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A CONTRIBUTION TO THE SYMPTOMATOLOGY AND SURGICAL TREATMENT OF SPINAL CORD TUMORS.

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CLINICAL PAPER BY DR. HUNT.

Introduction.—It is now a little over twenty years since Gowers and Horsley described their classical case of tumor of the spinal cord with successful extirpation and recovery. The reports which followed during the next ten years were, on the whole, very encouraging. In the last decade, however, with a more exact knowledge of the symptomatology and an improved surgical technic, this field has become one of the most promising in neurological surgery.

In Starr's [1] contribution to this subject published in 1895, 123 cases of spinal cord tumor were analyzed, in 22 of which an extirpation of the growth was attempted; of this number 11

died soon after the operation, recovery from the paraplegia taking place in six cases only.

A few years later, Collins [2] analyzed 70 cases which had been recorded subsequent to the publication of Starr's statistics. Of these, 30 received surgical treatment, in 12 of which the result was successful, and in eight only partially successful. In 10 cases the result was unsuccessful or fatal. Among the 40 cases of this series in which no operation was attempted, the autopsy revealed an operable tumor which could have been removed in 14.

In the more recent contributions, the percentage of recoveries is even higher; Schultze,[3] in 1903, recorded a series of seven cases of extramedullary tumor, in which extirpation of the tumor was attempted, with three recoveries. Two years later Oppenheim [4] published three successful cases in a series of six operations; and Pearce Bailey [5] in a recent paper reports six cases in which extirpation was attempted, with three recoveries, one doubtful case, and one death.

In Oppenheim's [6] latest discussion of the surgery of spinal cord tumors (1907), the statement is made that recovery takes place in about 50 per cent. of the cases presenting a typical clinical picture of extramedullary growth. Our operative statistics of tumors having this localization are even more favorable and I am convinced that with greater precision in diagnosis and an improved surgical technic, they will eventually be much better.

The series of cases forming the basis of this paper represents my clinical experience in this field, during the past ten years. Thirteen cases in all are recorded, of which six were extramedullary neoplasms. Of this latter group, one died as the result of the operative procedure; one survived the operation for nearly a year, the growth eventually recurring; and the four remaining cases may be regarded as successful, all the patients making fair recoveries from their paralysis and after a considerable lapse of time showing no symptoms of recurrence. In five other cases, an exploratory laminectomy was performed, but the nature or localization of the growth pre-

cluded removal. In a recent case of intramedullary tumor of the cervical region, an exploratory operation was performed and the cord was punctured, with the evacuation of two drachms of cystic fluid. Of the remaining two cases, the diagnosis was confirmed at autopsy, and these are included as contributions to the symptomatology of the subject.

I wish to express my thanks to Professor Dana for the privilege of observing and reporting a number of these cases, as well as for his valuable aid in the problems of diagnosis and localization. I am also indebted to Dr. Joseph Fraenkel for the privilege of observing Case I and to Dr. Abrahamson for a similar courtesy in Case V. The operations, in eight of the cases, were performed by Dr. Woolsey, who will treat in detail the surgical aspects of this subject. In two cases, exploratory laminectomy was performed by Dr. Frank Hartley and in one case by Dr. Bern B. Gallaudet.

Remarks on the Symptomatology of Cord Tumors.—The symptomatology of tumors of the spinal cord is dependent upon the nature and localization of the growth, and the relation which it bears to the long axis and the surface of the cord. It may be laid down as a general rule, that any group of symptoms indicating a progressive focal lesion of the cord should suggest the possibility of neoplasm. This is all the more important as recent observations have shown that many important and characteristic symptoms of tumor may be absent during the entire course of the disease.

The clinical picture of tumor in this region generally begins with *localized pain* due to involvement of the vertebral column, meninges, or more especially, the posterior roots. The pain is followed, after a variable period of time, by symptoms of gradual compression of the cord (sensory and motor paralyses and sphincter disturbances).

With vertebral and extradural tumors, these symptoms, both radicular and medullary, are usually bilateral, often even in the initial stage, while with intradural growths a unilateral symptomatology is more frequent, this often persisting for a considerable period. Exceptions, however, occur to both of these general rules.

Root pains are important, both as general and localizing symptoms. They may persist for years before the appearance of any medullary symptoms, and during this time are the cause of frequent errors in diagnosis. When these pains are situated in the extremities, they are often mistaken for neuralgia, neuritis, and rheumatism; and when referred to the trunk, are sometimes regarded as gastralgia, gall-stones, angina pectoris, appendicitis, and other visceral affections. These root symptoms, so characteristic when present, may fail entirely, and errors in diagnosis may often be attributed to this cause.

A zone of *hyperæsthesia* corresponding to the upper level of the compression is often present, but is far from constant. When demonstrable it has a definite localizing value.

Rigidity of the vertebral column, with localized pain and tenderness, are very characteristic of tumors of the spinal column. Such vertebral symptoms may accompany also intravertebral growths, and, when well defined, may be of distinct localizing value. In my own experience, vertebral symptoms are usually absent in intraspinal growths. Changes in the percussion note at the affected level of the canal have also been noted, but I was unable to demonstrate this symptom in any of my cases.

Extra- and Intramedullary Tumors.—In my series of cases, the general diagnosis of tumor and the localization in the long axis of the cord for purposes of laminectomy have not presented serious obstacles. I have, on the contrary, had great difficulty in deciding whether a tumor was an intra- or extramedullary growth. It is well to remember that some forms of chronic myelitis, multiple sclerosis, and even the early stages of certain systemic diseases of the cord, may simulate very closely the symptomatology of tumor. A careful study of such cases will usually reveal the true nature of the affection, but when in doubt and when a differentiation cannot be made, the patient should always receive the benefit of the doubt and exploratory laminectomy be performed without undue delay.

In this connection, the question of localized serous accumu-

lations within the meninges (meningeal cysts)[7] is of importance; for while these cystic accumulations may occur primarily, producing the typical clinical picture of tumor, they occasionally accompany chronic affections of the cord and vertebra (Oppenheim[8]), and their evacuation in the course of an exploratory operation might be attended with beneficial results.

The differential diagnosis of intra- and extramedullary growths is often so difficult, that in many cases it is impossible to reach a definite conclusion. As the extramedullary tumor alone offers the hope of successful extirpation, the recognition of this group is most important. But here again, when the clinician is in doubt, exploration is indicated and should be undertaken before the disease has progressed too far. I have more than once had occasion to witness exploratory laminectomy in doubtful cases, in which, even if the tumor could have been removed, the cord was already irretrievably damaged.

An extramedullary tumor, when situated beneath the dura mater, usually first manifests its presence by *unilateral root pains*. These may persist for many years without other symptoms; but eventually evidences of unilateral compression of the cord follow (Brown-Séquard type of paralysis). When the tumor is situated on the anterior surface of the cord, progressive paraplegia may develop, and the root pains may be entirely absent or appear late in the course of the disease,—as in a case which I observed in conjunction with Dr. Fraenkel in the Montefiore Home. If the tumor is located posteriorly, the root pains may, from the first, have a bilateral distribution from pressure upon adjacent roots. If, however, it occupies a central position between the roots, a clinical picture of ataxic paraplegia may result from pressure upon the long tracts of the cord (Oppenheim). It is also of interest to know, that rarely the effects of pressure on the cord may be greatest on the side opposite the lesion.[9]

The pains which result from pressure upon the posterior roots are segmental in their distribution, and do not follow the course of the nerve trunks, as in true neuralgia, and the

tender points so characteristic of neuralgia are absent. When present, these segmental root pains are of the greatest value in determining the level of the lesion, and according to Bruns are to be referred to, *a compression of the segment from which the root springs, and not to pressure upon the root in its intraspinal course,* a clinical law which has an important bearing on localization. In central tumors (intramedullary) the root pains are either absent or comparatively insignificant, and this constitutes an important differential sign from the extramedullary growths. Exceptions are occasionally noted.

The clinical picture of intramedullary tumor resembles somewhat that of a subacute or chronic transverse myelitis. The tendency to extension of the symptoms in an upward direction is frequently observed, and is another distinguishing feature from growths without the cord. In extramedullary neoplasms, on the other hand, the course of the affection suggests that the tumor is growing in width, and not increasing in length,—a clinical fact emphasized by Oppenheim, and which I have had frequent opportunity to verify. In central tumors (gliosis and glioma), vasomotor and trophic disturbances are of frequent occurrence, as well as a spinal deformity without pain or tenderness (kypho-scoliosis). Very characteristic also is a homolateral dissociated anæsthesia of segmental distribution (posterior horn anæsthesia). In extramedullary growths, root pains and root anæsthesias are present on the side of the tumor, and a contralateral anæsthesia below the level of the lesion. A dissociated anæsthesia (loss of pain and temperature sense) cannot be regarded as characteristic of central tumors, and may be encountered in vertebral and extramedullary localizations as well. *I have observed, however, that the tactile sense, under these circumstances while present, is definitely obtunded when compared with a normal area, which in some cases serves to separate this form of sensory disturbance from the dissociated anæsthesia of the syringo-myelic type.*

Atrophic palsies occur both in central tumors with invasion of the anterior horns and in eccentric growths involving the

anterior roots, although atrophy dependent upon extensive longitudinal involvement of the cord and accompanied by fibrillary twitchings is very characteristic of the central tumors, especially if associated with a loss of pain and temperature sense, homolateral and of segmental distribution. Fibrillary twitchings may, however, accompany extradural tumors situated on the posterior aspect of the cord, as occurred in several of my cases.

Symptoms resulting from an extensive longitudinal involvement of the cord are usually indicative of central tumors (an exception is the diffuse sarcomatous infiltration of the meninges). *In this connection I desire to emphasize a symptom which I have repeatedly observed in cases of extramedullary tumor in the cervical region. This consists of a distinct girdle sensation, or constriction, situated at the umbilical level or in the lower thoracic zones.* A similar observation has been recorded by Lenander and Henschen.[10] In all of my cases in which this symptom was present, it disappeared after the removal of the growth. I have also observed an abdominal girdle sensation complicating a central tumor of the upper cervical region, which disappeared after the evacuation of cystic fluid from the interior of the cord.

The presence of a girdle sensation in cervical tumor, both extra- and intramedullary, is in all probability caused by pressure and irritation of intraspinal tracts. They are of the same nature as the referred pains sometimes observed in the lower extremities, from irritation of sensory tracts by tumors situated in the higher levels of the cord. It is of importance that their occurrence in tumors of this region should be recognized, otherwise they may be assumed to indicate a much greater longitudinal invasion of the cord than really exists.

Localization in the Long Axis of the Cord.—In determining the level of the growth for purposes of laminectomy, I consider the initial root pains when present to be of the first importance.

These are usually so persistent and severe, that even if the

patient first comes under observation long after their disappearance, their original seat may, as a rule, be determined with certainty.

When pain is absent, other localizing signs must be depended upon, such as muscular atrophy, paræsthesia, and the upper level of objective sensory disturbances.

The disappearance of root pains, which have existed for a considerable time, is usually caused by degenerative atrophy of the compressed roots; in which event a radicular strip or patch of anæsthesia or hypæsthesia may usually be demonstrated. In this connection it is well to remember Sherrington's law of the overlapping of sensory distributions, so that two or more roots must suffer compression in order to produce a demonstrable objective sensory disturbance.

I have already spoken of Brun's law, which refers a root pain from tumor compression to the segment from which the root arises and not to the root, in its intraspinal course.

Hyperæsthesia may, however, be caused by irritation of the root, which arises from the segment just above the growth.

Symptoms indicating involvement of the anterior roots, such as atrophic palsies of the extremities, are also important as localizing signs, either alone or as more frequently happens in combination with posterior root symptoms. In tumors of the lower dorsal region there may be localized palsies of the abdominal wall with reaction of degeneration and dislocation of the umbilicus from the median line. With the onset of medullary compression, the highest level of the objective sensory disturbance becomes a very important sign, and in this connection a diminution of sensation (hypæsthesia and hypalgesia) is as significant as a more complete sensory loss.

When present, a definite area of spinal tenderness or deformity are most important as localizing factors, but should always, I believe, be considered in their relation to the purely neural symptoms, otherwise deception may result. I have more than once observed local tenderness and slight deformity in a region of the spine when the root and medullary symptoms clearly indicated a different level of the cord, and which was subsequently confirmed.

The percussion note is, in my experience, without value; it should, however, always be tested and may be of assistance.

The abolition of the tendon and skin reflexes is also important, but only in conjunction with other symptoms.

I have not found it of any great practical importance to determine the lower pole of the tumor; this is often difficult or impossible, as the compression of the cord above usually masks the root symptoms at a lower level. The eccentric or referred pains due to irritation of the intraspinal sensory tracts are of no localizing value, and unless their true nature is realized may give rise to error. The same is true of the girdle sensations, which I have observed so frequently at the waist level in intraspinal tumors of the cervical region.

REPORTS OF CASES.

Case I.—Extramedullary tumor (endothelioma) of the lower cervical segments, with successful extirpation.

Case II.—Extramedullary tumor (fibrosarcoma) at the eighth cervical and first dorsal segments, with successful extirpation.

Case III.—Extradural tumor (fibrosarcoma) of the upper cervical region (second, third, and fourth cervical segments). Extirpation, followed by recurrence and second operation which was successful.

Case IV.—Extramedullary tumor (fibrosarcoma) of the lower cervical and upper dorsal segments. Extirpation, patient dying three days after the operative procedure.

Case V.—Extramedullary tumor (fibrosarcoma) at the tenth dorsal segment, with successful extirpation.

Case VI.—Extramedullary tumor (fibrosarcoma) of the lumbosacral region. Extirpation, with relief of pain but recurrence of tumor within a year.

Case VII.—Extramedullary tumor (neurofibroma) at the cervical segment; with autopsy.

Case VIII.—Intramedullary tumor of the upper cervical region, with exploratory operation and evacuation of two drachms of cystic fluid from the interior of the cord.

Case IX.—Intramedullary tumor in the cervical region, with exploratory laminectomy. Growth inoperable.

Case X.—Sarcoma of the meninges in the upper dorsal region, with exploratory laminectomy. Inoperable growth.

Case XI.—Sarcoma of the meninges in the lumbar region, with autopsy. Inoperable growth.

Case XII.—Carcinoma of the spine, with compression of the spinal cord at the twelfth dorsal segment: exploratory operation.

Case XIII.—Melanoma of the sacrum, with compression of the corda equina: exploratory operation.

Case I (Summary).—*Extramedullary tumor of lower cervical segments successfully removed. Onset with pains in the back of the neck and left shoulder, later in the right. Duration of pains one year, followed by flaccid paralysis of the left arm, spastic paralysis of the left leg and dissociated anæsthesia of the opposite side below the level of the third rib. Pathological diagnosis of tumor, endothelioma. Nearly complete restoration of function. No recurrence after 7 years.*

History.—Mrs. S., aged thirty-one, married; no children, no miscarriages. A few months before the onset of present trouble she fell and injured right hip. In October, 1901, was seized with pains in back of neck, later extending into left shoulder, which were very severe and sometimes lancinating. Later the pains were also felt in right shoulder. Six months after the initial pains, sharp lancinations also felt in upper chest below clavicles. One year after pains had made their appearance the left arm became weak and the left leg stiff and awkward. These symptoms progressed gradually and she soon noticed that the right leg was insensitive to heat and cold. Of late there has been a disturbance of the vesical sphincter and a girdle sensation immediately above the umbilical level. She also has had paræsthesias of both arms, more marked in the left. She states that several months previously the neck had been quite stiff for a time and movements had increased the pain. This, however, disappeared and has not recurred since.

Examination (January 23, 1903).—The cranial nerves are normal. The pupils are equal and react normally. Movements of the neck are free. There is no abnormality of the spinal column. Sitting up and bending the head forward accentuates the girdle sensation at the umbilical level. Jarring of spine and deep pressure cause no pain. The paralysis of the left upper extremity is distributed as follows. There are normal movements

of abduction, external and internal rotation of the shoulder and of flexion and supination of the elbow. Adduction of the shoulder is diminished and there is paralysis of the movements of extension of the elbow, pronation, extension of the thumb and fingers, flexion of the wrist and fingers (with the exception of the flexor sublimis digitorum, which is weak) and of the intrinsic muscles of the hand. There is well marked atrophy of the paralyzed muscles, but no fibrillary twitchings. The circumference of the left arm and forearm is half an inch less than on the right side. No oculopupillary symptoms.

Sensations.—On the entire right side below the level of the third rib anteriorly and the fourth dorsal spine posteriorly there is complete loss of pain and temperature sense, with preservation of the tactile sensibility (dissociated anæsthesia). Corresponding to the upper limit of this anæsthesia there is a hyperæsthetic band which is present on both sides of the trunk. There is a slight but distinct tactile disturbance along the inner side of the left arm and forearm. The deep sensibility of the fingers of the left hand is absent, but in the lower extremities the articular sense of the toes is preserved. The tendon reflexes of the lower extremities are exaggerated, more especially on the left side, which is spastic and in which ankle clonus is present. Babinski reflex present on both sides.

Surgical History.—She was referred for operation by Dr. Joseph Fraenkel of this city who diagnosed and localized the tumor. The operation was performed February 2, 1903, under ether anæsthesia, with the patient in a prone Sims' position on the left side. The spines and laminæ of the fourth to the seventh (inclusive) cervical vertebræ were removed by bone cutting forceps and a rongeur respectively. There was absence of pulsation in the lower part of the dura exposed. Median incision of the dura. Gauze was inserted between the dura and the cord at the cranial side of the opening which checked the troublesome flow of cerebrospinal fluid. At first nothing was seen except some bulging of the cord opposite the sixth lamina. Here a probe encountered resistance on the left side, where, pressing the cord to the right, a dark bluish prominence was seen anterior to the posterior nerve roots and extending anteriorly. Two posterior nerve roots were cut central to the root ganglia to expose the tumor. After dividing its capsule along the curved

line where it was apparently continuous with the pia, the tumor was fairly easily removed by blunt dissection. The tumor was apparently attached at one point to the pia. It measured 2 cm. in length by 1¾ cm. in width and 1¼ cm. in thickness. The dura was sutured with fine gut, the muscles and aponeurosis with chromic gut and the skin with silk. A cigarette drain was inserted to the dura at the lower angle which was removed two days later.

Postoperative History.—After operation the paralysis of the left side was somewhat increased, and there was some weakness of the right side, which cleared up in about ten days. She complained of paræsthesia (prickling), particularly in the upper extremities, and profuse perspiration of the face and neck was very annoying. Healing occurred *per primam*. There was no improvement for two weeks except the disappearance of the paræsthesia and sweating, and the immediate disappearance of the root pains.

On March 23, 1903, there was no demonstrable anæsthesia corresponding to the posterior roots severed at the time of operation; there had, however, been some paræsthesia which had practically disappeared. Since then steady improvement for a year or two. Motion returned first in the right and then in the left leg. Six years after the operation there remained only a slight weakness of the left hand. The tumor was an endothelioma (Prof. Ewing).

Remarks on Diagnosis and Localization.—The diagnosis of tumor was based upon the onset with lancinating pains, at first unilateral, and always more severe upon the left side, atrophic paralysis of the muscles of the left arm (lower arm type), and the symptoms of progressive unilateral compression of the cord (Brown-Séquard type). The absence of rigidity and tenderness of the spine was in favor of an intradural growth. Of especial interest was the presence of a well-defined dissociated anæsthesia upon the right side of the body below the level of the lesion, which gave rise to some uncertainty as to the intra- or extramedullary seat of the growth. It is possible that the localization of the tumor on the lateral

surface of the cord in this case by pressure upon Gowers's tract was responsible for the dissociation of sensibility. The duration and severity of the root pains preceding the compression of the cord were in favor of extramedullary growth. Of especial interest was the presence of a girdle sensation at the umbilical level. This association Dr. Fraenkel and I had observed previously in a case of extramedullary tumor on the anterior surface of the cord in the cervical region, so that we were rather inclined to regard it in this case as possessing some significance as an extramedullary symptom. Since then, I have observed this symptom in central tumor in the cervical region. The atrophic paralysis of the arm was attributed to compression of the anterior roots of the sixth, seventh, and eighth cervical, and first dorsal segments. It is interesting to note that oculopupillary symptoms were absent, although the intrinsic muscles of the hands were paralyzed and tactile disturbances were present along the inner side of the arm.

Case II (Summary).—*Extramedullary tumor at the eighth cervical and first dorsal segments, successfully removed. Onset with pains in the back of the neck, the upper portion of the chest and the inner side of the right arm, followed seven years later by similar pains in the corresponding distribution on the left side. Duration of root pains before the appearance of spinal cord compression about ten years. These consisted of weakness of right hand and forearm with atrophy, spastic paralysis of the right leg, and tactile, pain and temperature disturbances below the level of the third rib, more marked on the left side. Pathological diagnosis—fibrosarcoma. Partial restoration of function. No recurrence after five and one-half years.*

History.—Mr. W. M., age forty-five, manufacturer, single, was admitted to the Presbyterian Hospital September 6, 1904. He is a man of moderate habits. No history of venereal disease or trauma. The present illness began twelve years ago with neuralgic pains in the upper portion of the right side of the chest, just below the clavicle, and along the inner side of the right arm. These pains continued with varying intermissions up to the present time. They are described as intensely neuralgic, somewhat like a toothache in character. Seven years later

pains of the same character made their appearance along the inner side of the left arm, as well as the upper portion of the left side of the chest. During this entire time there were no paræsthesia and no weakness of the arms, and he was treated for rheumatism and neuralgia without success. When the pains appeared upon the left side their intensity diminished somewhat on the right. They were often of a throbbing character. For the past year he has had a girdle sensation below the margin of the ribs, and for the same length of time has been impotent and very constipated. He has had a weakness of the vesical sphincter for the past six months and some uncertainty of the rectal sphincter. The girdle sensation is one of a feeling of pressure which comes on at night but has usually disappeared by morning after sleeping. It is increased in the sitting posture and disappears when standing or walking. In July, 1903, while in swimming he noticed that the right leg felt heavy and a little stiff, and this has been growing progressively worse. Occasionally he has paræsthesia of the feet, more especially of the right. He says that during the past week the neck has occasionally felt somewhat sore and stiff. This he had not noticed previously.

Examination (August 18, 1904).—Patient can stand and walk, but he drags the right leg which is distinctly spastic; and there is a marked Romberg symptom. Cranial nerves are normal. Pupils are equal and reactions present. The movements of the neck are quite free and cause no pain. There is no tenderness on jarring or direct pressure along the spine. There is a distinct weakness of the flexors and extensors of the right forearm, with slight atrophy along the ulnar sides of both forearms and in the intrinsic muscles of the right hand. Fibrillary twitchings are present in the intrinsic muscles of the hands, inner side of the forearms and the extensors of the forearms and triceps.

Sensations.—The tactile sense is practically abolished below the third rib anteriorly and the fourth dorsal spine posteriorly, as well as along the ulnar sides of the forearms. The pain and temperature sense are very much diminished below the nipples, more especially of the left leg. The deep sensibility of the right lower extremity is very much disturbed. There is a loss of pain and temperature sense along the inner side of the right

arm and forearm and a diminution of the pain sense along the inner side of the left arm. There is slight obtunding of the tactile sense along the ulnar sides of both hands. No hyperæsthesia. There is no ataxia of the upper extremities and the arm jerks are present. The abdominal and cremasteric reflexes are absent. The electrical responses in the intrinsic muscles in the hands and in the forearm to both faradic and galvanic currents are practically normal. The right lower extremity is weak in all segments. In the left there is good power but weaker than normal. The tendon reflexes are exaggerated on both sides, more especially the right. Ankle clonus and Babinski are present on both sides.

Surgical History.—Operation September 7, 1904. Anæsthesia, gas and ether. In a prone Sims' position on the left side, a median incision was made from the second thoracic to about the fourth cervical spine. The spines and laminæ of the sixth and seventh cervical and the first dorsal vertebræ were removed. The dura did not pulsate and appeared swollen. There was no spurting of the cerebrospinal fluid until the incision had been carried above the swollen area. On opening the dura, an area firmer and darker than normal was disclosed beneath the seventh lamina. After dividing many layers of arachnoid and a thin bridge of what appeared to be nerve tissue, a cystic cavity was opened disclosing in it a tumor on the right posterior aspect of the cord, extending down beneath the first thoracic lamina. On removal by blunt dissection it measured 3.7 cm. long by 12 x 6 mm. broad. The wound was closed and drained as in Case I.

Postoperative History.—The sutures were removed on eighth day, primary union. Not long afterwards the skin opened up down to the fascia. A few days after the operation there was a free discharge of clear cerebrospinal fluid from the site of the drain until it was checked by the pressure of a pad. It ceased after eighteen days. For the first twenty-four hours the patient was not on an air bed, and notwithstanding the shortness of this period a shallow bed-sore subsequently developed over the sacrum and on each heel in spite of careful nursing. After operation the power of the right leg was completely lost; that of the left leg partly so, and the arms were very weak. The paralysis gradually cleared up so that by the end of the third week the arms were freely movable, though the legs improved more slowly.

There was also pain and painful twitchings in the legs and arms, which lasted between two and three weeks, gradually diminishing. September 10 there was sensitiveness to noises and light and distinct oculopupillary symptoms in the right eye. He was catheterized for the first week. There was no increase of the anæsthesia. Much of the time for the first week he was irrational and delirious. A week after operation he was free from root pains. A peripheral peroneal palsy of the left leg was discovered, due to pressure on the operating table or during the early postoperative period when he was paralyzed. The improvement in the lower extremities was slow and steady, and the peroneal paralysis cleared up. He regained sphincteric control. Five years after operation (1909) there is no sign of recurrence, he has no pain and walks with a cane. The right leg is weak and spastic. The microscopic diagnosis of the tumor was "fibrosarcoma, vessels fairly numerous" (Path. Lab. Presbyterian Hospital).

Remarks on Symptomatology.—This case is of unusual interest because of the long duration (ten years) of the posterior root pains. For seven years neuralgic pains were confined to the inner side of the right arm and the upper segments of the right side of the chest, without any weakness or numbness of the extremity. As the pains appeared upon the left side in a corresponding distribution, they diminished in intensity on the right side. This diminution was evidently due to destruction of the root fibres, as objective sensory disturbances were demonstrable along the inner side of the arm. The symptoms of cord compression appeared after ten years of neuralgic pains, and were predominant upon the right side, as was evidenced by the greater weakness and spasticity of the right leg and loss of the deep sensibility of the lower extremity, and the greater anæsthesia upon the opposite side of the body. That fibrillary twitchings in the muscles of the right hand and forearm may be present in extramedullary tumor situated on the posterolateral aspect of the cord, is interesting as it might give rise to uncertainty in regard to the seat of the growth. Twitchings of this character are commonly associ-

ated with irritation and degeneration of the anterior horn cells of the spinal cord, and are therefore a common symptom in central tumors. It is possible that the long duration of pain in this case may reflexly have induced an irritable state of the anterior horn cells, with consequent fibrillations. The atrophy which was present shows, however, that the anterior roots must also have suffered from pressure. In this case also a girdle sensation was present in the lower thoracic zones, which disappeared after extirpation of the tumor. This sensory symptom, referable to a much lower level than that of the lesion itself, is in all probability an eccentric or referred sensory symptom from irritation of intraspinal tracts. Although the first dorsal segment of the cord was the seat of compression, oculopupillary symptoms were not observed until after the operative procedure.

CASE III (Summary).—*Extramedullary tumor of the cervical region (third, fourth, and fifth segments). Operation in two stages. Successful removal of tumor mass. Recurrence in ten months. Second operation with removal of growth, followed by recovery with fair restoration of function. No recurrence after four and a half years. Symptomatology consisted of pains in the neck and shoulders with rigidity, followed two years later by symptoms of compression of cord, paralyses of the arms and legs and mild sensory disturbances. Pathological diagnosis—fibrosarcoma.*

Mrs. C. C., aged thirty-one, was admitted to the Presbyterian Hospital Oct. 27, 1904. She was a patient of Dr. Max Mailhouse, of New Haven, Conn., whose diagnosis and localization of the tumor was confirmed by Dr. C. L. Dana who saw her in consultation. She has had one child, no miscarriages. No history of trauma.

History.—In January, 1902, she was seized with pains in the back of the neck, radiating into the left shoulder. This pain was severe but not constant and during the paroxysms the head would be drawn down toward the left shoulder, assuming somewhat the attitude in wry neck. These pains would come and go, sometimes lasting two or three months, then disappearing for a time, the longest interval having been three months. Even

during this time she was conscious of slight pain in the post-cervical region. She had no pain anteriorly in the cervical region and none in the arms. In January, 1904, there developed numbness in the fingers which gradually passed up the inner side of the left arm. This was soon followed by a weakness in the left hand and shoulder. In March, 1904, the left leg became weak and stiff and has been getting gradually worse. The right leg is also weak, but much less so than the left. At night she is subject to spasmodic contractions of the muscles of the arms and legs. Sometimes all four extremities contract simultaneously and are drawn up together in a flexion attitude. In September, 1904, she experienced difficulty in micturition and for the past few days catheterization is necessary. In August the numbness appeared in the fingers of the right hand. This also was followed by weakness, especially in the movements of the shoulder. Since June, 1904, there is a girdle sensation in the epigastric region, which is constant. There is a transient girdle sensation around the breast, and rarely around the hips. The epigastric girdle is accentuated in the recumbent posture and on standing. It is also increased on turning the head toward the extreme right.

Examination (October 29, 1904).—Cranial nerves are normal. The left pupil is somewhat wider than the right but the reactions are normal. There is no ptosis and no enophthalmos. There is well marked rigidity of the posterior muscles of the neck so that the head cannot be brought forward. Movements of the head to the right are also restricted owing to the rigidity, not however toward the left. Backward movements are free. The left upper extremity, except for slight movements in the index finger, is practically powerless. In the right arm slight movement is possible in all segments, but the power is very much diminished. The excursions of the intercostal movement are also diminished. The diaphragmatic breathing is normal. Both lower extremities are paretic, especially the left, which is spastic with ankle clonus. The Babinski reflex is present on both sides. The epigastric reflexes are absent.

Sensation.—The tactile sensation is slightly disturbed over both upper extremities and the trunk, below the fourth dorsal spine, although no definite areas of anæsthesia can be made out. There is, however, an anæsthetic patch posteriorly over the upper portion of the left scapula. Pain and temperature sense are well

preserved over the arms, trunk and lower extremities. There is a band of hyperæsthesia on a level with the clavicles and another on a level with the nipples. Except for the rigidity and some tenderness on pressure of the neck, no abnormality of the spinal column could be detected.

The general condition was poor, the patient having eaten very little for the past few weeks. The diagnosis was made of an extradural tumor at the sixth and seventh cervical segments.

Surgical History.—Operation October 29, 1904, under gas and ether anæsthesia. The spines and laminæ of the fourth, fifth, and sixth cervical vertebræ were removed, exposing an oval extradural, encapsulated tumor 3 x 1.5 cm., on the left postero-lateral aspect of the dura, opposite the fourth lamina and extending up under the third. The capsule, very adherent to the theca, was opened, disclosing an enucleable tumor, but at this stage the pulse and then the respiration suddenly failed. Artificial respiration and the intravenous infusion of 1000 c.c. of normal salt solution were employed and the patient reacted well to stimulation. The wound was temporarily packed and brought together by a few sutures. Stimulating and nutritive enemata for the next forty-two hours brought the patient into better condition than before the operation.

October 31 the operation was completed. The wound was reopened, part of the third cervical lamina was removed, and the tumor was removed piecemeal by blunt and sharp dissection. The oozing of blood was troublesome and was controlled by hot packing. The tumor seemed to spring from the dura in which a small opening was made, where the capsule was most adherent to it. This was closed by catgut suture. Wound closed as in previous cases. The condition of the patient remained good throughout the operation.

Postoperative History.—About the second day after the last operation she began to move the left hand. Power of motion improved rapidly and by the fourth day, motion, except in the left upper extremity, was nearly normal. By the fourteenth day, when she left the hospital, motion was normal except in the left upper extremity in which all but the finer movements were performed slowly. Pain in the extremities and sudden sharp pain in the wound was severe at first, but on the fourth day after operation it began to diminish, and was practically gone by the

thirteenth day. Urination was involuntary for a few days after operation and catheterization was employed. There were no oculopupillary symptoms (the left pupil is still a little wider than the right). The wound healed primarily. She made a practically complete recovery. The tumor was a fibrosarcoma.

A short time after her discharge from the hospital, November 13, 1904, she was practically well, except for stiffness in the left shoulder, and in January, 1905, the adhesions were broken up under anæsthesia and the arm restored almost to normal. There was no pain except occasional darts up and down the neck. Some stiffness of the neck always persisted.

In August, 1905, the first symptoms of recurrence appeared, consisting of pains in the neck and an aching pain in both hands. This was soon followed by weakness of both arms and legs, which gradually progressed. The girdle sensation in the lower thoracic zone reappeared. The symptoms have been symmetrical from the first and gradually progressive.

Examination (October 20, 1905).—Patient can stand and walk without assistance. The arms are weak in all segments, the right more than the left. Movements of the neck are somewhat restricted by rigidity. No ataxia of the arms. Tendon reflexes of the upper and lower extremities are all exaggerated. There is patella clonus on both sides, no ankle clonus. Babinski reflex on both sides. Abdominal reflexes faintly present. Superficial sensations of the trunk and extremities are normal, as well as the deep sensibility of the lower extremities. Pupils are equal. No vesical disturbances. There is a tender point about one and a half inches above the vertebra prominens. The general condition is far better than it was a year ago.

Surgical History.—Operation October 27, 1905, under gas and ether anæsthesia. Incision to the side of the old scar. The seventh cervical laminæ were removed to determine the level of the dura, which was covered by scar tissue above. The latter was readily separated from the dura to the upper end of the old laminectomy opening. The cord appeared flattened on the left side and on careful dissection a tumor 5 x 2 cm. was exposed on the left lateral aspect of the cord. This was removed piecemeal. It was well encapsulated, at least in part, and the capsule on the side toward the dura was removed cleanly, with a resulting

tear of the dura, which allowed the escape of considerable cerebrospinal fluid and was sutured. The tumor filled the left half of the canal extending out into two or more intervertebral foraminæ, where it was uncertain whether the tumor was entirely removed. Two or three nerve roots were exposed in the dissection but were apparently uninvolved and unharmed, though superficially scraped. The tumor extended no higher than before but somewhat lower. Wound closure as before, except that several silkworm gut retention sutures were employed, to be left in twelve to fourteen days to avoid the opening up of the wound as in Cases II and V. There was some postoperative shock but she responded to stimulation.

Postoperative History.—There was considerable paralysis of all extremities after operation. She soon began to move the right leg and a little later all the extremities, but recovery was much slower than after the first operation. Considerable pain was complained of in the legs and some in the neck. She sat up November 10, and went home November 12, when both lower extremities were moved well, the right arm was moved freely but was weak, while there was only slight motion in the left arm, which, however, was steadily but slowly improving. The microscopic diagnosis was the same as before, fibrosarcoma.

February 3, 1906: Recovery has been very slow, but has been more noticeable the past two weeks. She can walk with some assistance. The left side is still very weak and she has not yet regained the use of the left hand.

May 23, 1906: The gait has improved so that she walks very well, and can even stand on the left foot alone. There is still ankle-clonus and exaggerated knee jerks on both sides. The left arm remains spastic and paretic with flexion of the fingers, and she can do little with the left hand. No evidence of recurrence as yet. In view of the first recurrence, a bad prognosis was given, but in this we were wrong, for on November 3, 1909, four years after the second operation, Dr. Mailhouse writes, "Mrs. C. is practically well. She does her own housework and marketing, and goes out daily. She still presents evidence of the degeneration of the pyramidal tracts, produced by the long duration of the disease prior to operation, in a spastic condition of the left arm and leg and carries her head stiffly."

Remarks on Symptomatology.—In this case root pains preceded the onset of symptoms indicating medullary compression, by a period of two years. The pains were in the nuchal region and were bilateral, and when severe, extended into the left shoulder. Very interesting and very suggestive of extradural growth was the accompanying rigidity of the posterior muscles of the neck and the wry-neck attitude during the paroxysms of pain. It will be observed that the backward movements of the head were unrestricted, and the lateral movements only in a slight degree, toward the right side. That this symptom may be entirely absent in extradural tumor of the cervical region, is shown conclusively by a case which I saw in consultation with Dr. David Bovaird in the Presbyterian Hospital, in which an epidural perithelioma was successfully removed by Dr. Joseph Blake.

There was slight tenderness on pressure over the cervical region, but much less than is usual in primary affections of the vertebral column. In this patient a girdle sensation in the epigastric region was observed, as well as transient sensations of constriction about the hips and across the breasts, probably due to irritation of intraspinal tracts.

Case IV (Summary).—*Extramedullary tumor of the lower cervical and upper dorsal segments. Operation, removal of tumor; death after three days. Onset nine years ago. Without root pains. Gradually increasing paraplegia with sensory disturbances and loss of the sphincter control of the bladder and rectum. Pathological diagnosis—round-celled sarcoma.*

Mrs. R. A., aged forty-six, was admitted to the Presbyterian Hospital June 12, 1905. She was a patient of Dr. I. Abrahamson and was referred by Dr. C. L. Dana, who has seen her in consultation and confirmed the diagnosis. There was a history of a fall, striking on the vertebra prominens. One brother died of a brain tumor, thought to be due to a trauma.

History.—Nine years ago first noticed numbness and weakness in the ulnar distribution of the right hand and forearm, followed by weakness of the hand. These symptoms have pro-

gressed steadily but very slowly. Soon after noticed weakness of the vesical sphincter. Three years ago the right leg first became weak. Two years ago there were, for a time, sharp cutting pains in the right knee varying in intensity, not always present and not increased by use. Soon after this both legs became weak and the knees became stiff, making walking difficult, and finally impossible about nine months ago. For about six months she has had no control of urine, and for the past month no control of flatus. For the past three months, there has been a steady increasing pain in the right submammary region, and recently a girdle sensation, at first on the right and for the past week on both sides. Previous to this she had experienced no root pains.

Examination (June 12, 1905).—The muscles on the ulnar side of right hand and forearm are much weaker than the corresponding muscles on the left. Wasting of the interossei of right hand, less of left, with fibrillary twitchings. Ataxia of the right arm. Wrist and triceps jerks diminished on right, exaggerated on left. Motor power of the lower extremities much diminished, especially on right. Right leg more atrophied than the left. Right thigh and leg flexed, knee contractured, so that patient cannot walk. Knee and ankle clonus exaggerated on the left, but are less on the right (contractures). Babinski on both sides.

Sensation.—Sensibility is diminished along the inner side of the right arm and hand. On the right side from the jaw to the third rib diminished sensibility to touch, below this loss of tactile sensation. On the left side from the jaw to the clavicle there is hyperæsthesia, below this to fourth rib normal, from fourth to fifth ribs diminished sensibility and below this anæsthesia. Right side is anæsthetic to just above the knee, and on the left side to just above ankle. Posteriorly on the right above fourth dorsal spine, diminished sensation, below this anæsthesia; on the left down to the third dorsal spine hyperæsthesia, third to ninth normal, below this anæsthesia. The first dorsal spine is very tender on percussion; the seventh cervical spine is also tender but to a lesser degree.

No control of urine or flatus. Lately there has been pain in the right submammary region and a girdle sensation. The tumor was localized at the eighth cervical and first and second dorsal segments.

Surgical History.—Operation June 14, 1905, under gas and ether anæsthesia. Technic as in previous cases.

Operation.—The fifth, sixth, and seventh cervical and first dorsal spines and laminæ were removed and later most of the fourth cervical and second dorsal. Exposed dura tense and without pulsation. On opening it a small amount of clear fluid escaped as if under considerable pressure. This fluid came from a cyst overlying the tumor. The latter was elongated and lobulated and lay on the posterior surface of the cord, flattening it, between the upper margin of the fourth cervical and the lower margin of the second dorsal laminæ. The tumor was carefully dissected off the cord by blunt and sharp dissection. Wound closure as in previous cases. During the operation the pulse rose to 120 and there was some cyanosis as the respiration became feeble and irregular, and finally ceased, but it was quickly resumed. An infusion of 1250 c.c. of a 0.09 per cent. salt solution with adrenalin was given on the table. The operation was a long one, lasting over two hours, owing to the length of the tumor and the difficulty of its removal.

Postoperative History.—On recovery from anæsthesia she kept calling for air, but there was no cyanosis or dyspnœa. Two days later, breathing was more labored and on the following day, before death, there was cyanosis. Pain was complained of all over the body, and the patient was restless and at times irrational. The wound was dressed on the third day and a considerable amount of cerebrospinal fluid escaped on removal of the drain. In spite of stimulation the pulse and respiration failed and the patient died seventy hours after operation. During the last twenty-four hours the temperature rose, reaching 105, twelve hours before death, but there was no apparent infection. Microscopic diagnosis of tumor: round-celled sarcoma.

Remarks on Symptomatology.—This case is unusual in that the posterior root pains were absent, although the tumor lay on the posterior aspect of the cord and extended from the sixth cervical to the third dorsal segment. It was only in the later months of the disease, the history of which extended over a period of nine years, that lancinating pains were felt in the right mammary region, evidently corresponding to an irritation produced at the lower pole of the tumor. The clinical picture was ushered in by numbness and weakness of the right

upper extremity, and the early appearance of vesical symptoms. In this case also, as in Case II, fibrillary twitchings were noted in the atrophied muscles of the right hand. The sharp cutting pains in the right knee were probably eccentric in origin from irritation of intraspinal tracts. An abdominal girdle sensation was also present.

CASE V (Summary).—*Extramedullary tumor at the tenth dorsal segment. Successful removal with practically complete restoration of function. No recurrence after four and one-half years. Symptomatology consisted of localized root pain of seven years' duration, which was then followed by gradual compression of the cord, with spastic paraplegia and marked sensory disturbances. Pathological diagnosis: fibrosarcoma.*

History.—Mr. J. S., aged fifty-nine, married, was admitted to the Presbyterian Hospital August 14, 1905. No venereal disease. Trauma to knee and back below the left scapula three months before onset of symptoms. The present trouble began about seven or eight years ago with localized pain in the left side of the back and abdomen, corresponding to the level of the umbilicus. In the earlier years it occurred only at night and in the recumbent posture. It was more or less aching in character with occasional sharp darts. The pain was always unilateral and always limited to the same distribution. It has grown gradually worse during the past few years so that any sudden movement, and even a cough, is sufficient to bring it on. One year ago there appeared a numbness simultaneously in both great toes. This numbness gradually ascended the legs and thighs, eventually reaching the level of the umbilicus. He has also experienced sensations of burning and of cold in the lower extremities. Later there appeared ataxia and weakness of the lower extremities. He has a sensation of constriction in the region of the groins. No pain in the spine.

Examination (August 17, 1905).—Sexual power is diminished and there are slight vesical disturbances. Patient is unable to walk alone. There is a marked Romberg symptom. In the recumbent posture both legs present considerable ataxia. The gross motor power of the lower extremities is diminished, especially on the left side which is spastic, with ankle clonus and Babinski reflex. In the right lower extremity the knee jerk is exag-

gerated, there is pseudoclonus, no Babinski. Cremasteric reflexes are present and the abdominal reflexes at the level of the umbilicus are much exaggerated, especially on the left side. The umbilicus occupied a central position. The spine was not tender and the movements were free.

Sensations.—Below the level of the umbilicus all sensations are disturbed. The anæsthesia is almost complete in the distal portion of the extremities below the knees, very much diminished between the knees and the groin, and very definitely obtunded between the groin and the umbilicus. On the left side, corresponding to the third lumbar spine posteriorly and the umbilicus anteriorly, there is a well marked band of hyperæsthesia.

Surgical History.—Operation August 28, 1905, under gas and ether anæsthesia. Technic the same as in previous cases. The spines and laminæ of the eighth, ninth and tenth thoracic vertebræ were removed. The tumor, 2 x 1.5 cm., was exposed beneath the ninth lamina, surrounded by clear encysted fluid. It was situated posteriorly but somewhat more to the left, and shelled out easily after ligating and dividing a small vascular pedicle at either end. The wound was closed as in previous cases, save for a drain of three strands of catgut through the dura, on account of slight oozing from the veins of the cord.

Postoperative History (September 2).—Has complained of some pain in and above wound and at times he has been restless. Urination and defecation involuntary to-day for the first time. Drain removed; some watery discharge.

September 4: Sutures removed, primary union. Profuse watery discharge noticed on September 5 and on the following day the entire wound was found opened down to the fascia.

On September 7 his neck was retracted and stiff, he was restless and irrational and temperature and pulse had risen again (T. 103.5° on the sixth), after reaching normal. Discharge profuse, becoming more and more purulent, from the exposed granulating surfaces.

On September 9 there was marked tremor and muscular twitching over the entire body, and the patient was apathetic, restless and irrational.

September 14, the discharge has gradually diminished and the temperature fallen.

September 15, lumbar puncture withdrew one ounce of very

faintly turbid fluid which on culture gave non-pathogenic bacilli and cocci, perhaps due to contamination.

September 17, temperature normal. Since lumbar puncture patient has been quiet, more rational and without tremor.

September 19, again irrational. Lumbar puncture, withdrawing four ounces, with similar result. Culture showed saprophytes.

October 2, temperature remittent and when low patient is quiet and nearly rational; when high he is apathetic and has a marked tremor, most marked in the hands. The neck is still somewhat stiff. He has regained control of the rectum and bladder. The wound is nearly healed.

October 22, lumbar puncture, two ounces, fluid normal. Temperature normal and hereafter continued so. Knee jerks normal, no Babinski.

November 9, sat up in chair.

November 13, patient is clear mentally, more cheerful and stronger.

November 16, sensation in lower extremities normal except for muscular sense. Walked about fifty feet. Gait is ataxic. Left leg somewhat weaker than right. Reflexes slightly exaggerated; ankle clonus still present.

November 20, walks with one cane. Discharged improved. The tumor was a fibrosarcoma.

March 10, 1909: Three and one-half years after operation patient can now stand and walk well. No Romberg, no pains, and no paræsthesias. The vesical functions are normal. The left knee jerk is somewhat greater than the right. There is no clonus. The plantar reflexes are normal on both sides. The power of the left leg is somewhat diminished although its general strength is very fair. All qualities of sensations of the lower extremities are well preserved.

Remarks on Symptomatology.—The long history of unilateral root pains, of seven years' duration, limited to the tenth dorsal segment, followed by symptoms of spinal cord compression predominating on the left side, left little doubt as to the diagnosis of tumor and the extramedullary seat of the growth. The abdominal reflexes were greatly exaggerated at the umbilical level, especially on the side of the tumor.

CASE VI (Summary).—*Extramedullary tumor of the sacral region. Operation with successful removal of tumor. Relief of pain but little or no restitution of function. Probable recurrence about a year later. Symptomatology. Pain in the small of the back, left hip and left perianal region for three years, followed by weakness and sensory disturbances in the left lower extremity with loss of the sphincter control of the rectum and bladder. Pathological diagnosis: fibrosarcoma (glioma?).*

History.—Mr. F. N., aged fifty-eight, a manufacturer, was admitted to the Presbyterian Hospital November 13, 1906. He is a patient of Dr. S. A. Lewis, of Springfield, Mass., and was seen by Dr. C. L. Dana in consultation. No history of trauma and no positive venereal history. Present illness began in the summer of 1900 with pains in the small of the back, particularly on stooping and on movements of the spine. For three years pains remained about the same, after which they grew worse so that jarring or any sudden movement was quite painful. Pains are directly in the median line of the back and do not radiate into the sides. A few months later, pains developed in the left hip and gradually extended down the posterolateral aspect of the left thigh. These pains were very sharp and intense but varied considerably in their intensity. Pains were soon followed by numbness of the left thigh and external genitals, and to a less extent on the opposite side. The pain in the small of the back was the sole symptom for three years, and very soon after the pains appeared around the left hip and thigh there followed weakness in the lower extremities and some vesical disturbances. The pain is particularly distressing in the left scrotal and perineal regions and in the left gluteal fold. When a severe paroxysm of pain appears he finds the greatest relief in the upright posture. During these paroxysms the numbness appears over the right thigh. First he had difficulty of micturition and this was followed by incontinence. For the past year he has been unable to control either his urine or his fæces.

Examination (November 13, 1906).—Patient stands on the right leg, the left leg resting gently on the floor, slightly flexed at the knee. There is slight scoliosis. Bending movements of the spine are very fair, with perhaps a little stiffness in the lumbar region. There is no visible atrophy of the muscles of the legs or of the gluteal region. All movements of both lower

extremities are weak, but especially the left. This weakness is especially evident in the movements of the hip. Both knee jerks and both Achilles jerks are absent. The plantar reflexes are present but are diminished on the left. There is no Babinski. The spine is tender from the first to the fifth lumbar, more so over the third, fourth and fifth lumbar spines. There is no one spot of excessive tenderness. Rectal examination is negative. There is no Romberg symptom. He walks fairly well, but the left leg is not moved as freely as the right. The urine dribbles away constantly and is very turbid.

Sensations.—There is a well marked anæsthetic area over both buttocks, extending down the posterior surface of the thighs to about the knees, more marked on the left side. The sensations are also lost over the left hip and are diminished over the outer side of the left thigh, leg and foot. The scrotum, penis and peri-anal region are anæsthetic on the left side.

Surgical History.—Operation November 15, 1906, under gas and ether anæsthesia. Technic the same as in other cases. The spines and laminæ of the twelfth dorsal and first and second lumbar vertebræ were removed. Pulsation of dura not visible, but palpable. On opening dura, an elongated tumor, not attached to dura, was exposed extending from opposite the spine of the twelfth to nearly opposite that of second lumbar vertebra. Part of the eleventh dorsal and third lumbar laminæ had to be removed to insure complete removal of the tumor. The latter was situated posteriorly and was apparently composed of an upper smaller pinkish and a lower elongated yellowish-white cystic portion. Through the latter part passed two posterior nerve roots, which had to be divided in the removal of the tumor. A couple of small vessels from above required catgut ligature. Wound closed without drainage of dura and with reinforcing silkworm gut sutures.

Postoperative History.—He complained of much pain in the left ankle for the first two or three days. There was also considerable abdominal distress which disappeared only gradually. The urine and fæces were passed involuntarily.

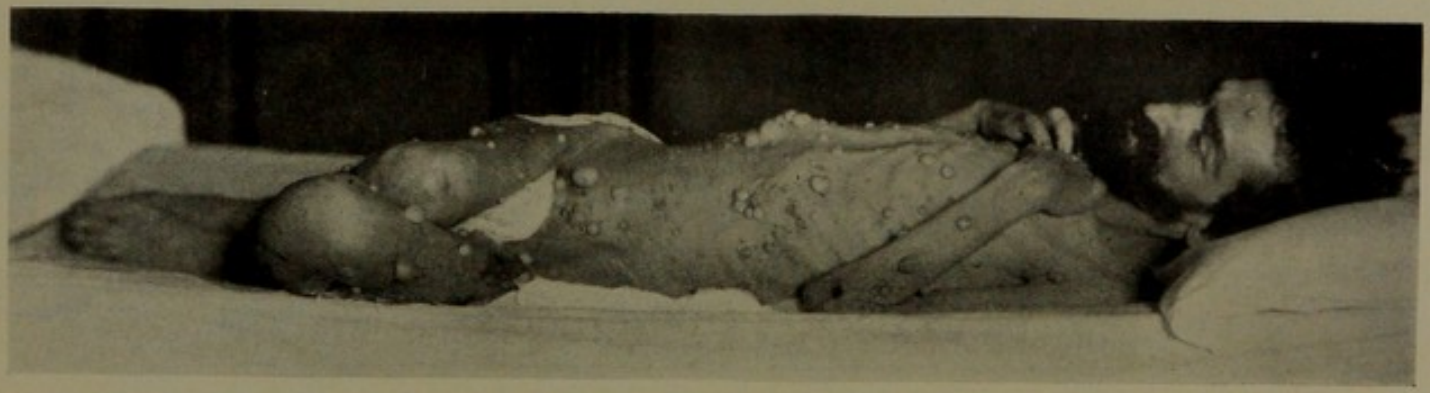
Examination (December 5).—All pains have disappeared except around the anus and perineum, which is similar to that he felt before operation. The left leg is moved in all its segments, but is still considerably weaker than the right. Cremasteric

reflexes not elicitable. Plantar reflex still diminished on the left. The sensations of the entire left leg are practically abolished, including the deep sensibility. Sensation on the right side is normal with the exception of an area corresponding to the right side of the scrotum, penis and perianal region. The right knee jerk is active, the left is still absent. Both Achilles jerks absent.

Allowed to sit up after fourteenth day. December 12, has attempted to get about with walking machine and crutches. He is gaining slowly in control of left leg. There is an area of partial anæsthesia in the sole of the left foot extending up the inner side of the leg, also a saddle-shaped anæsthetic area involving the perineum and buttocks. Wound healed by primary union. Went home December 14, 1906. Pathological examination of tumor, fibrosarcoma (glioma cells probably), but neuroglia stain failed, perhaps due to delay in sending tumor to laboratory. A letter from Dr. S. A. Lewis of Springfield, dated November 9, 1909, says: "The only benefit derived from the operation was the relief from pain, which had been excruciating. There was no improvement in the paralysis or in the control of the sphincters. In the winter of 1907–08 (somewhat over one year after operation) the pains began to recur, with soreness, and it seemed to me the tumor might be recurring. In March, 1908, he was taken one day with severe vomiting, the next day he developed hemiplegia and coma, dying on the second day after. The urine was free from signs of nephritis at this time." There was no autopsy.

Remarks on Symptomatology.—The earliest symptom in this case was localized pain in the lower lumbar region, limited to the median line of the back. It is very probable that this pain was a symptom of meningeal irritation, as during this time there were no referred pains in the region of the perineum, hips, or lower extremities. After the lumbar pain had persisted for about three years, lancinations appeared in the distribution of the lumbosacral nerves on the left side, and were soon followed by paræsthesias, weakness of the extremities, and incontinence of the sphincters. The absence of both knee-jerks showed that the pressure effects on the cord extended as high as the third lumbar segment.

FIG. 1



Case VII. Extensive neurofibromatosis of the skin (Recklinghausen's disease) in a case with compression paraplegia rom a neurofibroma at the fifth cervical segment.

FIG. 2.

Case VII. A solitary extradural neurofibroma at the fifth cervical segment in a case of Recklinghausen's disease. The dura mater has been cut away and the tumor left *in situ*.

CASE VII.—Patient was admitted to Bellevue Hospital on February 1, 1905, in the service of Dr. George Woolsey,[12] and was seen in consultation by Dr. Ramsay Hunt.

Summary.—Extradural tumor (neurofibroma) at the fifth cervical segment, complicating generalized dermal neurofibromatosis (Recklinghausen's disease); onset with lancinating pains in the shoulder, followed in six months by symptoms of compression of the spinal cord. Because of extreme weakness and emaciation, operation was impossible.

Family History.—Ten children, six of whom are dead; four died in early life, one brother the result of an accident, and one sister of heart disease. The other three children are living and well; all are married and have healthy children.

The patient was the sixth child and had always enjoyed excellent general health until the onset of the present trouble. He was always somewhat backward mentally, and solitary and peculiar in his disposition. He is of Irish extraction and his parents were not related.

There is no family history of tuberculosis, neuropathic tendencies, or of congenital marks or moles.

The patient is of unusually short stature, and as I have already stated, is backward mentally. He is shy and very easily frightened; has never had friends, and never learned to read or write. He is not alcoholic, but has smoked cigarettes to excess. For the past sixteen years he has worked in a wood-yard, earning $5.00 a week. He is good natured, and is not subject to outbursts of temper.

The multiple fibromata of the skin, which now cover the surface of his body, first manifested themselves about the fourth year, and have been steadily increasing in size and number ever since. He has never had any pain in them, and his mother is quite certain that they were not present at birth (see Fig. 1).

History of the Present Illness.—Present illness began one year ago, with pains in the left shoulder and left leg. The pain in the shoulder was sharp and lancinating in character, and was soon followed by sensations of pins and needles in the left upper extremity. Six months later, there was weakness of the left arm and soon after the left leg became similarly affected. These symptoms of weakness on the left side increased gradually, and were followed in the course of two months by weakness of the

right leg, when vesical symptoms also made their appearance. There has been a steady progression of the paralysis, with loss of sensation, complete incontinence of the sphincters, and the development of extensive bed-sores.

Examination (February 1, 1905).—Patient is of small stature, and very fragile skeletal development, except the head which is large and square. There is an extraordinary development of neurofibromatosis nodules of the skin, covering the face, trunk, back, and arms. They vary in size from a pin to a cherry. The pupils and cranial nerves are normal. Movements of the neck are free. No deformity or tenderness of the spine. The motor power of the left arm is almost abolished; external and internal rotation of the shoulder are, however, still present, but are very weak. Abduction and adduction are barely indicated by muscular contractions. There is also slight flexion of the elbow, which includes the supinator longus, but the paralysis of the extensors of the elbow and of the muscles of the wrist and fingers is complete.

In the right arm, movements of the shoulder, as well as flexion of the elbow, are preserved but weak; but there is a complete paralysis of the extensors of the elbow and of the muscles of the wrist and fingers.

The musculature of both hands and forearms is atrophic, but no fibrillary twitchings are observed. Breathing is purely diaphragmatic.

The left leg is paralyzed, with the exception of slight flexion of the left knee. The right leg is also paralyzed, save for flexion movements of the leg and weak flexion and extension of the foot.

Both legs are fixed in a flexed position and the knee-jerks are not elicitable (possibly because of the extreme flexion contracture). The left Achilles-jerk is present, but there is no clonus. On the right side, ankle clonus is present. Babinski's reflex is present on both sides. Abdominal reflexes are absent.

Shockingly large deep bed-sores are present over both hips and the sacrum, exposing the bony structure in all three localities, and discharging freely.

Careful examination of the peripheral nerves accessible to palpation fail to reveal any nodulations or varicosities, although the nerve-trunks themselves seem hard and thickened.

Sensations were somewhat difficult to test, because of the

mental state of the patient and his deplorable condition. There was, however, complete absence of pain, temperature, and tactile sensation as high as the third rib, anteriorly. There were also paræsthesias in the upper extremities, and the tactile sense was blunted, but the exact area on the arms could not be demarcated.

Note.—While the diagnosis, neurofibroma in the cervical region compressing the spinal cord, seemed reasonable, the condition of the patient precluded any attempt at operation.

In spite of careful nursing and care, the patient died on March 4, 1905. Permission was obtained to remove only the spinal cord and a few of the skin tumors, so that the condition of the brain and cranial nerves and the peripheral nerve-trunks could not be ascertained. A few of the posterior ganglia were removed with the spinal cord, but these were not enlarged.

At the level of the fifth cervical segment, a small rounded tumor the size of a hazel-nut was found outside the dura, at the junction of the anterior and posterior roots. It was pearly white in color and was encapsulated. On removing the dura, it was found that the tumor fitted into a depression on the anterolateral surface of the cord. Passing into the tumor was the anterior root of the fifth cervical nerve, the posterior roots passing over the surface of the tumor and being lost in its capsule. All the other nerve-roots were normal to the naked eye and presented no swellings or varicosities (see Fig. 2).

Histological Examination.—The spinal cord examined at various levels showed the typical secondary degenerations, above and below the level of the lesion,—more marked upon the left side. There were no evidences of neurofibromatosis in the nerve-roots or in the strands of the cauda equina.

Remarks.—This case is recorded because of the comparative rarity of the pathological lesions, and as an illustration of the diagnostic importance of cutaneous fibromata when associated with symptoms referable to the spinal cord. The tumor was correctly localized, and could have been removed with ease by an operative procedure had the general condition of the patient justified it. The small stature and low grade of mental development which were present have occasionally been noted in Recklinghausen's disease.

Histological examination of the spinal cord, including its roots, the cauda equina, and several spinal ganglia, fail to reveal any evidences of neurofibromatosis, with the exception of the tumor which had compressed the fifth cervical segment. So far, therefore, as the spinal axis is concerned, it was a solitary manifestation of the neurofibromatosis. Unfortunately, the brain and peripheral nerves were not available for examination. A solitary neurofibroma of the spinal axis as a complication of a generalized dermal neurofibromatosis may occur, but usually the tumors are multiple and are associated with varicose thickenings and nodosities of the nerve-roots. A case of this description I have already reported in detail,[13]—one in which an intravertebral neurofibroma in the cervical region had produced a complete destruction of the cord. In addition to this single large growth, all of the anterior and posterior roots in the cervical region were the seats of nodular tumor formation, and many of the spinal ganglia were similarly involved. There was also extensive neurofibromatosis of the peripheral nerve-trunks, and a large plexiform neuroma was situated in the subcutaneous tissues of the lower abdominal region.

Case VIII (Summary).—*Intramedullary tumor of the upper cervical region, fourteen years' duration. Onset with pain, lasting three years, followed by progressive spastic paralysis of the left arm and leg, and a contralateral anæsthesia (Brown-Séquard paralysis); slow progression of symptoms, with gradually increasing weakness of the left side, and ataxia and anæsthesia of the right.*

Exploratory Operation.—Third, fourth, and fifth cervical laminæ removed. Cord normal but somewhat swollen Evacuation of two drachms of cystic fluid from the interior of the cord on its posterior aspect.

[Referred to Dr. Ramsay Hunt by Dr. H. S. Paterson, of New York.] Woman, aged thirty-six, nurse-maid by occupation. No history of injury.

History (October 17, 1907).—Her present illness dates back twelve years and began with shooting pains in the posterior

aspect of the left shoulder. In the course of a few months, similar pains appeared in the corresponding region of the right side, but they were never quite so severe as on the left side. These pains lasted in all about three years, with occasional intermissions and varying considerably in their intensity. They gradually subsided and finally disappeared; during this time she was treated for rheumatism.

Soon after the pain in the shoulders appeared, she had pains in the knees on both sides, lasting for several months, which were of the same sharp and shooting character.

Nine years ago, *i.e.*, about three years after the onset of the shoulder pains, the left arm became weak, and a little later the left leg was similarly affected. The paresis of the left arm and leg has gradually increased, more especially during the past year, and is accompanied by increasing stiffness of the muscles.

For some years she has noticed that there is absence of perspiration on the left side of the body.

One year ago, numbness and prickling sensations were first noted in the right foot; these have gradually ascended the leg to the hip. In bathing, she has noticed that the right leg was less sensitive to heat than the left. A few weeks ago, the fingers of the right hand became numb. There have been no vesical symptoms at any time.

She has always been constipated, but more of late; there is no girdle sensation. She has no pain in the spine, and the left side of the body is quite free from paræsthesias.

Examination (October 17, 1907).—Station normal, but the gait is typically hemiplegic. There is a well-marked spastic paralysis of the left arm and leg, with exaggeration of the tendon reflexes and ankle clonus.

The tendon reflexes are also exaggerated on the right side, on which ankle clonus is also present. Babinski is present on both sides. The abdominal reflexes are absent. There is a slight atrophy of the muscles of the left shoulder, and distinct fibrillary twitchings are present in the left trapezius muscle, as well as in the second and third intercostal spaces on the left side.

The spine is mobile and absolutely free from any tenderness or rigidity. There is a distinct kyphoscoliosis in the cervical and upper dorsal regions, the convexity directed toward the left. The percussion note over the cervical region shows no dulness. The neck muscles on the left side are somewhat spastic.

Sensations.—The superficial sensations on the left side of the body are entirely normal, with the exception of the neck, where a zone of dissociated anæsthesia is intercalated between the lower margin of the jaw and the clavicle, anteriorly, and the lower occipital region and the spine of the scapula, posteriorly.

On the entire right side of the body there is a marked disturbance of sensation below the ramus of the jaw, anteriorly, and the occiput, posteriorly, involving the pain and temperature sensibility; tactile sensibility is also disturbed on the right side, but in a lesser degree, and chiefly over the distal portions of the extremities, *i.e.*, below the wrist and knee.

The deep sensibility of the hands is normal; there is no ataxia of the arms and the articular sense of the toes is undisturbed on both sides. Sensation of the face is normal.

Pupils are equal and react normally; no oculopupillary symptoms.

The probable diagnosis of a central gliosis of the spinal cord was made; as the patient was able to pursue her occupation as nurse-maid, and suffered no pain, an exploratory laminectomy was not urged. She was therefore placed alternately upon iodides and arsenic.

December 20, 1907: Patient has had no pain since last examination. No vesical symptoms.

For the past two weeks, she has felt a unilateral girdle sensation on the right side at the umbilical level, which increases in the recumbent posture.

The objective examination is unchanged, except that the left hand and arm are somewhat weaker, and the numbness of the right hand is more constant and annoying.

May 29, 1908: Patient is still free from pain; girdle sensation has disappeared. There is constant and increasing paræsthesia of the right hand. She has continued her occupation as nurse-maid and is still able to sew and work with the right hand. The objective examination practically unchanged.

March 17, 1909: For some weeks, patient has again experienced the unilateral girdle sensation on the right side at the level of the umbilicus, which was previously noted. No pain and no vesical symptoms. The cranial nerves are negative, and the objective examination remains unchanged. It was noted that the erector pili reflex is absent on the left side.

October 24, 1909: For the past two months the right hand has been stiff and awkward. The functions of the right leg, except for increasing paræsthesias and sensory loss, are unimpaired. She has experienced occasional sharp twinges of pain in the upper right intercostal region, but neither constant nor severe.

February 6, 1910: The right arm and leg are both worse. It is impossible to use the right hand now for sewing and finer work, and she was forced to abandon her occupation two months ago.

There is astereognosis of the right hand and the deep sensibility of the toes on the left side is abolished, but is present on the right. Numbness of the left leg is now present, which has ascended to the knee.

Examination.—Station shows slight Romberg. Spinal hemiplegia of the left side has increased. The cranial nerves are all normal; the optic discs are negative. Percussion of the cervical spine reveals no tenderness and no change in the percussion note. Fibrillary twitchings are present in the trapezius and supra- and infraspinatus muscles on both sides. No oculopupillary symptoms are present. The erector pili reflex is absent on the left side of the trunk, and occasional jumping and starting spasms occur in the extremities at night. No vesical symptoms.

Sensation.—The superficial sensations are very much as noted in previous examinations. There is anæsthesia from the level of the jaw, anteriorly, and from the lower occipital region, posteriorly, throughout the entire right side, which is complete over the distal portions of the extremities and the right side of the trunk and neck; it is less marked along the inner side of the arms and thighs.

The sensations of the left side of the body are normal, except for a strip of anæsthesia between the jaw and clavicle, anteriorly, and occiput and spine of the scapula, posteriorly, where the loss of pain and temperature sense is complete, and the tactile sensation is diminished but not lost.

There is marked astereognosis of the right hand. The deep sensibility of the toes on the left side is lost, but is preserved on the right.

There is a slight hyperæsthetic zone along the lower jaw on both sides and across the upper thoracic region (second and third ribs).

An exploratory operation was performed at my request, on March 28, 1910, by Dr. Woolsey. The third, fourth, and fifth laminæ were removed; the dura mater was swollen and there was no pulsation. After incision of the dura, there was a copious discharge of cerebrospinal fluid—about four ounces. In the middle of the bone wound and a little to the right of the median line, a dark and somewhat discolored spot appeared on the posterior aspect of the cord; its surface was smooth and covered by pia mater. The cord was swollen, but no other abnormalities could be detected. A puncture was made over the discolored area near the median line, and about two drachms of clear fluid escaped, and as it flowed out, the posterior aspect of the cord collapsed. The walls of the cavity, from which the fluid escaped, seen through the small puncture which was made, appeared of a brownish hue. The anterior and lateral regions of the cord and the nerve-roots were normal to the naked eye.

Examination (April 8, 1910).—Has made a good recovery from the operation. Had considerable pain in the shoulder for the first few days, and there was some weakness of the right arm, with increased weakness of the left arm and leg, which has rapidly improved. She has good control of the sphincters; there are no oculopupillary symptoms. Sensory symptoms unchanged.

Remarks.—The diagnosis of a tumor growth seemed clear from the occurrence of root pains in a circumscribed distribution, followed by symptoms of unilateral compression of the cord, gradually progressing. It was, however, by no means easy to determine whether the growth was extra- or intramedullary in origin. In favor of a tumor without the cord and compressing it were the initial pains covering a period of three years, a Brown-Séquard paralysis of very gradual development, and the extremely long and progressive course of the disease (about fourteen years). Central tumors (slowly growing glioma and gliosis) may, however, present a very similar picture, and this was regarded as the probable diagnosis. There were, however, no trophic disturbances, and the anæsthesia was not of the dissociated type, save the strip on the left side of the neck between the jaw and the clavicle. The fibrillary twitchings which were present may also occur in

extramedullary tumors, so that great weight could not be attached to their presence, and, in a hemiplegia of such long standing as had existed in the case, a kyphoscoliosis, so common in syringomyelia and spinal gliosis, would not have much diagnostic significance. As the condition of the patient grew worse and the right hand became seriously involved, she decided to submit to an exploratory operation. It is, as yet, too soon to say how great a benefit will be derived from the evacuation of the cystic fluid within the cord. The recovery from the operative procedure was rapid, and the initial operative paresis soon wore off. It is interesting to note that the girdle sensation disappeared after the operation.

Case IX (Summary).—*Central intramedullary tumor of the cervical region, exploratory laminectomy performed; growth inoperable, and the wound closed. Recovery from the operation; patient died some months later with complete motor and sensory paralysis. Onset of symptoms with weakness and numbness of the left hand, three months later appearing in the right. Gradual progression of symptoms; weakness and atrophies of the upper extremities, anæsthesia, and spastic paraplegia. Occasional pains and symptoms of posterior root irritation in the distribution of the cervical nerves.*

History.—The patient, a married woman aged thirty-seven, was referred to Dr. Ramsay Hunt by Dr. William M. Polk. She had borne seven children, all healthy. She had had two miscarriages, and the husband gave a positive history of syphilis acquired five years before marriage. There was no history of injury. Onset of symptoms, in November, 1908, with numbness on the ulnar side of the left hand, which was soon followed by weakness of the fingers. Three months later, a numb feeling developed in the middle finger of the right hand, which gradually extended over the entire palmar surface of the hand. She had occasional shifting pains in the arms and legs, but these were not constant and not severe. She also had occasionally pains in the back of the neck. The weakness of the hands gradually increased, and the numbness extended over the palms and fingers. There are no vesical symptoms. At times she experiences a feeling of numbness over the abdomen and on the left thigh; and the left leg, subjectively, is weak.

Examination (February 27, 1909).—The gait and station are normal. Pupils are equal and react normally. There is a distinct weakness of the intrinsic muscles of both hands, which is more marked on the left. Extension of the wrists is also weak. There is a moderate degree of atrophy of the intrinsic muscles of the left hand, which is also present to a lesser extent on the right. The supinator and biceps reflexes are present; the triceps jerks are absent; the knee-jerks and ankle-jerks are active on both sides. There is no ankle clonus, and no Babinski reflex on either side.

Sensations are normal, with the exception of a strip of anæsthesia along the ulnar side of the hands and forearms on both sides, more marked upon the left. The tactile, pain, and temperature sensations are all equally involved (there is no dissociation of sensibility). The spinal column is perfectly mobile, and there are no areas of tenderness.

April 28, 1909: The patient's condition is distinctly worse in spite of a thorough course of iodides and mercury. The hands are weaker, and she complains of the legs and trunk feeling numb and cold. There are also slight twitching and trembling movements in the fingers (coarse fibrillations); no oculopupillary symptoms. The sensations are about the same as at the last examination, except that the strip of anæsthesia which was present on the ulnar side of hands and forearms has ascended along the inner side of the left upper arm.

June 1, 1909: For the past ten days had had vesical trouble for the first time, which followed a very severe paroxysm of pain in the neck and arms, lasting several weeks. Coinciding with this paroxysm of pain, the left pupil became temporarily smaller than the right, and there was a slight drooping of the left eyelid. The left leg was also the seat of transient weakness.

June 22, 1909: Movements of the neck are free, and there is no pain except occasional painful paræsthesias in the left hand. The eyes are normal, and there are no vesical symptoms. At times the left hand swells and becomes red and tender. The left leg, subjectively, is weak and numb. The hands are weaker, and the anæsthesia has extended to the trunk upon the left side, reaching from the third intercostal space on the left side to the level of the umbilicus; all sensations are involved. The strip of anæsthesia on the arms, which at the last examination was con-

fined to the inner side of both upper extremities, has now passed around and includes the posterior aspect as well. Her condition has grown steadily worse, notwithstanding a hypodermic course of mercury and large doses of the iodides. The question of exploratory laminectomy was discussed, but it was decided to wait until the autumn, unless her symptoms took a sudden turn for the worse.

September 17, 1909: During July and August she had a few attacks of pain, centred in the midspinal region at the level of the sixth and seventh cervical vertebræ. These paroxysms of pain, however, were not so severe as the one noted in June. For the past few weeks she has had difficulty in controlling the sphincters, and the legs are growing weaker. The weakness is greater on the left side, and although she stands and walks well there is a tendency to drag the left leg. The right pupil is larger than the left, but there is no ptosis and no enophthalmos. The cranial nerves are normal. Ankle clonus is present on both sides, more marked on the left, and Babinski reflex on both sides. The spinal column is negative. There is complete anæsthesia to touch, pain, and temperature below the level of the third rib anteriorly, which includes the inner and posterior aspect of both upper extremities. The articular sense of the toes is also disturbed on both sides. The hands are weaker, their intrinsic muscles are more atrophied, and fibrillary twitchings are present.

October 6, 1909: For the past three weeks has had considerable pain in the back of neck, extending up to the occiput. Percussion of the spine is negative, and there is no tenderness or rigidity. Weakness of the sphincters of the bladder and rectum. There is extreme weakness of the movements of the wrists and fingers and extension of the elbows, more marked upon the left side. The flexion of the elbows and movements of the shoulders are well preserved. The oculopupillary symptom (ptosis, myosis, and enophthalmos) typically present on the left side. There is spastic paraparesis of the lower extremities, with clonus, more marked on the left. Superficial sensations are practically abolished below the level of the third rib anteriorly. The abdominal reflexes are absent.

An exploratory operation was performed October 11, 1909, at my request, by Dr. Frank Hartley at the New York Hospital. The spines and laminæ of the sixth and seventh cervical vertebræ

were removed. The dura does not pulsate and appears distended. After it was incised, there was a gush of cerebrospinal fluid under considerable pressure. The pia mater is smooth and glistening, but the cord itself is swollen, and is of a pinkish and mottled hue. It evidently contains an intramedullary tumor; extirpation was impossible. Exploratory puncture of the cord was not deemed advisable, and the wound was closed.

The patient recovered from the effects of the operation, but her condition grew steadily worse and she died four months later, having developed a total transverse lesion of the spinal cord, with contractures and bed-sores. No autopsy was performed.

Remarks.—The symptoms and clinical course of this case were in favor of a central, intramedullary tumor of the cord. She had experienced, however, from time to time, severe pains in the neck in the distribution of the cervical nerves, and as all other forms of treatment had been of no avail, and her condition was gradually progressing, it was deemed wise to give her the benefit of the doubt and explore the spinal cord at the diseased level. I would emphasize the fact that at no time did she present a definite dissociated anæsthesia (loss of pain and temperature sense), which is so common in central tumors. This, in conjunction with the symptoms of posterior root irritation, were regarded as sufficient to justify the exploration.

Case X (Summary).—*Spindle-cell sarcoma of the meninges at the level of the second, third, and fourth dorsal segments. Exploratory laminectomy, but extirpation of the tumor was impracticable, and the wound was closed. Onset of symptoms December, 1901, with lancinating pains between and beneath the shoulder-blades, also encircling the chest in the upper intercostal spaces. Six months later, bilateral symptoms of spinal cord compression, which rapidly progressed to complete motor and sensory paralysis. Rigidity of cervical and upper dorsal regions, with localized tenderness.*

Patient, a man aged twenty-three, was admitted to Bellevue Hospital in the service of Dr. Dana, through whose courtesy I was enabled to observe the case. He denies syphilis, and gives no history of injury. In the latter part of December, 1901,

he was seized with pain in the upper portion of the back between the shoulder-blades, which was especially severe and constant over the lower angle of the right scapula. At first the pain occurred only at night, and during the day he was practically free from it. Later the lancination became more severe, and radiated into the upper intercostal spaces on both sides; at times there were sharp pains in the depths of the axilla, which would shoot into the arm. In July, 1902, the lower extremities became weak and numb, and there was retention of urine. At this time there were frequent spasmodic twitchings of the lower extremities, and the legs would be drawn up under him by spontaneous contractions. By the latter part of July, the lower extremities were so weak that he was forced to take to his bed, and a complete paraplegia with incontinence of urine and sensory disturbances supervened.

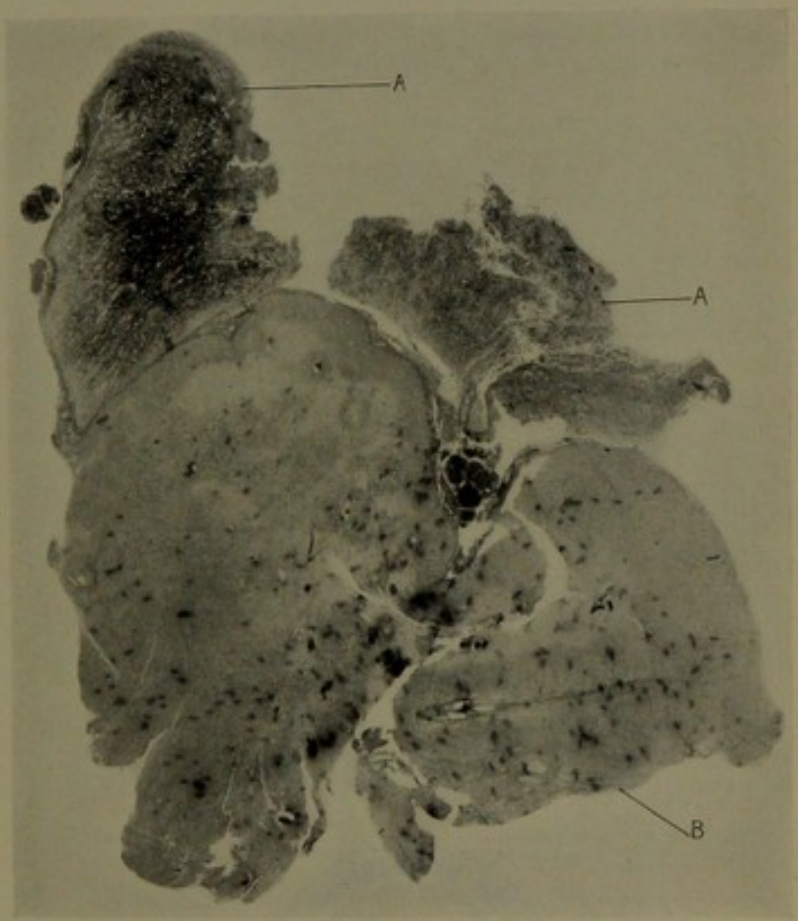
Examination (October, 1902).—The cranial nerves and pupillary reflexes are normal. Gross motor power, the sensation, and reflexes of the upper extremities are normal. The head is held in a position of fixation; lateral movements may be carried out, but are somewhat restricted. There is considerable restriction of the forward and backward movements of the head. Palpation of the pharynx is negative. In the upper dorsal region, corresponding to the sixth, seventh, and eighth dorsal spines, there is a slight prominence, and a distinct area of tenderness to the left of the sixth dorsal spine. Jarring of the vertebral column does not produce pain. There is complete paraplegia, with incontinence of urine, ankle clonus, Babinski, and exaggeration of the tendon reflexes. The abdominal and cremasteric reflexes are absent. There is also complete anæsthesia, reaching as high as the nipple line anteriorly, and the fifth dorsal spine posteriorly. Immediately above the line of anæsthesia is situated an hyperæsthetic band about three inches in width. The temperature is generally normal, but there are occasional rises to 100° and 101° F. The lungs are normal. On November 18, an injection of tuberculin was made, with negative result. On December 1, another injection of tuberculin was followed by a rise of temperature to 103.6° F., the highest point which the temperature had yet attained. Antisyphilitic remedies had been tried without avail, and as fixation and extension of the spine had produced no amelioration of symptoms, an exploratory operation was decided upon.

Operation (December 17, 1902).—Operation by Dr. Gallaudet. Ether anæsthesia. An incision was made in the median line over the upper dorsal region. The spines and laminæ of the fourth, third, second, and first dorsal vertebræ were removed in turn. No abnormality of bone or dura was detected. The dura was somewhat swollen and did not pulsate. On incising it, at the level of the second dorsal spine, the spinal cord bulged through the opening and was found to be enlarged, softened, and of a whitish color. The tumor could not be demarcated from the surrounding cord substance, so that any attempt at extirpation was found to be impossible and the wound was closed. The patient recovered from the immediate effects of the operation, but died January 3, 1903.

No autopsy was performed, but the wound was opened, and a section of the spinal cord between the seventh cervical and fifth dorsal spines was removed. At its middle portion, which corresponded to the second and third dorsal segments, there is a large tumor mass two inches in length and three-quarters of an inch in width, which is irregularly nodular externally and presents a white homogeneous appearance on the surface of section. The growth is intimately attached to the inner surface of the dura and the pia mater, and has caused almost complete destruction of the cord (see Fig. 3). Histologically, the growth is a spindle-cell sarcoma, apparently taking its origin from the inner surface of the dura, although sarcomatous infiltration is also present on the external surface of the pia arachnoid (see Fig. 4). The cord substance itself is compressed but not infiltrated (compression myelitis).

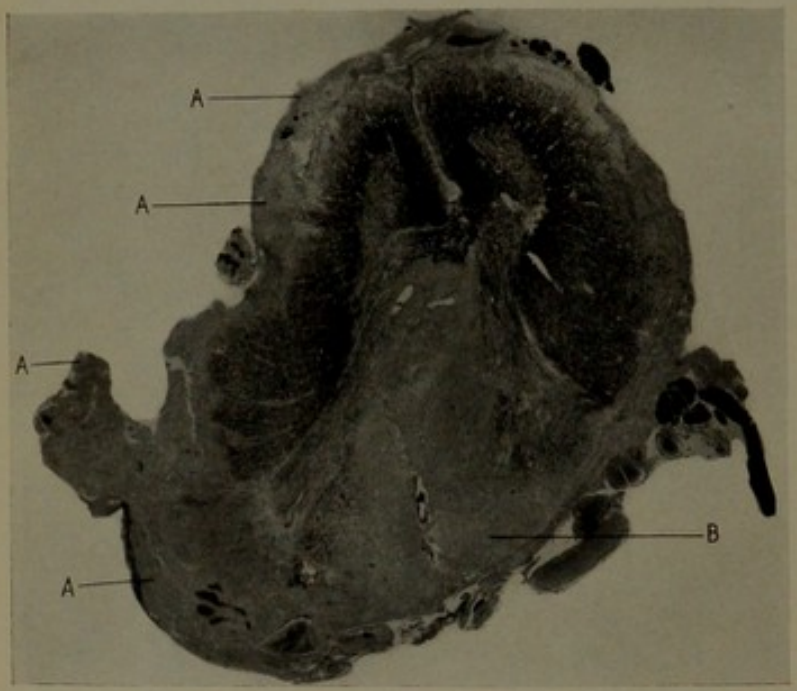
Remarks on Symptomatology.—The onset of the clinical picture, with lancinating pain, bilateral and segmental in distribution, followed in six months by symptoms of rapidly developing medullary compression, were in favor of a rapidly growing neoplasm. There was, however, some uncertainty regarding the nature of the affection. For a time, tubercular caries, with compression, was considered, and this view was confirmed by what seemed to be a positive tuberculin reaction. The rigidity, with slight vertebral deformity at the level of the sixth, seventh, and eighth dorsal spines, with tenderness

Fig. 3.



Case X. Spindle-cell sarcoma of the meninges, compressing the cord at the third and fourth dorsal segments (Weigert-Pal method). *A*, remains of spinal cord; *B*, tumor.

FIG. 4



Case X. *A*, spindle-cell sarcoma of the pia mater surrounding and compressing the anterior and posterior nerve roots; *B*, secondary degenerations in the posterior columns. (Weigert-Pal method.)

and occasional rises of temperature, were also in favor of this view. There was, however, no pain on jarring the vertebral column. A syphilitic affection was also considered, especially the pachymeningitis syphilitica, but no amelioration of symptoms followed the use of iodides and mercury, so that, as a last resort, an exploratory laminectomy seemed advisable.

Case XI (Summary).—*Onset with shooting pains in the hips, lower lumbar region, and front of the thighs. Four months later, weakness of the lower extremities, with paræsthesia and sensory disturbances. Rapid progression of symptoms, followed by complete paralysis of motion and sensation below the level of the twelfth dorsal segments. Extreme atrophy of the muscles in the gluteal region on both sides. Autopsy revealed a spindle-cell sarcoma of the meninges, with complete destruction of the cord in the lumbar region.*

History.—The patient, a woman twenty-three years of age, was seen in consultation by Dr. Ramsay Hunt with Dr. R. L. MacFarland at the Jamaica Hospital, L. I. There was no history of syphilis or injury. Onset of symptoms in April, 1902, with shooting pains in the region of the right hip. A few weeks later, similar pains, of lancinating character, were felt in the corresponding region of the left side. She also had pain in the lower lumbar region, and, later, shooting pains down the anterior and lateral aspect of the thighs. These pains continued during the early summer and were very severe. The last of July, weakness and paræsthesias of the lower extremities made their appearance. In August, the right leg was completely paralyzed, and the left partially so, with marked sensory disturbances. There was also retention of urine followed by incontinence. In November, the paralysis was complete. During this time lancinating pains had continued, but with less intensity.

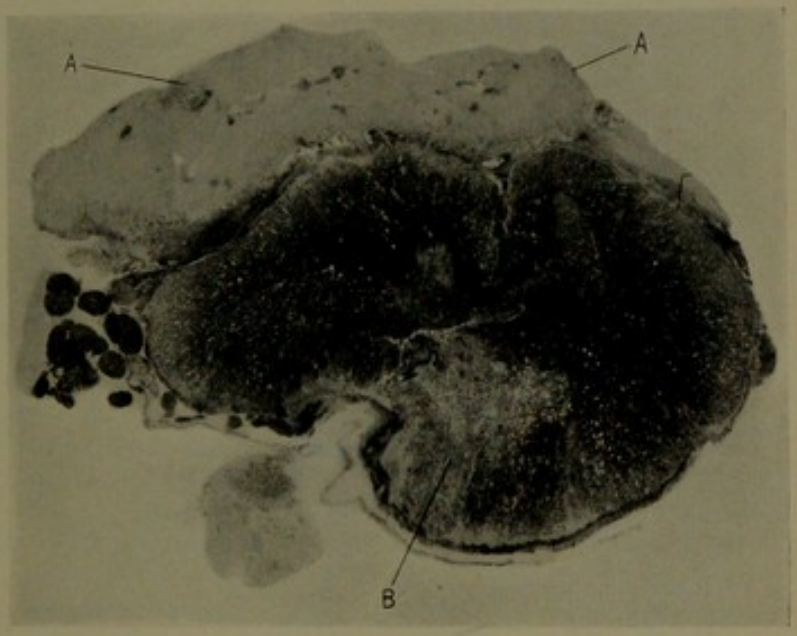
Examination (February 28, 1903).—The patient is well built and somewhat emaciated. Above the waist-line the physical examination is negative. There is a slight lateral curvature of the spine in the dorsolumbar region, but no kyphosis or abnormal projection of the spinous processes. The tenth and eleventh dorsal spines are very tender on direct pressure, but jarring produces no pain in the vertebral column at this level. In the sitting posture, there are pain and a girdle sensation which encircles the

body at the umbilical level. Posteriorly, there is practically complete atrophy of the gluteal muscles on both sides, so that all the anatomical landmarks of the pelvis stand out clearly on its posterior aspect. No fibrillations. The thighs and legs present a slight degree of general wasting, but no definite localized atrophy, as in the buttocks. There is a complete flaccid paraplegia, with loss of tendon and plantar reflexes. There is also complete loss of all sensation below a line midway between the navel and pubes anteriorly and the fifth lumbar spine posteriorly. The feet and ankles are somewhat œdematous. There is a bedsore over the sacrum, and others over the left buttock and the left heel.

The diagnosis was made of a rapidly growing tumor compressing the spinal cord in the lumbar region. The case was regarded as unfavorable for operation. A few months later the woman died, and the *autopsy* revealed a sarcoma of the meninges in the lumbar region. The vertebræ were free from disease. Through the kindness of Dr. MacFarland, the lower portion of the spinal cord was sent to me for examination. The tumor mass is a spindle-cell sarcoma, three inches long, and lay on the right anterolateral aspect of the lumbar cord. It apparently takes its origin from the inner surface of the dura mater. There is no evidence of growth on the external surface of the dura. The cord was not infiltrated by the growth, but was completely disorganized by the compression to which it was subjected. The tumor growth infiltrates the pia arachnoid on the anterior aspect of the cord in the lumbar region, surrounding and destroying the anterior roots (see Fig. 5).

Remarks.—This case is very similar in its course and symptomatology to Case X. Onset with lancinating pains in the distribution of the first, second, and third lumbar segments, which were followed in about three months by the symptoms of medullary compression, which progressed rapidly to complete motor and sensory paralysis below the level of the twelfth dorsal segment. Practically, the symptoms were bilateral in distribution, although the initial pain was felt first on the right side, and the right leg was the first to become weak. The extensive early wasting of the muscles of the buttocks

FIG. 5.



Case XI. Spindle-cell sarcoma of the meninges, showing infiltration of pia mater on the anterior surface of the cord, surrounding the anterior roots. *A*, tumor growth; *B*, degenerations in posterior columns. (Weigert-Pal method.)

is probably due to invasion of the anterior root of the lower lumbar and upper sacral segments. I consider the short duration of the root pains, their bilateral distribution, and the early appearance of symptoms indicating medullary compression as distinctly unfavorable signs as regards the operability of the tumor—these symptoms suggesting a rapidly growing malignant neoplasm of inoperable character.

Case XII (Summary).—*Onset with pains in lumbar region followed by lancinations in the distribution of the first lumbar segment on both sides. Ten months later, gradual development of a compression paraplegia. Vertebral column practically negative, save for an insignificant prominence of the tenth dorsal spine. Exploratory laminectomy revealed an infiltrating tumor of the spines and laminæ of the eleventh and twelfth dorsal vertebræ, compressing the nerve roots in the intravertebral foramina as well as the cord within the spinal canal. Pathological diagnosis—carcinoma (a small scirrhus growth was later discovered in the left breast which had remained latent).*

History.—The patient, a woman aged forty-seven, was referred to Dr. Ramsay Hunt by Dr. Frank Meara on December 26, 1908. She had borne two healthy children, and had had two miscarriages; no history of injury. She is well nourished, has a good color, but is very nervous as the result of her long suffering. Her illness began in December, 1907, with pain in the lumbosacral region, regarded at first as probably rheumatic, but which did not respond to treatment. These pains in the lumbosacral region continued with variable intensity until May, when there was an interval of about six weeks in which she was entirely free. The pains in the lower lumbar region then reappeared, and were accompanied by shooting pains around the hips on both sides. When severe, the pains extended up the spine between the shoulders. The pains continued during the entire summer, increasing in severity, and in November, 1908, was first noticed an unusual coldness of the feet below the ankle (sensation of freezing). This was soon followed by paræsthesias of the feet and ankles and, later, weakness, more especially of the left leg. When the lumbosacral pains were especially severe, the back became quite stiff in this region. No shooting or lancinating pains were felt except around the hips, and these were equal in intensity on the two sides. No vesical symptoms.

Examination (December 27, 1910).—Patient is bed ridden and cannot stand or walk without assistance. The spine is normal in mobility and in appearance (no deformity). There is absolutely no pain on jarring; there is, however, some tenderness on pressure over the second and third lumbar spines (which was slight and was not confirmed on subsequent examinations).

There is a spastic weakness of the lower extremities, more marked of the left leg, on which side ankle clonus is present; Babinski reflex present on both sides; abdominal reflexes present and active. There is a band of hyperæsthesia and hyperalgesia in the lower lumbar region, which encircles the body at the level of the groins.

Sensations.—The temperature sense of the lower extremities is disturbed. Tactile, pain, and deep sensibility are normal. There are areas of analgesia over the right hip in the distribution of the first lumbar nerve.

January 16, 1910: Patient was again examined in consultation with Dr. Dana. She still has pain in the lower lumbar region, especially at night, but less severe than formerly. Lancinating pains are still felt around the hips, of equal intensity on the two sides. No vesical symptoms. Weakness of the legs has progressed, in spite of the administration of iodides.

The spine is absolutely normal in appearance and mobility, and there is no tenderness demonstrable on pressure.

Sensations.—There is distinct loss of pain and temperature sensibility over the lower extremities, with preservation of the tactile sense. In the distribution of the first lumbar segment on both sides, distinct areas of anæsthesia to pain and touch are present.

February 26, 1910: Her condition is worse, paralysis has increased, and sensation shows greater impairment. There is now some disturbance of the vesical function. In the sitting posture there is noticeable for the first time a very slight prominence of the tenth dorsal spine. It is not marked, and there is no tenderness on pressure. Jarring of the spine produces moderate pain, which radiates in the region of the hips. There is an "erector-spinæ reflex" in the lumbar region, stroking or pricking of the skin invoking a muscular contraction.

March 5, 1910: Paralysis of motion and sensation continues to increase. Marked vesical disturbance. There is still pain in

the lumbar region and the hips. Sensation of pain and temperature especially, but also tactile sensibility is disturbed as high as the distribution of the first lumbar segment. The spinal column is perfectly normal in its mobility, and there is not the slightest trace of rigidity or of tenderness. *There is no pain on jarring.* The tenth dorsal spine is still slightly prominent, but this has not increased. There has been no elevation of temperature during her illness. The lungs are normal, and the other internal organs are negative. It was decided to perform an exploratory operation.

March 10, 1910: Exploratory laminectomy was performed by Dr. Frank Hartley at the New York Hospital. The spines and laminæ of the tenth, eleventh, and twelfth dorsal vertebræ were removed. On cutting away the spines from the eleventh and twelfth dorsal, they were found to be softened and infiltrated with tumor growth, which could be traced into the lumbar muscles of the left side. The roots of the twelfth dorsal and the first lumbar segments passed out through the growth on both sides. A collection of tumor tissue was also found within the spinal canal on the left side at the level of the twelfth dorsal and first and second lumbar segments, which had compressed and deformed the cord. The dura mater was normal in appearance and was not incised.

Immediately after the operation, patient went into collapse but revived after stimulation and the subcutaneous infusion of a salt solution. Histological diagnosis of tumor—carcinoma.

Note.—Following the pathological report, a careful palpation of the breasts was made, which revealed a small fibrous nodule on the left side. This had never been the seat of pain, and its presence was unknown to the patient. It was apparently a latent carcinoma of the breast which had caused no local symptoms. The patient made a good recovery from the operation, but the only result achieved was the amelioration of pain. Six weeks later, general cerebral symptoms developed and progressed rapidly, with stupor and choked discs, probably due to metastases in the brain. No autopsy was performed.

Remarks.—Prior to the operation in this case the symptoms were regarded as indicating in all probability an extradural tumor, compressing the posterior roots at the first lumbar

segment and later causing a spastic paraplegia from pressure upon the cord. The possibility of a primary growth of the vertebral column was very carefully considered, because of the long duration of pains in the lumbosacral region which persisted throughout the course of the disease. Owing to the complete absence of rigidity of the spinal column, and any constant point of tenderness or pain on jarring, an intravertebral growth (extradural) was regarded as very probable. For this reason, an exploratory operation was determined upon. The prominence of the tenth dorsal spine was so very slight that it did not weigh much in the scales against the practically complete absence of other vertebral symptoms; and severe localized pains over the spine at the level of the tumor, I have had occasion to observe in intravertebral growths as the result of meningeal irritation.

Operation showed that there was an extradural tumor in the vertebral canal which had also compressed the nerve-root of the twelfth dorsal and first lumbar roots, in their respective foraminæ, and so far the diagnosis was correct. The small latent growth in the left breast could have easily been detected had a careful search been made, but in the complete absence of subjective symptoms it was overlooked. The case is instructive in that a carcinoma metastasis of the spine may produce a symptom complex simulating very closely that of an extradural growth, in which the symptoms of vertebral involvement are absent or comparatively slight.

Case XIII (Summary).—*Melanoma of the sacrum, with compression of the cauda equina.*

Onset, September, 1906, with pains in the distribution of the third, fourth, and fifth sacral segments on the right side, followed by paræsthesias, diminution of the right knee-jerk and loss of the Achilles-jerk on the right side. In addition there was deep-seated bone pain and tenderness over the sacrum, the right tuber-ischium, and the right side of the pubes.

Exploratory operation (by Dr. Woolsey).—*Removal of the first, second, and third sacral and fifth lumbar segments, which were found red and softened, and the seat of tumor infiltration.*

The patient made a good recovery from the operation, but died two months later, greatly emaciated, with paralysis of the lower extremities and incontinence of the sphincters.

History.—The case was referred to Dr. George Woolsey by Dr. A. F. Warren of Chicopee Falls, and was seen in consultation by Dr. Dana and Dr. Hunt. He is sixty-eight years of age, and is a retired seafaring man. He was admitted to the Presbyterian Hospital on April 12, 1907. The symptoms of his trouble began in September, 1906, with pain in the right perianal region. This pain grew steadily worse and became a constant soreness and aching, so that he was forced to sit almost entirely upon the left side. He had been a sufferer from hemorrhoids for some years, and it was supposed that his pains were due to this cause. An operation for the relief of hemorrhoids was then performed in Chicopee Falls, but after a transient period of relief the pains returned with increased severity, and in addition to the constant aching pain in the perianal region, he also experienced lancinations down the back of the right thigh and over the right side of the buttock. He occasionally has deep-seated pain over the right inguinal region. In the course of a few weeks there appeared paræsthesias in the right perianal region, and the posterior surface of the right thigh. The genitalia also became numb, and he did not have proper control over the sphincters of the bladder or of the rectum. The sexual power has also failed and he is now impotent. There was little or no sensation of urine passing through the urethra and the passage of fecal matter was not attended by the customary sensations. There is some numbness over the left buttock as well. He has lost about 20 pounds in weight during the past few months. In December he commenced to limp badly with the right leg. When the pain is severe, he gets most relief by standing; in the recumbent posture, he lies with the right leg flexed.

Examination (March 5, 1910).—Patient is a small, poorly nourished man, is emaciated, and considerably prostrated by his illness. He is able to stand and walk, and the motor power of the lower extremities is good. The spine is normal in appearance and in mobility. There is a distinct area of tenderness over the upper portion of the sacrum. There is also deep-seated bone tenderness over the right side of the pubic arch, the right tuber-

ischium, and over the middle of Poupart's ligament. The movements of the hip-joint are free and unrestricted; there is no tenderness along the nerve-trunks. The right thigh and right leg are one-half inch less in circumference than on the left side, but the gross motor power is well preserved. The knee-jerk is diminished on the right side, and the Achilles-jerk is lost. The plantar, abdominal, and cremasteric reflexes are all present and normal.

Sensations.—There is a longitudinal strip of anæsthesia which extends along the posterior aspect of the thigh in the distribution of the third sacral segment. The tactile sensibility of the external genitalia and perianal regions is diminished. Rectal examination shows a relaxed sphincter, and, upon the right side of the pelvic wall near the sacrosciatic notch, there is felt a firm nodular body, freely movable, which suggests an enlarged gland. The bony structures are normal to the touch.

Examination of the urine for Bence-Jones albumin yielded a positive reaction on several occasions; at other times the tests were negative.

On March 16, 1910, an exploratory operation was performed by Dr. George Woolsey at the Presbyterian Hospital. The spines and laminæ of the three upper sacral and the fifth lumbar vertebræ were removed. On exposing the sacrum, the bone was found to be softened, spongy, and red in color, so that it could be easily scooped out and scraped away with a curette, and was very evidently diseased. The dura mater was incised, and a free flow of cerebrospinal fluid took place. The roots of the cauda equina were found to be normal, and a probe passed up the canal for two or three inches met with no resistance.

Pathological diagnosis of tumor was melanoma.

Note.—The patient made a good recovery from the operation, the wound healing by first intention. After the operation the pain was somewhat less, but the anæsthetic area remained unchanged. He was discharged from the hospital on April 12. Dr. Warren, his family physician, informed us that soon after the patient returned home, the pain increased and the right leg became paralyzed. Later the left leg was similarly affected, and there was complete incontinence of urine. He was unable to assume a sitting posture on account of the very severe sacral pain. He died six weeks after leaving the hospital, greatly emaciated.

Remarks.—It was very evident from the sacral pain and tenderness, as well as tenderness over other bony structures of the pelvis, that we were dealing in this case with a tumor of the sacrum, which had compressed the strands of the cauda equina. The pains were so intense and intolerable that an operation was deemed advisable for the relief of pressure. The result, however, was not very satisfactory.

SURGICAL PAPER BY DR. WOOLSEY.

The technic of operations for the removal of intraspinal tumors first involves a laminectomy. At the outset we must determine whether we will do a simple or an osteoplastic laminectomy. My personal preference is strongly in favor of a simple laminectomy, for as a rule the simplest technic is the best. It gives the best and most free exposure and can more readily be extended in either direction to meet the conditions in a given case. It is the easiest, takes less time and is the safest. It does not essentially weaken the strength or the carrying or supporting power of the spine to remove three to five laminæ, for the latter do not bear any weight except possibly to a slight extent in the upper cervical region. This is also borne out by experience. The cord is amply protected by the thick covering of muscles and fascia over the firm theca. Furthermore as, before the removal of the laminæ, an attempt is often made to spare the superficial periosteum, more or less of a bony covering may be reproduced. This was not found to be present however in Case III, reoperated one year after the first operation. The spine is somewhat stiff at the laminectomy site but no more stiff, if as much so, as where an Urban or Hartley-Bickham operation is done.

If any form of osteoplastic operation is done the only one I would consider would be that known as Cavicchia's as practiced by Durante. Abbe has employed a very similar procedure in the intraspinal division of the posterior nerve roots for neuralgia and also in operations on intraspinal tumors. It consists of laying back a muscular flap including the spinous processes. Through a slightly curved or angular

incision a little to one side of the median line the superficial muscles are split longitudinally a little to one side of the spines, the longissimus dorsi group of this side is divided transversely at the upper and lower ends of the slit and retracted toward the median line to allow the division of the spines at their bases. The muscles of the opposite vertebral groove are then elevated from the laminæ and retracted, with the severed spines and longissimus dorsi to allow the removal of the laminæ. There is little if any less hemorrhage than in simple laminectomy, in which the hemorrhage is readily controlled. The only bony portions left are the spines, and these can add little if any to the strength of the column. Besides, in the dorsal position the rough bases of the spines are pressed toward the dura and might possibly cause irritation of it. The method therefore seems to me inadvisable and should be discarded in favor of the simple laminectomy. The unilateral laminectomy employed by Taylor in the intraspinal division of posterior nerve roots does not give sufficiently free access for the removal of tumors. Sonnenburg attributed a fatal result from meningitis, due to infection, to the use of Urban's osteoplastic method.

A modified Sims' position on the left side with the patient as prone as possible, is suitable for any part of the spine. The patient should be on the left side, as this is more convenient for the operator, whether the tumor is on the right or left side. Or the patient may lie prone on the belly. The part to be operated on should be flexed as much as possible, to facilitate the laminectomy by separating the laminæ as much as possible and by making the spines prominent posteriorly; and it should be higher than the head and the rest of the spine as well to limit the escape of cerebrospinal fluid when the dura is opened. This position can be quickly obtained in part by lowering the head somewhat in the Trendelenburg position, or, better, by the use of the Lilienthal bridge on the operating table. The use of cushions under the part of the spine to be operated on answers all purposes in most cases. When the operation is upon the cervical region the prone

position, with the head supported on an extension head rest and the shoulders raised so as to allow thoracic and abdominal respiration, is a convenient one.

In view of the fact brought out by Crowe,[14] that urotropin is excreted by the cerebrospinal fluid, fifteen grains of this drug should be administered shortly before the operation, as its maximum concentration in the fluid occurs from one-half to one hour after its ingestion. It should also be continued after the operation in divided doses for several days, giving thirty grains or more every twenty-four hours, on account of its inhibitory effect on the growth of organisms in the cerebrospinal fluid, thus minimizing the danger of meningitis.

In order to determine the position of the incision the spine or spines should be found under whose neural arch the neurologist has localized the tumor. Except in the cervical region it is better to count the spines from above and below, above from the vertebra prominens, below from the fourth lumbar spine, on a level with the highest point of the iliac crests. In patients not too stout we can follow up the twelfth rib to the upper end of the twelfth thoracic vertebra as an additional landmark. It is also convenient to remember that the vertebral end of the spine of the scapula corresponds to the third thoracic spine, for in some cases, where the sixth cervical spine is more, or the seventh less, than usually prominent, it is hard to make sure of the vertebra prominens and to distinguish it from the sixth cervical or the first dorsal spines. When in such cases it is difficult to count the spines accurately, all such accessory landmarks are useful. In operations on the cervical region, after the spinous processes are exposed, it is well to remember that the spine of the sixth cervical vertebra is the lowermost bifid spine of the cervical vertebræ.

If a bed-sore exists on the back it should be thoroughly treated by 95 per cent. carbolic acid, followed by alcohol and then painted thickly with iodine. The area should then be excluded from the field of operation by a light dressing covered with thick gutta-percha tissue fastened to the skin around it by chloroform.

The median incision, having its centre opposite the diagnosed position of the tumor, is carried down directly to the tips of the spines and should be ample, at least 10 cm. and often 15 cm., corresponding to a minimum of three or four spines and often to five or more. A transverse incision through the aponeurosis at either end of the incision may be made to allow of easier retraction of the edges and exposure of the spine, but is not necessary. After dissecting around to either side of the three or more spines exposed, the soft parts are rapidly removed from either side of them by blunt dissection, aided by the knife, down to their junction with the laminæ. It is not necessary to do this subperiosteally. To give more room for the next step, the clearing of the soft parts from the laminæ, the spines may now be cut off at their bases by a bone forceps bent on the flat, after dividing the supraspinous and interspinous ligaments between them, or this step may be deferred until the laminæ are cleared. The latter is accomplished by a periosteal elevator or raspatory, by which it is sought at the same time to strip back the periosteum. In freeing the soft parts from the spines and laminæ, there may be considerable hemorrhage, mostly venous, but this is not invariable. This is readily controlled by packing with gauze wet with very hot salt solution alternately on the two sides, as we work on the opposite side. Few if any vessels require the use of forceps or ligature.

When the entire laminæ have been cleared their removal is the next step. This may present some difficulty at first, especially in the thoracic region where the laminæ are more imbricated. The difficulty lies in effecting the first entrance into the canal, the rest is easy. To effect this entrance one may use a Hudson or Doyen burr or a trephine, others use a bone-cutting forceps, and Bickham recommends a Doyen hand saw, for the entire removal of the laminæ. A quick, safe and easy method is to use a rongeur bent on the edge with a flattened lower blade, beginning along the lower border of the laminæ. With the same instrument, or a more powerful one, the laminæ of three or four vertebræ are removed

piecemeal to their outer limit. This is accomplished easily and quickly as soon as an entrance is made into the canal. If a hand saw is used the saw cut must be directed somewhat obliquely inward so as not to saw down into the pedicles. Some use a Gigli saw after an entry is made into the canal, but it is difficult to pass and hence is objectionable. With the use of a rongeur there will be little or no trouble with hemorrhage from the bone, but if the oozing from the bony surfaces is troublesome it may be checked by crushing the surface with a blunt rongeur or the pressure of an elevator, etc., by hot pads or by Horsley's wax. To give room for the operation within the canal and to allow for the possible uncertainty of localization, the laminæ of at least three and perhaps four vertebræ should be removed. But it may be preferable to open the dura after the removal of the laminæ of two vertebræ to see whether the laminæ above or below require removal.

So far the operation has been merely a laminectomy. The ligamenta subflava may adhere to the dura, but are readily peeled off, and the fat surrounding the dura is now exposed. If there is an extradural tumor, it is now exposed if, as is the rule, it lies in whole or in part on the dural aspect. If the tumor is extradural we proceed to remove it, removing as many more laminæ in either direction as may be necessary, for extradural tumors, especially cysts, often extend a considerable distance longitudinally within the canal. Care should be taken in separating the tumor from the dura, from which it commonly grows, to avoid injury to the latter, unless on account of its involvement a section of it must be removed. If an opening has been made in the dura with loss of its substance we may try to close it by suturing some of the overlying soft parts to the edges of the defect.

Starr advises opening the dura in extradural tumors, as a secondary growth may be found within it, but it is not often done. Before opening the dura a strong probe or a Horsley dural separator should be used to explore the extradural portion of the canal above or below the opening to make

sure that no extradural cause of pressure exists. The compressing masses of cicatricial tissue, secondary to a healed tuberculous process, which have been removed by Macewen, Trendelenburg and others, are extradural in position.

If no tumor is found extradurally, we expose the dura by pressing back the fat from either side of an incision in the median line and observe whether or not all the dura exposed pulsates. Lack of pulsation indicates increased intradural tension or shutting off of the arachnoid space at or above the point exposed, by a tumor, cyst, adhesions or some other cause. The dura should be palpated before it is opened, though an intradural tumor is not usually demonstrable before the dura is opened, even if it is situated posteriorly. If the dura feels more tense and elastic than usual, a tumor or some other cause of increased intradural tension probably exists. The dura is opened by the point of a knife and slit up and down in the posterior median line, the length exposed, by a pair of fine scissors. Its margins are held apart by silk retraction sutures, forceps or retractors. The cerebrospinal fluid escapes at first to some extent, sometimes as if under considerable pressure, but it offers no trouble by its continued flow, for it quickly ceases if the part operated upon is made higher than the rest of the spine and the head. In my first case, a tumor in the cervical region, I gently packed off the canal above the site of operation with gauze, but this was found unnecessary in subsequent cases even in the cervical region, though in the neck it is not so easy to give the spine a position higher than the rest of the arachnoid fluid. Schede used and spoke highly of Sick's proposal to pass a temporary elastic ligature outside the dura to shut off the fluid by its pressure, but this is more objectionable than packing off with gauze.

After exposing the cord, it is often not an easy matter to say at once whether there is a tumor present or not, or if present what its exact position and limits are. We can say that the cord does not appear normal and is prominent, but we may not be sure whether this is due to an intra- or an

extramedullary tumor. This is an important point and the cause of this difficulty lies in the fact that, in many cases at least, the arachnoid over the tumor is thickened and presents a number of lamellæ, often œdematous, which must be divided until the tumor or cyst, or both, are exposed. Sometimes one finds localized collections of fluid shut in between these thin lamellæ of arachnoid in the vicinity of a tumor, as in Case IV. Spiller, Munro, Krause and others have described encapsulated collections of cerebrospinal fluid which of themselves caused pressure symptoms, without other cause. In Cases II and V, I found a cyst, whose walls were formed by these lamellæ, about the tumor so that on opening the cyst, the tumor was fully exposed, though in Case V it was evident that a tumor was present in a dorsomesial position as soon as the dura was opened.

As a rule the tumor is on the dorsal aspect of the cord. This was so even in Case IV, where the motor symptoms predominated and the sensory symptoms were slight. The tumor may extend laterally or even ventrally as in Case I, so as to require the division of one or two posterior nerve roots. It is always advised to suture such divided roots, but as degeneration occurs in an ascending direction into the cord from the point of section and as no regeneration occurs in the fibres within the cord, I can see no object in such suture. If repair were to be expected under these conditions, the division of the sensory root of the Gasserian ganglion, proposed by Spiller and Frazier for tic douloureux, would be useless and the small length of the posterior spinal roots resected to cure intractable neuralgia (Abbe) would not insure against recurrence. Moreover the division of one or even of two posterior nerve roots intraspinally would have no serious effect on the sensation of the part supplied, for according to Sherrington and Greenbaum a given cutaneous area is supplied not by a single nerve root alone but by the root (or two roots) on either side of it, so that it would require the division of at least three successive roots to produce cutaneous anæsthesia. After division of one or two posterior roots the

cord may be gently retracted or pushed to the opposite side to give access to a tumor situated anteriorly.

When the tumor is exposed it is commonly found to be encapsulated and can usually be enucleated with only trifling hemorrhage by blunt dissection by the finger, a pair of forceps, a small scoop, or a Horsley's blunt separator. A few firmer strands of tissue may require division and at times one or more small vessels may require ligation by very fine catgut. The tumor, especially if of any size or of long standing, flattens the cord in a scaphoid manner, by bulging into the central part of the flattened area. The separation of the tumor from the cord is the first step in its enucleation and this may involve the division of a thin layer of tissue connecting the coverings of both. At times the tumor is found to grow from or to be so incorporated with one or more nerve roots (usually posterior roots) as to require their resection. To avoid any additional compression of the cord in enucleating the tumor, it may be wise in some cases to remove longitudinal wedge-shaped pieces from the tumor to reduce its bulk. After opening the dura sponging should be done with the greatest gentleness and care and to clear the field of operation drip irrigation with warm normal saline is preferable to sponging. In order to get above and below some of these tumors, we may have to remove two or three more laminæ. Thus in Case IV it was necessary to remove five or six laminæ to reach the limits of the growth.

Also if no tumor is found we should not hesitate to remove the laminæ higher up, to the uppermost limits indicated by the slightest changes in sensation. Even five or more laminæ should be thus removed if necessary, for there is less danger of a mistaken diagnosis than in failing to find the tumor. If this procedure is too much for the patient, it may be completed after an interval of a couple of days, as has been successfully done. If the tumor cannot be successfully removed, the posterior nerve roots, at and just beyond the level of the tumor, should be divided. This, together with the removal of pressure by laminectomy, would afford great

relief to the patient. If for any reason the cord is to be incised this should be done exactly longitudinally.

The dura should be completely sutured with fine catgut in a round needle to prevent leakage of the cerebrospinal fluid. If a needle with cutting edges is used, I have found (Case II) that leakage may occur through the needle punctures. In only one case (Case V) a small drain of three strands of catgut was left through a small opening of the dura. Some [15] advise incomplete closure of the dura or none at all, to allow free drainage of cerebrospinal fluid. This I consider objectionable unless there is oozing of blood (as in Case V). I have seen the free drainage of this fluid accompanied by a restless irrational condition, which cleared up with the stoppage of the outflow of the fluid. Brodnitz has suggested that it was the cause of the rise of temperature in two aseptic cases and, according to Henle, the free outflow of cerebrospinal fluid has repeatedly been followed by a fatal termination, even without infection. It is always annoying and there is also more risk of infection and of a resulting spinal meningitis, and there is more difficulty in avoiding bed-sores when the back cannot be kept dry. If after the operation there is any evidence or suspicion of an increase of the tension of the cerebrospinal fluid, it may be relieved by lumbar puncture.

The muscles are brought together with interrupted chromic gut sutures to obliterate any dead spaces, and the thick aponeurosis with a continuous suture of the same material. At the lower angle of the wound a small drain of folded rubber tissue is inserted down to the surface of the dura to drain away any blood or serum for the first twenty-four to forty-eight hours. If a suture is tied to the outside end of this, it may be removed by pulling on the suture without disturbing the dressings. For the skin, a continuous buttonhole suture of silk answers well, but it should be reinforced by three or more interrupted, figure of eight, silkworm gut sutures through the skin and the edges of the vertebral aponeurosis, which are left in from twelve to fourteen days. This is for the reason that the skin edges are liable to separate,

after apparent healing and the removal of the silk sutures, allowing the wound to open up. This occurred in two cases (Cases II and V) in both of which there was some leakage of cerebrospinal fluid, apparently through needle puncture holes in the dura, as a Hagedorn needle was used in suturing. Whether this was due to delayed union on account of natural slow repair in this situation, or on account of trophic disturbances at the site of the wound, or on account of the constant watery discharges, or to the pressure of the body and the lateral strain in case of restlessness (as in Case V), it should be avoided by the use of reinforcing silkworm gut sutures, which may and should be left in longer than the silk sutures, or by substituting for silk horsehair sutures, which can be left in as long as desired.

In the course of the operation the question may arise whether the operation is to be completed in one or in two stages. In Case III we were compelled to suspend the operation after removal of the laminæ and exposure of an extradural tumor on account of the failure of the pulse and respiration. The patient responded to stimulation, artificial respiration and an infusion of 1000 c.c. of normal salt solution. The use of stimulating and nutritive enemata brought the patient into much better condition than before the operation, so that she underwent the second stage, forty-two hours later, much better than the first. In Case IV, the only fatal one in the series, the operation was long and very difficult, the tumor extending under the laminæ of six vertebræ and being very adherent and difficult to remove from the much compressed cord. I have often wondered whether the result might not have been different had we operated in two stages, though the post-operative condition was not entirely that of shock or collapse. The blood pressure, taken from time to time during the course of an operation, would give an indication as to whether the operation should be suspended and completed subsequently or not. The previous and present condition of the patient, the amount of blood lost and the length of time the operation has already lasted also help one

to decide whether to operate in one or two stages. There is a very decided advantage in completing the operation in one stage. The increased risk of wound infection alone is enough to decide the question in favor of the one-stage operation, if that is possible. Horsley has advised the two-stage operation in cases of brain tumor, but I do not advise it in intraspinal tumors,[16] as Brodnitz, as a routine measure, has done. As an occasional resort in difficult cases or those in poor condition it may be of life saving service. The wound should be temporarily closed. In case we operate in two stages shall or shall we not open the dura in the first stage? Unless the condition of the patient forbids it I would advise opening the dura in the first stage to learn the presence or position of the tumor and the direction in which it extends and to determine whether or what additional laminæ require removal at the second operation. In a recent case operated on in two stages by Dr. Elsberg the tumor appeared at the first operation on opening the dura very much like an intramedullary growth, but at the second operation, the pressure of the cerebrospinal fluid having been relieved for some little time, the tumor was well demarcated from the cord, facilitating its removal. Again in other cases the absence of a tumor might possibly be demonstrated, thus making the second operation unnecessary. The dangers of the opening of the dura, sepsis and excessive loss of cerebrospinal fluid, are preventable ones. It adds but little to the time or shock of the operation. The dura should be temporarily sutured to prevent the leakage of cerebrospinal fluid.

The *mortality* of the operation itself was found by Harte[15] in his series of ninety-two cases (including cysts) to be nearly 47 per cent. Among the ninety-six cases of operations on intraspinal tumors collected by Krause the immediate mortality (within the first twenty-four hours) was 10.4 per cent.; the mortality within the first week 20.8 per cent. and within the first three months 39.5 per cent. Krause gave the mortality 43.7 per cent., and in the last twelve cases 25 per cent. Among the seven cases operated on by the writer, the mor-

tality was 14.3 per cent. This does not include two exploratory operations and one case where the pressure on the cauda equina was due to an endothelioma of the upper sacral vertebræ, in all of which the dura was opened and in all the patient recovered. McCosh has stated that the mortality of laminectomy itself should not be over 10 per cent. Including these three cases the mortality was just 10 per cent.

The chief causes of death are shock and meningitis. The former can be reduced to a minimum by guarding against hemorrhage and operating in two stages, if the laminectomy is not well borne. The shock as a rule is not serious, less so than in operations on the brain. As meningitis is due to infection, it should be avoided by careful technic and the administration of urotropin. Infection is most likely to occur when a bed-sore is present. Hence the presence of the latter makes the prognosis more serious. A bed-sore should be carefully sterilized as described above. Especial care should also be employed in sterilizing the sound skin, in cases where a bed-sore is present, by the free use of Harrington's solution, or by tinctura iodi, used on a dry surface. The danger from the excessive discharge of cerebrospinal fluid is one easily avoided at the time of operation and subsequently by the use of the precautions already mentioned.

The After-treatment.—The patient should be placed at once on an air bed in the dorsal position. As soon as the patient can be moved without much pain, he may be turned on the side for the relief afforded by the change of position. The prone position employed by some is not necessary, neither is any special support for the spine. For the relief of pain in the back and limbs, especially on movement, or of painful cramps, morphine is necessary, perhaps for several days. To prevent the formation of bed-sores the back should be kept carefully clean and dry and if a bed-sore exists its discharge must be kept away from the wound. The latter must also be carefully protected from infection by the discharges from the bladder and rectum. In cases with paraplegia care should be exercised to avoid pressure sores and pressure paralysis.

Thus in Case II there developed a peripheral peroneal palsy, which was due to pressure either on the operating table or in bed. The lower extremities were at the time paralyzed in this case. The drainage should be removed early and the retention sutures left for at least ten to fourteen days. If there is leakage of cerebrospinal fluid this may be diminished and finally stopped by the pressure of a gauze pad over the line of the incision. If moderate in amount it will probably do no harm, even if it continues for some time, but besides being annoying it increases the danger of bed-sores and of sepsis, as long as it continues. Until the incision is healed, it is wise to continue the regular use of urotropin to keep the cerebrospinal fluid sterile.

After the operation patients should be kept in bed for at least three weeks as a rule, but this period varies from two to six or even ten weeks, according to the special conditions present. In some cases, especially in extradural growths and cysts, the convalescence may be very rapid and the necessary rest in bed equally short. Thus in Case III the patient went home fourteen days from the operation. After the disappearance of the pain and hyperæsthesia, massage is of great service in hastening the functional recovery. Electricity should also be systematically used for the same purpose. During the entire course of the after-treatment, the most scrupulous care should be employed in attending to the functions of the bladder and rectum if these are wholly or partly paralyzed. On this may depend the result of the case, and here is where the nursing art is put to its most severe test. It is quite possible to continue for a year or more with continual catheterization without infection of the bladder, but this is a monument to the skill and carefulness of the nurse. Fortunately most of these cases require catheterization for a relatively short time only, but if this is required at all it must be done with the most scrupulous care. Urotropin should be regularly administered during this period also.

Results.—The *immediate result* depends upon the position of the tumor (extradural or intradural), the duration and

degree of its pressure on the cord, and the amount of injury of the cord in the removal of the tumor, in spite of the greatest care. In general, immediately after the operation, there is a decided increase of the paralysis present before operation, especially the motor paralysis, and often a paralysis of parts not previously paralyzed. This is due not only to the slight traumatism to the cord, but also to the consequent œdema. In extradural tumors, this increase of paralysis may be nearly or wholly absent and in them the paralysis is usually promptly recovered from as in Case III, where improvement began on the second day and by the fourteenth all but the finer movements could be slowly performed. In intradural tumors the diminution of paralysis may not commence for two weeks, as in Cases I and II, or a considerably longer time, as in Cases V and VI. When once begun the improvement in motion is usually slow and gradual but may continue for a long time. When the pressure of the tumor has lasted a long time the improvement may be particularly slow. In a case reported by Warren,[17] improvement continued five years or more after operation. Of course if the pressure upon the cord has been severe or long continued enough to cause any degeneration, the muscles supplied by the degenerated cells or the cells connected with the degenerated fibres do not recover their lost power, as neither the cells nor fibres of the cord regenerate. The same also holds in the case of the degeneration of sensory fibres. Where there is no such degeneration the paralyses may be entirely recovered from even when they have been complete or nearly so. Those parts improve first and most rapidly which were last and least paralyzed and vice versa. This is a very strong argument for early operation on all intraspinal tumors. In most reported cases the results would have been better if the operation had been done earlier. Very little time should be wasted in trying antisyphilitic treatment, unless the syphilitic history is very definite. Of course even where extensive degeneration has occurred a successful removal of the tumor arrests the progress of the disease and saves life. The sensory disturbances improve before the motor.

Some pain may persist for a time from the disturbance of the posterior nerve roots, but as a rule the root pain is nearly always speedily relieved to a marked degree. In Warren's case mentioned before, the pain continued for six years, but this is most unusual. Directly after the operation there is often considerable hyperæsthesia but this soon disappears. Passive motion, and later active motion, of the parts paralyzed may for a time occasion severe pains. A spastic condition of the parts most or first affected may persist for a long time or even permanently, owing to a degeneration of fibres of the pyramidal tract, due to the long continued pressure of the tumor, or there may be merely a tendency to cramps. In these cases the deep reflexes remain exaggerated on the side or sides which had been paralyzed.

As to the *ultimate result*, this is favorable so far as my experience goes. Out of the six patients operated on (seven operations), one (Case III) being operated on twice on account of recurrence, none of the five who survived the operation have died as the result of the tumor, with the exception perhaps of Case VI. Although at the time of the second operation in Case III, an absolutely bad prognosis was given, I received a note from Dr. Mailhouse, November 3, 1909, over four years after the second operation, stating that the patient is practically well, doing her own housework, though she has a spastic condition of the left arm and leg due to degeneration of the pyramidal tracts produced by the long duration of the disease prior to operation, and she carries her head stiffly.

This result in spite of the fact that the microscopic diagnosis has usually been some form of sarcoma shows either that such tumors are relatively non-malignant within the spinal canal or that there is a mistake in the pathological diagnosis of these tumors. As an example the tumor in Case I was called a fibrosarcoma by one pathologist and an endothelioma by another. Many tumors formerly called fibrosarcoma are now called endothelioma and the distinction is largely a matter of terms. The length of time that had

elapsed in most cases from the first symptoms to the time of operation is against a high degree of malignancy of most of these growths. It is now quite generally recognized that endothelioma or fibrosarcoma is a form of tumor quite commonly found in the brain and cord, growing most often from the meninges, and showing but little malignancy. According to Starr, intraspinal tumors usually recur, but in nearly or quite half the cases of intraspinal sarcomata in Hartes' table of cases removal insured against recurrence, hence their recurrence is less frequent than that of similar sarcomata elsewhere. In my own cases, Case III recurred but did not recur again after a second operation and Case VI may very likely have recurred.

Except in the case of the thickenings due to a healed tuberculous process, the results of operations on intraspinal tuberculous foci are not so good as those from orthopædic and general treatment, for there is danger of recurrence or of setting up tuberculous meningitis, and the lesion is frequently an inoperable one in the cord. I know of no report of a successful removal of an intramedullary growth. As a result of the laminectomy the spine itself may be somewhat stiff in some cases, in others altogether normal.

The six patients on whom the seven operations were done, which form the basis of the surgical part of this paper, were all seen by Dr. Ramsay Hunt and the diagnosis confirmed or made by him. The first six operations have been published in The Transactions of The American Surgical Association, volume xxiv, 1906. They were all operated on in the Presbyterian Hospital.

Case I has also been published in the Medical and Surgical Report of the Presbyterian Hospital, volume vi, 1904, and in *The Medical News*, October 1, 1904. The first six and the eighth and thirteenth cases were operated on by Dr. Woolsey.

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