THE MENINGIOMAS (DURAL ENDOTHELIOMAS): THEIR SOURCE, AND FAVOURED SEATS OF ORIGIN.[1]

BY HARVEY CUSHING, C.B., HON.F.R.C.S.

Professor of Surgery in Harvard University.

THE tumours under consideration have long masqueraded under so many guises that it is well-nigh impossible, historically, to do them justice. In their gross appearance, they are sufficiently striking to have attracted the notice of morbid anatomists from early times, and without carrying the subject farther back than Cruveilhier we may feel assured from the admirable illustrations in his famous " Anatomie Pathologique," that he at least had encountered before 1835 some four or five examples in the course of his extensive post-mortem studies.

As these, or similar tumours, were then known occasionally to involve and absorb the adjacent bone, a lively discussion had arisen as to whether they took their origin from the diploe or dura, and if from the dura whether from its internal or external surface. Earlier writers had referred to the lesion as a *fungus duræ matris*, a term which has survived to our times; but Cruveilhier substituted for this the designation *tumeurs cancéreuses des méninges*, thereby reflecting the pathology of his day, and as late as 1858 we find R. Bennett in this country using the term *epithelial cancer* for these meningeal tumours. Such epithets as these, however, could not survive the advent of the morbid anatomist armed with the microscope and aniline dyes, nor in turn the embryologist with his classification of tissues.

In the early days of histological pathology which had such an impetus in the 'fifties and which Sir James Paget in this country, the pupils of Johannes Müller in Germany, and Hermann Lebert, a disciple of Dupuytren, in Paris, had done so much to advance, it was customary to give descriptive designations to tumours. In 1854, in his celebrated lectures on surgical pathology, Paget confessed his inability satisfactorily to classify the large group of tumours "less malignant than cancer," to which Lebert had given the name *tumeurs fibro-plastiques*.

[1] The Cavendish Lecture, delivered before the West London Medico-Chirurgical Society, June 13, 1922.

He suggested the term *myeloid* or "marrow-like."[1] Billroth in 1856 gave the name *cylindroma* to a growth of the orbit which showed a peculiar tubular form of hyaline deposition, and at about the same time another term, still in common use for certain growths in which so-called "brain-sand" abounds, was first employed by Virchow. He had been among the first to call attention to the calcareous granules which, unrelated to any tumour growth, are found deposited in various situations in the cerebral appendages and meningeal envelopes. Though uncertain of their nature and origin, on finding these "sand-bodies" prevalent in two small dural tumours which had come to his attention, one arising from the olfactory groove and the other from the porus acusticus, he named them *psammoma*.[2]

Thus, names which are merely descriptive of degenerative processes of common occurrence in the tumours in question have since come to be widely employed.

At about this time there was a tendency among French writers, notably by Bouchard (1864), and by Robin [21], to substitute *epithelioma* for Lebert's "tumeur fibro-plastique," and when one considers that Robin was employing the current terminology for the lining of the serous spaces and vessels, and that he regarded the cells of the arachnoid as the source of origin of the growths, he deserves due credit for his views. This, however, was brushed aside by the greater authority of Rudolph Virchow.

In his classical "Vorlesungen" [23], though making some exceptions in regard to the psammomas, Virchow incorporated the tumours in question under the term *Sarkome der Dura mater*, and they continue for the most part to be so classified. However, in spite of their tendency to invade or absorb the bone, it came to be recognized that they were benign lesions of a peculiar histogenesis for which the designation sarcoma was inappropriate and misleading, and by the 'seventies this, in its turn, had begun to be qualified. Accordingly, such terms as

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[1] In his celebrated "Anatomie Pathologique Générale," Paris, 1857 and 1861, Lebert describes and pictures as fibro-plastic tumours of the dura a few examples of these lesions, and in his "Surgical Pathology," Paget cites a most extraordinary example of a myeloid tumour which must have been a widespread bilateral and parasagittal meningioma with extensive hyperostosis cranei. The preparation is still in the Museum of St. Bartholomew's Hospital.

[2] Virchow came to regret the introduction (1859) of this term, because of its misuse by others. In a later article [24] he expressly states that an epithelial or endothelial tumour containing concrements is not a psammoma, that true psammomas have a connective tissue groundwork. This statement merely added to the existing confusion, though it is fair to say that psammoma bodies are apt to be more numerous in the older and more fibrous forms of meningeal tumours.

alveolar sarcoma came into use, and in France Cornil with Ranvier substituted *sarcome angiolitique* for Virchow's psammoma. But the term, sarcoma, however qualified, could not permanently survive the changing terminology of the embryologists.

Camillo Golgi, in an important article published in 1869 [14], called attention to the existing confusion in regard to these tumours. He had an opportunity to study two specimens, one of which was a typical tumour of the ethmoid region, which had come to light at autopsy in the hospital at Pavia, and he was the first to suggest the term *endothelioma* out of consideration for the employment by His of the word endothelium as opposed to epithelium. Thus, the simple term endothelioma was introduced in Italy, whence it has gradually made its way into other countries, but, unfortunately, even in the country of its birth, cumbersome word-combinations soon became attached to it. Bizzozero and Bozzolo [4], for example, soon subdivided the dural endotheliomas into three types, as *sarcoma endothelioides alveolare*, *sarcoma endothelioides fasciculatum*, and *fibroma endothelioides*, according to the manner in which the connective tissue elements behave in their relation to the endothelial cell nests, and whether endothelial or fibroblastic elements predominate. In this fashion, during the fifty years which have since passed, pathologists have vied with one another in modifying and extending the qualification " endo-thelial" to a wide range of tumours in a great variety of situations, in bone, thyroid, parotid, ovary, and elsewhere, into peritheliomas, hæmangio- and lymphangio-endotheliomas, and so on, with such hair-splitting refinements as to produce histological chaos.

In consequence of all this, the striking and characteristic intra-cranial growths we are considering, to which many of these names were first attached, have become so obscured by a multiplicity of designations that it is highly desirable to rescue and to re-assemble them under some simple caption. For this, Golgi's term, which has in later days gradually come to prevail, might suffice ; but even this is now of questionable advantage, for it seems quite probable that, though attached to the dura, the tumours do not arise from this membrane proper, but rather from elements of the arachnoid which project into it ; nor are they, in the parlance of some embryologists, tumours which, strictly speaking, actually originate from what are to be considered endothelial elements.

Not everyone has adopted Minot's " mesothelium " even for the cells lining the serous cavities, and it is quite evident that he had no

intention of including the meningeal spaces in this category, as some appear to have taken for granted. However, should the term be thus extended, and many anatomists so employ it, *arachnoideal meso-theliomas* would be the proper name for these tumours. But even if correct, this designation is too cumbersome for convenience, and it would seem best to sweep all these terms aside and adopt a label which is simple, and at the same time non-committal, except in so far as it indicates that the growths in question arise from the meninges. For this purpose the term *meningothelioma* was first proposed, but it has, on further consideration,[1] been shortened to *meningioma*. This word, consequently, will be used to indicate the entire group of tumours which appear to arise from the pachymeninx, whether mesothelial or fibrous elements predominate; whether the overlying bone shows hyperostosis or is unchanged; whether the growth is pedunculated or flat and widespread, and regardless of the degenerative changes and the presence or otherwise of psammoma granules.

These tumours, the meningiomas, have, as we shall see, favourite seats of origin and, though they may differ considerably in their histological picture, they are, as a rule, easily recognizable not only by their gross appearance but because of the fact that the stalk from which in their simpler form they seem to arise is so intimately incorporated with the dura that they appear to originate from it.[2]

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[1] A note regarding the derivation of "thelium" and its combinations may not be amiss, and for the basis of what follows I am indebted to my colleague Frederick T. Lewis. The term *epithelis* (from ἐπί = upon ; θήλη = the nipple) appears to have been introduced by Ruysch early in the eighteenth century, and was first used for that transitional part of the epiderm at the lips and nipple—though in time "epithelium" came to be generally used not only for the two peripheral germ layers but for the lining of the serous and vascular spaces as well. In 1865 the word *endothelium* was first used by His as a designation for the lining membrane of these cavities arising from mesenchymal cells within the middle germ layer, and the term has come into general use not only for blood-vessels and lymphatics but all serous cavities as well. Kölliker in 1882 had used the term *mesepithelium* for the lining of the body cavities and urogenital epithelium, reserving the term endothelium for the vessels, synovial cavities, meninges, and so on ; and to the same tissues Minot a few years later gave the name *mesothelium*. All three terms, *epi-*, *endo-*, and *mesothelium*, would appear to be unfortunate in view of their derivation in part from θήλη, but they, nevertheless, have come to convey an idea.

[2] There are a few tumours which possibly are allied to the meningiomas, but which have no dural connection : they appear to arise from the pia. They are rare tumours of an angiomatous nature, whereas those under discussion are relatively non-vascular. Another still more rare tumour (particularly so in man) is the so-called cholesteatoma of the choroid plexus. It is actually an endothelioma with extensive psammoma deposit, and is often bilateral.

INCIDENCE.

Some years ago all of the material relating to the several meningiomas, intraspinal as well as intracranial, then included in my tumour series, was gathered with the intent of publishing in detail our clinical and operative experiences with these interesting lesions. This project, however, was interrupted by the discovery that the acoustic tumours (neurinomas of Verocay), which in several instances had been diagnosed as fibro-endotheliomas, were distinctive tumours of an entirely different order. The " endotheliomas " were consequently dropped for the time being, in order to make a more thorough study of the tumours originating from the eighth cranial nerve, commonly described, in view of their location, as tumours of the cerebello-pontile angle.

In a monograph ultimately published on the subject of the acoustic tumours [8] it was pointed out that these lesions when bilateral are not infrequently accompanied by multiple small meningeal endotheliomas, so that tumours of these two types (neurinoma and meningioma) are in certain respects related. Nevertheless, it is far more usual for one or the other to occur in isolated form, and until something more is learned of a common ætiological factor it is undoubtedly best to consider them apart and as distinctive lesions.

The time has long since passed when we could hope to advance our knowledge of intracranial tumours to any great extent by considering them as a whole. Even their mechanical or pressure effects, which might be expected to be more or less similar in all cases because of the rigid character of the bony chamber within which they arise, differ widely, and it is notably true of these meningiomas that they may attain a huge size without giving rise to any of the so-called cardinal symptoms of tumour, notably headaches and objective changes in the eye-grounds.

Intracranial tumours, indeed, are so protean in form ; they behave in such different ways ; they provoke such varied clinical pictures ; and the proper method of dealing with many of them, even when they are exposed by an operation, is in many cases still so problematical, that our only hope for progress is to particularize on certain groups of cases.

There are three ways in which a large material such as is before us may be profitably attacked. We may (1) concentrate our attention upon tumours of certain histogenetic types whatever their situation ; (2) we may study tumours of all types in a given situation ; or (3) what is perhaps better still, we may restrict our analysis, as was done with the acoustic tumours, to tumours of a single type in a given situation.

Only by the adoption of one of these methods can one's casual acquaintance with a disorder, made at the bedside or operating table, ripen into familiarity. Each has its advantages, but for the purposes of this particular study I shall adopt the first, and consider the meningiomas as a whole.

VERIFIED MENINGIOMAS.

On various occasions an explanation has been given of the system under which the tumour cases of my clinic are classified. They are listed as (1) *tumour verified*, when the character of the lesion has been histologically determined at operation or autopsy; as (2) *tumour unverified*, when the presence of a growth is reasonably certain or, indeed, when it may actually have been seen but without removal of a fragment for verification; and as (3) *tumour suspect* to include those cases referred to the clinic with a presumptive diagnosis of tumour, of the justification of which there remains considerable doubt.

In our present connection we are interested only in the 751 verified intracranial tumours, and without going into the detail, unnecessary for our present purposes, of distinguishing between the various sub-varieties of gliomas, adenomas, and so on, the cases may be tabulated as follows, in order to indicate the ratio of the meningiomas to other main tumour groups.

TABLE OF VERIFIED INTRACRANIAL TUMOURS TO MARCH 15, 1922.

Gliomas		314 cases	(41·8 per cent.)
Adenomas (chiefly pituitary)		159 ,,	(21·2 ,,)
Meningiomas		85 ,,	(11·3 ,,)
Neurinomas (acoustic)		63 ,,	(8·4 ,,)
Congenital tumours		40 ,,	(5·3 ,,)
(a) Suprasellar tumours (chiefly of pharyngeal pouch origin)	28		
(b) Cholesteatomas, dermoids, and teratomas	12		
Granulomas		33 cases	(4·4 per cent.)
(a) Gummas	12		
(b) Tubercles	21		
Papillomas (choroid plexus)		11 cases	(1·5 per cent.)
Angiomas		7 ,,	(0·9 ,,)
Metastatic and invasive		27 ,,	(3·6 ,,)
Miscellaneous and unclassified		12 ,,	(1·6 ,,)
		751	

The meningiomas, as can be seen, stand in about a one-to-four ratio to the gliomas or brain tumours proper, and if we add to this intracranial group of eighty-five cases twelve others which have arisen in

the spinal canal, there are, at the time of writing, nearly 100 tumours to deal with.

Anything like a complete analysis of these cases would far exceed the possibilities of a single address if the innumerable questions which would naturally arise were answered with any measure of completeness. The interest of the physician and neurologist would centre on the symptomatology and diagnosis—particularly upon the mistakes in diagnosis, and in these the psychiatrist, for reasons to be pointed out, is concerned perhaps more than any other. In the province of the ophthalmologist lie the visual field distortions, the examples of unilateral exophthalmos, and, above all, the changes—or what is possibly more important, the lack of changes—in the eye-grounds, for a choked disc may be absent or at least long delayed; on the other hand, in the supra-sellar lesions a primary optic atrophy may be the essential guide to the site of the lesion. Some of the tumours originate near the porus acusticus with loss of hearing as an early symptom, and so concern the otologist. Others which arise from the olfactory groove and invade the ethmoid cells come into the province of the rhinologist, and that newest of specialists, the endocrinologist, doubtless may have difficulty in distinguishing primary pituitary disease from the dyspituitarism secondary to one of these growths which so commonly arise from the meninges bridging the sella. And, last of all, the interests of the surgeon are focused on the methods employed for the removal, particularly of the more inacessible of these tumours, and upon the end results which may be obtained. Being one of them myself, the temptation is strong to yield to the desires of my own kind, and yet, in view of the very seriousness of his therapeutic measures, it behoves the surgeon, even more than others, to know all that he can learn regarding the origin, site, and characteristics of the lesion he plans to attack before he goes into action. I propose, therefore, though it is a somewhat less exciting story, to confine myself on this occasion largely to the two points mentioned in my title—the source, and the seats of predilection of the meningiomas.

THE SOURCE OF THE TUMOURS.

In 1911 an opportunity was afforded for an enlightening post-mortem study of one of these growths which had been undisturbed by previous operative manipulations. Including three spinal tumours, it was the fifteenth case in the series, and we were then still labouring under the impression that the growths took origin from the dura and were of

various kinds.   Most of the preceding tumours had possessed a broad
base of meningeal attachment, and until this case no particular atten-
tion had been paid to the meninges remote from the lesion, except to
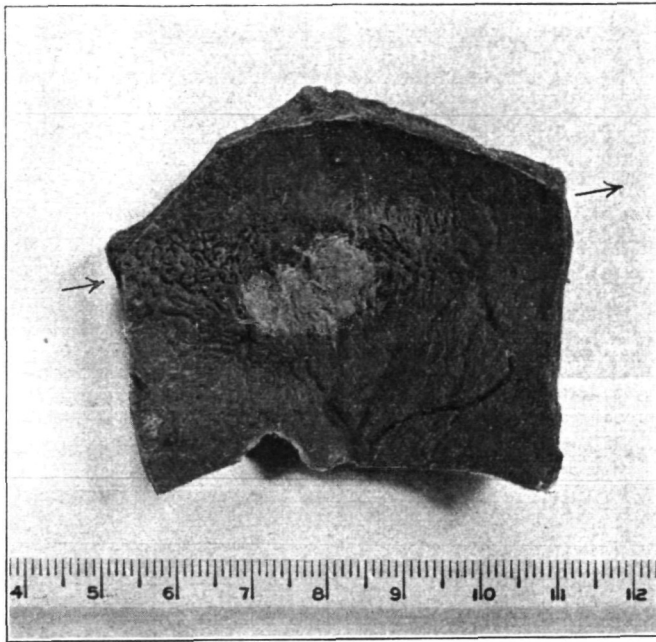note the presence of multiple herniations which had early aroused our
interest.

FIG. 1.—Fragment of calvarium overlying point of origin of tumour, showing slight invasion
of inner table without hyperostosis.   (Arrows show groove of sinus sagittalis.)

The patient, a woman aged 41, was admitted to the John Hopkins Hospital
in a profound stupor, obviously in the terminal stage of compression from a
brain tumour.   An incomplete story was secured from a relative, of headaches
for many years, of five months' confinement in bed with increasing disability of
her left side, of progressive mental impairment, and finally of somnolence.
She succumbed twenty-four hours after a first-stage osteoplastic procedure,
at which time the dura was not opened.   Had her condition at this first
session justified a more prolonged exploration with exposure of the brain, the
tumour would in all probability not have been disclosed, in view of its small
surface area confined to the mesial edge of the hemisphere.

As is our custom at autopsy when circumstances permit, the brain was
fixed before removal by a formalin perfusion through the carotids in order to
preserve the pre-existing distortions which are otherwise considerably modi-
fied.   On removal of the calvarium there was disclosed, about 5 cm. anterior
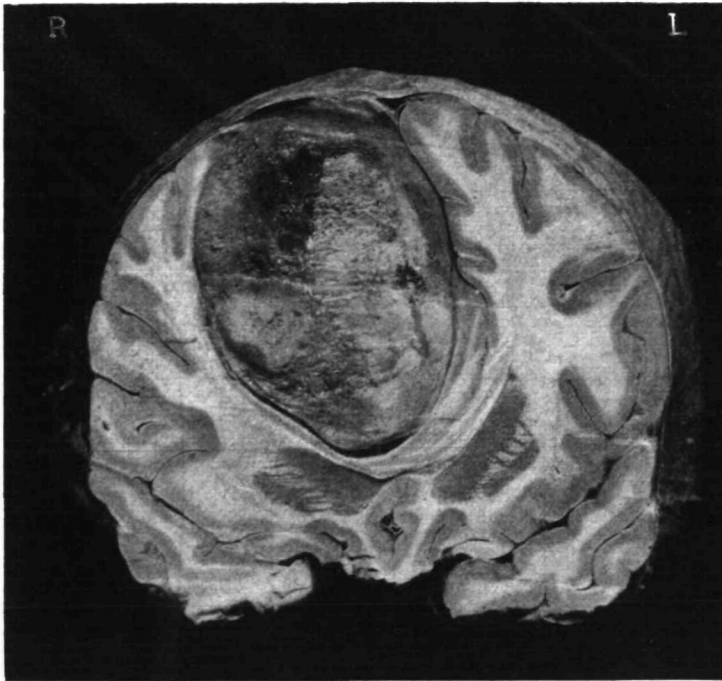to the Rolandic point, a small area (fig. 1) overlapping the groove of the

FIG. 2.—Coronal section through tumour, viewed from before, showing great dislocation of falx and corpus callosum.
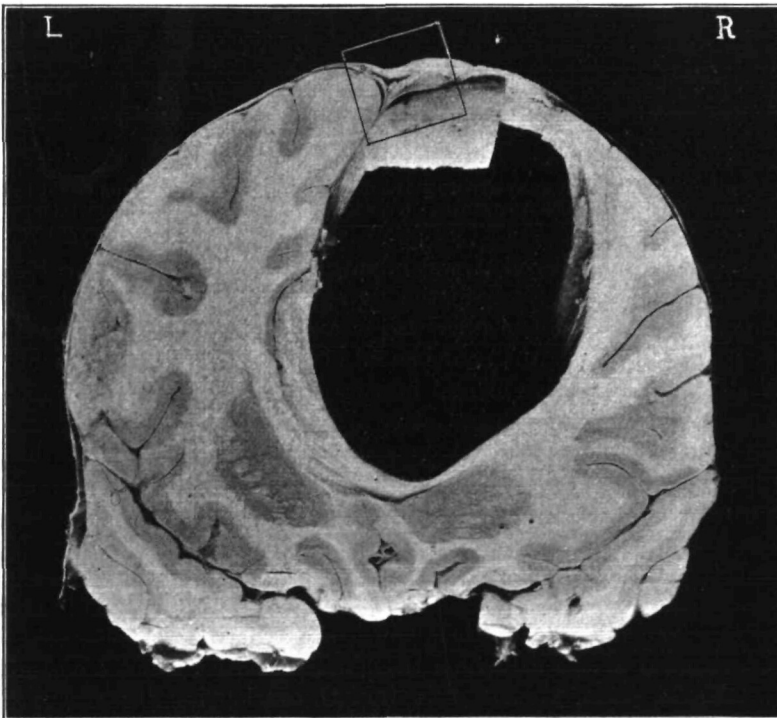

FIG. 3.—Coronal section viewed from behind, showing cavity occupied by the tumour and its only point of attachment under the lateral expansion of the sinus and at the angle of the falx.

sagittal sinus where the dura was adherent. The brain was removed, so far as possible, with its dural envelope intact, and a coronal section, through the point where the adhesions had been noted, transected a large tumour (fig. 2). of about 150 grm. weight, which had greatly deformed the hemisphere, and practically obliterated the ventricles. Except for the small stalk, from which the growth evidently arose, situated in the parasagittal angle and underlying the parasinoidal expansion of the sinus, the tumour was nowhere adherent (fig. 3). Hence, though apparently within, it actually lay outside of the hemisphere, whose pial covering remained intact over the deformed convolutions.

Microscopic sections through the point of meningeal attachment showed (fig. 4) that the tumour had invaded the sinus without thrombosing it, and though traces of the intervening dura still remained, it had been so effectually destroyed that to regard the sinus wall as the starting-point of the growth was an inevitable conclusion.
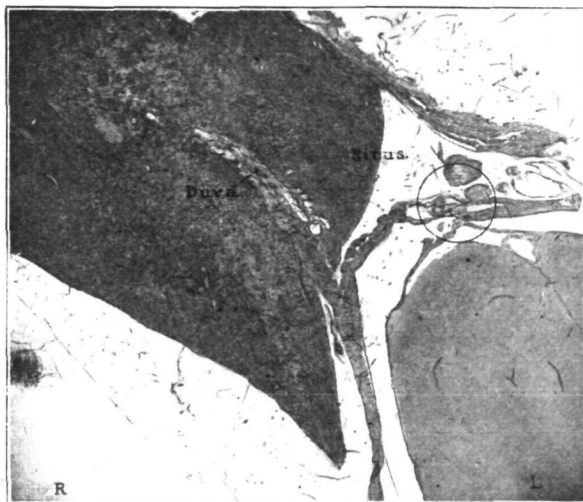

Fig. 4.—Section from area of attachment (squared area of fig. 3), showing invasion of sinus by tumour on right, and on left the arachnoid villi and cell clusters.

The lesion itself presented in different areas a most varied appearance. In some areas (fig. 5) it had a fibromyxomatous appearance, but for the most part (fig. 6) there were masses of endothelial cells with a more or less well-marked alveolar arrangement surrounded by bands of fibrous tissue, the cells of which in some places formed large fibrous whorls. Many areas showed extensive hyaline degeneration, and psammoma bodies together with so-called corpora amylacea were in abundance.

There is nothing unusual in the foregoing description of this particular tumour, for which a variety of names might be used.   It
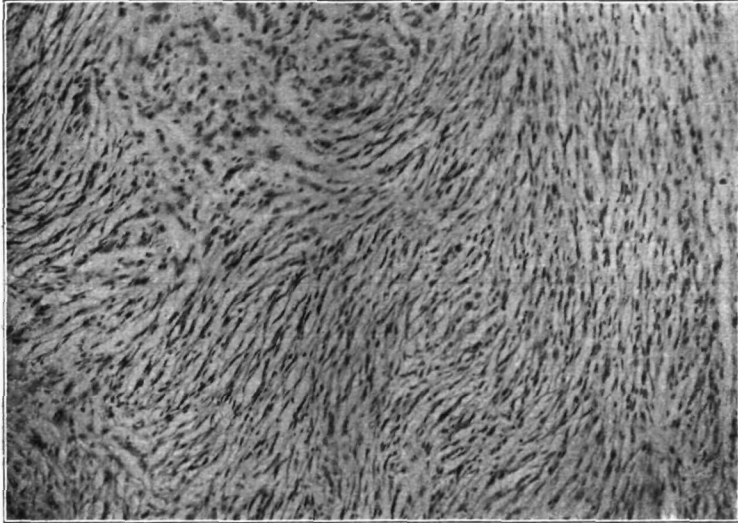
FIG. 5.—Fibromyxomatous area (mag. × 100).
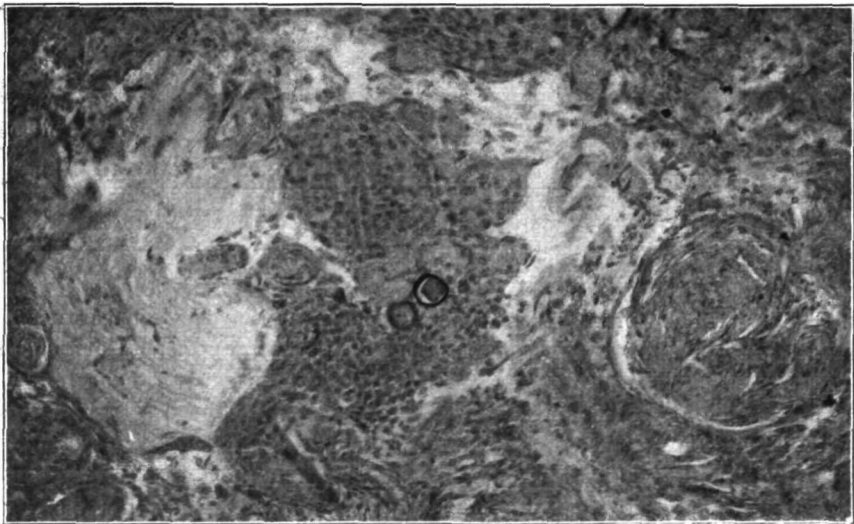

FIG. 6.—Endothelial cell alveolæ with fibrous whorls, psammoma bodies and hyaline areas (mag. × 100).

would probably deserve the term fibro-myxo-endothelio-sarcoma, and its seeming invasion of dura and bone would justify the assumption that it had malignant qualities which in time might have produced metastases. The whole story is essentially commonplace, and tumours of corresponding nature, beyond enumeration, have from time to time been reported in the literature.
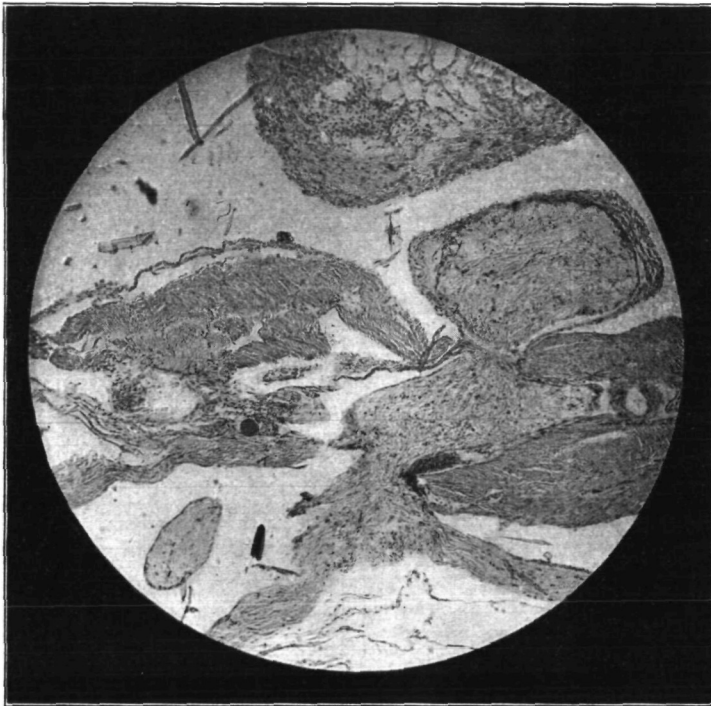

FIG. 7.—Showing an arachnoid villus projecting through dura into sinus. Also nests of arachnoid cells and psammoma body lying within dura. (Area circled in fig. 4.)

But something apart from all this, of importance in our present connection, was observed in the meninges remote from the tumour. As already mentioned, the brain after fixation [1] had been removed with its

[1] A word in regard to this may not be amiss, for I believe that nothing has served to further our understanding of the mechanical effects of tumours so much as the abandonment of the time-honoured method of handling and sectioning the unhardened brain at autopsy after removing the calvarium and stripping off the dura. This unfortunate procedure, which is still an habitual one, has done much to delay our knowledge, particularly of the secondary disorders in cases of brain tumour which concern the cerebrospinal fluid pathway in ventricles, cysternæ and leptomeninges. For not only is the tumour topography largely altered if fluid escapes before the tissue has been fixed, but with the meninges stripped from the brain there has been little incentive in the past to study them in their relation to the adjacent cortex.

meninges largely intact, and sections through the unusually small stalk of the tumour gave a definite clue to the histogenesis of the lesion. Projecting into the sinus on the side of the uninvolved hemisphere were a number of hypertrophied arachnoid villi (fig. 7), capped by clusters of endothelial cells of precisely the same character and staining reactions as those of the alveolated masses of cells comprising the bulk of the tumour. Many of these cell-clusters disclosed in the dura showed a tendency to the familiar whorl formation (fig. 8), and in association with them were psammoma bodies in considerable numbers,
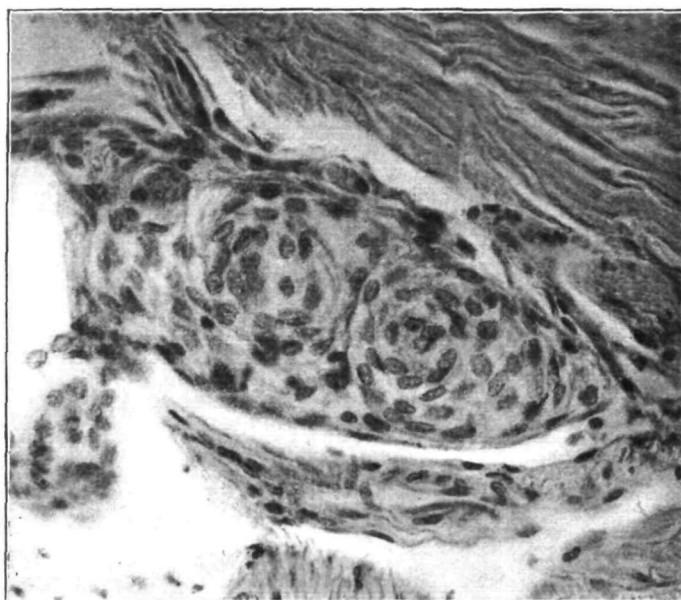

FIG. 8.—Showing typical cluster of arachnoid cells arranged in whorls and lying within dural layers remote from tumour.

In short, scattered through the uninvolved and presumably normal meninges were all the elements characterizing the tumour proper, these elements being of arachnoidal rather than of dural origin, though encased within the latter membrane.

This observation, so enlightening to us eleven years ago, proved, as will be seen, to be by no means an original one. It gave us, nevertheless, a new conception of the possible source of origin of these interesting tumours and suggested studies in two directions, the first of which might not have been so vigorously pursued had we then been

aware that our views were far from being novel. We undertook, on the one hand, a detailed study of the meninges in areas distant from the tumour in all similar meningeal growths; on the other hand, we began to investigate the arachnoid villi, and this in due course led us into a consideration of the cerebrospinal fluid circulation as a whole.

During the first two years after my transfer in 1912 to Boston, these studies, which had been started in the Hunterian Laboratory at the Johns Hopkins some time before, were continued in collaboration with Lewis H. Weed in the Laboratory of Surgical Research at Harvard, and due largely to his unusual gifts as an investigator considerable progress was made. In the series of papers which were published in 1914 [10], special attention was paid to the arachnoid villi whose function as points of escape for the fluid from the arachnoid spaces into the dural sinuses, though previously surmised, Weed, for the first time I believe, conclusively demonstrated.[1] The villi, in short, appeared to us to play a far more important physiological rôle than had been commonly ascribed to them. But before considering further this aspect of the subject and its bearings upon the tumour question, it is proper to make due acknowledgment to at least three authors by whom our views regarding the origin of these tumours proved to have been anticipated. It is not at all unlikely that there may have been others who have expressed similar ideas in papers under obscure titles which have not come to my attention.

In a brief article published in 1864, John Cleland [7], late Professor of Anatomy in Glasgow, set forth with prescience, the more remarkable when one considers the source of his material for study, the view that two tumours which he had found in the dissecting room, one of them arising from the cribriform plate and the other from the right frontal region adjacent to the superior longitudinal sinus, took their origin from the arachnoid rather than the dura. He observed that in structure they resembled the Pacchionian granulations in a number of points; that connective tissue bands ran through them, that concretions were present in both tumours, and new bone formation in one of them. In pointing out the proximity of these tumours to the falx, he mentioned the bony plaques often found attached to this membrane, and in agree-

[1] On his return to Baltimore, Weed's further pursuit of these investigations led, among other papers, to the publication of his monograph ("The Development of the Cerebrospinal Spaces in Pig and Man." Contributions to Embryology, No. 14. Carnegie Institution of Washington, Publication 225, 1917) on the development of the arachnoid, which represents the most important advance in our knowledge of the meninges since the classical work of Key and Retzius.

ment with Rokitansky attributed them also to the arachnoid rather than to the dura. Similarly, Ch. Robin [21] in France, described in 1869 two tumours likewise met with in the dissecting room. He also attributed them to the arachnoid, and in a long and scholarly article made a strong plea for their epithelial origin.

In another more extensive study published ten years before our interest in the matter was first awakened, Martin B. Schmidt, of Zürich [22], likewise called attention to the probable relation of the Pacchionian granulations to the so-called sarcomas and psammomas of the dura. In the course of his post-mortem examinations Schmidt had chanced to encounter twelve small meningeal tumours which he made the subject of special study. He was led to make a thorough histological survey of the meninges, and gave the first clear description of the microscopic islands of endothelial cells (Zellzapfen) which are found between the layers of the dura, in numbers which increase with advancing age in practically all individuals.[1] He recognized that these cell masses are related to the arachnoid tufts or villi, that they are themselves unquestionably of arachnoid origin, that they have certain seats of predilection, and, inasmuch as the cells comprising them were identical with those in the small tumours he had studied, he came to the same conclusion that Cleland and Robin, on less sufficient evidence, had reached years before, that they were the starting-point of these growths which, therefore, strictly speaking, have a leptomeningeal rather than pachymeningeal origin.

In medicine perhaps more than in other walks, discoveries are constantly being re-made and views being readvanced, for knowledge spreads slowly and facts once known and recorded are easily overlooked or forgotten. In 1915, in the last of our series of papers on the cerebrospinal fluid and its pathway, a paper chiefly devoted to the calcareous and osseous deposits associated with a cellular hyperplasia of the arachnoid [11], we in turn put forward as novel precisely the same views Cleland had advanced fifty years before regarding the derivation of these tumours from the arachnoid cell clusters. Five

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[1] Others had observed these cell masses before Schmidt. They had possibly been seen long before by Rainey [20], who imagined them to be ganglionic structures which regulated the blood supply of the cerebral vessels. Fifteen years later Ludwig Meyer [18] [19] in a more accurate study of the meninges in cases of dementia referred to them as " epithelial granulations." Meyer recognized their relation to the arachnoid, noted the calcareous deposits which Virchow later named, and pointed out the relation of these cell clusters to the bodies of Pacchioni, which Luschka [16] a few years before had conclusively shown to be of arachnoid origin.

years later, Mallory [17] re-advanced the same views, and designated the tumours with the histological aspects of which he was chiefly concerned, as *arachnoid fibroblastomas*. Weed in the same year, though more interested in the physiological rôle of the membrane as a fluid container, nevertheless presented a convincing series of pictures from the meninges of the cat, showing that the clusters of cells may range from a moderate hypertrophy to actual tumours, in which most of the characteristic degenerative changes of these growths, as met with in man, occur.

MULTIPLE CEREBRAL HERNIATIONS.

There is another matter relating to the arachnoid villi, apart from their histological characteristics and their possible relation to tumours, which had engaged the attention of a few pathologists. In 1870, before the Würtzburger Medical Society, von Recklinghausen exhibited as a curiosity a brain from a case of cerebral tumour in which small bits of cerebral substance, projecting into minute openings of the dura, more especially over the temporal lobe, had been torn off in the course of its removal. These minute lesions he recognized as multiple hernias of the cerebral substance. They had been observed by others long before him, by Cruveilhier for example, but no particular significance had been attached to them.

The matter excited no great interest until twenty years later when Benecke [2] reported as a great rarity two further cases showing these herniations, which he attributed to pressure. He pointed out that nests of endothelial cells were invariably present somewhere on the surface of the minute cerebral protrusions, and this led him to recognize their relation to the Pacchionian granulations.

Though in 1901 four other cases were incidentally recorded by Blasius [6] from Benecke's laboratory, the first thorough study of these lesions was published in 1908 by S. Burt Wolbach [28] who had observed them in a series of cases in which there had been tension, not, however, always due to tumour. Wolbach emphasized what is important in our present connection that the herniations occur in the regions where the normal arachnoid villi abound, a fact which carries with it the implication that the dural venous sinuses and their main branches are to be found in the same situations. He showed, furthermore, as did Schmidt, that these are microscopic or what one might call potential Pacchionian granulations, and concluded that "the multiple hernias of cerebrum and cerebellum always enter the dura through fissures occupied by arachnoid villi."

Though Schmidt himself published nothing further on the subject of the *Zellzapfen*, his interest evidently did not lag, for at least two papers, bearing on these matters, appear to have emanated from his laboratory. The first of them by Sophie Wojno [27] was on this subject of cerebral herniations which she recognized as occurring in the villi; but she dwelt chiefly on the fact that they may be found in conditions unrelated to tumour and attributed them, it would seem, to defects in the pia subjacent to the villi, which thereby permit the herniations to take place.

It may be recalled that all but one of the twelve meningiomas Schmidt had described were small growths and accidental post-mortem findings. Nevertheless, even under these conditions he had observed some of these herniations, more especially in the middle cerebral fossa. Apparently, therefore, he and his pupil were on the look-out for some explanation for them other than tension. They consequently were regarded as " physiological " herniations rather than pressure phenomena, and were attributed by Wojno to leptomeningeal defects.

There is, it seems to me, a much more plausible explanation of the presence of these herniations when there is no demonstrable increase of intracranial tension—a matter indeed very difficult to gauge by post-mortem appearances alone. In view of what we now know of the ease with which the brain takes up fluid and becomes œdematous, there are probably few individuals who with advancing years escape from periods ·of increased intracranial tension due to one cause or another. These must be particularly common in association with arterio-vascular ·disorders, and it is easily conceivable that the arachnoid villi under these circumstances may not only become hypertrophied into visible Pacchionian granulations, but that actual herniations may occur and subsequently recede with the subsidence of the œdema. Even in the presence of tumour when intracranial pressure is relieved by withdrawal of cerebrospinal fluid, by the intravenous administration of hypertonic salt solution, or more permanently by a generous decompression, it is not unlikely that these minute hernias may become reduced just as may the large hernias which protrude through operative ·defects in the skull. An illustration of this in the process of taking place is shown in the accompanying figure (fig. 9). The condition ·came to light during the study of the meninges of a patient who had been operated upon over the cerebrum through an error in diagnosis, when in reality there was a cerebellar tumour with internal hydro·cephalus and great tension. A cerebrospinal leak communicating with

the ventricle occurred, and fatal meningitis was the result, but for the
few days before death there was a complete release from the pre-existing
supernormal tension; and at autopsy it was evident even to the naked
eye that many of the large and multiple hernias which abounded were
being withdrawn from their pockets in the arachnoid.

These minute herniations, as a matter of fact, are very commonly
produced by long-continued states of increased pressure. That they
project into and dilate pre-existing spaces there can be no doubt, and
that these spaces communicate with the arachnoid is evident from the

FIG. 9.—A cerebral hernia in the process of withdrawal from an arachnoid villus.

character of the cells lining them. What interests us chiefly at this
time are the areas in which they are most commonly observed, since
they betray the situations of the chief arachnoid villi and their asso-
ciated cell-clusters. They abound, as might be surmised, along the
major dural sinuses where the tentorium and falx unite with the dura
over the cerebral and cerebellar convexities, but they are also to be
found in the basal meninges, being especially common over the tips of
the temporal lobes and in the region of the Gasserian ganglia, where
they correspond likewise with the situation of the venous sinuses. They
can be best studied in previously hardened brains removed with their

envelopes so far as possible intact ; the accompanying figure (fig. 10), in which the relation of the protrusions to the branches of the vasa meningea media is apparent, gives an illustration of their distribution over the convexity.
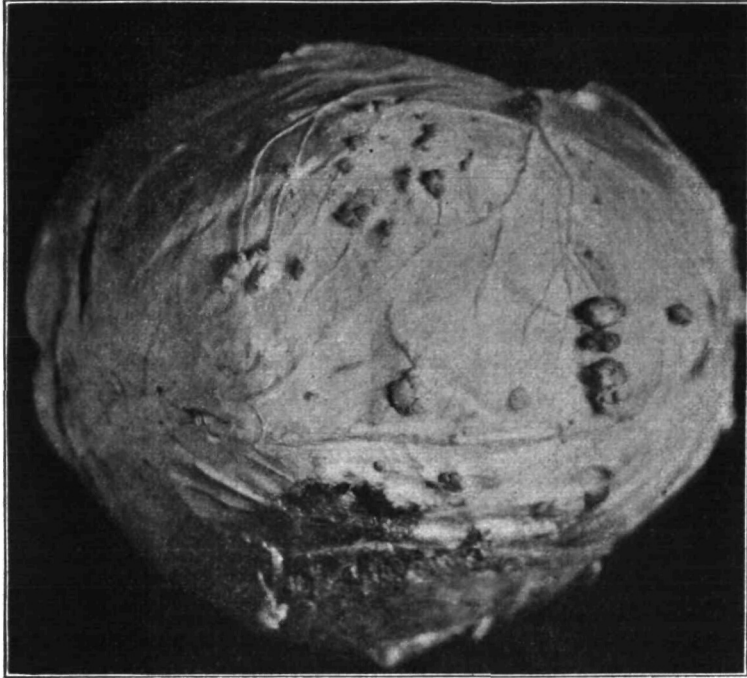

FIG. 10.—Showing multiple herniations, projecting through the dura over the left hemisphere, produced by pressure due to a large suprasellar endothelioma.

ÆTIOLOGY.

Why should these cell-clusters in the arachnoid have a tendency in middle life to undergo tumefaction ? An answer to this question, owing to the many and wide gaps in our knowledge, must be essentially speculative. However, some approach to it can be made. As in other tumours, the more obvious factors are age, congenital predisposition, trauma and physiological activity. Schmidt's original observation that the cell-clusters are absent or difficult to demonstrate in infancy and become more pronounced with increasing age, has been confirmed by others. In this connection the age of the ninety-seven patients with meningiomas, as recorded at the time of their admission to hospital, fall in the successive decades as follows :—

0—10	..	..	.. 0	50—60	..	..	.. 21
10—20	..	..	.. 3	60—70	..	..	.. 10
20—30	..	..	.. 11	70—80	..	..	.. 0
30—40	..	..	.. 23	80—90	..	..	.. 1
40—50	..	..	.. 28				

These figures naturally represent the age when symptoms had become pronounced, and probably an average of five or ten years should be subtracted if one were to estimate the age of onset. Nevertheless it can be seen that these tumours, unlike the gliomas, are rare in the first two decades, and reach their maximum in the fifth, a decade at least later than the period of maximal frequency for the pituitary adenomas and the acoustic tumours.

The fact that in cases of neurofibromatosis (Recklinghausen's disease), multiple meningiomas occasionally co-exist with multiple neuromas of the cranial nerves, suggests that some congenital fault may be responsible. However, they occur singly with far greater frequency. Curiously enough, they bear unmistakably a close relation to trauma of one sort or another[1]. In so many of the cases in the series has a tumour been found at the exact situation where a stunning blow had been received on the skull years before, that this must represent something more than mere coincidence. On the circumstantial evidence it is tempting to assume that the injury has bruised the meninges and caused an extravasation, to aid in the absorption of which the local cell-clusters have been incited into a state of morbid activity. It is not improbable, too, as emphasized by Borst, that some form of injury other than a blow may serve to incite a pachymeningeal reaction and lead to tumour growth. In one of the cases included in the series, an unsuspected frontal endothelioma was found post mortem associated with a subjacent chronic abscess. Moreover, psammomas and endotheliomas have been observed by Berger [3], Dufour [12], Henschen [15], and probably by others, in connection with old cases of healed spinal tuberculosis in which there were unmistakable evidences of pachymeningitis. Henschen, in particular, lays great stress on this relationship in reporting a case which showed multiple tumours. They have been observed, too, in association with pachymeningitis interna hæmorrhagica. In explanation of all this it must be borne in mind that the cells which line the arachnoid actually represent an organ of great

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[1] The youngest case in the series, for example, a boy of 13, with a 100-grm. meningioma which originated from the lower margin of the falx, had had symptoms for five years. He had received at birth an extensive cranial injury, associated in all probability with a tear of the falciform membrane.

functional potentialities. It is here that the studies of L. H. Weed and his co-workers have thrown a guiding light on the subject, for though an anatomist, Weed's interests have been on the side of function rather than structure.

To state the matter briefly, the arachnoid villi in close association with which the cell-clusters abound, act as organic filters interposed in the pathway of the cerebrospinal fluid, between the subarachnoid spaces and the dural sinuses. Their non-development or their occlusion by foreign particles, whether the product of injury or disease, or suspensions of substances such as lamp-black introduced artificially into the cerebrospinal fluid, will lead to stasis of the fluid and hydrocephalus, provided the occlusions are sufficiently widespread [26].

Furthermore, the cell-clusters under the stimulus of these injuries are prone to hypertrophic enlargement. It has been shown by Essick [13] that when the villi are experimentally blocked by particulate matter, whether sterile or the product of inflammatory reaction, the arachnoid cells proliferate abundantly, take on the function of phagocytes, and even become free-moving macrophages in the subarachnoid spaces. We may regard these cells, therefore, as agents which play a rôle in keeping the points of outlet of the fluid free from the mechanical obstructions produced by debris.

It is conceivable, therefore, that with advancing years the mesothelial cells comprising the cell-clusters are called upon from time to time to undergo periods of increased functional activity in their phagocytic rôle, after which they remain permanently hypertrophic or subsequently undergo the characteristic and well-known degenerative changes to which they seem predisposed. Hence their apparent increase in size and number with advancing age. On the other hand, some of the cell-clusters, possibly in consequence of these periods of activation, show neoplastic tendencies under certain circumstances obscurely related to the genesis of tumour formation in general.

THE SITUATION OF THE TUMOURS.

It is evident from what has gone before, that at least four observers between 1864 and 1920 have independently come to the conclusion that these tumours, herein called meningiomas, are derived from the arachnoid cell-clusters. The relation of these groups of mesothelial cells to the functionating villi and of the villi to the dural venous sinuses, has been emphasized. It has been shown further that the

places where the villi abound is indicated by the distribution of the minute cerebral hernias which protrude into them in cases of marked intracranial tension. It remains to be seen whether there is any definite correspondence between these regions and the points of origin of the tumours themselves.
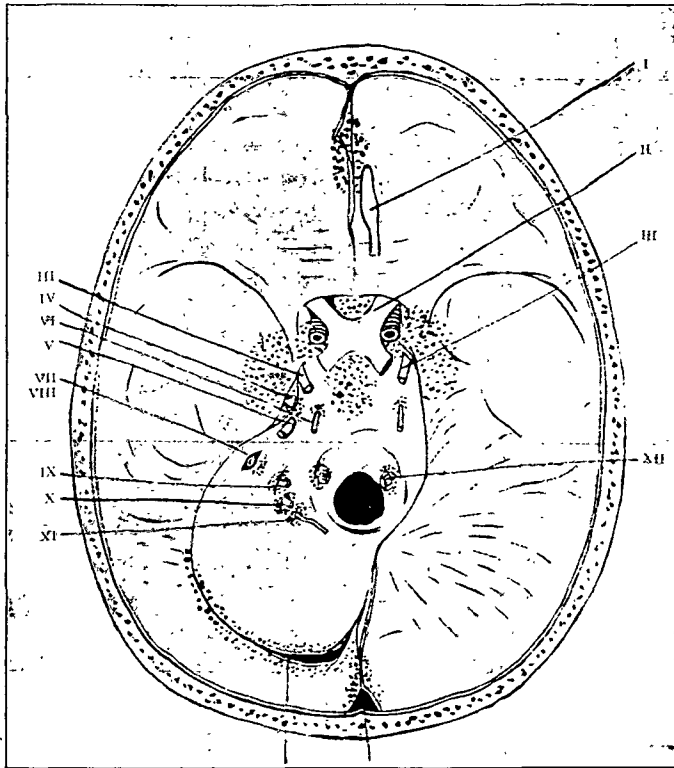

FIG. 11.—From Aoyagi and Kyuno, showing the situations of the cell clusters.

The only paper on this subject, to my knowledge, was published in 1912 by Aoyagi and Kyuno [1] and for a translation from the Japanese I am indebted to Professor Tanaka, of Okayama. These authors made studies of the dura of individuals of various ages to determine the seats of predilection of the arachnoid cell-clusters, and identified their presence in the following situations (fig. 11), viz., along the sinus sagittalis superior; near the crista galli; the sinus transversus; surrounding N. oculomotorius, trochlearis, abducens, and trigeminus; around the hypophysis; near the sella turcica; the plexus basilaris; at

the point of penetration of the dura by the third, seventh, ninth, tenth, eleventh and twelfth cerebral nerves; and also at the points of penetration of the nerve-roots of the cervical spine.

Furthermore, they gathered from the literature thirty-six cases of so-called dural tumour (variously termed sarcoma, psammoma, endothelioma, sarcomatous endothelioma, spindle-cell sarcoma, &c.) and added three cases of their own, all evidently " meningiomas." The situations in which these thirty-nine tumours were reported corresponded sufficiently well with the principal locations of the cell-clusters to justify the conclusion that all the tumours—endotheliomas, psammomas and sarcomas alike—arose from these bodies.

For the purpose of this lecture, the accompanying drawings have been made, with as great accuracy as our records of operations and the study of autopsy material permits, to indicate the areas of dural attachment of the meningiomas in my personal series. It must be admitted that in certain cases it may be difficult, even with the material in one's hand, to judge of the exact point of origin of a meningioma. This is particularly true of the spreading flat tumours[1], for such a small stalk of attachment as appears in the case herein recorded in some detail (figs. 2 and 3) is unusual even in the large potato-like growths which tend to be more or less pedunculated.

The meningiomas, in short, may be divided into two general classes : the large growths, often more or less irregularly lobulated, which incline on the whole toward a spherical form, and the tumours *en plaque* which are but slightly elevated and tend to spread over the inner dural surface. These latter meningiomas represent but a small proportion of the tumours in the series, and without the microscope would hardly be recognized as belonging to the same general group. They are more common among the growths arising from the basal meninges than from the convexity, though three of them occupied the parasagittal angle and a number have been found spreading over the dura in the sbheno-temporal region. In this latter situation they appear to arise from near the pterion, where the meningeal vessels and sinuses so commonly channel the bone. Though these meningiomas *en plaque* are but slightly elevated and resemble a granulomatous meningitis rather than a new growth, they are particularly prone to push through the dura and to invade the overlying bone.

This tendency of the meningiomas to provoke a cranial hyperostosis

[1] An example of one of these lesions, which are particularly apt to be associated with an overlying hyperostosis cranei, has been recently reported in another connection [9].

constitutes a story by itself, and it must suffice to say that a considerable percentage of all these tumours produce a marked effect on the adjacent bone. There may be a very slight involvement of the inner table (as in fig. 1), or a marked endostosis corresponding approximately to the centre of the area of dural attachment which is indented thereby. Occasionally the bone is enormously thickened over the growth, as much as three or four centimetres in extreme cases, and under these circumstances the canaliculi are filled more or less extensively by tumour cells, which in time may replace the thickened bone by a core of solid tumour. These characteristics are schematically shown in the accompanying
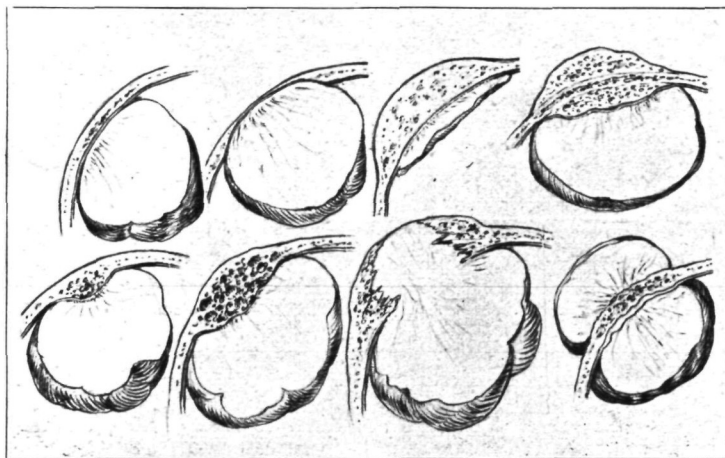

FIG. 12.—Diagrams of the various ways in which the meningiomas affect the overlying bone.

drawings (fig. 12), and they are mentioned because the photographs, X-rays and measurements giving the situation of these hyperostoses have been an additional help in placing the situation of a number of the tumours in the series. There are other ways by which the location of the seat of origin may be identified with fair accuracy, though chief reliance has been placed on the sketches and diagrams of the operations which accompany the old case records.

With due allowances, the plotted charts (figs 13 to 16) are sufficiently dependable. Though self-explanatory, there are certain features to which attention may be called. It is evident that the lesions are more numerous in the frontal regions, both of the vault and base, so that the frontal lobes have been involved through deformation far more often than any other part of the brain. Many years ago attention was

called by Blackburn [5] to the fact that frontal endotheliomas are a
not infrequent post-mortem finding in those who have died in asylums,
but until these diagrams were made I would not have believed that
the tumours in our surgical series would, on the whole, have tended to
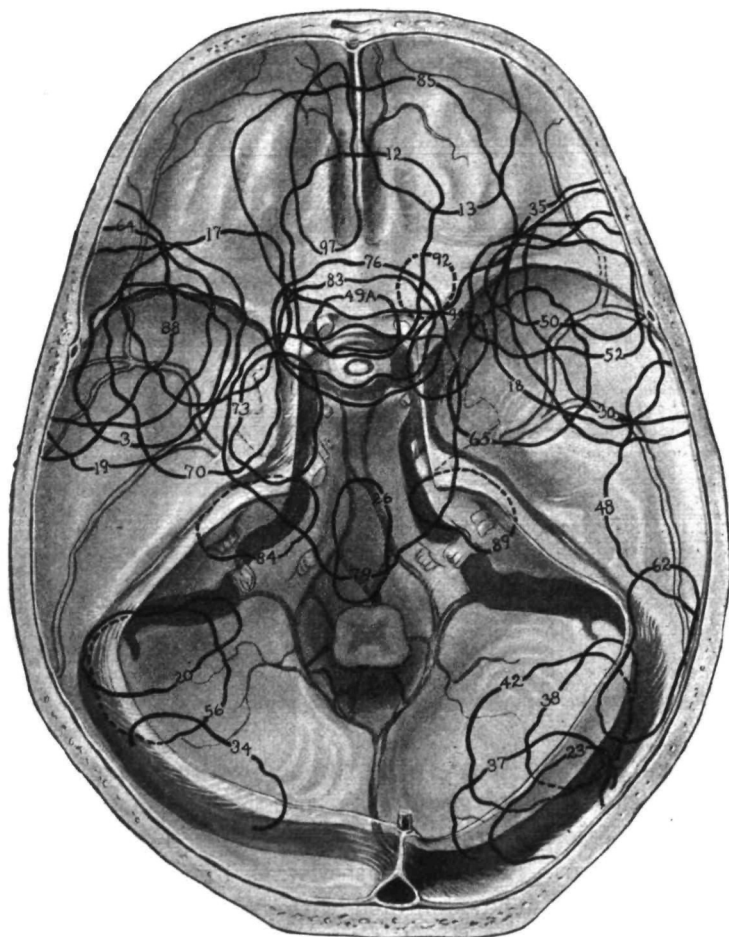be so far forward.

FIG. 13.—To show the areas of dural attachment of the meningiomas in the series in
their relation to the major sinuses of the basal meninges.

Unquestionably many of these lesions are never recognized during
life, and even if a diagnosis of "tumour suspect" actually be made, the
localization of the lesion may be extremely difficult in the absence of
an area of hyperostosis, either palpable or shown by X-rays. It is
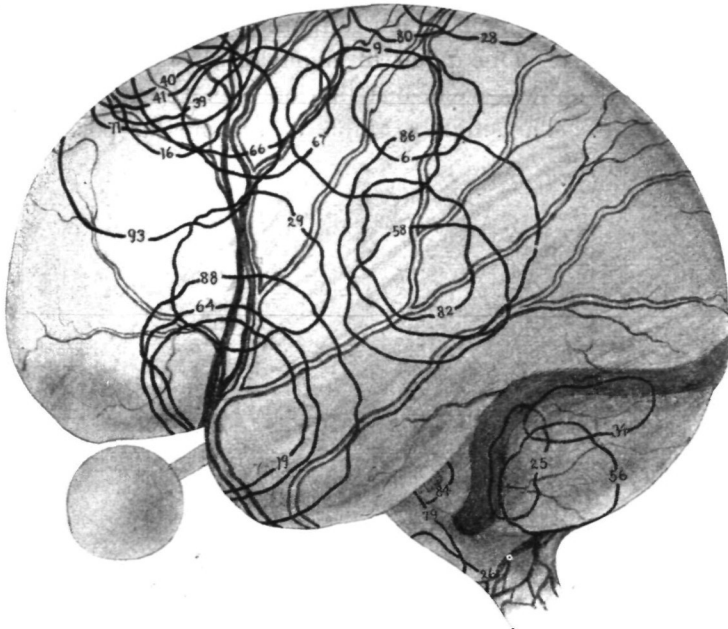possible, therefore, that the blank areas in the diagrams merely repre-

FIG. 14.—To show areas of dural attachment of the meningiomas and their relation to the dural sinuses on the left lateral aspect of the brain.
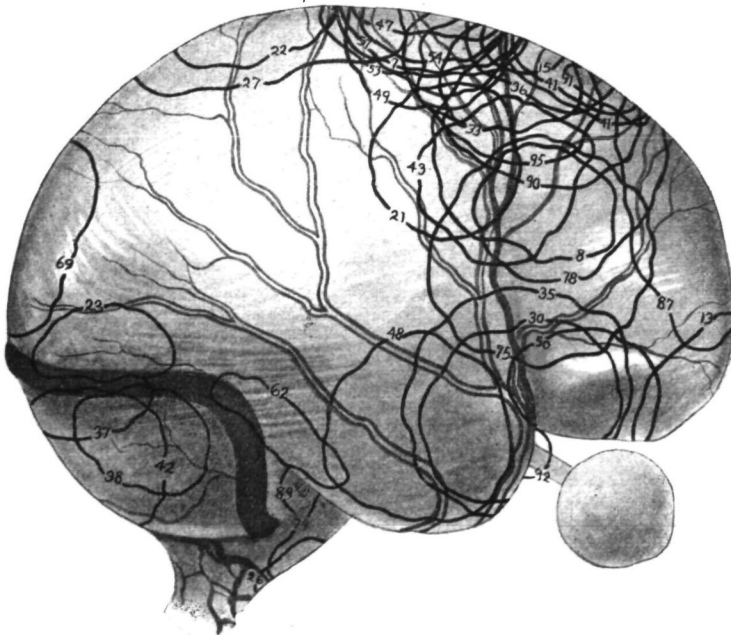
FIG. 15.—To show areas of dural attachment of the meningiomas and their relation to the dural sinuses of the right lateral aspect of the brain.

sent relatively silent fields in which tumours are less likely to have been recognized clinically. One point in favour of this is the fact that the recorded tumours show a wider distribution over the left than over the right hemisphere. The single example of tumour far posterior on the
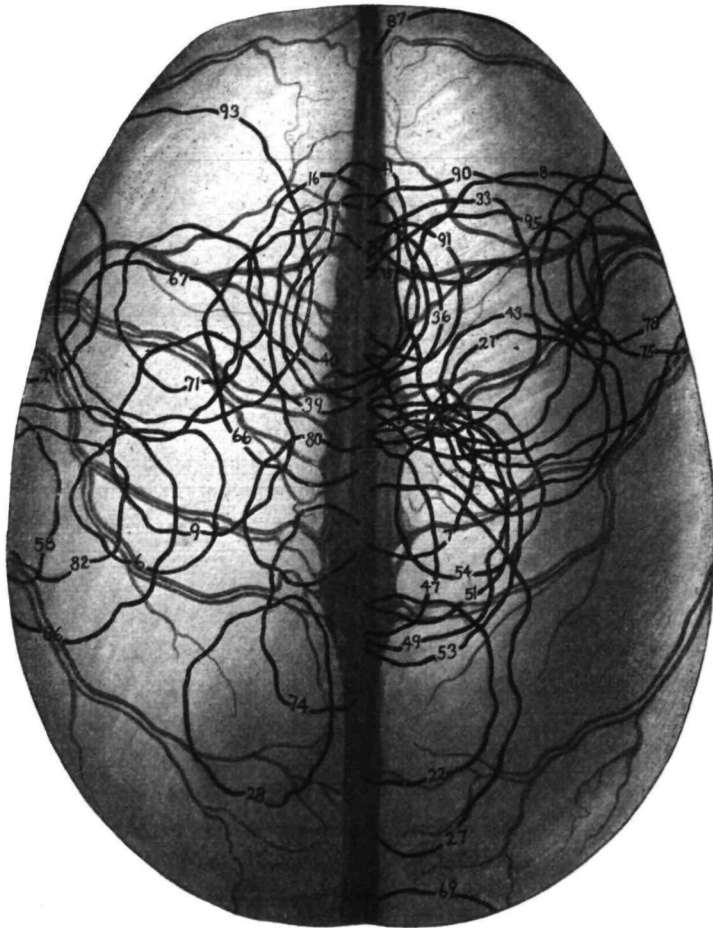
FIG. 16.—Superior view of the meninges, showing the tendency to an anterior disposition of the tumours, and the prevalence of their origin from the lateral expansion of the sinus sagittalis.

convexity of the right hemisphere (No. 27, fig. 19) was a purely accidental post-mortem finding. The patient was an acromegalic with a primary optic atrophy and homonymous hemianopsia attributed to a pituitary adenoma, and owing to the combination of his profound psychosis and an inaccurate clinical history he passed through our

hands with the meningioma unsuspected. He died a year later in an asylum, where at autopsy a large parasagittal meningioma (fig. 17) was unexpectedly disclosed.

Mere diagnostic oversight, however, cannot alone explain the predominance of anterior lesions, for notably in the posterior fossa under the tentorium, where localization should be easy, meningiomas are particularly rare. This is true, also, of the growths involving the occipital lobe, of which there have been only three in the series,
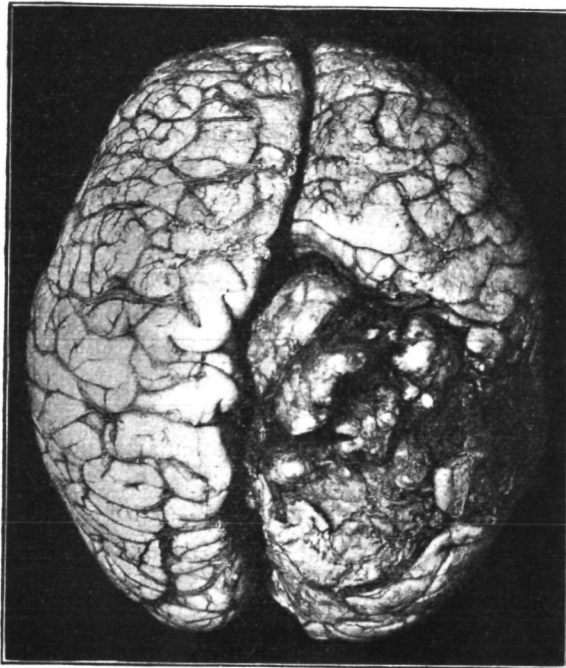

FIG. 17.

whereas on the other hand the extraordinary prevalence of tumours which take their origin from the meninges of the suprasellar region and cribriform plates of the ethmoid cannot be accounted for on the basis of chance alone.

I have spoken of the three ways of approaching the study of a large series of tumours and, so far, have refrained from any discussion of the meningiomas according to their locality. The endeavour has been made with no great success to subdivide them for working purposes into several clinical groups. These may deserve a brief mention.

(1) *The spinal meningiomas.*—These occur at different levels of the cord, and judging from my small series of twelve cases in which the greater number are midthoracic, they arise more often from upper than lower areas of the spinal theca. They are well-known lesions, frequently operated upon with success since 1888, when Horsley and Gowers so brilliantly led the way. What, however, is not commonly recognized, or at least emphasized, is the fact that they take their origin from the arachnoid at the point of emergence of one of the nerve-roots, so that the growth usually lies at the side of the cord, and is overlain by the nerve-root in question. This explains the characteristic discomforts of these cases, and the frequent tendency to a Brown-Séquard type of spinal palsy.

(2) *The cranial-nerve foraminal tumours.*—These cases fall into three groups, though they may be capable of greater subdivision since the cell-clusters from which they arise are said to exist at the foramina of exit of all the nerves. The tumours we have encountered have arisen (*a*) at the porus acusticus with loss of hearing as the inaugural symptom, suggesting an acoustic neurinoma (1 case); (*b*) from the trigeminal sheath, a common seat of origin, with trigeminal pain and hypæsthesia as early symptoms (5 cases); and (*c*) in the orbit itself, from the arachnoid sheath of the optic nerve, producing a unilateral painless exophthalmos (1 case).

A peculiarity of the basilar tumours, particularly those of the trigeminal region, is that they may spread widely in the basal meninges and become thereby irremovable. This, however, is not invariable, for one tumour (No 26) in the series which arose from the dura over the basilar process just within the foramen magnum, was egg-shaped with a small stalk of attachment.

(3) *The suprasellar tumours.*—These are fairly common, the series containing eight examples. The tumours arise from the meninges covering the Willisian circle of sinuses surrounding the pituitary diaphragm. Except for the fact that they occur in adults, whereas the suprasellar tumours originating from the cranio-pharyngeal pouch (Rathke) usually give symptoms in childhood, the manifestations of the tumours of the two types are very similar, consisting chiefly of primary optic atrophy, of field distortions often with hemianopsia, and finally of secondary dyspituitarism.

The growths may project upward into the region of the third ventricle, and may reach an enormous size. As several of them have been unexpectedly encountered at operations conducted for presumed pituitary tumours, they have merely been verified by the removal of a

small fragment of tissue and, except in one instance where a small, easily dislodged tumour was found, no attempt has been made to extirpate them. Consequently, except for the two cases encountered at autopsy, both of which show a remarkable similarity, the exact delimitations of the areas of attachment are somewhat conjectural.[1]

(4) *Tumours arising from the olfactory groove of the ethmoid.*—In Cruveilhier's plate one of these characteristic growths is pictured, and the later literature contains reports of many others in the same situation. Though more anterior than those just referred to as suprasellar, the growths have very much the same appearance. They are exceedingly difficult to diagnose. Occasionally a fortunate stereoscopic X-ray may show some local bone absorption and unexpectedly reveal the situation of the lesion, but otherwise there may be nothing more than some obscure mental derangement possibly with anosmia until the growth extending backward reaches a sufficient size to press upon one or both optic nerves. The tumour may be median and separate the two frontal lobes widely, or, if unilateral as in the single case in the series in which a total extirpation was successfully accomplished, it may press upon the homolateral optic nerve and give a primary atrophy, whereas the opposite eye shows a choked disc.

(5) *Sphenoidal ridge tumours.*—The growths which lie astride the sphenoidal ridge, with a portion of the tumour resting on the orbital plate under the frontal lobe and a portion in the middle fossa indenting the temporal lobe, are fairly common and characteristic. Most of them have been unexpected findings, though one or two have been recognized because of an absorption of the sphenoidal ridge shown by an antero-posterior röntgenogram. They may cause uncinate seizures and not infrequently encroach on the side of the chiasma and produce an homonymous hemianopsia.

(6) *Sylvian cleft tumours (temporo-frontal).*—These are, on the whole, similar to the above and doubtless arises from the same sinus, but they lie sufficiently far lateralwards to be brought into view by a subtemporal decompression. Two of them which gave no localizing symptoms were unexpectedly disclosed in this way and were subsequently removed by an osteoplastic exposure. In this region, too, for some unexplained reason, the tumours *en plaque* are common, and as these meningiomas are apt to provoke hyperostosis and cause a palpable thickening of bone at the temporo-sphenoidal junction, they are easily

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[1] One of these cases was fully recorded because of its pituitary manifestations in my monograph, "The Pituitary Body and its Disorders," 1912, Case No. viii, pp. 63-72.

recognized through this indication of their presence, as well as by the marked exophthalmos which occurs if the hyperostosis involves the outer orbital wall.

(7) *Tumours of the convexities.*—These, twenty-eight in number, naturally represent a large proportion of any surgical series. They are not only easily accessible, but when they encroach on the sensori-motor cortex, characteristic and well-known symptoms of definitely localizing value are often produced. For this reason, small surface meningiomas which cause Jacksonian seizures followed in time by palsy not uncommonly fall to the lot of the general surgeon.

The tumours arise from arachnoid cell-clusters in connection with the spheno-parietal sinus and the vasa meningea media. They may be subdivided into *temporal, frontal, paracentral, parietal* and *occipital* tumours, and the diagrams show that in spreading up from the last described group which centres around the Sylvian notch, they dispose themselves in some correspondence with the fan-shaped distribution of the sinusoidal veins of the dura. They predominate over the frontal areas and their points of origin may be found even as far forward as the tip of the lobe. The series contains no examples of tumours arising over the posterior surfaces of the hemispheres except those which take origin from the major sinuses. They are included in the following groups :—

(8) *The parasagittal meningiomas.*—These, in a way, are the most interesting and characteristic of all. The case (No. 15) selected as a text for this lecture was of this type, and the series contains twenty-six other examples. The tumours arise from the wall of the sinus or its lateral expansion, and are apt to have some attachment to the surface of the falx as well. Consequently, as the growth enlarges, the mesial edge of the hemisphere gets pushed away to a greater or less extent from the parasagittal angle.

When a parasagittal tumour is surmounted by a dome of hyperostosis, its situation and identity are easily recognized. Also when Jacksonian seizures originating in a foot are followed in the course of years by a spastic paralysis which begins in the corresponding leg, one may feel reasonably assured that a parasagittal meningioma will be disclosed at operation, provided the mesial edge of the hemisphere can be brought into view.

When, on the other hand, the parasagittal tumours arise well in front of the motor cortex or, what is less common, posterior to it, they may be exceedingly difficult to localize by symptoms alone. An example

of this has already been cited in connection with Case 27 (fig. 17). There have been only two tumours in the series deforming exclusively the occipital lobe. One of them (No. 69, figs. 15-16), a parasagittal tumour originating near the tentorial angle, was successfully enucleated with perfect recovery. The other, a huge 200-grm. tumour not represented in the diagram as its point of origin remains obscure, was incompletely removed, and there was a continuance of the growth with fatality at a secondary operation some years later.

(9) *The meningiomas of the falx.*—No mid-line diagrams permitting the representation of these tumours have been made, for the series contains only two examples. Both of them were large tumours of almost spherical form, with the smallest possible area of attachment at the lower margin of the falx. Their presence in each case was identified by exploratory punctures, and both were removed by transcortical incisions with death in one case and recovery in the other.

This I cannot believe represents fully the true percentage of tumours originating from the sides of the falx, for bony plaques and endotheliomatous patches, as is well known, are not uncommonly found there in the ordinary run of post-mortem examinations on old people.

(10) *Tumours of the sinus transversus and sigmoideus.*—The series contains only two supra-tentorial tumours of this origin (Nos. 62 and 23, fig. 15). One which gave no localizing symptoms was first unexpectedly exposed during a right subtemporal decompressive operation. Its comparatively small attachment corresponded to the knee of the sigmoid sinus. One other (No. 23) was farther posterior, a large tumour which had caused a hemianopsia.

On the other hand, there have been five subtentorial tumours giving a cerebellar syndrome. All of them arose from the lower wall of the transverse sinus, and all were successfully removed at operation. I confess to some surprise that these growths are not more common in this situation, in view of the abundance of arachnoid villi which project into the subtentorial wall of this sinus and which all surgeons familiar with cerebellar explorations have been accustomed to observe.

These, then, are the chief topographical subdivisions into which the tumours have been tentatively grouped for clinical purposes. Doubtless some far better regional classification will be made as the particular symptom-complex called forth by a growth in these several regions comes to be more clearly understood. Certain of them, like the parasagittal tumours which impinge on the motor cortex, can with a fair

degree of diagnostic accuracy be foretold before operation, but in the absence of an accompanying hyperostosis most of the others are as yet chance findings in the course of an exploration, though a long history of slowly advancing trouble may make one suspect the presence of a meningioma.

I hope some day, using this lecture as a basis, to give the detailed report of the individual cases in this series with their triumphs as well as their tragedies. Our experience may be summarized as follows: (1) A few of these tumours have been accidental post-mortem findings in patients in whom brain tumour was unsuspected; (2) three of them have been late post-mortem findings in patients who had been operated upon some years before for presumed tumour, but as this procedure revealed neither tumour nor tension the cases had been variously diagnosed as some condition other than tumour; (3) in some of the cases (possibly ten) the growth, which produced no localizing symptoms, was accidentally disclosed during the course of a subtemporal decompression; (4) in the majority of the cases the presence of a tumour was obvious and its location definite, but there is no pre-operative statement in the case history to show that its nature was anticipated; (5) in a few of the operated cases not only was the location of the tumour evident, but a presumptive diagnosis was made of its character. This, of course, applies to all tumours with hyperostosis, as well as to several trigeminal, suprasellar and parasagittal lesions without osseous changes. Naturally, if one makes a diagnosis of meningioma in all patients with symptoms of brain tumour, he will be correct in about 10 per cent. of his cases, but we should aspire to something far better than this low figure.

The foregoing rough subdivision is made in order to encourage others and to spur ourselves in an effort to enlarge the percentage of cases falling in the last group. Certainly, with our present knowledge of these lesions we should to-day with a corresponding group of cases be able to make a correct pre-operative diagnosis in at least half of them. Small tumours such as those described by Schmidt as accidental post-mortem findings give no recognizable symptoms and have no surgical bearing unless they happen to impinge upon some important cortical area and provoke Jacksonian seizures. But the larger tumours, even when in silent areas, ought to be capable of recognition if chronology and duration of symptoms, age of patient, extracranial circulatory signs and the frequent hyperostoses are taken into account. Accordingly, it should be possible in an ever increasing percentage of cases to foretell

not only the situation of the growth, but to anticipate its character as well. This, in an operation so elaborate as one for brain tumour, is an enormous advantage.

There is no gainsaying that despite the enucleability of these tumours when they are easily accessible the operations are often attended with great hazard, and more often than in the case of other tumours this must be done in two or even three sessions. One reason for this is that before its presence has been even suspected, the growth may have attained a large size, and by venous stasis have greatly increased the vascularity of scalp and bone.

There is to-day nothing in the whole realm of surgery more gratifying than the successful removal of a meningioma with subsequent perfect functional recovery, especially should a correct pathological diagnosis have been previously made. The difficulties are admittedly great, sometimes insurmountable, and though the disappointments still are many, another generation of neurological surgeons will unquestionably see them largely overcome.

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