SOME ASPECTS OF THE DIAGNOSIS AND SURGICAL TREATMENT OF TUMORS OF THE SPINAL CORD*

WITH A STUDY OF THE END RESULTS IN A SERIES OF 119 OPERATIONS

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With the advances in our knowledge of the location and functions of the different cell groups and fibre tracts in the spinal cord, there has come a better understanding of the symptoms and signs of slowly increasing cord pressure, and the possibility of a finer differentiation between the disturbances caused by spinal cord tumors and those which result from intrinsic disease of the cord.

Manometric studies of the pressure of the spinal fluid and the investigation of the physical, histological and chemical changes which occur in the fluid when the subarachnoid space has become blocked by an expanding new growth have added much to our knowledge, advances which are due especially to the studies of Froin, Mestrezat, and Sicard and Foix in France, of Raven and Queckenstedt in Germany, and of Ayer and his co-workers, of Stookey in our clinic, and of others in this country.

Much progress has also been made in our understanding of the mechanical effects of tumors within the spinal canal and of the manner in which nerve roots and fibre tracts are involved by a slowly increasing pressure.

From the progression of the symptoms and the objective signs of disturbed function, we are now able, in many instances, to say with certainty that an individual has a spinal cord tumor, and it is possible to diagnosticate not only the level at which the spinal cord is compressed, but also the side of the cord—whether anterior, posterior or lateral—upon which the expanding lesion is exerting its pressure.

Rarely, however, does the patient first seek out the neurological expert on account of his symptoms; more often he consults the general practitioner, and not so rarely the general surgeon on account of pain in one or other part of the body.

Pain in Spinal Cord Tumors.—Pain referred to the back, to the chest, to the abdomen or the extremities is very frequent in spinal cord tumors—occurring in my series of 115 cases in about two-thirds of the patients with extramedullary and extradural growths, and in less than one-sixth of the patients with growths within the substance of the cord. In high cervical tumors, the pain may be felt in the suboccipital region or in the nape of the neck, on one or the other side. The pain in the neck from a tumor which compresses the cervical spinal cord may be very severe, and may be so much

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increased by movement that the head and cervical spine are held absolutely rigid and the patient presents the clinical picture of an affection of the cervical vertebrae.

Pain due to involvement of the upper thoracic sensory roots is often referred to the axilla, underneath the scapula, or to an intercostal space, and may simulate a disease within the thoracic cavity, while pain due to pressure of a tumor on the lower thoracic sensory roots is often referred to some part of the abdomen, and not so rarely to one or the other hip-joint. Pain in the bladder or rectum is frequent in tumors of the lower portions of the spinal cord, and pain which has the characteristics of a sciatica is often seen when the roots of the cauda equina are affected.

Pain which is made worse by movement may be, and often is, the earliest symptom of a spinal cord tumor; it may appear suddenly and persist for a long period, or may occur in attacks during the progress of the disease. It is frequently made worse by forced expiratory movements such as occur in coughing and sneezing, and not rarely the parts of the body to which the pain is referred are sensitive to pressure.

Upon careful examination, it is possible in many instances to determine that an apparent tenderness to deep pressure is really a hyperalgesia of the skin, but in some patients deep pressure over the region of subjective pain is actually painful. This is especially the case when the pain is referred to the back, because in many cases of cord tumor, one or more vertebral spines are found to be tender.

Remissions are not unusual; the periods of freedom from pain may last for weeks, months or years. For many months pain may be the only symptom of a cord tumor and the recognition that it is a root symptom may for a long period be difficult or impossible.

It is not surprising, therefore, with these difficulties in the interpretation of the symptom, that many patients are treated for a long period for "neuralgia," and that before the patients' symptoms had become more advanced and they came under our observation, attempts had been made to afford relief by various operative or non-operative methods. The following experiences are briefly cited in order to emphasize the difficulties encountered and the errors that may be made.

Pain in the back was complained of as a prominent symptom in 28 patients of my series of cord tumors, and on account of changes in the vertebrae found by X-ray examination, not a few of the patients had been suspected of having Pott's disease, and had worn plaster cuirasses for a shorter or a longer period.

In two of the patients the pain in the back had appeared a few months after an attack of typhoid fever, and both patients had been treated for "typhoid spine."

Pain in and around one hip-joint had persisted for a long period in three of our patients, which had led to a kidney operation in one instance, and to
immobilization of the hip in plaster-of-Paris for suspected tuberculosis in another.

Two patients had suffered from recurrent attacks of pain in the right hypochondrium, and one from gastric disturbances with pain and sensitiveness in the left hypochondrium; one of these had been operated upon for gallstones and another for suspected gastric ulcer.

Pain in one or other part of the abdomen had been complained of by seven patients, and the persistence of the pain without other symptoms and signs had led, in one instance, to a laparotomy with removal of one ovary; in another, to a hysterectomy; in a third to a cholecystectomy; in a fourth to an exploratory operation for gastric ulcer, and in a fifth to the removal of the appendix.

In many of the instances cited, the errors were perhaps unavoidable, but
all teach the lesson that the possibility of a spinal nerve root origin for a localized pain in the chest, abdomen, or extremities should always be kept in mind—even in the absence of any confirmatory signs or symptoms.

*The X-ray Changes in the Vertebrae in Spinal Cord Tumors.*—While a localized increase of pressure within the cranial cavity often causes very definite changes in the cranial bones visible on the X-ray plate, this does not seem to be the case in the vertebrae, and in the majority of instances, an expanding lesion primarily within the spinal canal does not give evidence of its presence in the röntgenogram.

Arthritic changes at the level of the growth occur, however, with some frequency and possibly these changes, usually called "arthritis" or "spondylitis" by the röntgenographer, may in the future be shown to have some direct relation to the increased intraspinal pressure.

In our patients with intradural extramedullary tumors, the X-ray was normal in most instances. Thus, of 71 cases, the X-ray revealed normal conditions in 56; in 10 instances, there were the changes of arthritis or spondylitis at and below the level of the new growth; in one patient, the vertebrae above and in three, the vertebrae below the level of the tumor, showed some spondylitis on the X-ray plate; in one patient there was a defect in the lower lumbar and upper sacral vertebrae (spina bifida occulta) overlying the new growth.

Two of our patients had had, at some previous time, a tubercular disease of the bony spine, and the röntgenograms showed the characteristic changes of an old vertebral disease. In one of the patients, the changes in the vertebrae were at the actual level of the growth, so that the differentiation between Pott's disease and a spinal tumor was difficult (Fig. 1). The second patient had a marked kyphoscoliosis and the X-ray evidence of old bone disease at a somewhat higher level than that of the cord tumor.

In the extradural tumors, the X-rays showed nothing abnormal in 15, while there was a definite loss of substance from bone erosion in one patient, a fusion of the two vertebral bodies at the level of the growth in another, and a calcareous tumor in a third (Figs. 2 and 3).

In 13 patients with verified intramedullary tumors, there were no X-ray evidences of any kind of change in the vertebrae.

These figures are of some interest, because *a priori*, one should have expected a larger proportion of the extradural growths to have caused bone changes visible in the X-ray films.

Whenever there is found on the X-ray plate a change not of a spondylitic character, it is probable that the growth is not a true spinal neoplasm, but rather primary or secondary malignant or tubercular disease of the bone.

*The Differential Diagnosis between Spinal Cord Tumor and Secondary Extradural Malignant Disease.*—When an individual who has or has had malignant disease in any part of the body, begins to complain of persistent and severe pain in some part of the back or in one of the extremities, the diagnosis of a secondary growth in or about the vertebrae is probable. When spinal
symptoms appear which progress rapidly and cause a flaccid paraplegia within a few days, the diagnosis of metastatic disease of the vertebrae is certain.

When there is no previous history or evidence of malignant disease, of syphilis, of tuberculosis, or of trauma, the development of a flaccid paraplegia within a few days after a period of pain, is always indicative of the rapidly advancing cord lesion that results from an inflammatory process or from malignant disease.

In some instances, however, the symptoms and signs of malignant vertebral or paravertebral disease progress more slowly; there may be root pain for a considerable period, followed by a slowly advancing spastic paralysis with sensory disturbances, and in these patients, the differentiation from true cord tumor may be difficult.

The course of extradural malignant disease is generally shorter than that of a cord tumor, and there is often a loss of flesh out of proportion to the
length of time that the patient has been ill. The pain complained of may be over the area of distribution of a spinal root, but more often, the pain is strictly localized to some part of the back or to one of the large joints such as the shoulder or the hip. The patients often complain of pain which runs from the spine directly forward to the anterior part of the body, and state that the pain is made worse by the slightest movement of the affected part.

Spasticity and weakness of the limbs usually progress rapidly and very often both lower limbs are affected at the same time. The X-ray may show early erosion of one or more vertebral bodies, but when the disease has begun in the muscles and has secondarily invaded the arches of the vertebrae, there may be little if any changes from the normal seen in the röntgenogram.

The sudden development of a flaccid paraplegia—perhaps overnight—is very characteristic of malignant disease, and rarely occurs in true spinal cord tumors. Occasionally in patients with extramedullary cord tumors lumbar puncture and withdrawal of fluid is followed by an exaggeration of all of the signs of compression and unless the patient is operated upon without delay, the signs of a complete transverse cord lesion may rapidly appear. In several patients of our series, the history obtained was that a flaccid paraplegia had followed a lumbar puncture. All in all, however, a flaccid paraplegia is rare in true spinal cord growths—occurring only in the very terminal stage of spinal compression by a neoplasm and of course in tumors between the roots of the cauda equina.

In every patient with the signs of cord compression in whom a neoplasm is suspected but in whom the symptoms and signs of a level cord lesion has been of only a few months’ duration, extradural malignant disease should be suspected, and a careful search should be made for a primary lesion in some other part of the body. The urine should be examined for the Bence-Jones bodies, in order to exclude multiple myeloma. Metastatic disease in and around the spine is most often due to primary malignant disease of the breast, uterus, thyroid or prostate gland. It is often, also secondary to or a direct extension of malignant disease within the thoracic cavity. As we have pointed out, the spinous processes in malignant bone disease that are sensitive to pressure are often those at the vertebral level of the disease, while in true cord tumors, the sensitive spines are somewhat lower.

The Frequency and the Prevention of Errors in the Diagnosis of Spinal Cord Tumor.—We had, for many years, divided our operations for cord tumor into three groups: (1) those in which an unqualified pre-operative diagnosis of tumor was made; (2) those in which the tumor was considered probable, although not certain; (3) those in which a tumor was considered possible but not probable, and in which the operation was an exploratory one.

In the patients of the first group, errors in diagnosis were infrequent, while in those of the second group (probable cord tumor) a new growth was often exposed but in not a few cases, the diagnosis was proven erroneous. In the third group, finally, no tumor was ever found.

Since we have paid more attention to the results of the manometric tests
for partial or complete spinal block, we have altered our classification of the patients, and in the large majority of instances for a positive diagnosis of cord tumor, we now demand not only a good history and clear physical signs, but also evidence that there is a complete or incomplete interference with the normal flow of the spinal fluid by the manometric tests.

The manometric studies of the spinal fluid that have been made in my clinic by Doctor Stookey have contributed greatly to improvement in our diagnosis and from the time that these careful studies have been made, errors in diagnosis have become less and less frequent.

The results of the studies of incomplete spinal block have been especially useful. Stookey has shown that a very slight interference in the outflow of the spinal fluid—small differences in the rapidity of the rise and fall of the column of fluid in the manometric tube, slight and momentary slowing or hesitation in the rise and fall of the fluid, changes in the level of the fluid upon the slightest compression of the jugular veins (touch compression of
Stookey) as well as upon deep compression of the veins (Queckenstedt test), etc.—all these changes have great insignificance for the demonstration of an incomplete blocking of the spinal subarachnoid space in early and slight cord compression. The manometric tests have also been of great value to us in the patients in whom the disease has run an atypical course and in whom the physical signs of cord compression were vague and ill-defined. In some of those patients, the positive results of the tests led us to operate and find the cord tumor, while in an increasingly large number of patients the entirely negative results of the tests have thrown the weight of evidence against the diagnosis of cord tumor and have thus prevented an exploratory operation.

A diagnosis of cord tumor should, of course, never be made from the results of the manometric tests alone, for a complete spinal block may be due also to inflammatory disease of the cord with adhesions between the pia and arachnoid, to intramedullary disease, or to a fracture-dislocation of the vertebrae, etc., and a partial spinal block may be caused by any of the conditions already mentioned and perhaps may occur with a marked spinal curvature. It is well to remember also that a patient with a cord tumor which is still small may give a typical early history of a slowly increasing spinal compression and signs which justify a strong suspicion that he has a tumor, before any evidence of the slightest degree of spinal block can be obtained by the manometric tests. While cases of this kind are possible, they are certainly rare. The manometric tests are of great value for the diagnosis of spinal cord tumor and if they are entirely negative, a diagnosis of cord tumor is rarely justifiable at that stage of its development, and it is probable that the signs of disturbed cord function will also be so indefinite that the further progress of the symptoms and signs will have to be awaited before a diagnosis of cord tumor can be made. At the present time I have two patients under observation who belong in this category.

In previously published papers I have called attention to the fact that in every patient in whom a compression by a spinal new growth is considered possible, a careful neurological examination should be made not only before the lumbar puncture, but also after spinal fluid has been withdrawn. Vague and indefinite level signs often become distinct after the lumbar puncture.

During the past few years, the number of instances in which operations were performed under the erroneous diagnosis of cord tumor has become much smaller, but in order to give a fair idea of our past experiences, I have included in the following figures, all of the cases in which, during the past six years, a laminectomy was performed under the diagnosis cord tumor or in which the operation was done in order to exclude compression of the cord by a new growth.

There were 116 patients who belonged in this category. In 97 of them, the pre-operative diagnosis was “spinal cord tumor” or “probably cord tumor,” and in 81 the diagnosis was verified at the operating table. In 16 patients, however, no tumor was found and the diagnosis must have been an erroneous one.
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In 19 other patients, we did not believe that the patient had a spinal new growth, but we did not feel that the diagnosis of tumor was absolutely excluded and therefore gave the patients the benefit of the doubt and did an exploratory operation. In not a single one of these nineteen cases was a tumor found!

In 35 of the 116 cases, therefore, no spinal tumor was demonstrated. In some of these 35 patients, gross pathological changes were observed when the cord was exposed, while in others, nothing abnormal was seen at the operation. Four patients suffered from a neuritis of the cauda equina, three from meningomyelitis with adhesions between the membranes, one from an unverified intramedullary lesion, one from varicose veins of the cord and eight from multiple sclerosis. In five cases, the cord was found to be small and atrophied, and in thirteen nothing abnormal was found at the operation and the nature of the disease remained unknown.

Recurrences After the Removal of Cord Tumors.—When an intradural tumor has been removed in toto, recurrences are rare. In my series, I have seen three instances. One was in a case of an extramedullary sarcoma, 2 x 1 centimetres in size, adherent to the dura at the sixth cervical segment, which was removed in one piece. Two years later, there was a recurrence of symptoms, and at the second operation, a tumor of the same size was removed together with a piece of dura. The operation was done four and a half years ago, and there has been no recurrence.

In a second patient, there were two recurrences of a neurofibroma at the sixth cervical segment. At each of the three operations upon this patient, a piece of dura was excised with the growth. Each recurrence took place after an interval of about two years.

In a third case, operated upon eight months ago, an extramedullary tumor had been removed from the sixth thoracic segment by another surgeon. About two years later I removed another growth—an endothelioma—together with a piece of dura from the same location, since which there has been no recurrence.

Among the extradural tumors which could be completely removed, there has been one recurrence. This occurred in a patient from whom I had removed an extradural fibrosarcoma from the seventh cervical level in 1912. She remained well for eight years, and then had a recurrence at the same level for which she was operated upon by Dr. Emmet Rixford, of San Francisco.

There have been, therefore, in my own series of spinal tumor operations, three recurrences, or 2.6 per cent., in patients in whom the records stated that growth had been entirely removed at the first operation.

In the first of the four patients, a recurrence might not have taken place if a piece of dura had been excised with the growth, but in the second case, I am at a loss to explain the recurrent neurofibromata. The late recurrence in the fourth patient (with an extradural fibrosarcoma) is of interest.

There are only a few reports of recurrences of intradural extramedullary
tumors in the literature—a case of A. V. Lambert,9 one of J. B. Murphy,10 and one mentioned by Frazier and Spiller.11

In every instance in which a tumor is found to be adherent to the inner surface of the dura, it should be treated in the same way as we treat the intracranial dural growths—by excision of the piece of dura to which the growth is adherent. If the defect in the dura is so large that it can not be closed by suture, the exposed cord should either be covered by a piece of Cargile membrane, or a fascia transplant should be performed.

Some Technical Features of the Operation of Laminectomy and Removal of Cord Tumors. —“Though I may not live long enough,” said Astley Cooper12 just about one hundred years ago, “to see the operation of laminectomy frequently performed, I have no doubt that it will be occasionally performed with success.” “We must submit to hear many strange proposals for the improvement of our profession in the present day from young men ambitious of notice,” responded Charles Bell,13 “but that a man of Sir Astley’s years and station should talk as he has done before students, and give them his authority for laying a patient upon his belly, and by incisions laying bare the bones of the spine, breaking up these bones, and exposing the spinal marrow itself, exceeds all belief.”

Tempora mutantur et nos mutamur in illis. The indications for the operation of laminectomy, and the technic of the exposure and removal of spinous processes and laminæ is now so well understood, that a description of the various steps of the procedure is superfluous. Whether the surgeon makes the cutaneous incision in the midline, over the tips of the spinous processes, or to one side or the other, is of little importance. Flap operations, as they are more complicated and have only theoretical advantages, have been almost
entirely discarded. Nor does it make a great deal of difference whether the spinous processes are first removed with rongeur forceps and the laminae bitten away with smaller rongeurs, or if one or more laminae are first perforated or divided with a drill or burr. My own preference is to bite away the spinous processes with large rongeur forceps, and the lamina with smaller rongeurs, because the use of a burr is a more complicated method and requires more time than the simpler procedure in which the bone is removed with rongeur forceps. This part of the operation requires little time; in most of our patients, the arches of three vertebrae had been removed within ten to thirty minutes from the time of the skin incision.

When the dura is incised, the attempt should be made to leave the arachnoid sac unopened, so that that membrane can be thoroughly exposed and pathological changes in it noted. The normal arachnoid is transparent and is not adherent to the dura, and the cord covered by the posterior spinal vessels can be seen through the transparent membrane and the subarachnoid fluid (Figs. 4 and 5). The respiratory and cardiac pulsations of the fluid and of the cord can often be well seen through the unopened arachnoid. Another advantage is that the cord will be protected from any little blood in the operative field, and if in rare instances the surgeon has to deal with a growth which is outside of the arachnoid sac and is adherent to the inner surface of the dura, it may be possible to extirpate the growth without opening the arachnoid.

The primary opening in the arachnoid should be small—only large enough to permit the escape of the spinal fluid. If the growth is not seen within the area exposed, and congested and tortuous posterior spinal veins make it probable that the tumor is a little higher, a probe or soft catheter is carefully
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passed upwards in the subdural space, and the obstruction searched for. The searcher should first be passed upwards over the midline of the cord, and if nothing is found, should be passed upwards more laterally.

On the posterior surface of the cord, this exploration is easily made, but when the subdural space in front of the cord is to be explored with the probe, it is advisable to grasp a slip of the dentate ligament with mosquito forceps, to divide it at its dural attachment, to raise and rotate the cord by traction on the divided slip of dentate ligament (Fig. 6) and only then to pass the searcher upwards. The same procedure should be followed when the exploration is made in a downward direction.

The tip of the exploring probe may be arrested from one of several causes, by impinging upon a nerve root or a slip of the dentate ligament, by the curve of the vertebral column, by an arachnoid adhesion or by one of the calcareous plaques often found on the outer surface of that membrane, or, finally, by the tumor itself. While we have sometimes wrongly interpreted an obstruction felt, with the exploring probe, the elastic resistance due to tumor can generally be recognized.

If the cord level of the compression has been correctly diagnosticated and the proper spines and laminae have been removed, the tumor is generally found in the exposed area and this exploration is unnecessary. Occasionally, however, a small ventral or ventro-lateral growth within the exposed area of the cord will escape detection unless the ventral subdural space is explored with a probe. In a patient recently operated upon, a small ventro-lateral tumor which lay in the middle of the exposed area, and which has caused no backward dislocation of the cord, was found only when the subdural space in front of the cord was explored with the probe.
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The removal of growths on the dorsal or dorso-lateral aspects of the cord presents no especial difficulty, but the exposure and extirpation of a ventrally situated neoplasm is always a more complicated procedure. In the exposure of ventral growths, the cord has to be rotated and drawn to one side by traction on one or two divided slips of the dentate ligament. Even when in addition one or several nerve roots have been divided to permit of further dislocation of the cord, the exposure obtained may not be an ideal one. It may be necessary gently to pull the cord away from the growth, but this procedure—no matter if done with the most meticulous care—causes a certain amount of trauma to an already changed cord, and may be followed by more marked disturbances in the affected part of the cord. The attempt should always be made to do as wide a laminectomy as possible and to reduce to a minimum the amount of handling of the cord. In a patient recently operated upon the spinal canal was very small, and so much dislocation of the cord was necessary in order to even partly expose a median ventral growth, that only fragments could be removed. In spite of great care in the manipulation necessary to control a brisk hemorrhage from the tumor, the patient presented—after the operation—the signs of a complete transverse lesion of the cord. This was the most difficult extramedullary tumor operation that I have performed, and presented many problems of technic.

In secondary operations the technic has to be somewhat modified. The scar tissue which extends down to, and includes the dura, may make it difficult to determine when the plane of the dura has been reached, and as a result the division of the subcutaneous tissue has to be made with especial care. In some cases the meninges are adherent to each other, and injury to the spinal cord can only be avoided by a slow and careful dissection. In the operations for recurrent symptoms that I have performed, I have found that the manipulations are much simplified in the following manner. After the incision through the skin and part of the muscle planes which overlie the arches that had been removed at the first operation has been made, the skin incision is extended downwards, and the next spinous process and laminæ are removed. This exposes a normal area of the dura, and this dura is a useful guide for the depth to which the tissues are to be divided, and for the incision in the dura that has to be made.

The Operative Mortality of Laminectomy for Spinal Cord Tumors.—Up to November, 1924, there have been performed in my clinic 119 laminectomies for spinal cord tumor, and 270 laminectomies for other affections. Thus of the total of 389 spinal operations, 119, or 30 per cent., were performed upon 114 patients for verified new growths within the spinal canal.

The operative mortality of the tumor cases can be seen in the following table:

<table>
<thead>
<tr>
<th>Total number of operations</th>
<th>120</th>
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<tr>
<td>For extramedullary tumors</td>
<td>106, 10 deaths = 9.5%</td>
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<tr>
<td>For intramedullary tumors</td>
<td>14, 3 deaths = 21%</td>
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The extramedullary tumor operations were as follows:

| Intradural extramedullary tumors | 69, 5 deaths = 7.3% |

67 1069
Tumors of conus and cauda equina ............... 12, 3 deaths — 25%
Extradural tumors .............................. 25, 2 deaths — 8%

As the following tables show, the operative mortality is much higher in the patients in whom the tumor could not at all or could only be partially removed. These were: tumor of the conus and cauda equina (1 case), large intradural malignant growth (1 case), intramedullary infiltrating growth in the upper cervical cord (2 cases), extradural sarcoma (1 case).

Thus of the 120 operations:
The tumor was removed in 95, or in 80 per cent.
The tumor was only partially removed or was irremovable in 22, or in 18 per cent.
The tumor was not found at the first operation in 3, or in 2 per cent.
In the 95 operations with complete removal of the tumor, there were 8 operative fatalities, or 8.4 per cent.
In the 22 operations in which the tumor was partially or not removed, there were 5 operative fatalities, or 23 per cent.

These figures show, as one would expect, that fatalities from the operation occur more often when the tumor is found to be irremovable, or when only partial extirpation is possible.

The operative fatalities in the patients in whom the tumor was removed, mostly occurred many years ago, and were in some instances due to causes only indirectly connected with the operative procedure. The causes of death in these patients were the following: One from respiratory failure after the removal of a high cervical intramedullary growth (1910); two of postoperative pneumonia, one after nineteen days in a patient seventy years of age (1915), and one a very stout patient (1918); one from shock after the removal of a large extradural growth secondary to a mediastinal ganglion neuroma in a child of three years (1916); one of diabetes in diabetic coma (1917); one from nephritis and uræmia (1918); one from shock after the fragmentary removal of a large tumor of the conus and cauda equina (1918).

A fair idea of the dangers of the operation can be obtained from the statement that in the last 58 patients subjected to operation, there were three operative deaths—one in a case of partial removal of a large intradural and a second of an extradural sarcoma in the upper thoracic region of the cord, and the third in a case of intramedullary spongioblastoma of the upper three cervical segments which infiltrated, but had not caused any enlargement of the upper cervical cord and which was found only at the post-mortem examination.

The End Results After Operations for Spinal Cord Tumor.—In making a study of the end results after operations for spinal cord tumor, the patients must be divided into two groups: A, those in whom the growth was removed, and B, those in whom radical extirpation was impossible.

A. End Results After Complete Removal of Tumor.—Total number of patients, 93. Extramedullary tumors, 74. Extradural tumors, 16. Intramedullary tumors, 3.

Of these 93 patients, 40 were well and free from any disturbances and 27 were greatly improved, so that they were able to return to their occupation,
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although some disturbances such as weakness of a limb, areas of disturbed sensation, etc., remained. These 67 patients, 72 per cent. of the total, can be considered as satisfactorily relieved of their symptoms. In 11 patients, or 11 per cent., there was little or no improvement after the complete removal of the growth; most of these patients were operated upon when they were in a very advanced stage of their disease. In several, spastic paraplegia had existed for from four to six years, and in several motor and sensory paralysis was complete, and the cutaneous and tendon reflexes had disappeared—an evidence that the lesion of the cord was a very advanced one.

Of the 67 patients above mentioned, who have remained well or greatly improved, the operation was performed 7–15 years ago in 21 patients; 3–6 years ago in 17 patients; 1–2 years ago in 19 patients; less than one year ago in 10 patients.

Three patients died, about two years after the removal of the tumor from other causes; three patients had a recurrence of the growth, seven patients died at periods from one to eight months after the operation from a disease (cystitis, pyelonephritis, other tumors in v. Recklinghausen's disease, etc.), directly traceable to the cord compression from which they had suffered, and the final results in five patients are unknown.

These end results are summarized as follows: Total number of patients, 93. Operative fatalities, 8. Well, or nearly well, 67 = 72 per cent. Little or no improvement but alive 1–9 years, 5 = 5.3 per cent. More or less improvement, but death after 1–8 months from a complication of the spinal lesion, 5 = 5.3 per cent. Recurrences, removed at a second operation, 3 = 3. per cent. End result unknown, 5 = 5.3 per cent.

The End Results After Incomplete Removal of the Growth or When the Growth is Irremovable.—In these patients, the final results are mostly unsatisfactory, and many of the patients succumb within a period of a few months or one to two years from the advancing cord involvement.

With surprising frequency, however, after only a partial removal of the growth, either due to the decompressive effect of the operation, the slow increase of size of the neoplasm, or the partial extrusion of the growth if intramedullary, the spinal symptoms improve very much after the surgical interference so that the patients recover a great deal of power in the limbs. The improvement may persist for a considerable number of years. Thus one patient with a verified intramedullary growth almost completely recovered after a laminectomy and incision of the cord, so that he was able to return to work and to take active exercise, but the spinal symptoms recurred after two years and he was not improved by a second operation and succumbed a year later.

Three patients with irremovable growths remained alive for six, eight and ten years respectively. Two of these had intramedullary gliomas, and the third is still alive with a spastic paraplegia ten years after an operation for an intramedullary perithelioma. In the latter patient, a second operation
was performed after six years and the spinal canal at the level exposed was found filled with the growth.

One patient, a physician, is still alive and able to be about, though suffering from marked disturbances in the upper extremities eight years after laminectomy and incision of the cord for an intramedullary glioma. A woman who was operated upon fourteen years ago for a large tumor of the conus and cauda equina, which was only partially removed, has borne two children since her operation and is still alive, although she now has a spastic gait and still has bladder disturbances. It is difficult to believe that this patient still has a tumor, and the suspicion is justifiable that the partial removal caused an interference with the blood supply of the remaining growth with a shrinking and perhaps disappearance of what had not been removed.

Few of the patients in whom radical removal of the tumor was impossible who received X-ray or radium therapy after the operation, survived for a longer period than others in whom radiotherapy was not used. The only unequivocal result from Röntgen therapy or radium that I have seen was in a patient with a metastatic spongioblastoma over the conus and cauda equina secondary to a growth in the posterior cranial fossa that had been removed by Doctor Cushing, in whom only a piece of the spinal tumor was removed at my operation. There was no improvement in the spinal symptoms after the laminectomy or after the radiotherapy. The patient succumbed after about one year with the signs of recurrence of the growth in the cerebellum and increased intracranial pressure for which a puncture of the corpus callosum was perforated by another surgeon. I was informed that at the post-mortem examination, all evidence of spinal growth had disappeared.

The end results in our patients with irremovable tumors are summarized in the following table:

<table>
<thead>
<tr>
<th>Type of Tumor</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extramedullary tumor</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Extradural tumor</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Intramedullary tumor</td>
<td>11</td>
<td></td>
</tr>
</tbody>
</table>

Operative fatalities          | 5†     |
Died after 3 to 6 months      | 3 = 14% |
Unimproved, but alive when last heard from (4-10 years) | 3 = 14% |
Unimproved, duration of life unknown | 4 = 18% |
Improved for 2 to 14 years    | 3 = 14% |
Improved at first, but finally succumbed to their disease after 1-4 years | 4 = 18% |

The end results after operations for spinal cord tumor, when complete eradication of the growth is possible and the paralytic symptoms have not been of more than two or three years' duration, are very good. Seventy-two per cent. of the patients recover entirely or are so much improved that they can return to their work and become useful to themselves and to the community.

† Two patients with high cervical intramedullary growths; one patient with an intramedullary tumor in the mid-cervical cord; one patient with a large irremovable intradural sarcoma over the upper thoracic cord; one patient with an extradural sarcoma.
TUMORS OF THE SPINAL CORD

When, however, the growth cannot be entirely removed, either because it is within the substance of the cord and not well localized, or because of the extensive nature of the growth and its intimate relation to other structures, the results are, in the main, unsatisfactory. Some of these patients may be much benefited by the decompressive effect of the laminectomy and the partial removal of the growth, and may improve very much for a number of years.

BIBLIOGRAPHY

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