causes reflex changes—depressed abdominal reflexes and a tendency to an extensor type of plantar reflex—on the opposite side of the body.

Tumor growth is usually too insidious to cause the conjugate deviation of the eyes seen commonly after vascular accidents interfering with the frontal lobes. Left-sided tumors of these areas commonly produce deterioration in speech in appropriate persons. The picture so far presented is somewhat cloudy, but reference must be made to a syndrome which gives an exact diagnostic indication of certain expanding lesions of the frontal lobes, and at the same time is not difficult of elicitation. This consists in the occurrence of true retrobulbar neuritis with the formation of a central scotoma and primary optic atrophy on the side of the lesion, together with concomitant papilledema in the opposite eye (see colored plate).

The fibers of the optic nerve maintain fairly definite relative positions in their course, and it has been found that fibers originating in the macular region of the retina lie as a wedge-shaped bundle towards the outer side of the nerve, the apex of the wedge being directed medially, while the base is covered completely by fibers coming from retinal areas other than the macula. This macular bundle subserves central vision; physiologically more delicate than its fellows, its structure presumably is proportionately more fragile,\(^1\) the result being that direct pressure on the optic nerve has, as a first consequence, a deterioration of function and, later, a primary atrophy of the macular fibers with loss of central vision, and this in spite of the fact that the grosser strands retain functional activity though subjected by their peripheral position to more immediate and direct trauma.

The sequence of events described is that which takes place when, from the earliest inception of disease, one or other optic nerve is directly subjected to pressure. If, however, the expanding lesion be situated in the substance of the frontal lobe, not implicating at first the underlying optic nerve, but producing a general rise of intracranial pressure, there will be brought about at first a bilateral papilledema without central scotoma or loss of visual acuity.

The tumor or abscess (in one of the writer’s cases the lesion producing this syndrome was an aneurysm of the right internal carotid artery) expands until at last it presses directly on the upper surface of the ipsilateral optic nerve. The following phenomena will then result: the papilla contralateral to the tumor will remain edematous and visual acuity in that eye will, for a considerable time, remain good. In the ipsilateral eye edema will rapidly subside and visual acuity will quickly diminish, a central or paracentral scotoma will develop, and in a few days’ time a decided temporal pallor will be seen ophthalmoscopically—an expression of atrophy, which, at a later period, will be observed in all four quadrants of the disc. Owing to the proximity of the olfactory bulbs to the optic nerves, it almost invariably happens that trauma to the latter is accompanied by damage to the former. On this account it is usual to find in this syndrome that depression or loss of the sense of smell is practically always found on the side on which retrobulbar neuritis has occurred (Fig. 3).

When tumor formation takes place not on the under surface but in the body of the frontal lobes, the resulting papilledema will usually be seen first in the ipsilateral eye. Apart from the effects of direct implication of the optic nerve just described, the edematous phenomena in this ipsilateral eye will run their life history rather in advance of those on the opposite side—the side on which papilledema first develops is.

\(^1\)Brouwer ascribes the greater fragility of the macular fibers to their phylogenetic youth.
of less and less diagnostic value in tumor formations affecting areas increasingly remote from the optic nerves. In infratentorial growths, choking may begin on either side without much reference to the side on which the tumor occurs.

Expanding Lesions of the Occipital Lobes.—These lesions are characterized especially by homonymous hemianopic defect in the contralateral visual field.

The same general principles governing the occurrence of paretic or irritative symptoms in tumors of the motor zones are applicable here also. Primarily subcortical growths will cause interference with optic radiations and crossed homonymous hemianopia; primarily cortical lesions of the occipital pole, especially involving the walls and floor of the calcarine fissure, will cause visual jacksonian fits in the opposite field, followed usually by deterioration or loss of function in that field—consequences of irritation which, at first temporary and postparoxysmal, become permanent when destruction of tissue has been produced by pressure.

The subjective phenomena produced by irritation of the calcarine cortex are crude and lack constructive quality. One of the writer’s patients, a child with a hemorrhagic cyst in the left occipital pole, used to cry out: “I see the twinkles,” by which she meant flashes of light occurring at first in the temporal periphery of the right visual field. These twinkles increased in violence and in number until, after some five or ten minutes, they filled the entire right field. Consciousness was then sometimes lost and a little twitching of the right side of the body occasionally occurred. After recovery, however, there was right half blindness for form which, lasting for some hours, gradually disappeared, to be succeeded by color blindness in the same distribution, which was replaced a little later by normal vision. If this child had been able to read, it is probable that a transient alexia could have been demonstrated. Visual disorientation only occurs when both occipital lobes have suffered injury, an improbable result of tumor growth.

The writer has never been satisfied that he has succeeded in eliciting Wernicke’s hemianopic pupillary reaction, which seems frequently to have brought illumination to others; he has had to depend for exact occipital localization on the phenomena already described, on neighborhood symptoms, and on the type of quadrantic defect produced in the contralateral field.

Tumors of the Temporal Lobe.—Tumors of the temporal lobe, and especially of the right temporal lobe, are usually considered the most difficult of all intracranial growths to recognize; this is chiefly because of the comparative latency of the region affected. However, the fewer important centers there are in any given brain area, the more likely are surgical procedures to meet with success in that area; for which reason, and because the temporal lobe is so often the seat of abscess formation of otitic origin, it seems proper to discuss the symptomatology of expanding lesions of these areas in some detail.
Owing to the fact that the temporal lobes are vast and uncharted regions containing only one known bilateral center, that of smell and taste, situated in the uncinate lobules, and one unilateral center for the storage of auditory memories in the transverse gyri of Heschl, we are forced, in many instances, to look for exact localizing signs to the pressure effects of temporal tumors on neighboring structures. The clinical picture produced by implication of the latter, together with the centers of specific function contained in the area, can best be appreciated by a brief consideration of a case in which the diagnosis was exceedingly easy.

M. P., a woman, aged 51, was admitted to Bellevue Hospital in November, 1910. In June of that year she had had several convulsions during sleep, vomiting, and severe left temporal headache. In July these were repeated. In August, while standing in her home, she suddenly became terribly frightened—"frightened in the stomach"; became dizzy, "everything seemed to turn"; she sat down and experienced without loss of consciousness a typical left-sided Jacksonian fit which lasted about ten minutes. "I could speak if I held my mouth. I kept spitting all the time." There was weakness in the left arm after the fit. In the latter part of the attack she noticed an awful smell like rotten weeds. This lasted a minute or so, and was followed, when the fit was over, by vomiting. Half an hour after the vomiting attack had passed, "the smell came again and at the same time I felt queer; everything seemed funny and different." Again there was no loss of consciousness. "Then I distinctly saw a woman standing near me, to my left. I was afraid of her. I did not know her. She was dressed in blue. She moved and made motions as if she were talking, but I could not hear anything."

In the following weeks, this patient had frequent subjective sensations of an offensive odor as before. The woman always appeared to her left, always in blue, and always frightened her. "I always felt queer before I saw her. The queer feeling usually lasted a quarter of an hour." There were no motor fits just then but headaches became severe. The smell came often and was always disgusting and paroxysmal—she would wipe her mouth with a handkerchief to try to get rid of it. "I do not know whether it was in the mouth or in the nose."

The left arm and leg gradually became weaker, and in October, she began to have burning pains in the left arm and hand and, to a less extent in the left trunk and in the left leg. "If I put my left hand in hot or cold water the pain was terrible." In the middle of October she had another left-sided focal fit followed by the evil smell and apparition, after which the left arm and leg were definitely weaker. About the same time she noticed a "crawling sort of movement" in the left fingers which occurred apart from the attacks. Headaches and the burning pain in the left side of the body both became more severe. There were no changes at any time in the optic discs—an unusual occurrence in temporal tumors. Hemianopia and relative hemianesthesia were found on the left side, in the arm of which side there were profound ataxia and athetosis. A severe left hemiparesis was also present. She was discharged from hospital six weeks after the removal by Dr. John Hartwell of a large endothelioma from the posterior parts of her right upper and middle temporal gyri. She was then without headache or fits, and power and sensation were almost completely restored to the left arm and leg.

The convulsive seizures in this case were particularly characteristic, beginning always with an aura of fear referred to the epigastrum and spreading through the central gyri. By the time the motor fit had exhausted itself, there was produced a true uncinate fit—a crude subjective sensation of a foul odor, with nausea and vomiting. This was associated in many of the attacks with that most curious of psychic conditions, a true "dreamy state" in which consciousness, though retained, is strangely transformed, and in which the relationship between the individual and the external world becomes apparently altered in a manner too subtle for concrete description. In this respect, this woman contented herself by saying she "felt queer," that everything seemed "funny and different," but this failure to portray her defective objective consciousness was almost made up for by her clear-cut description of her increased subjective consciousness, namely the projection of her submerged memory of a woman dressed in blue who caused her fear.

Doubtless these "voluminous mental states," as they were called by Hughlings Jackson, often accompany so-called idiopathic epilepsy, but it is noteworthy that when sensory resuscitations of this kind have occurred and organic intracranial disease has later been found to have been present, the lesion has always been found in the temporal lobe. In a series of 9
proven cases of tumor of the temporo-sphenoidal lobe of one or other side, the writer obtained a clear history of the incidence of dreamy states in 7, and of subjective sensations of special sense in 8, and the 9 patients had had

at some period of their histories one or other type of phenomenon.

One should notice that, when subjective visual spectra occur as a result of temporal lobe disease, they have a constructed, coördinated character entirely absent in those crude scintillations produced by irritation of the calcarine cortex. Oppenheim takes occasion to remark that crude sensations of taste and smell may also result from direct lesions of the olfactory tracts: from this the writer entirely dissents. Such a contention ignores all known physiological facts; from such premises, we should expect to find multicolored visual fits resulting from trauma to the optic nerves by sphenoidal sinusitis or subfrontal tumors, and focal convulsions from internal capsular hemorrhages. More to the point is his observation of occasional cases of fixed pupils in patients suffering from temporal tumors. This occurs, though rarely, when a growth placed mesially in the lobe, invades secondarily the region of the corpora quadregemina. In one of the writer’s patients, later operated on by

Dr. Elsberg, limitation of conjugate upward and downward movement of the eyes was seen during periods of great pressure, accompanied by transient absences of the light reflex in the pupil before complete pupillary paralysis took place.

The optic thalamus is often compressed in these conditions; it is common to find effects of depression of function of the ipsolateral thalamus in an abolition or marked diminution of emotional expression on the opposite side of the face (Figs. 4a and 4b). It is unusual to find so complete a thalamic syndrome as was present in the woman just described. The posterior position of the growth probably accounted partly for this greater incidence of pressure on the thalamus as it did for the hemianopic defect in the contralateral visual field. In the hemiparesis caused by temporal growths, weakness is usually most evident in the face, less so in the arm, and least of all in the leg.

The question of the speech defects in these conditions now requires consideration. The effects of gradually expanding cerebral lesions on the vari-

FIG. 4a.—TUMOR INVOLVING RIGHT OPTIC THALAMUS PRODUCING WEAKNESS OF LEFT FACE FOR EMOTIONAL EXPRESSION.

FIG. 4b.—THE SAME PATIENT SHOWING RETENTION OF POWER FOR VOLITIONAL, I.E., NON-EMOTIONAL, MOVEMENTS.
experimentally or in the course of nature. In these vascular lesions, the damaged area is sharply delimited and within its boundaries destruction is usually rapid and decisive; in the expanding cerebral lesions, a gradual deterioration of function takes place, producing abnormal speech conditions less obvious, but equally informing. Some stress is laid on these facts because in text-books, it is usual to find the statement that word-deafness is to be expected in cases of tumor or abscess formation in the left temporosphenoidal lobe. This assertion is entirely misleading, in that such a situation can only be brought about by destruction of the transverse gyri of Heschl and the posterior three-fifths of the superior temporal convolution; this destruction practically never occurs, except in the terminal stages when exact diagnosis is unnecessary.

Differences in size, situation, and rapidity of spread of left-sided temporal lobe tumors, will, of course, produce differences in speech affection, but one feature is constant: a depression of the power to recollect names, especially those of persons, places and things; this discrimination is accounted for by the fact that our conceptions of persons and things are less closely connected with their names than are the abstractions of their circumstances and properties. Thus one patient, when shown a familiar gold coin, recognized it as, "money, good to have," while an envelope was called by another patient, "something to put a letter in." In these, as in most other cases, there was no loss of word memory; the memories were intact, but in a degree submerged and capable of being brought up to consciousness only by a great effort of will, or by the aid of an additional cognate auditory or visual stimulus. Often such a patient has no speech defect in ordinary conversation, but makes frequent mistakes when asked to name familiar objects shown to him. This condition is perhaps the most characteristic of all the temporosphenoidal speech defects, and is dependent on a degradation of function in the association tracts uniting the visual and auditory centers. These naming errors are instantly perceived by the patient and annoy him. The right word is recognized as soon as it is heard, and so far are these people from being word-deaf that an inaccurate prompting is invariably rejected.

**Tumors Affecting the Centrum Ovale and the Basal Ganglia.**—These tumors are usually difficult to diagnose, unless the optic thalamus be implicated. In that event, the thalamic syndrome touched on in the last section may be manifest: contralateral athetosis, astereognosis and depression of the power to appreciate touch on the affected side, combined with explosive sensibility as regards superficial and deep pain and temperature, and much subjective burning pain of a characteristic nature in the same parts of the body. These symptoms are accompanied by a motor hemiplegia of only relative degree. Simultaneous and equable implication of arm, face, and leg is an indication of direct capsular affection as opposed to the monoplegic distribution occasioned by neoplasms more superficially situated.

**Tumors of the Corpus Callosum.**—Tumors of the corpus callosum usually give rise to a slowly progressive quadriplegia, and are especially unlikely to produce cranial nerve palsies until late in the history of the disease. The profound interference with main associative fibers produces a slurring of speech and a blurring of intelligence. Torpor and involuntary sphincter relaxation are common and the weakening of the extremities may not be accompanied by the appearance of pathological reflexes; the muscles, however, are waxy and over-toned, so that alternate movements are initiated with difficulty. One patient under the writer's observation, a police-sergeant, first discovered the fact of his illness by finding himself unable to relax his grip of an offender's arm! The growth in this case, however, only partly involved the corpus callosum. When tumors are confined to that area they are usually diagnosed at autopsy.
Tumors of the Corpora Quadrigemina.—Tumors of the corpora quadrigemina almost always originate in the pineal body; they are consequently most usual in young persons. In these cases one finds precocious puberty—the secondary sexual characteristics developing not infrequently during the first decade of life. Pineal growths give rise to the reverse picture of that produced by certain pituitary tumors. These neoplasms compress but do not infiltrate contiguous brain tissue; in one patient under the writer’s observa-

![Fig. 5.—Pineal Tumor, with Midbrain Symptoms, Blocking Iter.](image)
tion the tumor mass had descended and completely corked the passage from the third to the fourth ventricle (Fig. 5). The pressure on the midbrain by such processes, exerted chiefly on the region of the quadrigeminal bodies gives rise to palsies of conjugate deviation of the eyes; the first movements thus to be interfered with are usually those in upward and downward directions. All conjugate ocular deviations may finally be impossible after implication of both the posterior longitudinal bundle and oculomotor nucleus. Sluggishness of pupil reactions occurs early and passes into immobility. A gross nystagmus is usually developed with the loss of conjugate movements of the eyes. As might be expected, the gait is ataxic, and motor incoordinance is present in the movements of both arms.

Evidences of pressure on both pyramidal tracts are seldom absent, though they may consist only in depression or loss of the abdominal reflexes and the presence of a bilateral extensor type of plantar reflex. The blocking of ventricular drainage in these cases makes a gross papilledema inevitable, and ballooning downwards of the floor of the third ventricle may cause early blindness by direct pressure on the optic nerves. These patients are intensely drowsy, a symptom usually explained by the great intracranial pressure which exists. In view of our experience in cases of encephalitis lethargica, however, it may well be that a tendency to morbid sleep is a focal symptom of subthalamic disease quite apart from general pressure conditions produced by such disease.

Tumors Involving the Tegmentum of the Midbrain.—Tumors involving this area of the brain seldom fail to produce a coarse tremor in the contralateral hand by implication of the rubrospinal tract and of the red nucleus itself. In the latter instance there will probably be found an ipsilateral third nerve palsy, with ptosis of the eyelid and characteristic defects of extra-ocular movements. Such a symptom-complex is not infrequently produced by conglomerate tubercle of a crus cerebri in children and adolescents.

Tumors of the Pons.—Tumors of the pons are usually not difficult to recognize early because of the great number of focal points represented therein. Combinations of ipsilateral palsies of the fifth, sixth, and seventh nerves may be seen, together with pyramidal paralyses of the opposite limbs. Interference with the functions of these cranial nerves from pontine disease is due to deterioration in the nuclei rather than in the nerves themselves. It is important to determine the nuclear
origin of these palsies in that abducient lesions are frequent as a result of increased general intracranial pressure. In such cases, however, they will not be accompanied by ipsolateral facial paralysis nor will the movement of the contralateral internal rectus muscle be decreased in amplitude or force. Pontine gliosis may be quite diffuse and slow, producing the appearance of simple pontine hypertrophy; in such cases resultant damage is apt to be bilateral in distribution and papilledema very late in appearance (Fig 6). Disturbance of urinary secretion and temperature control may occur in cases of pontine tumor but are seen less often than as a result of vascular accidents in the same location. The fillet is extraordinarily resistant to compression, and objective sensory change from such processes is consequently rare.

**Tumors of the Cerebellum.**—Tumors of the cerebellum may be divided for purposes of localization into those originating within the substance of the brain and those which, arising from the infratentorial meninges or nerve sheaths, compress secondarily the cerebellar lobes or vermis. The progress of the disease and the severity of the symptoms are likely to differ widely in these two classes. As one would expect, intracerebellar tumors, in most cases, are soft, rapidly expanding, and malignant, though conglomerate tubercle does not quite justify such description; while extracerebellar growths are usually hard, fibrous, and of tardy growth, and essentially benign in character. Headache in the former type occurs early, and is intense and paroxysmal. It is usually suboccipital in position and is associated with dull, aching pain in the neck. Sudden changes in position of the head are likely to produce violent headache and vomiting. Papilledema appears early, and runs its life history quickly; as has already suggested it may be seen first in the ipsolateral or contralateral fundus. Dizziness has been mentioned as being caused by some cerebral tumors, but it is rarely absent in growths below the tentorium.

Efforts have been made to correlate tumor disturbances of certain cerebellar areas with certain types of vertigo, but deductions made on these lines are likely to be faulty, probably owing to the widespread functional deterioration caused by such gross injuries as occur through tumor masses. However, objective signs are not wanting by which the sidedness of a cerebellar growth may be determined. These are nystagmus, motor ataxia, decreased muscular tone, and weakness. Nystagmus is apt to differ according to whether the eyes are conjugately deviated towards or away from the side of the lesion. It is usual to find that the movements are of grosser amplitude and slower on looking towards, and finer and more rapid on looking away from, the side of the lesion. The other signs just mentioned are all more evident on the same side as the tumor. Decomposition of rhythmical movements may be present in the ipsolateral arm; the finger-nose test may be poorly performed on that same side, and hypermetria may also be seen. The patient may be less well able to stand on the ipsolateral than on the contralateral foot and in walking may tend to fall towards the side of his tumor. Defective muscular tone may be demonstrated by increased passive extensibility in the ipsolateral joints especially in the fingers and at the wrist and knee. The condition of the deep reflexes varies. Pressure on the pyramidal tracts by the bony ring
SYMPTOMS OF INTRACRANIAL TUMORS

of the foramen magnum may lead to their being increased but, on the other hand, infratentorial tumors are just those most capable of deranging pressure conditions sufficiently to abolish the tendon jerks through interference with the posterior spinal roots. A curious tilted attitude of the head seen in these cases is probably of vestibular rather than of purely cerebellar origin (Fig. 7).

Tumors growing in the cerebello-pontine angle most often originate in the endoneurium of the acoustic nerve; the first manifestation is tinnitus and vertigo, followed by progressive nerve deafness. The next nerve to be involved is usually the trigeminus: subjective numbness and tingling in the face and the side of the tongue. Depressed sensibility to touch and superficial pain in the affected fifth nerve area occurs considerably later, though the writer has observed that the appreciation of pain produced by electrical currents in the trigeminal distribution is lowered before any other objective sensory alteration can be discovered. Palsy of the motor root of the fifth nerve is indicative of a tumor of the base rather than of the cerebellar angle.

By the time the seventh nerve is involved, definite evidence of cerebellar compression is forthcoming. These follow the general lines already laid down for intracerebellar neoplasms.

As has been said, these tumors have a more tardy life history than those within the cerebellum: often two to five years may elapse before successive involvement of contiguous structures makes plain the diagnosis. Cushing has a mortality of 20 per cent. in operations on growths of the acousticus, which is a very much lower figure than could be claimed for any intracerebellar tumor.

Tumors of the Medulla Oblongata.—
Tumors of the medulla oblongata are characterized by bilateral pyramidal paralyses, and affections of the lowest cranial nerves, producing difficulties in articulation and swallowing, and arrhythmia of the heart and respiration. The writer has seen trigeminal pain and anesthesia result from neoplastic interference with the nucleus of the fifth nerve. If the fourth ventricle is invaded, glycosuria is usual and vertigo becomes even more pronounced.

Tumors of the Hypophysis.—The hypophysis is not uncommonly the seat of tumor growth. Such a process can usually be diagnosed both by neighborhood signs and the evidences of altered pituitary function. The former include most typically bitemporal hemianopia, but almost all varieties of hemianopic defect may occur especially in the earlier stages of the disease. Papilledema is very rare in these cases and only occurs when the growth has blocked drainage by invading the third ventricle. Primary optic atrophy is the rule. Headache is usual and severe through distention of the gland capsule. An incomplete Fröhlich syndrome, characterized by adiposity, eunuchism, and abnormal sugar tolerance, may be an expression of defective pituitary secretion in these cases; acromegalic symptoms are less usual and result from simple adenomatous hypertrophy of the anterior portion of the gland rather than a malignant process involving the whole
organ. In the writer's experience, errors in pituitary function often result from circumscribed luetic exudation in the interpeduncular space.

**TREATMENT**

There is nothing to be said for the expectant treatment of brain tumors. When the evidence in the case has been collected and digested, action should follow—even if that be only a decompressive procedure. Gummata, though rare, are to be regarded as tumors and ultimately treated by excision; they seldom yield to antiluetic measures.

Supratentorial decompression avails little in lessening pressure originating in the posterior fossa; for these conditions a bilateral cerebellar opening is best; the bone defect should include the dorsal part of the foramen magnum.

Callosal puncture is often useful when focal diagnosis has been impossible, or as a preliminary measure to decompression or exploration.

*Local anesthiesia* combined with oxygen administration creates usually the most advantageous conditions for cerebral surgical procedures.

*Lumbar puncture* should only be performed with great caution in patients suffering from severe infratentorial compression (Fig. 8).

*Simple trephining operations* are quite improper in persons suffering from increased intracranial pressure: bone defects should be large enough to permit stabilization of abnormal pressure states; in cases where pressure is greatest and decompression consequently most urgent, the bone area covered by the temporal muscle is often not large enough to satisfy this condition.

![Fig. 8—Medullary Pressure Cond.](image)

He who cares for patients suffering with brain tumor must bring to his problem much thought and stout action. There is need also of a formidable optimism for the dice of the gods are loaded!