That convalescent measles serum has a very definite value, under certain conditions, is well known to all, but possibly it has not been used outside of the large cities to the same extent that it might have been.

In the hope that those who have not already done so may be induced to give it a trial, when the next measles epidemic appears, lies my reason for bringing this matter to your attention.

AN OUTLINE OF THE DIAGNOSIS OF SPINAL CORD TUMOURS*

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WHEN there is evidence of interference with the normal function of the spinal cord or spinal nerves it is important to correctly diagnose the cause. It is true that, in many instances, after the diagnosis is made very little remains to be done in the way of treatment. However, in certain cases much can be done. This is especially true if the lesion is a spinal cord tumour, and if the diagnosis is made before there is irreparable damage to the cord. When it is recalled that nearly one-half of the spinal cord tumours are benign and relatively easily removed, it is worth while investigating very fully any case which presents signs or symptoms suggesting a tumour. The object of this brief presentation is to review the usual signs and symptoms of a spinal cord tumour and to point out the manner in which a case may be investigated and a diagnosis made.

The practitioner is likely to have his suspicions aroused by such complaints as pain, which is persistent and has no obvious cause, weakness of various muscle groups, changes in sensation, or interference with bladder control. The investigation of a case is interesting and frequently does not involve any difficult technical procedures. The history should disclose the onset and duration of the various symptoms. The examination should elicit information regarding changes in sensation, in reflexes, weakness of muscles, or evidence of disease of the bony spinal column. The blood is tested for anæmia; the cerebro-spinal fluid is examined.

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EXAMINATION FOR CHANGES IN SENSATION

This important, but tiring, part of the examination is usually carried out first, before the patient and the examiner become fatigued. With the patient stripped and on his face, sensation for light touch is tested systematically by asking the patient to say "Yes," each time he is touched with cotton wool. The patient's ability to differentiate heat from cold is tested by using two test tubes, one filled with hot water and the other with cracked ice. Sensation for pain is tested by a pin. Any area of hypersensitiveness is carefully noted. Vibratory sensation is tested by a tuning fork placed on the tibia. With the patient on his face the examination of the important sensory areas supplied by the sacral segments and nerves is not neglected. When this examination is completed it is convenient to analyze any history of pain which may have been obtained.

Irritation of a dorsal nerve-root causes pain. This pain will be referred to that part of the body which the nerve supplies. For instance the pain produced by irritation of the right eleventh dorsal root will radiate to the right lower abdomen. Tumours still lower, involving the cauda equina, may cause pain which radiates into the legs and feet. This pain is usually accompanied by other symptoms such as muscle weakness, numbness, or difficulty with bladder control, and should lead one to suspect that the patient is not suffering from some malady such as chronic appendicitis or sciatica. Occasionally, however, pain is the only symptom for months or even years before other outstanding signs or symptoms arise. The pain may be continuous or intermittent and is

usually aggravated by any procedure which raises the tension of the cerebro-spinal fluid, such as sneezing or straining at stool.

Pain may also be complained of in parts of the body not subserved by the dorsal root or cord segment involved. This is exemplified by a patient who two years ago had an extra-dural tumour removed at the fifth dorsal segment. She was almost completely paralysed and had practically a total loss of sensation below the level of the lesion, yet for months before and after her operation she complained bitterly of pain in the calves of both legs. This pain was not associated with any spasmodic contraction of the muscles. Recently she has recovered sufficiently to walk and this pain has disappeared. A paper by Purves-Stewart and Riddoch* suggests that interference with the nutrition of the lower segments of the cord will cause pain in a situation far removed from the actual lesion. If this be the explanation it follows that other symptoms, such as paralysis or loss of sensation, should direct suspicion to a lesion of the central nervous system. When, however, the pain is caused by pressure on a dorsal root and precedes other symptoms it not infrequently happens that these patients are operated on unwisely, and especially is this true when the pain is referred to the abdomen. Of course pain is not a constant symptom of tumours of the cord. Tumours which arise within the cord itself usually cause little or no pain. This is one of the chief differential points between extra- and intra-medullary tumours.

Any disturbance in sensation together with areas in which pain is felt are charted on a sketch, and the lesion may be localized by referring to an anatomical diagram.

EXAMINATION OF THE BACK

A careful examination of the spinal column is made, preferably with the patient standing, and any muscle spasm or limitation of motion, deformity, or tenderness is noted. A roentgenological examination may or may not be considered necessary.

EXAMINATION FOR MUSCLE WEAKNESS, ATROPHY OF MUSCLES AND CHANGES IN THE REFLEXES

Commencing with the shoulders and arms, then passing to the trunk, and finally the legs, a note is made of any muscular weakness or atrophy, or changes in reflexes. The usual reflexes tested are the bicipital at the elbow, the upper and lower abdominal, the knee, ankle and the Babinski.

Muscle weakness, atrophy, and changes in reflexes are brought about in two ways:

1. When the tumour sufficiently compresses the cord so as to interfere with the pathways from the brain, signs of an upper motor neuron lesion develop below the level of the tumour. These signs will be, first, an increase in the reflex contraction of the muscles to a stimulus, followed by weakness or paralysis of the muscles. The muscles will be spastic and show only a slight atrophy from disuse. The increased tonus enables one to demonstrate an ankle clonus. Interference with the pyramidal tract causes dorsi-flexion (positive Babinski sign) instead of plantar flexion, on stimulating the sole of the foot.

2. At the site of the tumour one or more peripheral nerves may be involved, and in the area supplied by these roots or cord segments there will be the signs of a lower motor neuron lesion, namely, marked weakness and atrophy of the muscles with the reflexes diminished or absent. The muscles will be flaccid, not spastic. Tumours low in the spinal canal, which are below the cord and involve the cauda equina, cause this flaccid paralysis with marked atrophy and loss of reflexes by direct pressure on the nerves before they leave the spinal canal. Analysis of the cord segment or spinal nerves involved may be carried out by reference to anatomical diagrams.

DISTURBANCES IN FUNCTION OF THE BLADDER AND RECTUM

A patient with a compression of the cord usually develops bladder and rectal symptoms relatively late in the progress of the disease. According to Spiller and Elsberg, this is true even in lesions involving the cauda equina. In tumours above the lumbo-sacral cord the first symptom is usually a difficulty in starting urination. This may lead to a retention of urine and overflow. True incontinence oc-

* Quoted by Theodore Thompson, Leptomeningioma of the spinal cord, *The Lancet* 1: 327, Feb. 16, 1929

casionally occurs from loss of all reflexes in the musculature of the bladder and sphincters in the case of a large growth involving the lumbo-sacral cord or cauda equina. Constipation is almost the rule in spinal cord tumours. Incontinence does occur if the contents reach the rectum in a fluid state. Early bladder and rectal disturbance is suggestive of an intramedullary lesion of the lumbo-sacral segments of the cord.

EXAMINATION OF THE CEREBROSPINAL FLUID

In many cases such a systematic examination and history, as outlined, will enable one to make a diagnosis, and, by reference to anatomical charts, the localization of a spinal cord tumour. Indeed, until a few years ago, apart from an exploratory laminectomy, the diagnosis depended entirely on these procedures. To-day, earlier and more exact diagnosis is made possible by the examination of the cerebro-spinal fluid and its pathway around the spinal cord. This examination is conveniently discussed under three headings.

1. *Lumbar Puncture.*—About 10 c.c. of cerebro-spinal fluid are obtained. The colour is carefully noted by comparing it with an equal amount of water in another test tube. If the fluid has a yellowish tinge it is strong evidence in favour of a tumour. One of the simple tests for globulin is carried out. An increase in globulin is also evidence in favour of a tumour. A cell count is made, and special care must be taken to make sure that any cells seen are not red blood corpuscles. A small amount of fresh blood will cause confusion by giving a yellowish tinge to the fluid and a positive test for globulin; if there is blood in the fluid it should be centrifuged and the supernatant fluid will then appear clear. Any increase in the normal cell count is in favour of an inflammatory lesion rather than a tumour. A Wassermann test is carried out on the remainder of the fluid. A patient may have syphilis of the central nervous system and give a negative Wassermann reaction in the blood and a positive test in the cerebro-spinal fluid.

Queckenstedt and Ayer Tests.—It is obvious that any expanding lesion which is interfering with the function of the spinal cord will sooner or later block, either partially or completely, the cerebro-spinal fluid pathway about the cord. When this occurs the transmission of any increase in the pressure of the cerebro-spinal fluid above the block will be interfered with. It is on this basis that Queckenstedt developed his test.

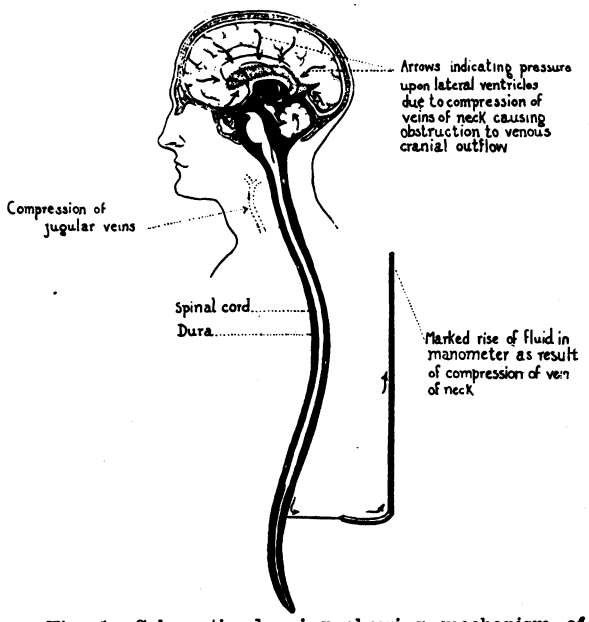

Fig. 1.—Schematic drawing showing mechanism of alterations in the cerebrospinal fluid pressure. A marked rise in intracranial pressure takes place when the venous cranial outflow is obstructed by compression of the veins of the neck. The cerebrospinal fluid is forced out of the cranial cavity into the spinal subarachnoid space, causing a marked rise in the manometer in connection with the lumbar sac.

From a paper by Stookey, Merwarth and Franz

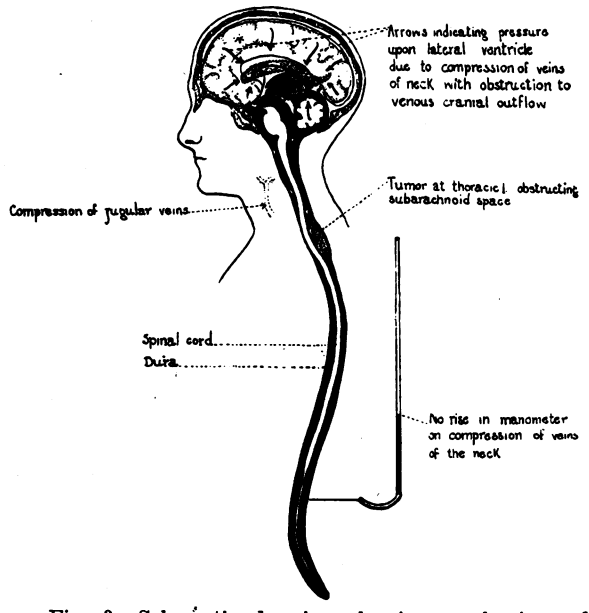

Fig. 2.—Schematic drawing showing mechanism of alterations in the cerebrospinal fluid pressure in the presence of a subarachnoid block. Compression of the veins of the neck forces fluid into the spinal subarachnoid space; however, a block in the subarachnoid space does not permit transmission of the increased pressure of the fluid *above* the tumour to the fluid *below* the tumour; consequently, no rise in the manometer in connection with the lumbar sac takes place.

From a paper by Stookey, Merwarth and Franz

With the patient on his side a lumbar puncture is done, and a manometer which registers pressure by the height to which the cerebro-spinal fluid rises is attached to the needle. The pressure of the cerebro-spinal fluid about the cord is then increased by compressing the jugular veins, thus causing an increased volume of blood in the cranial cavity. Normally, there will be an immediate rise of the cerebro-spinal fluid in the manometer, and when the pressure on the jugulars is released there will be an immediate and rapid fall to the original level. (Fig. 1). If on the other hand there is an obstruction in the cerebro-spinal fluid pathway about the cord, the fluid in the manometer will respond sluggishly or not at all, as the increase in pressure cannot be transmitted readily past the lesion (Fig. 2). When the block is complete, interpretation of the test is easy, but, if only partial, the differentiation of a sluggish rise and fall from the normal rapid rise and fall may be difficult. Stookey has suggested refinements in the test which in his hands have made possible the diagnosis of very slight blocks. Personally, when there is doubt in the interpretation of the test, I prefer to do a double puncture, as advocated by Ayer. With this test, when there is a partial block the difference in the rise and fall of the cerebro-spinal fluid in the two manometers (one above and the other below the lesion), is very striking. (Fig. 3).

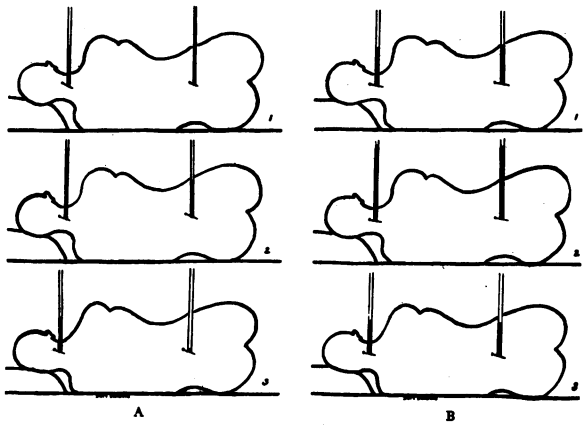

Fig. 3.—A, diagrammatic representation of some of the findings in Case 4, showing spinal subarachnoid block. (1) Initial pressures, on same level; (2) effect of jugular compression. Pressure rises promptly in cistern, not at all in lumbar manometer. (3) Effect of withdrawal of 6 c.c. of spinal fluid from lumbar sac. Pressure here falls to zero; pressure in cisterna magna unaffected. The lumbar fluid contains an excess of protein; that from the cistern is normal.

B, same case as in A. Tests repeated two months after removal of extradural tumour. (1) Initial pressures; (2) effect of jugular compression; (3) result of withdrawal of 5 c.c. of fluid from lumbar sac. The fluids in both manometers now maintain the same level under all conditions. The two fluids are now similar in character.

From a paper by James B. Ayer

Lipiodol Injection into the Spinal Cerebro-Spinal Fluid Pathway and Examination With X-Ray to Determine if There is Any Obstruction to the Flow of the Lipiodol Down the Pathway

This test is only used after one has determined by the Queckenstedt or Ayer test that a block exists and a sufficiently accurate level cannot be established by clinical examination to justify operation. When this situation arises injection of lipiodol is a most valuable aid. One c.c. is injected into the cisterna magna. The patient is immediately examined in the upright position with the fluoroscope and the downward flow of lipiodol is observed. If there appears to be an obstruction a plate is taken to check the observation. If there is a complete obstruction, operation should be performed within twenty-four or forty-eight hours before the lipiodol becomes encysted by an inflammatory reaction. After the tumour has been removed, the head of the bed is kept raised for a week or so to make sure that the lipiodol finds its way to the bottom of the lumbar sac, where it becomes encysted and apparently gives rise to no trouble.

Differential Diagnosis

Diseases of the spinal cord can be separated into two large groups:

1. *The System Lesions.*—Those in which the morbid changes are confined within the limits of certain columns.
2. *The Non-System Lesions.* — Those in which the morbid changes are distributed irregularly through the substance of the cord quite irrespective of column formation.

The System Lesions.—Reference to the accompanying diagram enables one to quickly review the more common system diseases. A number of these lesions cause paralysis. A spinal cord tumour which has progressed far enough also causes paralysis, but sensory changes usually follow quickly. Only in No. 5, (sub-acute combined degeneration), do we have this combination of paralysis with sensory changes. Usually, however, the differential diagnosis is not difficult. Sub-acute combined degeneration is

DIAGRAM

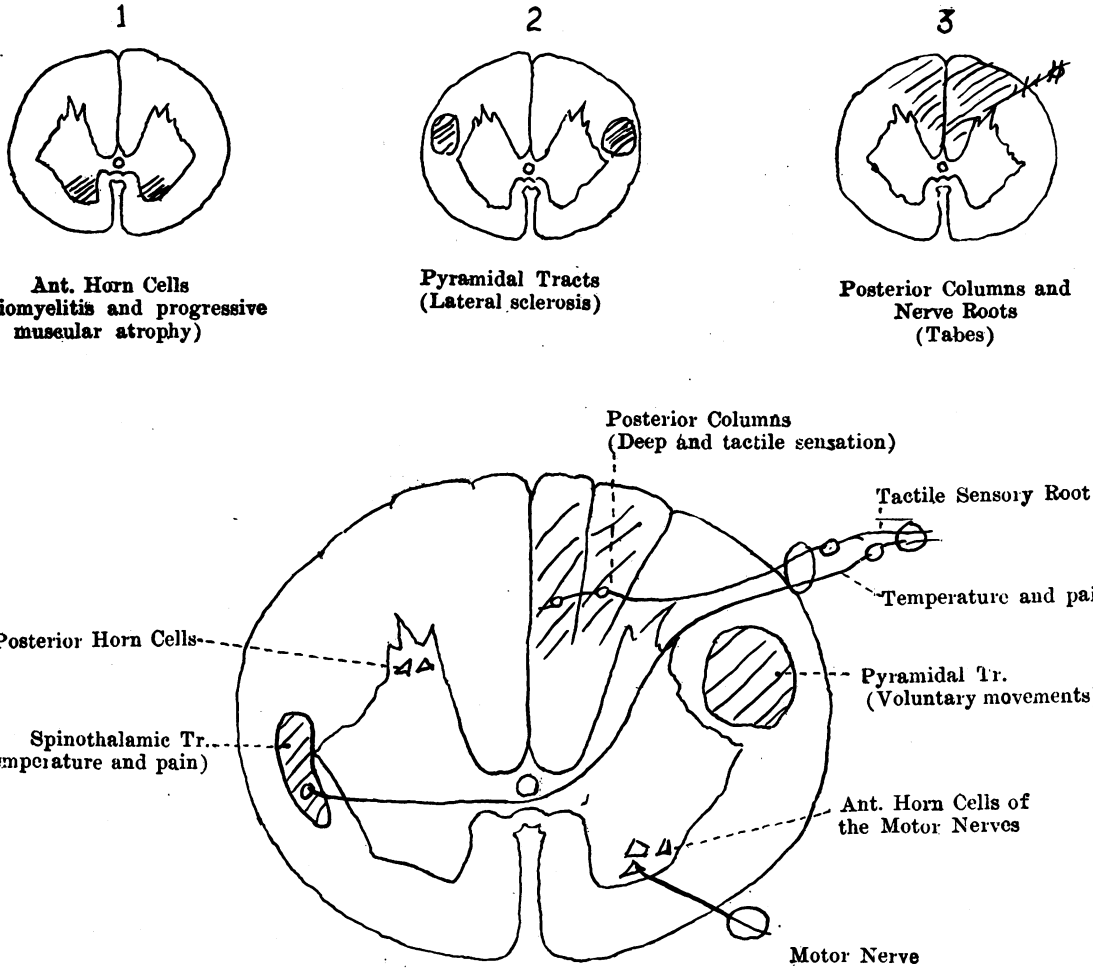

FIG. 4

generally associated with some severe anæmia or toxæmia. The symptoms from involvement of the pyramidal tract (weakness, spasticity, etc.), usually precede by some time any sensory changes. Frequently with a tumour one side of the cord is more affected for a time than the other (Brown-Séquard phenomenon), whereas in sub-acute degeneration the signs are symmetrical. The examination of the cerebro-spinal fluid and its pathway will not present any evidence suggestive of a block.

The Non-System Lesions. — The non-system lesions present more difficulties in differential diagnosis.

(a) *Inflammations (myelitis) and Vascular Lesions.*—In some cases there is a primary inflammation brought about by the direct invasion of organisms or their toxins by way of the lymph and blood streams. In other cases the changes in the cord are secondary to interference with the blood supply. Acute infective diseases and syphilitic endarteritis are the more common causes. The signs and symptoms will vary with the level and extent of the lesion. When associated with acute infective diseases the onset of paralysis and sensory loss is usually rapid, often only a matter of hours. When a vascular lesion is the underlying cause the onset may be slow and simulate closely a tumour. If the Wassermann test is negative, a spinal cord tumour must be ruled out by the negative findings in the cerebro-spinal fluid and its pathway.

(b) *Diffuse and Disseminated Degenerative Processes, such as Syringomyelia and Disseminated Sclerosis.* — In disseminated sclerosis the sclerotic patches may be scattered in various places throughout the central nervous system, so that at some stage this disease may simulate almost any other of the degenerative lesions and also a pressure myelitis from a spinal cord tumour. When one sees the fully developed and typical syndrome as in Fig. 5, the diagnosis is not difficult. Often however, a spinal cord tumour can only be ruled out by study of the cerebro-spinal fluid and its spinal pathway.

Syringomyelia, when typical, is not difficult to diagnose. The degeneration in the centre of the cord causes a wide band of loss of pain and temperature sense, by interfering with the sensory fibres as they cross to the spino-thalamic tract. Extension of the disease into the anterior horns causes atrophy and paralysis in the area subserved by the levels involved in the cord. The lesion is most commonly situated in the upper part of the cord, so that there are relatively few signs in the legs. When the lesion occurs lower down and gives signs in the legs the diagnosis from a cord tumour may be very difficult. The length of the history and the examination of the cerebro-spinal fluid and its spinal pathway are the most helpful aids.

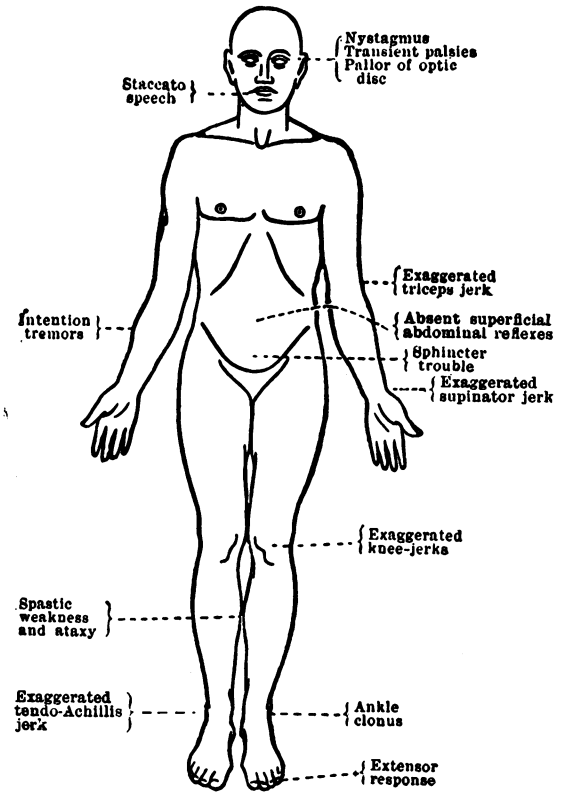

Fig. 5.—Scheme of the principal symptoms occurring in the course of disseminated sclerosis.

Diseases of the Nervous System, Thomson

(c) *Pressure from without as in Spinal Caries, Injuries, etc*—Lesions due to these causes seldom offer great difficulty in diagnosis when a thorough examination of the back and roentgenological studies are carried out.

In conclusion I would emphasize that tumours are relatively common lesions of the spinal cord, and, that approximately one-half of the tumours are benign and can be removed. Complete return of function is to be expected if complete paralysis has not persisted for more than a few months.