LOCALIZATION OR ELIMINATION OF CEREBRAL TUMORS
BY VENTRICULOGRAPHY

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From the Johns Hopkins Hospital and University

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IT seems incredible that a brain tumor as large as one's fist can exist in either cerebral hemisphere and still escape localization by expert neurologists and neurologic surgeons. Yet nearly all cerebral tumors eventually attain this size, and a very high percentage of them can neither be accurately localized before operation nor be found by an exploration of the brain.

In a recent analysis of a series of 70 cases with neoplasms of the brain, Dr. Heuer and I have shown that of 45 cases which were presumably located in the cerebral hemispheres, 20, or 44.4 per cent, escaped detection at operation; and at the time of that publication we considered this a high record in verifying the location of cerebral tumors. This percentage is not strictly correct, for several of the cases were submitted to more than one operation before the tumor was disclosed. On the other hand, in many cases which seemed to present definite signs of localization, the tumor could not be found because it was situated too deeply in the brain.

A more careful analysis of these figures disclosed to an even greater extent the limitations of the neurological signs which are helpful in localizing brain tumors. Nearly all of the tumors which could be localized with certainty were in one of three locations, in each of which the signs are pathognomonic: (1) hypophyseal or third-ventricle tumors gave the characteristic disturbances of the optic tracts and destruction of the sella turcica; (2) precentral or postcentral lesions were evident by the contralateral motor or sensory disturbances; and (3) neoplasms affecting the motor or sensory speech centers produced the typical deficiencies of speech. The remaining cases which were localized exclusively by other methods, such as changes in the eye-grounds, disturbances of the other cranial nerves, etc., really comprised a very small group.

There is only one satisfactory form of treatment for brain tumors, i.e., complete operative extirpation of the tumor. It is not conceivable that neoplasms of the brain ever disappear spontaneously or are cured or even benefited by any form of medical therapy. Nor, in our experience, has radium or the X-ray produced even temporary beneficial results. All attempts at medical treatment only cause delay which is disastrous to the individual; just as in the growth of malignant neoplasms of the breast, there is a time in the development of the tumor when its removal is possible and relatively easy and a complete cure will result. This opportunity


2 These statements, of course, have reference only to lesions of the cerebral hemispheres and do not include tumors of the brain stem or the cerebellum. This paper is intended to consider only the localization of tumors which are supposed to be situated in the cerebral hemispheres.
is now too frequently lost in tumors of the brain because the diagnosis is made too late and because time is lost in misdirected and useless therapy. The treatment of intracranial tumors is now passing through the incident and least fruitful stages, and is roughly where the treatment of breast tumors was 25 years ago, or where the treatment of appendicitis was 30 years ago. In both of these conditions the treatment has gradually become exclusively surgical and every effort has been directed toward an early diagnosis. The results of these efforts are now so thoroughly recognized that for all delay in treatment the physician in charge is held responsible.

When intracranial tumors are recognized and localized early, extirpation will be relatively simple and the permanent results will be vastly greater than those of today. The character and position of many tumors will, of course, preclude the perfect results which obtain in the operative treatment of appendicitis today, but they will undoubtedly surpass the operative results in early malignant lesions of the breast. Gliomata arising very deeply in the brain or in vital parts of the brain must still be looked upon as hopeless, but the vast silent areas harbor most of the incident brain tumors, and from these regions tumors can be removed with impunity.

There are even important areas which, with proper caution and due respect, no longer challenge us with *noli me tangere*, and from which tumors can be extirpated without permanent disability. At the present time, the operative procedures are greatly in advance of the methods of diagnosis, and in competent hands are fairly adequate. Small *enucleable* brain tumors can be removed with very little danger, and even large enucleable tumors can be removed with but a slight mortality, though the hemorrhages in these cases require an operator of large experience. Small *infiltrating* tumors can be removed with the contiguous brain tissues with but little danger, but there is little chance of removing a large infiltrating tumor without a recurrence. Other things being equal the results, immediate and remote, are directly proportional to the stage of growth of the tumor.

Only as a last resort should an exploratory craniotomy or a decompression be done. A subtemporal decompression, though the simplest major cranial operative procedure, is often not only a useless operation to the patient but is frequently accompanied by a pronounced injurious effect. As a routine procedure it is questionable whether it does more good than harm. In all cases of hydrocephalus no relief can possibly result, for the cause of the hydrocephalus nearly always being in the brain stem, is unaffected and the ventricular dilatation continues to increase as rapidly as the extra space afforded by the bony defect will permit. This of course causes greater brain destruction. In advanced cases the result is not infrequently fatal, particularly so when the larger procedure of a combined exploration and decompression is performed.

To perform a decompression or an exploration, an internal hydrocephalus should always be excluded. If a hydrocephalus is present a cerebellar exploration is usually, though not invariably, indicated. But here again the question of diagnosis is all important. It is frequently just as difficult to tell whether a lesion is in the cerebral or cerebellar hemispheres as it is to define its exact location.

At best a decompression is only palliative treatment and by the delay between the time at which a decompression is made for a so-called unlocalizable tumor and the later operation for its removal, after self-localization, the patient's chances of a complete cure have dwindled tremendously. The crux of the whole matter is that no brain tumor can be cured without operative removal; and that the earlier the diagnosis and localization is made the better the chances of a cure. The future outlook in the treatment of brain tumors is dependent almost entirely upon early recognition and localization of the tumor.

In a recent publication by the author, a new method—ventriculography or pneumoventriculography—was introduced, by which it was hoped that intracranial localization would be greatly assisted. At that time the procedure had been tried in only a few cases, but the results were such as to indicate
DANDY: VENTRICULOGRAPHY

alluring probabilities. I now hope to show the efficiency of this method in cerebral lesions and where all other means at our command have failed to localize the growth. I venture the prediction that by an intelligent use of this method\(^1\) in the hands of competent neurological surgeons but few cerebral tumors will escape localization. During the past two years I have completely removed over twenty brain tumors in Professor Halsted’s service. Many more have been partially removed or treated by palliative procedures. Many of the tumors treated partially, and therefore unsatisfactorily, could have been completely removed had they been received earlier. The time will come when it will be just as reprehensible for a physician to delay the proper treatment in a case of brain tumor as it is now to await developments in a case of acute appendicitis. When one considers the terrible train of events which must inevitably follow the development of a brain tumor—blindness, headache, paralysis, aphasia, etc.—the burden of the delay must fall heavily upon those who are responsible for the failure correctly to diagnose the lesion or at least for the neglect in sending the patient to a competent neurological surgeon.

PROCEDURE FOR LOCALIZATION OF THE TUMOR BY VENTRICULOGRAPHY

Each lateral ventricle occupies a large area in the interior of its corresponding cerebral hemisphere. It is evident that a tumor of any size situated in either cerebral hemisphere will modify the shape, size, and position of the corresponding lateral ventricle. Quite frequently the lateral ventricle in the opposite hemisphere will be dislocated and its size also will be greatly modified. These changes in the ventricles, both homolateral and contralateral, yield many opportunities for locating brain tumors by ventriculography. Fortunately following the injection of air into one lateral ventricle, it is possible to obtain a roentgenogram of each lateral ventricle separately, and thus determine alterations produced by a tumor in either cerebral hemisphere. Owing to the angles of the ventricular system, it is possible to fill only one lateral ventricle with air when the head is in a given position. After a roentgenogram has been taken, the head must be carefully turned in such a manner that the air can pass the various ventricular angles and the interventricular foramina (of Monro) and the third ventricle, and thus reach the opposite lateral ventricle. After a lateral view of each ventricle has been photographed, the head should again be carefully turned in order to direct the air into the anterior horns of both lateral ventricles; the occiput will then be on the plate and the roentgenogram will give the size, shape, and position of the anterior part of both lateral ventricles. Then by placing the forehead on the plate, the size and position of the body, and of the posterior and ascending horns, can be demonstrated. It would seem that most tumors must give some manifestations of their presence in one of these views, and the findings must therefore absolutely indicate the position of the tumor.

To introduce air into the ventricles of an adult, it is of course necessary to make an opening in the skull. This can be done either under local or general anaesthesia, the choice largely depending upon the patient. Personally, I prefer local anaesthesia with a responsive patient. The procedure need be but slightly painful and after transferring the patient to the X-ray room his co-operation eliminates respiratory movements and allows a much better exposure; moreover a considerable period of anaesthesia is avoided during the time necessary to dress the wound and transfer the patient to the X-ray room.

A ventriculogram will in many cases at once tell whether the tumor is cerebral or cerebellar. In the latter cases an internal hydrocephalus will be evident by the symmetrically enlarged lateral ventricles.

In some cases it will be found that the size of the ventricle has been so reduced that it is impossible to withdraw sufficient fluid to make the injection of air a safe procedure. It is then best to make a ventricular puncture on the opposite side and inject air into this ventricle, though occasionally both ventricles

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are too small. Not infrequently we can localize a tumor merely by the difference in size of the two lateral ventricles as determined by the ventricular puncture or often by the abnormal position at which either ventricle may be reached. In a general way a very small ventricle is presumptive though of course not absolute evidence of a cerebral as against a cerebellar tumor or a tumor of the brain stem; when there is a difference in the size of the two lateral ventricles the tumor is usually on the side of the smallest ventricle. Even a bilateral ventricular puncture, which is only occasionally necessary, is a small procedure compared to an exploratory craniotomy or even to a decompression, and the results obtained in localization of the growth not infrequently make the puncture far more valuable than an exploratory craniotomy. In infants and very young children, a puncture can be made through an open fontanelle or through sutures which have been separated by the abnormal pressure.

During the past six months I have used ventriculography in over seventy-five cases from Professor Halsted’s clinic. The majority of these cases had hydrocephalus; in many cases ventricular dilatation was suspected and the injection of air made the diagnosis certain. In many others the injection was made in order to determine whether the disease was progressive or stationary, in other words, as a means to determine whether or not operative treatment should be instituted. These cases will not be considered here but will appear in a subsequent paper. I shall describe here only the instances of tumors in the cerebral hemispheres or for very strong reasons suspected of being located there, and only those in which the ventriculogram has been the sole means of diagnosis. In many cases the localization of the growth has been easily determined by signs and symptoms and in such instances there is at present no purpose in instituting ventriculography, though I feel that eventually this method may be important in differentiating the type of tumor and determining the kind of operative treatment which is necessary. This possibility is strongly suggested by two of the cases which will be described, but such a decisive stand in treatment, which in many cases might eliminate exploration of the tumor, will only be determined by an extensive experience in the interpretation of the X-ray findings in a large series of brain tumors.

Five cases are described here, each representing entirely different findings and showing the range of usefulness of this procedure when tumors of the cerebral hemisphere are suspected. Ventriculography will be seen to exclude a cerebral tumor when the lesion is situated elsewhere; precisely to locate the tumor when it exists in either cerebral hemisphere. In two of these cases there was no localizing sign by which the location of the tumors was even suspected. In both, the ventriculograms showed the precise location of the growth. In one case the tumor was entirely removed and the patient is now well; he had previously submitted to two exploratory craniotomies but the tumor could not be found. In the second case a decompression had been done; after localization of the tumor by a ventriculogram, a very large infiltrating glioma was found at operation but could not be removed. The patient was spared further useless operations by the ventriculographic localization of the tumor. In a third case the signs were differently interpreted; a large localized bulging in the right temple seemed to indicate an underlying tumor. There was a complete sensory and motor paralysis of the trigeminal nerve which could have resulted from pressure on the gasserian ganglion; or the paralysis might have been due to involvement of the trigeminal root in the posterior cranial fossa. The ventriculogram conclusively determined the location. In a fourth case, an exploratory craniotomy in a case of focal epilepsy disclosed a greatly dilated ventricle—apparently hydrocephalus; subsequently the ventricles were injected with air and the ventricular dilatation was found to be unilateral—a very rare condition. A fifth case can hardly be included as a result following ventriculography for air could not be injected, but the attempt at the procedure was responsible for locating the tumor. The ventricle was found by a ventricular puncture to be markedly dislocated to the left, but it was so small that only a few drops of fluid could
Fig. 1. Ventriculogram of a normal ventricle, lateral view.

be obtained from the needle. Under such conditions it is not safe to inject air. The dislocated position of the ventricle could only be caused by a tumor in the opposite side of the brain. The extremely small size of the ventricle must be due to the intracranial pressure produced by the tumor. The neoplasm was found in the right prefrontal region and completely removed.

LOCALIZATION OF A TUMOR IN THE OCCIPITAL LOBE, BY VENTRICULOGRAPHY

The difficulties and oftentimes the impossibilities of correctly localizing a brain tumor by the older methods and the simplicity of making the diagnosis by ventriculography will be seen in the observations which follow.

A sallow young man of 23, consulted me for disturbances caused by a tumor of the brain. The diagnosis of a cerebellar tumor had been made by one of America’s foremost neurological surgeons and a cerebellar operation performed by him one year previously; the tumor was not found and consequently no relief was obtained. A year later he complained of constant headaches, with severe periodic exacerbations, and particularly of a progressive loss of vision. That the patient had a brain tumor was evident at a glance. A huge cerebellar hernia had followed the first operation and at once indicated a high degree of intracranial pressure. There was a bilateral choked disc measuring 6 diopters in each eye. But the position of the tumor was obscure. The only real objective finding was a complete deafness on the right side; bone conduction as well as air conduction was entirely absent. There was a suggestive Romberg; at times a slight fine

nystagmus, and a suggestive bilateral ataxia of the fingers. The patient insisted that the deafness followed the operation. He was sure of this because he had been in the telephone business and had used both ears equally well; moreover the deafness was noticed immediately after recovery from the cerebellar operation. The subjective symptoms were equally confusing and at that time could not be correlated into the results of a single intracranial lesion. His illness dated back 4 years, at which time severe attacks of bifrontal headaches and vomiting occurred periodically and steadily progressed in frequency and severity. Sixteen months ago diplopia appeared and after lasting for a weeks, disappeared and never returned. One month later the left half of the face became anesthetic over night. He claims the left side of the face was paralyzed also. (He says he could not close the left eyelid and the left corner of his mouth drooped.) The sensory change was quite typically confined to the trigeminal area, ending sharply at the midline. The sensory (and motor) changes of the face lasted about two weeks. The left side of the face is still subjectively slightly numb, but there is no objective sensory or motor difference between the two sides. There was a sudden exacerbation of the headaches at the time of onset of these facial disturbances and vision then began steadily to diminish first in the left eye, later in the right. It is worthy of note that neither arm nor leg were affected at this time or subsequently. Two months after the onset of these symptoms, the previously mentioned cerebellar operation was performed. Four months later the patient had a convolution
and remained comatose for 4 days. No localizing signs were noticed by anyone during the convulsion. The patient insists that following this period of coma the large occipital hernia which resulted from the operation almost disappeared and later gradually resumed its natural fullness and hardness. There had been a slight disturbance of gait with a tendency to stagger; but it was inconstant and the patient thought it no more than his general weakness could easily explain. No staggering had been observed by his friends. The visual fields showed great restriction of vision in both eyes. There was only slight vision for color in the left eye and this seemed to show a nasal hemianopsia; this was not considered significant because it was the terminal phase of color vision and the field of vision in the right eye showed no such form. A slight grade of convolutional atrophy was present in the skull, indicating that an intracranial pressure existed.

The problem then was how much reliance to place upon the patient’s subjective sensations, which seemed paradoxical. It was difficult to see how a complete deafness could result on the right side from the operation as he had claimed. It was impossible to put much confidence in his assertion that the left side of the face was paralyzed (facial nerve). He might easily have thought his face was paralyzed because of anesthesia; or as happens most frequently the facial paralysis, if present, may have been on the opposite side. As is well known patients and even physicians often mistake the side of facial paralysis. If the left trigeminal nerve (V) had been paralyzed, obviously the right auditory nerve (VIII) could not be destroyed by the same lesion. The patient could not by any possibility mistake the side which had been anesthetized (cranial nerve V). If the facial nerve paralysis had been present and had been on the left side it seemed conceivable that a lesion in the left cerebellopontile angle could explain the anesthesia and facial paralysis, but it would be necessary to disregard entirely the right auditory paralysis (nerve VIII) which he claimed had followed the operation. On the other hand if the auditory paralysis (nerve VIII) had resulted from the tumor and not from the operation a cerebellopontile tumor could explain it and also a possible right facial palsy (VII) but not the anesthesia of the left side of the face (V). In either case it seemed most probable that the tumor was located in either cerebellopontile angle or possibly in a lobe of the cerebellum. To support this was the transient nystagmus, suggestive Romberg and ataxia, and possibly a slight staggering gait. Transitory hemianesthesia of the face and facial paralysis are not uncommon in angle tumors. The absence of sensory or motor weakness of the arm and leg seemed to indicate that any facial paralysis must be a peripheral involvement of the facial nerve (VII) rather than involvement of the facial area of the pyramidal tract.

As a result of these deductions I was led again to explore the cerebellar region. It seemed either that the tumor might have been overlooked by the previous operator or that a tumor lying deeply in the cerebellum might by this time have grown nearer the surface. All these presumptions and analyses proved false. A thorough exploration of the cerebellar region and both cerebellopontile recesses revealed no evidence of a tumor. The foramen of Magendie was normal. The large hernia was mainly due to an enormous collection of cerebrospinal fluid, which of course would inevitably reform. Though greatly disappointed at the negative outcome of two big operations, the patient still hoped for a
diagnosis which we saw little hope of attaining. A ray of hope appeared in ventriculography, but its value at that time had not been tried. The procedure was mentioned as a possibility to the patient; its uncertainties and possible dangers were emphasized. He eagerly grasped the opportunity.

Seventy-five cubic centimeters of cerebrospinal fluid were removed from the right ventricle and an equal amount of air substituted. Roentgenograms of both right and left lateral ventricles were taken, first in profile and then in an anteroposterior view. The shape of the right lateral ventricle is normal although it may be slightly enlarged (Fig. 4). (The normal variations in size of the lateral ventricles have not yet been accurately determined.) The size of the left lateral ventricle was the same as the right but it suddenly ended near the middle of the body of the ventricle (Fig. 5). The anterior horn and the anterior portion of the body of the left ventricle were almost exactly like the corresponding parts of the right ventricle, but no air reached the posterior end of the body, the posterior horn or the descending horn of the left ventricle. These portions of the ventricle therefore threw no shadows and were absent in the roentgenogram. The air shadow terminated at a sharp curved line, with concavity directed forward. These findings could admit of but one interpretation—

—the tumor had completely occluded the body of the ventricle and had prevented the air reaching the posterior and descending horn. The tumor must, therefore, be situated in the left occipital lobe. The anteroposterior ventriculogram (Fig. 6) shows the left ventricle pushed toward the right and partially occupying the right half of the cranial chamber. The right ventricle is also dislocated farther to the right than its normal position. The anteroposterior ventriculogram alone would have shown the tumor to be in the left cerebral hemisphere, but the lateral view of the left ventricle disclosed the exact location of the tumor.

As a subsequent operation a craniotomy was performed directly over the tumor in the left occipital lobe (Fig. 9). An area of tumor about 1 by 1 centimeter reached the surface of the brain. After circumvision of the blood vessels, the cortex over the tumor was divided and the tumor readily shelled out of its bed (Fig. 8). It was perfectly encapsulated except at one point; here the tumor arose from the ependyma in the upper outer wall of the descending horn, near its junction with
the posterior horn. It was, of course, necessary to open the ventricle widely and thoroughly resect the wall of the ventricle from which the tumor arose. The glomus of the choroid plexus had attached itself to the tumor. It was stripped away and left intact. The ventricle was apparently completely occluded by the intruding growth. The descending horn of the ventricle was definitely enlarged (localized hydrocephalus); the body of the ventricle was well over to the right of the midline exactly as the anteroposterior ventriculogram had indicated. The entire tumor with the wall of the ventricle was removed. It is now two years since the operation and the patient is perfectly well and at work. There has also been a marked restoration of vision.

In the light of the operative findings, it is now evident that the patient’s history was largely correct, but I am still uncertain about the facial paralysis. The auditory nerve paralysis (nerve VIII) undoubtedly resulted in some way from his first operation. The sudden but transient attack of severe headache, vomiting, left trigeminal anaesthesia (nerve V) was due to a sudden occlusion of the ventricle by the ingrowing tumor. A left facial paralysis (nerve VII) could not by any chance have occurred. A right facial paralysis is conceivable from pressure of the localized hydrocephalus, on the face center of the pyramidal tract, but this hardly seems probable. He probably mistook the anaesthesia for motor paralysis. The block in the ventricle had produced an acute hydrocephalus localized to the descending horn of the ventricle (because the ventricle is situated distal to the obstruction). This sudden localized hydrocephalus compressed the gasserian ganglion or the three branches of the ganglion, producing the left trigeminal anaesthesia. The tumor was situated too far posteriorly to have produced direct pressure on the gasserian ganglion. A channel in the ventricle subsequently opened and the sensory and possibly motor paralyses were relieved to a great extent. The enlargement of the descending horn is now understood, for there is only one outlet for the cerebrospinal fluid in the descending horn and that is into the body of the ventricle.

DIFFERENTIAL DIAGNOSIS BETWEEN A TUMOR IN THE TEMPORAL FOSSA AND THE CEREBELLOPONTILE ANGLE

The above localization of a cerebral tumor when a cerebellar neoplasm is suspected, has a counterpart in the following diagnosis of a
cerebellar tumor when a temporal lobe tumor is suspected. At least there are very valid reasons for the differences of opinion in the diagnosis.

A girl of 13 had suffered from headaches most of her life, but during the past 3 years they had become gradually more violent. There were numerous spells of projectile vomiting. Since childhood a large swelling in the right temple had caused a marked facial disfigurement. Diplopia had been present at times. Only recently signs of cerebellar involvement had appeared. There was a definite Romberg with tendency to fall to the right; staggering gait with tendency to waver toward the right; a slight but definite ataxia of the right hand; a slight diminution in hearing on the right; adiadochocinesia, and nystagmus. All these opoken

The boss and the amesthesia had been present for several years. The masseter and temporal muscles were completely atrophied on the right side there being no muscular response whatever; the anæsthesia over the entire trigeminal area was complete. The boss and the anæsthesia had been present for several years. The boss in the right temporal region (Fig. 12), a complete sensory and motor paralysis of the fifth nerve and a right facial paralysis which was also nearly complete. The boss was present but less acute on the right. There were two possible locations for the growth and plausible reasons for each diagnosis. During the previous three years she had been to two very prominent surgeons, each of whom had wished to remove the tumor mass from the temporal region. They thought the growth was a bony tumor which had originated there, and in its later growth had projected into the cerebellar fossa, producing the cerebellar signs of comparatively recent onset. There were three very good reasons for this diagnosis. First, the large local protuberance had all the appearance of a tumor; second, the complete paralysis of the trigeminal nerve and its long duration before the more recent involvement of the other cranial nerves particularly the facial nerve (VII), and the auditory nerve (VIII) which arise very close to the fifth nerve. The complete fifth nerve palsy (V) could easily be explained by direct pressure of the presumed tumor of the middle cranial fossa on the gasserian ganglion, especially since the trigeminal paralysis had been present for years and was complete.

The X-ray showed increased density in the right parietal region; this was definite but not sufficiently pronounced to be a primary tumor of the bone; if a tumor at all it could only be an underlying soft tumor of the brain. On the other hand the assumption of tumor in the region of the gasserian ganglion or elsewhere in the middle cranial fossa, rendered the explanation of the cerebellar signs difficult. Only an extension of the tumor through the tentorium cerebelli into the posterior cranial fossa could produce the cerebellar signs. Such an extension of a tumor may indeed occur but it is quite exceptional. On the other hand if the origin of the tumor was in the region of the cerebellum, how could one explain the large unilateral boss in the temporal fossa? It could only be said that occasionally in hydrocephalus, there is a localized bulging in the temporal fossa, but I have never seen one so prominent. Such an explanation of course presupposed a hydrocephalus which was not known to exist and it further assumed that the hydrocephalus dated back to early childhood when the skull was very plastic. The head was possibly slightly larger than normal. The swelling had been present as long as the parents could remember, but they thought it was still growing although very slowly. Paralysis of the temporal and masseter muscles accentuated the prominence of the swelling but could not explain it as relative rather than actual.

The solution of the confusion in the diagnosis lay in the presence or absence of an internal hydrocephalus. If an internal hydrocephalus was not present the boss in the temporal region would probably be due to a tumor in that locality and the right lateral ventricle would probably show signs of dislocation or compression from the tumor. On the other hand if a hydrocephalus was
present it could not have resulted from a tumor in the temporal fossa but the tumor must have been situated in the posterior cranial fossa. Except in rare instances, only tumors in the brain stem or cerebellum can produce a symmetrical bilateral internal hydrocephalus.

The entire operative procedure for relief of such a case was dependent upon the ventriculogram. The ventricles were found by ventriculography to be greatly and equally dilated. Unfortunately the patient was in the terminal phase of pressure when she arrived and her condition did not warrant a cerebellar operation. A subtemporal decompression would have accomplished nothing beneficial but would no doubt have ended fatally. At necropsy the tumor was found in the cerebellar region as indicated by the internal hydrocephalus shown in the ventriculogram. It was an invasive glioma probably of congenital origin. No doubt the tumor had remained comparatively dormant for years and then resumed a sudden activity. The high grade of hydrocephalus and the corresponding reduction in the cerebral cortex are well demonstrated in the ventriculogram (Fig. 13).

In both this case and the preceding one the tumor could not be located by the usual methods. In the first case two operations were performed in the wrong location because of misleading signs and symptoms. In the second, two surgeons wished to operate on the temporal region and were prevented only by the patient's hesitancy to undergo the operations. I thought the tumor to be in the cerebellar region but the diagnosis could not be certain; others regarded the tumor as in the middle cranial fossa instead of in the posterior cranial fossa. Although a very high grade of hydrocephalus existed, only the ventriculogram could prove it. In both cases the ventriculogram alone was decisive.

LOCALIZATION OF AN INOPERABLE SUBCORICAL CEREBRAL TUMOR

Another instance of a brain tumor clinically unlocalizable, but clarified by the ventriculogram, was in a man aged thirty-seven. His symptoms were almost fulminating—headache and vomiting of only three months' duration. A bilateral choked disc of 4 dipters was the only possible objective finding. A subtemporal decompression had been performed by Dr. Heuer but the tumor grew so rapidly that the decompression had ceased to be of value in less than a month. A right ventricular puncture was then made under local anaesthesia. Because of the extreme intracranial tension which was indicated by a very tight decompression I was afraid of acute pressure symptoms and injected less than 30 cubic centimeters of air which was sufficient to fill only the descending horn of this ventricle (Fig. 10), but the size of the left ventricle (Fig. 11) was so reduced that the injected air was ample to fill it entirely. The ventriculogram therefore indicated a normal right ventricle and a left ventricle greatly and fairly uniformly reduced in size. The various horns of this ventricle were about equally affected. The anterior horn, however, was pushed backward and downward by the tumor. Later a left craniotomy was performed and the tumor was found to be a very extensive infiltrating glioma but coming to the surface in the frontal region. The surface compression of the convolutions suggested an extensive subcortical involvement.
of the frontal and temporal lobes. The tumor was too large to attempt removal, but an extra large decompression was performed to further alleviate his symptoms.

UNILATERAL HYDROCEPHALUS DEMONSTRATED BY VENTRICULOGRAPHY

During a recent craniotomy for Jacksonian epilepsy in a child of six years I was surprised to find what seemed to be a large cyst in the right post-Rolandic region.

On incision this cyst proved to be a huge lateral ventricle. The posterior horn and the descending horn had lost their normal configuration because of the tremendous distention. There had been no reason to suspect an internal hydrocephalus; the eye-grounds were normal; the roentgenogram of the head showed no signs of intracranial pressure. There was a distinct abnormality of the surface of the brain. Extensive obliteraion of both the cerebral arteries and veins in the parietal and occipital lobe had left a pale white, soft cortex posterior to the Rolandic fissure. Numerous tiny new arteries passed through the meninges, apparently a recent and new development to replace those which had been destroyed.

For months prior to the operation and since the onset of the Jacksonian epilepsy, the patient had had a high irregular fever, a marked tachycardia and at times had been comatose. Apparently there has been an extensive vascular thrombosis at this time.

After convalescence from the operation, permission was obtained from the parents, to inject air into the ventricles for ventriculographic observations. The results of these studies are graphically shown in the accompanying ventriculograms. The hydrocephalus is unilateral, a most unusual condition. The left ventricle is of normal shape (Fig. 15, a), its size somewhat larger than normal though I have not had a sufficient number of normal ventricles to tell how large the normal variations may be. The right ventricle is a tremendous cyst (Fig. 14 and Fig. 15, b) but the enlargement is principally posteriorly, where the vascular affection was most pronounced. In the strict sense this cannot be a true hydrocephalus, for there is, at least now, no increased intracranial pressure. The unilateral dilated ventricle is undoubtedly due to softening of the cerebral walls from the vascular disturbance. The softened area atrophied from the pressure in the ventricles. In a true
unilateral hydrocephalus the foramen of Monro must necessarily be occluded. At a subsequent operation I removed the choroid plexus from the dilated ventricle and occluded the foramen of Monro by a transplant of fascia as I have done on animals, following Professor Halsted's suggestion. There was immediate cessation in the attacks but this phase of the story will be considered in a subsequent paper.

The condition in this case could not have been known, even after the operation, without a ventriculogram. In fact a ventricular puncture and a roentgenogram would have given the same information without the exploratory craniotomy, and the patient might have been spared the first operation.

LOCATION OF A CEREBRAL TUMOR BY VENTRICULAR PUNCTURE WHEN THE VENTRICLE IS TOO SMALL TO PERMIT THE INJECTION OF AIR.

In some cases of brain tumor, possibly due to a very rapid growth of the tumor, the size of the ventricle on the side of the tumor and at times even of the contralateral ventricle is so reduced that only a few drops of fluid can be obtained by a ventricular puncture. In these cases enough fluid cannot be aspirated safely to permit the injection of the air for the purpose of obtaining a ventriculogram. If air should be injected under such conditions, an acute rise of intracranial pressure might follow, possibly with disastrous results. But in these cases there is usually a definite dislocation of the ventricle; this is frequently great enough to cause difficulty in locating the ventricles by a puncture. But when the ventricle is found, its position may explain the location of the tumor.

A young woman of 24 was suffering from a rapidly growing intracranial tumor. The signs and symptoms gave absolutely no clue to the location of the growth. Pursuant to our newer conception of the importance of an early localization of the growth, I made a right ventricular puncture and found the ventricle dislocated toward the left side, but only three or four drops of fluid escaped from the needle. Since air could not be injected under these circumstances without risk, a ventricular puncture was at once made on the left side but the left ventricle was no larger and despite the high grade of intracranial pressure (6 diopters swelling in each optic disc) only a few drops of fluid escaped...
and no more could be aspirated. This ventricle also was dislocated markedly to the left. It was evident that the tumor must be in the right cerebral hemisphere and that it had pushed both lateral ventricles toward the left; however, the exact localization of the tumor on the right side could not be made in any way. In view of these findings a right exploratory craniotomy was performed and a large extracortical circumscribed tumor completely removed from the right frontal lobe. The patient recently left the hospital perfectly well.

CONCLUSIONS

1. Ventrivulography is invaluable in the localization of obscure brain tumors. So-called unlocalizable tumors comprise at present over half of the total number.

2. Practically all brain tumors either directly or indirectly affect some part of the ventricular system.

3. Hydrocephalus is easily demonstrable by ventriculography and when present usually though not always restricts the location of the tumor to the posterior cranial fossa—that is, the brain stem or the cerebellum.

4. Local changes in the size, shape, and position of one or both ventricles as shown by the ventriculogram will accurately localize most obscure tumors of either cerebral hemisphere.

5. Every effort should be made to localize the tumors before resorting to any operative procedure.

6. The usual subtemporal decompression is useless and dangerous when a hydrocephalus is present, that is when the tumor is in the brain stem or cerebellum.

7. A suboccipital decompression (cerebellar operation) is extremely dangerous when the lesion is in the cerebral hemispheres.

8. To differentiate between cerebral and cerebellar lesions is frequently one of the most difficult tasks in intracranial localization. Ventrivulography at once separates these two groups and indicates the operation of choice.

9. The only cure for brain tumor is ex-  
tirpation. The results in terms of complete  
cures of brain tumors will be in proportion to  
the early localizations which are made. A  
decompression is a purely palliative pro-  
cedure and should be adopted only when the  
tumor cannot be located. Ventrivulography  
permits of an early and accurate localization  
of the growth when all other methods fail.

10. It is possible to get a separate profile ventriculogram of the whole of each lateral ventricle. Any change in size or contour is easily demonstrated. Anteroposterior views will show the same points in cross section but they are chiefly useful in showing any lateral dislocation of the ventricles.
11. The results in localization of five types of cases of brain tumor are shown with ventriculograms. In all but one of these, the ventriculogram was the only means by which a positive localization could be made. One tumor occluded a lateral ventricle and displaced both lateral ventricles. Another tumor altered the size and shape of one lateral ventricle. In a third case a cerebral tumor, though suspected, was eliminated by the hydrocephalus. In a fourth case a unilateral hydrocephalus was demonstrated.

12. Occasionally the size of both ventricles is so reduced that air cannot be safely injected. In one case the dislocated position of both ventricles, which were greatly reduced in size, made the localization possible.

13. Ventriculography is also useful in precisely localizing the growth. This permits of an exploration directly over the tumor and greatly simplifies the operative procedures.

14. Many useless and harmful operations will be spared the patient by a judicious use of ventriculography.

15. Doubtless the type of tumor will often be indicated by the ventriculogram. Such knowledge will be useful in prognosis and in determining whether radical or palliative operative treatment should be instituted. These determinations will result from accumulated experience in the interpretation of the ventriculograms together with the correlative operative findings presented in a large series of cases.

16. With experience and care in the use of ventriculography, I believe few tumors will escape accurate localization.

NOTE.—The accompanying ventriculograms were taken by Miss Mary Stuart Smith from Dr. Baetjer's department. The shadows have been very slightly accentuated by Mr. Broedel to overcome the loss of detail in reproduction. The original X-rays are just as sharp as the figures as they are here reproduced.