FIG. 2.—Ventriculography from a case of Medulloblastoma shewing symmetrical distension of the ventricular system, beaten silver appearances of the vault, and separation of sutures.

FIG. 4.—Ventriculography from a patient with astrocytoma of the left cerebellar hemisphere situated far anteriorly shewing distension of the ventricular system including the third ventricle without separation of the sutures.

SUBTENTORIAL TUMOURS.

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Subtentorial tumours constitute a fruitful section of the field of neurological surgery. Not only are some of the most satisfactory tumours which one can be called upon to treat situated in this area, but in addition syndromes of the posterior fossa may occasionally be revealed to the enquiring eye in cases where an entirely different pathology had been held to account for the patient's symptoms. The main pathological types at first sight constitute a rather bewildering array of which the following is a suggested classification:—

1. Cerebellar Gliomas.	Medulloblastoma.
	Astrocytoma.
	Ependymoma.
	Hæmangioblastoma.
2. Brain Stem Gliomas.	Astrocytoma.
	Spongioblastoma Polare.
3. Cerebello-Pontine Angle Tumours.	Acoustic Neurofibroma.
	Fifth Sensory Root Neurofibroma.
	Meningioma.
	Ependymoma.
4. Chronic Granulomas.	Tuberculoma.
	Gumma.

Considered as a whole, the subtentorial gliomas are predominantly tumours of childhood and early adult life. Indeed, the only common subtentorial tumour occurring over the age of thirty is the acoustic neurofibroma.

The accompanying figure which illustrates the results of Cushing's investigations of the age distribution of subtentorial tumours, is eloquent of this fact.

FIG. 1.—Chart shewing age distribution of subtentorial neoplasms (after Cushing).

It is therefore possible to subdivide one's classification of these tumours according to their age incidence, and since each type has a characteristic situation which is of help in diagnosis, this may be included in the table.

Tumours of Childhood.

Cerebellar Gliomas.	Medulloblastoma.	Mid-line vermis.
	Astrocytoma.	Lateral lobes.
	Ependymoma.	Fourth ventricle.

Tumours of Adult Life.

Cerebellar Gliomas.	Hæmangioblastoma.	Lateral lobe or Fourth ventricle.
Extra-Cerebellar Tumours.	Neurofibroma. Meningioma.	Cerebello-pontine angle. Cerebello-pontine angle. Jugular Foramen.

Two general considerations arise from the intimate anatomical relationship of the various structures located in the posterior fossa. Firstly, the proximity of most tumours to the site of cerebro-spinal fluid outflow accounts for the early onset of internal hydrocephalus in these cases. If allowed to progress unrelieved, this may not only lead to permanent impairment of vision but may even bring the patient to operation in coma, thus greatly increasing the risks of surgical intervention. To obtain good results in treatment early diagnosis is vital and can only be achieved by a constant lookout for the possible syndromes.

Secondly, although many of the syndromes presented are characteristic, especially those of extra cerebellar origin, on consideration of the close relationship of the cerebellum to adjacent cranial nerves it will be realised that in the late stages a tumour of the cerebellum may be of sufficient size to produce secondary symptoms by extra cerebellar pressure. A careful history of the chronological order of development of symptoms is therefore important in distinguishing the main syndromes.

In order to obtain a fair and comprehensive view of subtentorial tumours in general let us start by considering the unfavourable cases first, reserving the more cheerful considerations to the end. Perhaps the final impression left by this method may be the true one—that the majority of subtentorial tumours are amenable to some form of surgical treatment.

Tumours of Childhood and Early Adult Life.

Medulloblastomas. These tumours are characterised by their incidence in young subjects, by their predilection to affect the vermis of the cerebellum, and by their high grade of malignancy. Not only does a glance at a typical section, showing closely packed sheets of small cells with abundant mitotic activity, immediately convince one of this fact, but they have also a tremendous tendency to produce scattered secondary deposits throughout the leptomeninges which may extend from the vertex to the lumbar theca and even into the ventricles. These considerations render the prognosis of the medulloblastoma the most unfavourable of all subtentorial neoplasms. Within the vermis they produce an expansion and widening of this structure which betrays their presence at operation (cf. Fig. 3 inset), the increase in bulk being at first compensated for by herniation of the cerebellar tonsils below the arch of the atlas. Anteriorly they project in to the fourth ventricle, as a reddish-grey highly vascular mass of tissue, usually rather friable in consistency, producing obstruction of the ventricular drainage and the early onset of acute internal hydrocephalus. The symptoms of these tumours are therefore those due

to internal hydrocephalus and herniation of the cerebellar tonsils associated with localising signs referable to the cerebellar vermis.

Clinically.—They occur most frequently between the ages of 5 and 15, being three times as frequent in males as in females. The symptoms in the early stages are slight, and due to the associated hydrocephalus. Recurrent attacks of projectile vomiting resulting from stimulation of the medullary centres are common. These occur, independently of taking food, with changes of posture, especially in the morning, and are associated with some headache, which is often not severe at first owing to the decompression provided by the separation of sutures in a young child. An erroneous diagnosis of gastro-intestinal disturbance is often made at this stage since, as will be seen, the early localising signs are few. There is, however, usually a suboccipital pain and stiffness in the neck, since by the time the tumour is of sufficient size to produce ventricular obstruction, herniation of the cerebellar tonsils has occurred beneath the arch of the atlas. Any movement of the neck increases this discomfort and the muscles become rigid and tender. This together with a certain degree of dizziness and unsteadiness in walking should direct attention to the posterior fossa. Enquiry will then elicit additional evidence of the hydrocephalus; increasing size of the head and impaired concentration and listlessness will probably have been noticed by the parents, but defective vision is seldom complained of by young children. In the later stages, failing vision, gross enlargement of the head, and loss of equilibrium which makes walking impossible, can leave no doubt as to the diagnosis; and finally, cerebellar fits, accompanied by partial or complete loss of consciousness, opisthotonos, pallor, sweating and variation in the pulse and respiration appear, in one of which the patient eventually dies.

Examination, in an early case, elicits few physical signs. The most important is papilloedema, which is however often less than one would expect. There may be some degree of optic atrophy with concentric constriction of the visual fields and enlargement of the blind spot, but this is hard to detect in such young children. The head is frequently obviously enlarged, and is held rigid on the neck, the muscles of which are tender and resist the painful movement of flexion. Signs of cerebellar involvement are slight. The connections of the vermis being especially concerned with the muscles of the trunk and lower limbs, neither nystagmus nor cerebellar incoördination of the upper extremities may be seen. The majority of evidence of cerebellar dysfunction is seen as a trunkal ataxia and difficulty in walking and standing. The child stands with its feet wide apart, has a tendency to fall backwards, and in walking reels as though drunk, and walks with a wide stanced gait. Despite the obvious defect in equilibrium little evidence of ataxia can be detected, only the lower extremities, as a rule, showing some degree of dysmetria and asynergia, together with hypotonus. In later cases, confusing symptoms arise either from pressure upon the nerves of the posterior fossa or the effects of secondary deposits in the spinal leptomeninges, producing girdle pains and areas of anæsthesia.

Diagnosis is between the gastro-intestinal disturbances of childhood and the other causes of internal hydrocephalus. With regard to the former, one is apt to receive a distorted idea of the ease of differentiation for by the time the case is referred numerous possibilities have already been ruled out, and it is easy to return a positive answer to the specific query, can this child have an intracranial tumour? In general diagnosis, however, the possibility of such a cause for repeated vomiting, recurrent headache, or enlargement of the head in childhood should be kept in mind, and examination of the optic discs should frequently provide a correct answer.

Confusion sometimes arises between the craniopharyngiomata and cerebellar tumours. Thus suprasellar tumours may produce marked incoördination and also by obstruction of the third ventricle lead to acute internal hydrocephalus. *Vice-versa*, distention of the third ventricle in the hydrocephalus accompanying a cerebellar tumour may cause symptoms of hypothalamic origin, and also lead to complete destruction of the posterior clinoid processes; sometimes erroneously diagnosed as indicating a pituitary or suprapituitary neoplasm. If doubt exists, ventriculography is justifiable, in order to obtain a view of the third ventricle, but it must be remembered that a certain risk attaches to this examination in high pressure cases. Relief of tension above the tentorium may be followed by herniation of the cerebellum into the incisura, setting up a mid-brain pressure cone. It should therefore only be performed immediately prior to operation. (Fig. 2, Plate 10.)

Treatment. Radical extirpation followed by deep X-ray therapy should be undertaken for the relief of the urgent symptoms.

FIG. 3.—Operation for Medulloblastoma of the vermis showing inset appearances prior to removal and electro-surgical dissection in progress.

The discussion of surgical technique is beyond the scope of this article. A few points may, however, be summarised. The approach may be made either through a midline or transverse incision; the latter, which figures in the illustration of a recent case, is our practice. As in intracranial surgery in general, absolute hæmorrhage, which should be achieved at each step, the use of electrosurgical methods, and the administration of saline and blood during the course of operation, permit extensive and deliberate operations to be performed with a greater immediate margin of safety and prospect of ultimate cure. Continuous ventricular drainage through a short cannula or No. 3 soft rubber catheter is of great advantage in decreasing local congestion during the operation and in cases where the hydrocephalus has been marked, may usefully be continued afterwards, for periods up to 48 hours, thus avoiding much of the severe post-operative reaction.

On exposure of the cerebellum, the tumour may not present upon the surface, but widening of the vermis usually betrays its presence and occasionally the reddish mass projects between the tonsils. Careful examination of the leptomeninges for evidence of local metastases should be made first, following which the vermis should be incised and the tumour, which is frequently of surprising extent, enucleated by dissection around its periphery.

Considering the age of these patients and the late stage at which many, unfortunately, come to operation, the immediate mortality—which varies from 20—30 per cent., in one experience 25 per cent.—is not unduly high, but the highly malignant character of these growths renders their ultimate prognosis very grave. The longest recorded survival period in Cushing's series is only one of over seven years, (Eisenhardt 1935), in which the patient was perfectly well following extirpation and deep X-ray therapy. Several other examples with five years' survival are known, but in these local or spinal recurrences have necessitated further operation or deep X-ray treatment. Without X-rays recurrences always occur within one year; indeed, few patients survive longer than this. Medulloblastomas are, however, the most radiosensitive of all intracranial tumours, and under treatment show the usual changes of degeneration of tumour cells, diminished vascularity, and connective tissue increase. (Tarlov 1937). Energetic radiotherapy must therefore be commenced at the first possible moment and, in view of the risk of metastases or dissemination at operation, should be given to the entire cerebro-spinal system. Life may be prolonged by this means. Sachs (1936), describes a series of thirty-five cases on whom he performed fifty-two operations with a mortality of 19.2 per cent. Of those patients treated by operation alone none survived longer than seven months: by combined treatment, one patient was still alive despite two operations for cord recurrence at $4\frac{1}{2}$ years, another at 3 years. We have two patients alive and at present free from recurrence for almost 2 years following intensive and repeated irradiation. Cutler (1936), however claims to have secured palliation for an average of 2 years and 8 months in twelve patients without operation, the longest survival being 4 years and 10 months. These results demand attention since they compare favourably with those of combined operation and X-ray therapy. Is operation worth while? We feel that operation should be employed in preference to a preliminary diagnostic radiation as the difficulties of precise diagnosis are such that even a characteristic syndrome does not exclude an astrocytoma of the vermis or an ependymoma, which are non-radiosensitive but amenable to surgical treatment.

Ependymomas. As already indicated, it is seldom possible to differentiate these relatively innocent growths from the highly malignant medulloblastoma, except at operation. They are, unfortunately, far less common, the average distribution of medulloblastomas and ependymomas in any series being approximately 12 per cent. and 4 per cent. They are essentially slow-growing, as evidenced by the microscopic structure which shows a majority of well-differentiated cells similar to adult ependyma, together with a small proportion of more primitive ependymoblasts. In the posterior fossa they occur at two sites. Rarely they take origin from a finger-like process of ependyma which projects through the lateral foramen, in which case they are found in the cerebello-pontine angle (Hardman & Jefferson 1938), but they far more commonly arise from the ependyma over the floor of the fourth ventricle, to which they are firmly attached. As they enlarge their posterior surface indents the vermis but remains entirely distinct; while the upper pole may extend up to block the aqueduct. Inferiorly the tumour extends between the cerebellar tonsils and not infrequently comes to lie beneath the arch of both the atlas and axis vertebræ.

Clinically.—These tumours may give rise to symptoms at any age, but are more commonly met with in childhood and early adult life. From their situation it will be seen that their symptoms will closely parallel those of the medulloblastoma, the signs of internal hydrocephalus and cerebellar herniation being associated with incoördination of both lower extremities and interference with walking and standing from pressure on the vermis of the cerebellum.

The attachment to the floor of the fourth ventricle, however, produces additional symptoms which may sometimes be recognised and permit an accurate diagnosis prior to operation. Thus sudden movement of the head from the position in which it is held by the contracted neck muscle may produce attacks of vomiting, apnoea, or even syncope, from medullary stimulation, while visceral disturbances such as præcordial and epigastric discomfort, and alterations in bladder function, are also seen.

In the latter stages again cerebellar fits appear and in these marked alteration of the rate and volume of the pulse, flushing and vaso-constriction, sweating and dyspnoea, give further evidence of irritation of the medullary centres.

Treatment. The avascular structure of these tumours and the sharp line of cleavage between their surface and the cerebellum make attempts at complete enucleation extremely tempting. Their attachment in the region of the vital centres, however, renders this a very hazardous procedure since it is accompanied with alarming variations of pulse rate and blood pressure, if not with a fatality. Partial removal, leaving a cuff of tissue at the site of attachment, or even an efficient decompression, will give an extremely satisfactory result in view of the slow rate of growth. It is however sometimes necessary to remove the arch of the axis and atlas vertebræ in order to provide a really free decompression. Our own experience has been that this simple procedure, as well as having a lower operative mortality than attempted excision, gives surprisingly satisfactory results, patients remaining free from symptoms for many years: from Cushing's series Eisenhardt describes a survival of over thirteen years in which the patient is alive and well, and completely free of symptoms, following decompression and the removal of a few fragments only from a large tumour of the fourth ventricle.

It is doubtful if X-rays have much influence on the rate of growth of these gliomas owing to their well differentiated character; increased cyst formation and connective tissue overgrowth occasionally appear following treatment, but it is suggested that in other cases stimulation of growth has occurred. (Tarlov, 1937.) The fact that irradiation of normal cerebral tissue may occasionally produce degeneration of nerve cells and changes in the blood vessels, leading to localised hæmorrhage, suggests that it should not be used indiscriminately on tumours of radio-resistant character, and should therefore be reserved for those which shew evidence of cellular activity.

Astrocytomas. Several points of difference distinguish the cerebellar astrocytomas from the more malignant medulloblastomas. The tumour occurs at a slightly later age and usually affects the lateral lobes of the cerebellum, instead of the midline. The growth is relatively benign and there is no tendency to local metastasis. The cystic character of the tumour and its situation in the lateral lobes favours its extirpation by surgical means, so that it is without doubt the most satisfactory form of all gliomas to treat.

The histological structure is usually of the fibrillary type, the less favourable protoplasmic astrocytoma being more commonly found in the cerebral hemispheres. The rate of growth is slow, and cyst-formation is extremely common as the result of necrotic changes. Usually a single large cavity is found into which projects a dark mural nodule of tumour, which, having escaped the necrosis, continues to grow and by transudation of serum from its surface vessels leads to further distension of the cyst. The slow increase in size of the cyst causes pressure atrophy of the overlying skull, whilst the corresponding hemisphere is always enlarged, the structures of the midline being displaced slightly to the opposite side and the tonsil of the affected side broadened out and herniated into the foramen magnum. This unilateral distortion of the tonsil, which is of value in locating the tumour at operation, is shown in Fig. 5 (inset), which illustrates the features in a recent operation.

Clinically. These tumours most frequently occur between the ages of 10 and 20, although examples are encountered in later years. The hydrocephalic signs are of insidious onset owing to the slow growth and at this later age are not accompanied by increase in size of the head. Vomiting of the projectile type is again the commonest presenting symptom, but older patients may just notice a progressive difficulty in coordination of one upper extremity or a tendency to deviate to one side in walking owing to unilateral involvement of one cerebellar hemisphere. Headache is often severe, since no decompression is provided by separation of the cranial sutures, and is associated with the sub-occipital pain and rigidity of tonsillar herniation. The signs in an early case are deceptively slight, but are steadily progressive until a typical triad of papilloedema, nystagmus and unilateral cerebellar ataxia, is established. Examination at this stage discloses certain striking differences in comparison with those tumours which affect the middle line. Thus, whereas the medulloblastoma characteristically affects the coordination of both lower extremities with little or no nystagmus or involvement of the upper limb, the symptoms of an astrocytoma are usually unilateral, involving especially the upper extremity of the affected side, and nystagmus is often present. In certain cases, of course, a mid-line syndrome may be produced by an astrocytoma of the vermis.

Certain differences of posture and gait will therefore be noticed. The head is inclined towards the affected side, the shoulder of which is elevated, and walking reveals marked incoordination of one lower extremity with a tendency to veer or fall towards the side of the lesion, especially if turning or pushed in that direction. The signs of cerebellar ataxia are detectable in both limbs on the same side as the lesion, but are more apparent in the upper extremity: the incoordination is evidenced by the asynergia and hypermetria disclosed in the finger to nose or heel to knee tests, and is accompanied by dysdiadokokinesis evidenced by a lag of the affected side on performing rapidly alternating movements. Astasia and pointing towards the side of the lesion on deviation of the outstretched arm may also be seen, while the muscles of the extremities are hypotonic, permitting abnormal plasticity of the fingers, wrist and knee; are æsthenic and tire readily. Little change is detectable in the reflexes unless with the patient in the sitting position a pendulum knee jerk is elicited.

Examination of the eyes reveals a variable degree of papilloedema, typical cerebellar nystagmus with the slow, coarse phase towards the side of the lesion, and in late cases squint and diplopia may be seen as the result of extended pressure to the cranial nerves, which may also produce facial weakness, facial hypoesthesia or dysarthria with slurred, explosive speech.

Diagnosis usually presents no special difficulty, but differentiation from tumours of the opposite frontal lobe may occasionally cause confusion. Should a careful analysis of the order of onset of symptoms and of the physical signs fail to resolve this, ventriculography is justifiable and should be performed prior to operation. A plain X-ray picture in these cases is usually completely negative, but may shew the beaten silver appearances of the cranial vault and erosion of the posterior clinoids resulting from raised intracranial pressure, separation of sutures, as in medulloblastomas, and the occasional calcification detectable in ependymomas, being, of course, absent. (Fig. 4. Plate 10.)

Treatment. The benign character of these growths and their accessible position in the lateral lobes, render surgical removal the treatment of choice. Following such a procedure the prognosis is excellent and, indeed, superior to that of the cerebral astrocytomas, which are more invasive and less readily removed. Extirpation is usually followed by a complete cure but it must be borne in mind that evidence of recurrence may be delayed for many years: the longest recorded survival (Eisenhardt, 1935) is one of over 26 years, the patient remaining perfectly well following complete extirpation of a fibrillary astrocytoma from the left cerebellar hemisphere. The usual history of such early cases is not, however, so gratifying since it is only of recent years that the importance of removal of the mural nodule has been appreciated. If this is not removed, but the cyst merely opened and drained, the cavity will rapidly refill from further transudate from the tumour surface; an occurrence which has led to numerous operations for "local recurrence" of astrocytomas. The longest survival of this type of case is one of over 28 years, in which the patient is alive and well following six operations for drainage of the cyst, followed, 18 years after the original drainage, by radical extirpation of the tumour.

Operation must, therefore, have as its object the removal of the mural nodule, the cyst being opened and the nodule dissected out with a layer of normal cerebellum by diathermy technique. These features are illustrated from a recent operation in Fig. 5.

FIG. 5.—Operation for removal of astrocytoma shewing inset appearances prior to operation and dissection of the mural nodule following evacuation of the cyst.

In most cases this is all that is necessary but, should a ragged appearance of the cyst wall or other suspicious features indicate that further tumour tissue is present, it must, of course, be removed.

The immediate operative mortality is low and in a large series should not be more than 10 per cent., varying according to the age and condition of the patients. In a series of favourable cases in which excision was performed we have been impressed by the greater smoothness of the post-operative period of these patients as compared with that of earlier patients in whom a decompression only had been carried out.

The satisfactory condition after discharge and the infrequency of local recurrence render the prognosis very good indeed. Indeed, if all visible tumour is

removed there is a confident expectation of complete relief, numerous cases being perfectly well 7-10 years after operation. When local recurrence takes place secondary operations are well tolerated and are preferable to relying on the use of deep X-ray for this insensitive tumour. The fibrillary astrocytoma is probably little affected by irradiation: only one of five cases examined by Tarlov shewed evidence of degeneration as compared with previous biopsy specimens. X-rays when used exclusively in the presence of a simple decompression give unsatisfactory results, relief being seldom obtained for periods longer than two years, when increasing tension in the area of decompression evidences local recurrence. In view of the fact already mentioned that X-rays occasionally produce damage to cerebral tissue, it is our custom to restrict the use of this treatment to cases where the operative removal has been incomplete.

Tumours of Adult Life.

Hæmangioblastoma. Apart from isolated cases of ependymoma and astrocytoma, this is the commonest variety of cerebellar glioma occurring in later years and may be encountered either in the lateral lobe or within the fourth ventricle, producing the characteristic syndromes of these areas, but at a later age than the tumours previously described, the age incidence reaching its maximum between the years of 30 and 40. Macroscopically these tumours are of two varieties, a cystic type situated usually in the hemispheres, and a solid variety occurring within the fourth ventricle. This latter type is always extremely vascular and firmly attached to the floor of the ventricle in the region of the calamus; occasionally it projects down between the tonsils in much the same manner as an ependymoma sometimes does but presents as a reddish vascular mass with large pulsating vessels surrounding it.

Similar solid masses may be found on the surface of the hemispheres, but usually within the nervous system cyst formation occurs as the result of transudation from the surface vessels. In such cases the gross appearance is frequently indistinguishable from an astrocytoma occurring at the same site, differentiation being made by examination of the mural nodule, which shows solid masses of epithelioid cells surrounding cavernous blood spaces—or occasionally pseudo-xanthomatous cells.

Occasionally hæmangioblastoma of the nervous system is associated with similar growths of the retina (Hippel's disease) and with cystic disease of the kidney and pancreas—a syndrome to which Lindau directed attention. In a suspected case of hæmangioblastoma the retina should therefore be examined for evidence of a tumour, to which the best guide is the presence of two large vessels radiating out from the optic disc of which the artery has a beaded appearance. Although the association is sometimes met with, either Hippel's disease or hæmangioblastoma of the central nervous system may of course occur alone, the two being occasionally associated in the complex described by Lindau.

Treatment consists of the combination of surgical extirpation, if feasible, and deep X-ray. Removal of the mural nodule from the less vascular cystic type is frequently quite successful; the cyst, however, may be many times the size of the tumour, which may be hard to identify in the smooth glistening lining of the cyst. It must always be sought for and dissected out, when vascular connections between the tumour and the surface vessels will be disclosed. The solid variety is less

readily dealt with: in the fourth ventricle its attachment to important structures and the alarming hæmorrhage provoked by attempts at piecemeal removal preclude interference. In the lateral lobes amputation of that portion containing the solid tumour may be carried out.

It is to the centrally situated, solid variety with its high operative risk that Cushing (1932) attributes the relatively severe operative mortality of this group. Thus in his series of 24 patients, 44 operations were performed with 6 deaths—a case mortality of 25 per cent., and operative mortality of 13.6 per cent.

The longest recorded survival following complete excision in his series is one of 22 years, in which the patient remained perfectly well following radical extirpation of a solid vascular hæmangioblastoma of the right cerebellar hemisphere. He was subsequently killed in a motor accident and post mortem examination shewed no evidence of any local recurrence. It may therefore be anticipated that if complete removal can be effected it will result in a permanent cure. Should operative removal prove impossible, decompression alone produces relief for a period of approximately two years, and X-ray therapy is undoubtedly helpful, since these tumours are radio-sensitive. Radiation therapy should therefore be instituted as a routine in all cases where excision proves impossible. Sachs (1936) in a description of 17 cases occurring in various regions of the brain mentions a survival of 6 years obtained by operation alone in two tumours of the cerebellar hemisphere and fourth ventricle, and quotes as evidence of the palliation provided by deep X-ray that recurrent symptoms were relieved by X-rays alone in 3 out of 4 patients.

The **Acoustic Neurofibroma** is the most frequent variety of subtentorial tumour occurring in adult life and accounts for from 8 to 10 per cent. of all intracranial tumours. It may arise as an isolated growth, or form part of the generalised neurofibromatosis of Von Recklinghausen: occasionally it is bilateral. From its origin from the sheath of the vestibular division of the 8th nerve within the internal auditory meatus it produces expansion of this orifice and pressure on the structures of the cerebello-pontine angle. As seen at operation the tumour is at first obscured by a cyst-like covering of the arachnoid membrane, which may lead the unwary to neglect the underlying neoplasm, and is often buried in the substance of the cerebellum which envelops it. Its relations are characteristic: at the upper pole the 5th and occasionally the 6th nerves are distorted and pressed upon; the facial nerve is stretched over its anterior surface and very adherent, whilst the 8th nerve is indistinguishable in the substance of the tumour. In advanced cases pressure is also exerted on the 9th, 10th and 11th nerves at the lower pole. Mesially, it presses on the brain stem, producing an internal hydrocephalus and the cerebellum as well as being indented shews the usual herniation of the corresponding tonsil within the foramen magnum. The macroscopic appearance of these tumours varies according to the degree of fatty degeneration, hard grey areas alternating with softer yellowish zones, the proportion of which accounts for the variable consistency of different growths. The microscopic appearances are essentially innocent, streams of interlacing bipolar cells forming a meshwork enclosing areas of hyaline or lipid degeneration.

Clinically. These growths are uncommon before the age of 20. The symptoms which are very slowly progressive will vary slightly according to the

direction of the main growth of the tumour. There is, however, always a history of long-standing tinnitus and deafness of the affected side, followed later by weakness of the same side of the face and drooping of the corner of the mouth. Symptoms of pressure on the 5th nerve usually appear next, subjective numbness and blunting of sensation, or rarely attacks of severe neuralgic pain, whilst pressure on the peduncles or cerebellum itself cause awkwardness in the use of the upper limb, ataxia, and instability of gait. As soon as the tumour is of sufficient size to produce internal hydrocephalus headache, vomiting and papilloedema appear, associated with pain and stiffness in the neck, and at this stage dysphagia and slurring speech may evidence pressure on the 9th and 10th nerves.

Diagnosis in a typical case is straightforward since the insidious progression of symptoms is often disregarded by the patient, so that the majority of cases are well advanced before they come under treatment. X-rays are sometimes of value in showing enlargement of the internal auditory meatus of the affected side. Neuralgic pain is rare but is liable to cause confusion, unsuccessful injections or even operations being performed in some cases before attention is directed to the posterior fossa. Distinction from the neoplasms occurring in the cerebello pontine angle is of course difficult and can only be made on a careful chronological history, noting especially that in such other growths involvement of the 8th nerve occurs late in the history. In this respect neurofibromas of the fifth sensory root, ependymomas of the lateral recess, tumour of the pons, and more commonly meningiomas require distinction: meningiomas arise in the posterior fossa, in relation to the great venous sinuses, transverse or sigmoid and it is from the latter situation that they project into the cerebello pontine angle, producing symptoms similar to those of the 8th nerve tumour, but with a different chronological order, acoustic symptoms being late in appearing. At the jugular foramen also, they produce a syndrome of involvement of the 9th, 10th and 11th nerves with cerebellar symptoms, which again should not cause confusion.

The subject of meningeal tumours has been fully discussed elsewhere. In the posterior fossa they do not differ in their age incidence or pathology from similar tumours at other sites. Their frequency is, however, far less than that of the acoustic neuroma, which remains the most probable diagnosis in a sub-tentorial lesion shewing progressive symptoms, with marked involvement of the cranial nerves in a patient over the age of 25.

Treatment. The benign character of these tumours and their situation at first sight suggest that total extirpation is desirable. Such a procedure is frequently very precarious. Numerous large vessels ramify in the capsule, derived from the basilar artery, and if severe bleeding arises in the course of operation, during removal of the capsule from the side of the pons, damage to the vascular supply of the brain stem may result. Whilst it is possible in the majority of cases to dissect free the 5th & 6th and the 9th, 10th & 11th nerves, the facial nerve is intimately adherent and often engulfed in the tumour; and lastly it is impossible to completely remove all that part which lies within the internal meatus. Indiscriminate radical removal carries with it the risk of hemiplegia and facial paralysis, and has in addition a relatively high mortality. For these reasons the majority favour intracapsular removal, employing radical methods only in selected cases.

FIG. 6.—Unilateral operation for acoustic neurofibroma shewing inset skin incision and area of bone removed, and exposure of the tumour following excision of the overlying shell of cerebellum. The capsule is figured as collapsed following evacuation of its contents.

Operation may be performed through a unilateral exposure (see Fig. 6) if the tumour is of moderate size, manipulation of the cerebellum being assisted by puncture of the cisternæ. In larger growths ease of operation is increased by using the more roomy transverse incision, and exposure is also facilitated by excision of the shell of overlying cerebellum (see Fig. 6). Following this the capsule should be incised and the tumour tissue removed by suction and spoon. As much as possible of the collapsed capsule is then removed. The results of this method are satisfactory. Although there is admittedly the chance that secondary operations may be required, this is more than offset by the low operative mortality, which should not be more than 10 per cent. In Cushing's series there is a case living and well over 26 years after treatment, having been operated on originally in 1909 and again in 1912. Despite a fairly prolonged period of disability in walking and talking, she has led a useful life. As Cairns (1936) remarks, "little is written of the capacity of these cases, prolonged disability after operation is not unusual." Perhaps as many as 1 in 4 of the patients operated on for this disease shew some ataxia, facial weakness, dysarthria or dysphagia following operation, for a variable period of time. The majority are, however, relieved without serious disability. Should recurrence occur following intracapsular removal, it is seldom seen before 3—4 years after operation, and it is then readily dealt with through a unilateral incision, such secondary operations frequently giving permanent relief.

We therefore feel that the more serious radical operation has few advantages over this method, and should certainly be reserved for carefully selected cases.

In the past five years we have had seven such tumours in our personal records. In only one was radical excision performed. The tumour which was of large size and adherent, having the advantage of being relatively avascular. The patient made a good recovery, but with evidence of damage of the glossopharyngeal nerve and slight ataxia. In the remaining six cases intracapsular excision was carried out: one patient died of hyperthermia following operation—a case mortality of 14.2 per cent.

We have recently seen one patient with evidence of recurrence who will require further treatment. The remainder are well and leading a normal existence.

It remains to consider briefly certain points concerning tumours of the pons and medulla, and the granulomas.

Brain stem gliomas are usually of a relatively benign type, either astrocytoma or spongioblastoma polare, the latter running true to form in its unfortunate tendency to affect the surgically inaccessible portions of the central nervous system. Visualization of the intimately associated cranial nerve nuclei and the ascending and descending fibre tracts explains the characteristic crossed symptomatology of tumours in this area. Multiple nuclear involvement of the various cranial nerves being associated with contralateral sensory and motor signs below the level of the lesion. Bilateral symptoms are frequently seen from the pressure of a small tumour mass in this crowded area, while cerebellar signs from involvement of the tracts and peduncles are not unusual. Since such marked local signs are produced by a small tumour mass, internal hydrocephalus and raised intracranial pressure may in certain cases appear late in the clinical picture, and papilloedema may be completely absent despite numerous local signs. Whilst similar symptoms may be produced by vascular lesions, progressive loss of function is suggestive of a tumour which should be suspected even in the absence of papilloedema.

Differentiation of these tumours is sometimes necessary from those of the cerebello pontine angle and cerebellum. Whilst cerebellar tumours can produce cranial nerve symptoms late in their course the lesion is characteristically partial and not a complete nuclear destruction. The typical sequence of the acoustic neurofibroma syndrome and the frequency of papilloedema in both cases is also of importance.

Treatment. Surgery is of course of no avail in the treatment of these tumours, but considerable improvement may be effected by repeated X-ray therapy. Thus Eisenhardt records a case of protoplasmic astrocytoma of the pons, treated by decompression and biopsy. Following this massive X-ray therapy was given, and repeated whenever symptoms occurred, with symptomatic relief. A total survival of 8½ years was obtained. We have ourselves two such cases in which satisfactory progress is being maintained with sufficient improvement for the patients to resume their normal life, under X-ray therapy which is repeated at regular intervals without awaiting signs of recurrence.

Finally, with regard to the treatment of tuberculoma. It was at one time commonly held that any interference with these tumours was certain to produce dissemination and tuberculous meningitis. This is by no means so. Local interference by puncture or biopsy will undoubtedly produce this complication, but radical excision with a fair margin of normal tissue, removing the nodule intact has, we feel, very little more risk than the removal of a tumour from the same area of the brain provided that the lesion is well encapsulated, or even calcified, and not a diffuse area of acute tuberculous infection. In the latter case, or where

the position of the mass precludes its complete removal, simple decompression alone should be carried out, with no local interference at all. Such operations should, of course, only be undertaken in the absence of active disease elsewhere, as for example, the lungs, and when good evidence exists that the lesion is an isolated one. Ventriculography is therefore required prior to operation.

In our experience also, the incidence of these granulomas is more frequent above the tentorium in adults than in the posterior fossa in children as usually stated. We have only met with four tuberculomas of the posterior fossa at operation. The results are characteristic. In one the tumour was cut into and then removed; the patient showed a slight pyrexia lasting for two weeks after operation. For two months he remained well, with relief of symptoms, but then developed increasing tension in the area of decompression and died of tuberculous meningitis. In another case a large tumour was completely removed from the left cerebellar hemisphere, but the patient died shortly after, post-mortem showing diffuse pulmonary tuberculosis, which had not previously been detected—a wasted operation. In two cases in which localised tumours have been excised completely, however, the patients continue well, with relief of symptoms. A fifth case is also of interest. A patient showing signs of an upper pontine tumour with a strongly positive Wasserman in the blood and cerebro-spinal fluid was treated without relief by anti-syphilitic measures. He died and post mortem revealed a large diffuse tuberculoma, which only goes to show that, as elsewhere, so beneath the tentorium, things are not always what they seem.

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