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THE ASTROCYTOMAS

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It is well known that the astrocytomas differ histologically among themselves, and that this difference in structure, in what appears to be a relatively uniform group of tumors, may sometimes be surprisingly great. This has been apparent to one of us for some time, since a routine study of these tumors will soon convince anyone of their variation in structure. This observation is by no means new, for Cushing and Bailey (1) in their original descriptions recognized both a fibrillary and protoplasmic type of astrocytoma, each with its more or less clearly defined clinical syndrome. That this is not all that can be said for a differentiation of the astrocytomas seems to be clear.

The problems which appear to need analysis are: (a) what are the different types of astrocytomas from the histological point of view; (b) is there any correlation between the histological features and the clinical characteristics of the tumors in question?

In order to answer these questions, we have analyzed a large group of astrocytomas in an effort to classify them histologically and to correlate their histological with their clinical features.

Material and Methods

All the astrocytomas from the years 1930–35 inclusive were studied. No selection was made because it was felt that over a five-year period it should be possible to obtain for study all the various types. The total astrocytomas studied number 128. These were of the following types:
The various types will be examined in more detail subsequently.

All the cases were studied by the following methods: hematoxylin-eosin, Mallory's phosphotungstic acid-hematoxylin stain, Laidlaw's connective-tissue stain, gold chloride stain for astrocytes, and Hortega's silver methods for nuclei, connective tissue, nerve fibers, and astrocytes. By means of these it was possible in all instances to obtain a good idea of the structure of the astrocytomas.

**Analysis of Material**

**Fibrillary Astrocytomas**

*Gross Features:* The fibrillary astrocytomas constitute by far the largest group in the entire series. There were 96 tumors of this type or 82 per cent of all the astrocytomas observed. Since the fibrillary astrocytomas grow slowly, it is reasonable to assume that they may have gross characteristics distinguishing them from other sorts of infiltrating brain tumors which have a different clinical course. Unfortunately this is not borne out too strongly by the facts. A survey of all our autopsied cases of fibrillary astrocytoma reveals the fact that, despite their slow growth, they are not as clearly defined from the rest of the brain as one would wish. The majority of these tumors infiltrate the brain in such a way as to be lost in the surrounding tissue. A few are relatively well defined; that is to say, they are fairly clearly demarcated from the surrounding brain tissue. Still others, such as the cystic tumors, are very well defined, but these will be dealt with separately. Often there is a hyperplasia of the glial elements in the surrounding brain tissue with a subsequent enlargement of much of the affected hemisphere. Sometimes this occurs with a very small tumor.

Usually these tumors are confined to the cerebral and cerebellar hemispheres and do not infiltrate the basal ganglia or base of the brain. A few of our tumors, however, extended into the basal ganglia and 8 of them were found in the pons and other parts of the base of the brain. No special predilection for one or another lobe of the brain could be determined. In our cases all lobes of the cerebrum were involved and one cerebellar hemisphere as frequently as another. In children these tumors had a predilection for the vermis of the cerebellum.

The size varies. A few of the tumors were small, measuring no more than 2–3 cm. in diameter. Others occupied a whole lobe and still others more than one lobe. In general we found that they did not tend to assume as large a size as the glioblastomas.

The gross appearance varies. Usually at operation these tumors have a pale white appearance which makes it difficult to distinguish them from the surrounding white matter. Some are very vascular, and others are extensively necrotic. Necrosis, however, is not usually present to any real degree
and is an uncommon feature of the astrocytomas. Their gross blood supply is sufficient to maintain good nutrition of the tumor.

**Histological Features:** While the classification indicates a homogeneous group, it is only too obvious on careful study that there is more than one type of fibrillary astrocytoma. In order to avoid a burdensome and meaninglessly minute classification, all these tumors have been classified as diffuse or piloid, no effort being made to differentiate further subgroups among them. It will be clear from subsequent descriptions that nothing is to be gained from an extensive subdivision of this large group. In our study of these tumors no effort will be made to describe the two groups separately, but it will be clear from the descriptions that a distinction has been made between them.

![Diffuse Type of Fibrillary Astrocytoma Showing the Scattered Cells, the Diffuse Fibrillar Net, and the Few Vessels. Hematoxylin-Eosin](image)

In general the fibrillary astrocytoma is characterized by the presence of fibrillary astrocytes, of neuroglia fibrils in varying numbers and arrangement, of a varying number of blood vessels, and of a limited amount of collagen and fibrils.

**Cells:** The number of cells in these tumors is variable. Usually they are scattered and quite widely separated, so that most of the tumors would be described as having a moderate cell population. In some cases the cells are more numerous and more closely packed, but these are quite exceptional. In none of the tumors do the cells have a characteristic architecture. They are scattered about diffusely as a rule (Fig. 1). In some places there is a perivascular grouping of cells but not to the same degree as in the astroblastomas (Fig. 2). Often, where the number of cells is greater than usual there is a tendency to arrangement in rows.
The cellular structure is quite uniform. The nuclear shape is almost invariably round or oval. The nuclear membrane is heavy and regular. There are a few coarse chromatin granules within the nucleus and a number of scattered fine chromatin granules. With hematoxylin-eosin stains the cytoplasm is seen as a round homogeneously stained mass surrounding the nucleus except in unusual circumstances, when the typical cytoplasmic prolongations of the astrocyte are stained even with the usual aniline dyes.

By means of special staining methods (gold chloride, phosphotungstic acid-hematoxylin, Hortega's double silver impregnation method) it is possible to study more minutely the cytoplasm of these tumor cells. Most of them are composed of adult tumor astrocytes (Fig. 3), but it must be stated emphatically that not all the cells are of the adult type. In most fibrillary astrocytomas it is possible to find not only immature cells (astroblasts) in varying numbers, but in practically all of them except in the most highly differentiated tumors one finds protoplasmic astrocytes as well as the more numerous fibrillary cells.

The astrocytes of the fibrillary astrocytomas resemble the normal adult cell only in general superficial features. The cytoplasm is more abundant and voluminous. It is more distended and blown-up so that the tumor cell has a plumper appearance and has lost the delicate angulation between the cytoplasm and the point at which the processes are given off. The processes themselves are generally thicker than normal, but some cells retain the normal proportions. The prolongations are usually tortuous when seen in gold stains; when impregnated with silver they have less tendency to appear so distorted. In most cases no connection with a vessel is visible; where such a connection is clear, the sucker foot is often found to be larger and plumper than normal. Not infrequently the processes contain knobs and swellings.

Not always are the astrocytes of the adult type. In almost every tumor it is possible to find astroblasts with all their typical features. Their number is greater in some tumors than in others, but it is our experience that if a close enough search is made they can be found in practically every tumor. Sometimes there is a surprisingly large number of these immature cells.

In practically all the fibrillary astrocytomas there is also a varying number of protoplasmic astrocytes or, we might better say, non-fibril-forming astrocytes, since it is not clear in our own minds whether these are mature protoplasmic astrocytes or fibrillary astrocytes which in the process of development have never gone on to complete maturity.

Penfield (2) has called attention to long astrocytes with fewer processes which deposit long fibrils, called by him piloid astrocytes. There are piloid cells in most of the astrocytomas and some are made up almost entirely of this type of cell.

Fibrils: Among the tumor cells is a fibrillar net or carpet which varies both in amount and arrangement. In most tumors of this type the fibrils are arranged in what we have termed arbitrarily a diffuse fashion (Fig. 4), i.e., in a loose net surrounding the cells. This net consists of intertwining fibrils, most of which are short because they run in many different directions. Among these fibrils lie the cells which, as seen in hematoxylin and eosin preparations, seem to hang suspended in space. At times the fibrils are found in more condensed fashion around the vessels. Here they form a sort of peri-
Fig. 2. Perivascular arrangement of cells and fibrils in astrocytoma. Gold-chloride stain of Cajal

Fig. 3. Large, hypertrophic tumor astrocytes from a fibrillary astrocytoma. Gold-chloride stain of Cajal
vascular neuroglial net which may become quite thick and dense. By means of the silver staining methods it is possible to observe a close relationship between the cells and the fibrils; that is, the fibrils lie in close approximation to the cells and often across them.

In other cases the fibrils are arranged in parallel rows (piloid type). In such instances the fibrils are long, parallel, and densely packed (Fig. 5). There is little or no tendency to the criss-crossing seen in the diffuse type of tumor, nor is there any interlacing of fibrils. Among the parallel rows of fibrils are more or less elongated cells, the so-called piloid astrocytes (Fig. 6). In many of these tumors there are few cells, the number of fibrils far exceeding the number of cells. Or rather, the number of fibrils is far greater than the

![Fig. 4. Diffuse Fibrillar Net of Fibrils in a Diffuse Fibrillary Astrocytoma. Phosphotungstic Acid-Hematoxylin Stain](image)

cells seem to be able to produce. In other instances fibrils and cells are abundant (Fig. 7). There is no characteristic tendency for the fibrils to be arranged around vessels.

In some cases, where there is much swelling of the intercellular tissue, the fibrils are so arranged as to give the appearance of a myxomatous arrangement.

One feature of the fibrillary astrocytomas deserves special mention, and that is the fact that there seems to be no strict relationship between the number of cells and the number of fibrils in the tumor. In some fibrillary astrocytomas there are many cells and relatively few fibrils, while in others, as has been pointed out, there are few cells and an over-abundance of fibrils. The explanation for this is not clear. In some tumors the astrocytes, if of the non-fibril forming variety or if immature in type, will not form fibrils. In others a few astrocytes may apparently be stimulated to deposit numerous
Fig. 5. Parallel rows of straight, hard fibrils in a piloid type of fibrillary astrocytoma. Phosphotungstic acid-hematoxylin stain

Fig. 6. Long, hard fibrils arranged in parallel rows among elongated cells in a piloid type of fibrillary astrocytoma. Phosphotungstic acid-hematoxylin stain
fibrils just as in the normal state a marked fibrillary gliosis may be formed by
a few normal astrocytes.

**Blood Vessels:** In most of the fibrillary astrocytomas there is a moderate
number of thin-walled blood vessels. As a rule, these are not very numerous.
They seem to be sufficient in most cases to maintain the tissue in good con-
dition, but in a few there are necroses of varying extent and degree. In some
tumors the necroses are so extensive as to occupy a large part of the tumor.
In rare cases the vessels show malignant changes, such as proliferation of
their endothelial and adventitial coats (Fig. 8). We have observed this in a
few cases of fibrillary astrocytoma which are more malignant than others.

**Stroma:** As a rule there is very little collagen stroma in these tumors
except around the blood vessels (Fig. 9). This can be seen as islands of

![Fig. 7. Piloid Type of Fibrillary Astrocytoma Showing the Cells and the Intercellular Fibils. Hematoxylin-Eosin](image)

coarse collagen fibrils which are particularly clear in the silver stains. These
collagen strands do not penetrate far beyond the immediate vicinity of these
vascular islands. A fine reticulum is sometimes seen with Laidlaw's stain
(Fig. 10).

**Clinical Correlations:** The fibrillary astrocytomas made up the largest
group of the entire series. On a histological basis they seemed divisible into
sub-types, the piloid and the diffuse. From a clinical standpoint these types
are not sharply differentiated. Nevertheless, it seems worth while to analyze
briefly the fibrillary astrocytomas from the standpoint of this pathological
classification before considering the characteristics of the group as a whole.

Thirteen tumors were of the *piloid type*, 11 in males and 2 in females.
The age average was twenty-four years, 5 patients being less than ten years
old. The clinical history was relatively short in most instances, averaging
Fig. 8. Blood vessels with proliferation of their walls in a diffuse fibrillary astrocytoma. Hematoxylin-eosin

Fig. 9. An island of connective tissue in a diffuse fibrillary astrocytoma. Hortega's silver stain
nine months. All patients gave a history of headache or vomiting, and at the
time of admission papilledema was present to some degree in all but a few
instances, with an average of 2.4 diopters. The majority of the tumors (69
per cent) were located in the posterior cranial fossa, involving the cerebellum
in 7 cases, the brain stem in one, and the fourth ventricle in one. The cerebel-
lar tumors were characterized by definite clinical evidence of cerebellar dys-
function, and the patient with a pontile and mesencephalic astrocytoma showed
the usual combination of pyramidal tract, cranial nerve, and cerebellar signs.
On the other hand, the location of the fourth ventricle tumor was only dis-
covered through ventriculography. The other tumors occupied the temporal
or frontal lobes, in all cases being rather extensive lesions.

In keeping with the rather rapid and severe clinical picture in the cases
of piloid astrocytomas, the results of operation were only fair. Among the
70 per cent who survived the operation for more than one month, the average
duration of life was one year and three months.

The diffuse type of fibrillary astrocytoma made up the great bulk of the
group and in general showed no distinguishing clinical characteristics beyond
those presented for the whole group. In contrast to the piloid type, however,
it may be pointed out that the average age for this group was thirty-one years
and the average preoperative duration of symptoms twenty-seven months,
while the lesions were cerebral in location in 65 per cent of the cases.

Summary: While histologically there seem to be definite subgroups among
the fibrillary astrocytomas, efforts to correlate these with clinical data have
been disappointing. The piloid astrocytomas, which are histologically benign
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and slow-growing, do not give a similar clinical impression. The number of cases studied, however, was not great enough to be absolutely certain of the data. There seemed to be nothing characteristic of the diffuse type of astrocytoma except its slow growth and benign character.

It is not possible, therefore, to demonstrate a correlation between the histological and clinical features in the subgroups of this, the largest of the astrocytoma group of tumors. On the other hand, the group as a whole supports the view that these are slowly growing tumors both clinically and pathologically.

Cystic Astrocytomas

Clinical Characteristics: Of the 16 patients in this group, 11 were males and 5 females. The age incidence was somewhat lower than that for astrocytomas as a whole, the average being twenty-four years, with the youngest patient five and the oldest fifty-six. In general, as might be expected, the clinical picture was that of a slowly progressive intracranial lesion. In one instance symptoms had existed for twenty years before the patient came to operation. Including this case, the average preoperative duration of symptoms was twenty-seven months, while without it the figure dropped to twelve months. Symptoms of increased intracranial pressure, as headache, nausea, vomiting, stupor, etc., were present in all cases, and signs of intracranial hypertension—papilledema, abducens palsy, or increased spinal fluid pressure—were noted in 81 per cent at the time of admission.

Not only was the intracranial pressure increased in most instances, but focal neurological changes were clearly demonstrable. One-fourth of the cysts occurred in the cerebellum. These patients all showed definite ataxia and dyssynergia. The remaining tumors were located in various cerebral areas and produced clear-cut clinical pictures in all cases but one. In this instance the tumor lay chiefly in the diencephalon and mesencephalon and caused only somnolence and bilateral primary optic atrophy.

Surgical drainage of the cyst, or drainage and removal of the tumor nubbin, was carried out in all cases. In general the results were good. Four patients died within one month of operation. The average duration of life in the remainder of the group was slightly over two years. However, over half of these patients were alive at the time of the last follow-up report, so that the ultimate average survival period may be expected to be much longer.

From a clinical standpoint the cystic astrocytomas (a) occur chiefly in younger individuals, (b) produce a history of symptoms for one year or more, (c) cause definite neurological signs as well as signs and symptoms of increased intracranial pressure, (d) respond very favorably to surgical treatment.

Gross Features: The cystic astrocytomas are in reality part of the fibrillary group, but because they form cysts require special discussion. These tumors are found in both the cerebral and cerebellar hemispheres. They are seen more frequently in the cerebellum in children and in the cerebrum in adults. They are well defined and readily separated from the surrounding brain tissue. The cyst wall can be pulled away, not, however, without tearing the surrounding tissue, to which it is attached by slender fibrous and glial
processes. There is always in the neoplastic cysts some solid tissue. This may be no larger than a small pea or it may fill half or two-thirds of the cystic cavity. The solid tissue lies in the wall of the cyst. It is firm, usually white, and moderately vascular. It projects into the cyst cavity but in the case of very small nubbins may hardly rise above the level of the cyst wall. The cyst is filled with a yellow fluid which contains large amounts of protein and coagulates on standing.

Microscopic Features: The solid portion of the tumor is always, in our experience, a fibrillar type of astrocytoma. The cells are usually not very numerous. In some tumors they may be quite scarce and in others moderately abundant. Gold stains bring out only moderately well the astrocytic nature of the cells, since these are usually of the elongated piloid variety. There is almost always a rich carpet of fibrils among the cells. These are often arranged in bundles lying in parallel rows. The diffuse, interlacing type of fibrillar structure is not as a rule seen in these cystic tumors. Fibrous stroma is not very abundant. Around the vessels one sees small amounts of connective tissue. The structure of the cyst wall is usually similar to that of the rest of the nubbin. In our experience there is nothing to distinguish it from the rest of the tumor.

Gross Features:

This type of tumor is not very commonly encountered among the astrocytomas, our series having included but 10 cases, or 7.6 per cent. It constitutes, nevertheless, a well defined group histologically. These tumors have been described under various names, as astrocytome giganto-cellulaire (Roussy and Oberling) and plump-cell astrocytoma (Penfield). There is little in the gross characteristics of these tumors to differentiate them from the fibrillary group. In all respects the features which have been outlined for the fibrillary astrocytomas are equally true of the giant-cell type.

Histological Features: Cells: These tumors are cell-rich, containing many cells which are frequently packed closely together. Parts of the tumor are richer in cells than others. The cells of this type of tumor present a very striking appearance even in the ordinary routine stains. Indeed the hematoxylin and eosin is probably the most useful cell stain for this tumor type.

The cells are very large (Fig. 11), and possess large nuclei with a stout nuclear wall and many fine chromatin granules. Often small vacuoles may be seen in the nucleus. In many cells the nuclei are multiple, the number of nuclear parts numbering from two to twelve or even more. The size of these multiple nuclei varies greatly, no two being of the same size. In some cells there is a very large nucleus with one or more smaller nuclear partitions, while in others there are several small nuclear fragments. Sometimes the various nuclear partitions are connected by filaments as previously described in giant-cells within gliomas (Alpers, 3). The nuclei are often eccentrically placed, but they may be scattered throughout the cytoplasm.

The cytoplasm of these cells is very extensive. It surrounds the nuclei as a large mass of an irregularly round or oval shape. In routine stains it is possible to see a few short processes projecting from the cytoplasm. In most
of the cells there are several projecting processes, so that the identification of the cell as an astrocyte is easily made. By means of silver and gold stains it is possible to determine that there are many cellular processes which have a structure similar to those described in the fibrillary astrocytomata. They are shorter than in the latter, tortuous, thick, and sometimes are connected with vessels by sucker processes and feet.

None of the tumors is composed entirely of these large cells. There are parts which are made up of a structure resembling the fibrillary astrocytomata. In some the giant-cell portion occupies most of the tumor. In others it constitutes a small part of the total structure.

**Fibrils:** The giant-cell type of astrocytoma is usually quite fibrillar, but some of these tumors contain only a few fibrils, as was true of two of our tumors. In most of them there is a moderate number of fibrils forming a fairly heavy carpet, and in some the fibrils are extremely dense. Sometimes they are diffusely arranged in an interlacing network which resembles closely that encountered in the fibrillar type of astrocytoma; in others the fibrils are deposited in dense bands which lie parallel to one another, the fibrils being long, straight, and coarser than in the preceding type. As in the fibrillar type of astrocytoma, the number of fibrils and the number of cells are not parallel.

**Vessels:** The number of vessels in these tumors is enough to maintain a well preserved tissue, but extensive necrosis is sometimes encountered. In one of our cases proliferative changes were found in the vessels.

**Stroma:** The stroma is similar to that in the fibrillar type.
Clinical Correlations: The age range in the giant-cell tumors was from twenty-two to sixty-one; 5 of the 6 patients were between twenty and forty. With one exception, all were males.

The preoperative duration of symptoms varied from four to thirty months, with an average of twenty-four months. This length of time, as well as the relatively long survival period, is the more surprising when it is considered that in all but one instance the tumors were entirely subcortical in location. In other words, the involvement of the deeper more important cerebral centers, and the more frequent and more extensive obstruction of the cerebrospinal fluid spaces, were more than balanced by the very slow rate of growth of these neoplasms as compared with other types of astrocytomas. The characteristic location doubtless accounted for the presence of clear-cut signs of increased intracranial pressure in all but one instance (83 per cent), as well as the absence of any definite focal neurological changes in 4 of the 6 patients (66 per cent).

Two-thirds of the patients in the group underwent more than one operation. On consideration, this seems the logical outcome of the usual location and type of growth of these astrocytomas. At the first operation the lesion was, as a rule, not seen on the surface, or extended so deep that the operator, hampered, too, by a considerable increase in intracranial pressure, was forced to satisfy himself with a partial extirpation and a decompression. The rather slow recurrence of symptoms then frequently led to another attack upon the tumor, occasionally with much more satisfactory results. In two instances, however, what was thought to be a complete removal was carried out at the first sitting. In one the patient survived only six months. In the other there was a return to essentially normal health for fourteen years.

In summary then, on the basis of a small series of cases, the giant-cell type of astrocytoma may be characterized clinically primarily by (a) a relatively slow growth, (b) a location in the cerebrum, (c) often a subcortical situation, and (d) in some instances a very late recurrence after radical surgical removal.

Summary: In this group, small as it is, there appears to be a fairly accurate correlation of the clinical and histological data. Histologically these tumors, while benign in appearance, show more evidence of cell division (amitotic) than the fibrillary group. In a sense, also, the giant cells themselves may be regarded as evidence of cell activity. They are, therefore, more rapidly growing benign tumors. Clinically, this seems to be shown also by the more rapid development and course.

Cellular Type

Gross Features: The gross features of the cellular type of astrocytoma are similar to those of the preceding groups.

Histological Features: There were 6 tumors of this type in our series, constituting about 4.6 per cent. This group corresponds probably to the protoplasmic type of Cushing and Bailey, to the astrocytome peu fibrillaire or a fibrillaire of Roussy and Oberling, and to the protoplasmic astrocytomas of Hortega. Histologically, these tumors differ from either of the other two groups by virtue of their greater cellularity and the paucity of fibrils. It is
quite possible that some of the tumors included by us in the fibrillary group would have been placed by others in this group.

**Cells:** The nuclei differ in no way from those of the fibrillary type. They are oval or round with a stout nuclear membrane, scattered coarse chromatin granules, and fine chromatin dust (Fig. 12). The nuclei are almost always single, but more than one nucleus is sometimes present in a cell. The cytoplasm is not visible with the hematoxylin and eosin stain, but gold and silver stains reveal a typical astrocytic cytoplasm with the characteristics of tumor astrocytes noted in the fibrillary group. It has been our experience that it is more difficult to stain the astrocytes in this group and that there are more immature cells than in the other types of astrocytoma.

![Fig. 12. Cellular Type of Astrocytoma Showing the Numerous Cells and the Few Intercellular Fibrils. Hematoxylin-Eosin](image)

These tumors are cell-rich. They contain many cells closely packed, usually arranged in no definite manner but sometimes gathered in rows or streams. The cells are sometimes so closely crowded that there is little or no room for intercellular tissue.

**Fibrils:** While the tumors are cell-rich, they are decidedly fibril-poor. These are not fibril-producing tumors. Most of them have only a few scattered fibrils among the cells, forming a loose carpet less dense than in the fibrillary type. Large areas of the tumor contain no fibrils. In two of our cases it was not possible to demonstrate any fibrils except in isolated portions of the tumor. By means of silver stains the fibrils are seen to be uniformly thin, interlacing, and crossing the cells in loose groups.

**Vessels and Stroma:** The vessels are thin-walled and show no proliferative changes. The stroma is gathered around the vessels in coarse bands of collagen. It does not penetrate into the tumor.
Clinical Correlations: Five of the 6 patients with cellular astrocytomas were males. The age range was from five to fifty-six years. The preoperative duration of symptoms was strikingly short, varying from two weeks to nine months, with an average of only three months. Despite this short clinical course, all cases were characterized by signs and symptoms of markedly increased intracranial pressure at the time of admission to the hospital, and in over half of them there were sufficiently clear-cut focal neurological changes to localize the lesion. In all cases there was a history of headache, and in all but one vomiting had been a persistent symptom. One patient had been troubled by attacks of vomiting for four months, and to such a degree that a variety of tests of gastric function and gastro-intestinal x-ray studies had been carried out. At the time of admission all patients were found to have some degree of papilledema, varying from a slight elevation of the optic discs with blurring of the margins to $5\frac{1}{2}$ diopters of choking, with an average of 3 diopters. The intracranial pressure increase was sufficient in slightly more than half the cases to produce some weakness of one or both abducens nerves, and, as a final evidence of high intracranial pressure, two patients were stuporous when brought to the hospital.

Focal neurological symptoms and signs were sufficiently clear in 50 per cent of the cases to lead to a correct localization of the lesion, even before air injection was carried out. The difficulties in the other cases were largely dependent upon two factors: (a) the greatly increased intracranial pressure, which often made a complete examination impossible, and (b) the deep location of the tumors, with a corresponding absence of the usual signs produced by damage to the cortex.

The position of the tumors in the brain, as well as their location in relation to the surface, varied widely. The cerebellum was the site of the neoplasm in two instances; one tumor occurred in the diencephalon, and the others were scattered through the cerebral hemispheres, as a rule involving both the cortex and the subcortical structures.

On the basis of these cases the prognosis in this group of cellular astrocytomas is notably poor. Among the 6 patients, 4 (66 per cent) survived the operation for periods of less than one month.

In brief then, the cellular astrocytomas are characterized by (a) a brief clinical course, (b) a high degree of intracranial pressure increase, (c) a poor response to surgical attack.

Summary: There seems to be some correlation between the histological and clinical features of this group. Histologically the tumors are more cellular and less mature. They appear to be less benign than the fibrillar group of astrocytomas. They grow more rapidly and have a shorter clinical course. In these features at least the histology and history are in good agreement. Discussion

The practical advantages of a clinico-pathologic classification of a group of varying brain tumors are obvious. With the accumulation of pathological data and the more careful delineation of clinical pictures, more accurate preoperative diagnoses may be achieved, and the operative attack upon the
lesion may be planned and executed more intelligently. After histologic ex-
amination of the tumor, either through immediate biopsy or postoperative
examination, such vital questions as the radicalism of the removal, the advisa-
bility of irradiation, the probabilities of recurrence, and the ultimate prog-
nosis, may be answered with reasonable accuracy.

Briefly the classification of astrocytomas which we have proposed is as
follows:

I. Fibrillary
   (a) Solid
      (1) Piloid
      (2) Diffuse
   (b) Cystic
II. Giant-cell
III. Cellular

The division of the astrocytomas into these three groups serves a definite
practical purpose. It indicates, first of all, the great preponderance of the
fibrillary group and makes possible in the majority of instances a safe predic-
tion of the course which the tumor will take. In general, tumors of the fibril-
Iary and cystic groups grow slowly and have correspondingly slow clinical
courses. The piloid group of fibrillary astrocytomas, while very benign histo-
logically, seems to be less benign in clinical features. Tumors of the giant-
cell and cellular groups grow more rapidly and correspondingly follow a more
rapid clinical course than the fibrillary astrocytomas.

Our large main group of fibrillary astrocytomas is in good agreement with
the investigations of others (Cushing and Bailey, 1; Hortega, 4; Roussy and
Oberling, 5). Penfield classifies his fibrillary astrocytomas as piloid astrocy-
tomas. It has been our experience, however, that the piloid type of tumor is
better regarded as a subdivision of the larger fibrillary group. Only 26 of
our 112 fibrillary astrocytomas could be regarded as piloid astrocytomas,
with the features described by Penfield: long fibrils arranged in bundles, and
few elongated cells having some but not all the features of classical astrocytes.
Since the type cell in these tumors is the astrocyte, and since, also, their out-
standing characteristic is the presence of neuroglia fibrils, it has seemed to
us that they are best regarded as a type of fibrillary astrocytoma with special
histological characteristics, but not with pathognomonic clinical features.

Most of the fibrillary astrocytomas are represented by the diffuse, inter-
lacing neuroglial carpet which simulates the neuroglial arrangement in the
normal white matter. The reason for the difference in appearance of these
slowly growing tumors must remain at present a matter of speculation: whether
it is due to a difference in the inherent properties of the astrocytes or to the
effects of exogenous stimuli carried to the cells by the blood is not clear.
Nor is it clear why the number of fibrils within the fibrillary astrocytomas
varies so greatly; why, for example, there are many fibrils and few cells in
some tumors and many cells but few fibrils in others. In the former group
the number of fibrils is so great that, while it is conceivable that they have
been deposited by the few cells which lie among them, it is hard to dismiss the
possibility of formation from some other source. A similar preponderance of
fibrils over cells is seen in some fibroblastomas, and in the gliosis which occurs
under certain conditions in the brain. Granting that the preponderance of fibrils is due entirely to their formation by the cells, it is still not evident what the stimulus is for their heavy deposit in some tumors as compared with others, nor why some fibrillary astrocytomas develop as diffuse types and others as piloid types, all of them being the result presumably of the same cell, the fibrillary astrocyte.

No attempt has been made to divide the astrocytomas into fibrillary and protoplasmic types. In all the fibrillary tumors it is possible to find protoplasmic types of astrocytes as well as immature forms. It may be argued that the cellular form of astrocytoma which we have described is in reality the protoplasmic type, but even in these tumors there is some fibrillar formation. Since it is not clear whether the lack of fibrils is due to the presence of protoplasmic astrocytes or to immature cells, it has been deemed best to refer to these tumors as cellular astrocytomas.

Similarly there is little doubt that the giant-cell astrocytomas constitute a group in themselves. In appearance and structure they are quite different from the other groups.

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