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CORD.

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THE clinical study of diseases of the spinal cord has been given new impulse and placed upon a reliable scientific basis by the establishment of the principles of localization. Lesions can now be definitely estimated, and their importance properly assigned. To work out fully their extent, whether in the center or periphery of the cord, or limited to its columns, requires thorough acquaintance with the anatomy and physiology of the cord. Localization is but the correct interpretation of symptoms—motor, sensory, reflex, vasomotor, and trophic—arising in any case of spinal disease. It is to be noted that most diseases of the spinal cord are limited in area, and may involve but one segment or spinal unit. In actual disease, however, even if incipient, more than one segment is usually affected.

The motor symptom most prominent in spinal disease is diminished function or paralysis, although we do have symptoms of increased function, as shown in spasms, cramps, and rigidity.

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<sup>1</sup> Read before the Tri-State Medical Society, Keokuk, Iowa April 4, 1893.

Paralysis of spinal origin may be caused by two distinct lesions: first, when voluntary impulses from the brain to the spinal motor centers are cut off, as in compression; secondly, when the spinal motor centers are destroyed (Starr), as in acute anterior poliomyelitis. The first type is not followed by atrophy, and the electric reaction is normal, while in the second, the paralysis is followed by more or less degenerative atrophy, and the electric reaction of degeneration is marked. Starr emphasizes the importance of separating these two forms of paralysis, because the line of treatment is determined by the condition found. In the first type surgical treatment may remove the cause of paralysis, while in the second nothing can be done.

By the use of electricity we can estimate the degree and distribution of the paralysis, and in this way assist in localizing the lesion. The diagnostic uses of electricity are, therefore, important, and the general rule of Bramwell should be borne in mind, viz.: "When the nutritive condition of muscles and nerves is not profoundly altered—that is, when the trophic-nerve nuclei, the motor nerves, and motor-nerve endings are healthy—the electric alterations are merely quantitative; when, on the contrary, the trophic-nerve nuclei are destroyed, when the trophic-nerve influence is shut off from the muscles by severe lesions of the peripheral nerves, when, in short, the peripheral motor nerves and motor-nerve endings are degenerated, qualitative alterations in the electric reactions, to which the term *the reaction of degeneration* has been applied by Erb, appear."

During the past week I met a case in which the alterations of degeneration, while present, yet required considerable time to work out their extent, and to localize the lesion, thus emphasizing the fact that it is only by observing the muscles, or groups of muscles, thus affected that we can localize the lesion. We must also call to our assistance the very valuable table of Starr,



which is to be found in all recent works on diseases of the nervous system.

The sensory symptoms are localized by a study of the distribution of the posterior nerve-fibers and the character of the alterations of sensibility, such as temperature-perception, pain, anesthesia, hyperesthesia, etc., by means calculated to show the impairment of functions in the sensitive areas to be investigated.

The ability to localize sensibility depends greatly on the thoroughness of the tests used. "The point of chief importance in testing sensation is to find some part of the patient's body which is unaffected, and with this part as a standard, to compare affected parts" (Starr). The sensory functions of the individual segments of the cord have been pretty thoroughly determined, so that by defining the area of surface affected we can determine the localization of the lesion.

In the study of the localized functions of the cord the level of origin of the nerves, their point of exit in relation to the spinous processes, and their final distribution, are of paramount importance. The diagram of Gowers, to be found in all standard works, shows the relationship of the vertebral and spinal segments and spinal nerves. The spinal nerves have their exit lower through the spinous processes than they arise in the cord, and as we descend the cord these lengths of the nerves increase before passing out of the canal, so that when we reach the end of the cord we find quite a bunch of nerves forming the cauda equina. We must bear in mind, therefore, that the lumbar nerves are not opposite the lumbar vertebræ, nor, in fact, are any of the spinal nerves directly opposite the vertebræ of the same name. This fact is of great importance in surgical diagnosis. Spinal lesions are generally bilateral, and especially so in sensory disturbances, although in what is termed Brown-Séquard's paralysis we find "paralysis of motion and muscle-sense on the same side as the lesion, while

sensibility is paralyzed on the opposite side, pain and temperature being especially affected." Hyperesthesia and increased reflex action are noted on the side of the lesion.

Other primary considerations in the localization-study of diseases of the spinal cord are the reflexes. They show the condition of portions of the segment through which the reflex passes. To insure reflex action requires that the sensory or efferent fibers be intact, the ganglion-cell perfect, and the afferent or motor fibers preserved; this combination constitutes the reflex arc, and any interference with one or more of these essential elements, affects reflex action. Disease may destroy the lateral columns and postero-internal columns without affecting reflex action. The reflex system of the spinal cord is made up of a series of these arcs or loops, and disease may affect one or more of them, being manifested either in increased or diminished action. Disease may not be indicated by the absence of a reflex, for through an idiosyncrasy in the physiologic make-up of a person it may be absent; again, disease outside of the cord may affect reflex action. Disease affecting special portions of the cord, as in locomotor ataxia, will destroy reflex action.

Excessive or increased reflex action is caused by disease that increases the irritability, and, consequently, diminishes the specific resistance of the arc in any part of its course, as excitability of gray matter from adjacent inflammatory disturbances, and then diseases which arrest conduction, as in diseases of the lateral columns, where both superficial and deep reflexes are affected.

The localization of reflex disturbances enables us to confirm motor and sensory symptoms. The superficial reflexes are the plantar, gluteal, cremasteric, abdominal, epigastric, and interscapular, each having local significance and importance.

The interscapular reflex embraces the seventh and eighth cervical and the first and second dorsal segments; the epigastric, the fourth to the seventh dorsal, inclusive; the abdominal, the eighth to the twelfth dorsal, inclusive; the cremasteric, the first to the third lumbar; the gluteal, the fourth and fifth lumbar; and the plantar, the first to the third sacral. These reflexes are obtained by gently irritating the skin with the point of a sharp instrument or with the finger.

The important deep reflexes are the patellar tendon-reflex and the ankle-clonus. The patellar tendon-reflex is obtained by striking the ligamentum patellæ while the knee is semi-flexed, or, as Buzzard recommends, by having the patient, who is seated, plant his foot firmly down at such a distance that the leg forms a little more than a right angle with the thigh, whilst the observer rests the palm of his left hand upon the patient's thigh, and with the right strikes the ligamentum patellæ about one-eighth of an inch below the knee-cap. The quadriceps muscle can be felt, and can be seen to contract more or less vigorously in response. If the patient is in bed, the knee should be flexed and the heel held firmly down upon the bedding whilst the blow is struck. The quadriceps will be seen to contract. If the phenomenon be absent, we must then endeavor to locate the interruption in the arc and ascertain its cause. If the patient can walk freely, and can flex and extend the leg with vigor, we may exclude the motor side of the arc. The most conspicuous illustration of a flaw on the sensory side is furnished by *tabes dorsalis*.

Trophic disturbances will cut off reflex action, as the seat of this influence is known to be in the large ganglion-cells which lie in the anterior horn. Interruption in this case may exist either in the anterior root outside the cord, the short portion within the cord, or in the anterior horn of gray matter itself.

As regards the second of these possibilities, nothing is

certainly known that will enable us to localize the lesion in that particular portion of the anterior root.

Ankle-clonus is only present in case of disease, and it signifies that from some cause the inhibitory influence of the higher centers is no longer normally exercised. The natural impulses from above are somewhere interfered with. Sclerosis invading the antero-lateral columns interferes with nervous impulses travelling down this path, and ankle-clonus is marked. Changes in these columns, of several months' duration, are usually permanent, and so excessive a reflex as is represented in ankle-clonus means structural change that will be unalterable.

In spastic functional paraplegia we elicit ankle-clonus, but this is not necessarily an indication of chronicity, and in hysteria<sup>1</sup> we will find increased tendon-reflex. In the latter the cerebral influence is considerable, and this Buzzard thinks is sufficient to inhibit the nervous impulses reaching the spinal centers. The absence, then, of impulses downward through the lateral columns seems to result in an effect upon the tendon-reflex very similar to that occasioned by the resistance to their propagation through the columns which is interposed by the structural changes occurring in sclerosis.

The organic reflexes, viz., the vesical, rectal, and sexual, offer special and important considerations in the study of diseases of the spinal cord as factors in localization. They belong to the independent functions of the cord, and their action is not concerned in volition. Disease may affect each center separately, but usually they are simultaneously affected because of their location. These centers are situated in the lower portion of the cord, the genital centers reaching from the first to the third sacral

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<sup>1</sup> I use this term "hysteria" as differing from functional, according to Bastian, in his recent valuable contribution to the study of hysterical and functional paralysis.



segment, inclusive. The bladder and rectal centers extend from the fourth to the fifth sacral segment, inclusive. Starr says that they are adjacent to one another, and the sphincters are uncontrollable when the lesion involves the lower three sacral segments. The center then is probably in the two lower. Disease may affect these centers by excessive stimulation, and as a result both the bladder and rectum fail to act normally.

We may have incontinence or retention of urine: incontinence when there is excessive stimulation of the nerves, as in cystitis, and the presence of a foreign body in the bladder, or when, as in children, it is due to spasm of the bladder, or lack of tone of the sphincter. Retention is the result of paralysis, and localizes the lesion in the lumbar region. The rectum is similarly affected. We often note in spinal disease localized in the dorsal region that defecation and micturition are affected; that is, the functions are performed with normal regularity, but the control of the will over these functions is lost. I saw recently such a case. The bladder and rectal centers were unaffected, because they were not included in the diseased area, but, as the patient expressed it, he "could not hold his water, or control his passages," because of dorsal disease.

The sexual reflex controls erection and ejaculation, and is an important one. Impotence is due to destruction of this center, or to inhibition of it, by reason of general spinal weakness. By reason of the intimate nervous connection of the genito-urinary organs with the cerebro-spinal system, we may have nervous disturbances growing out of this reflex arc. The sensory portion of the arc is enormous; the conducting cords which attach the genital organs to the centers are highly developed.

Robinson says that "branches from the second and fourth sacral and the entire third sacral segment go to

make up the enormous nerve-supply for such small organs as the genitals." The bladder and rectum also receive branches from this same supply, so that we find the action of the bladder, rectum, and genitals wonderfully harmonious.

In woman we note this dominating influence more than in man, for the great and complicated nerve-supply to the female genitals accounts for the danger of nervous complications and its stubborn pathology. Robinson says: "It may be laid down as a general proposition that the viscera have their normal function in rhythm and the disturbance of the rhythm is what induces disease." It may also be said that the main pathology of the sympathetic is reflex action from some distant viscus. All have noticed the close nervous connection of the genitals with the nervous system. In woman uterine disorders occasion a thousand and one ills, while in man the reflex irritation of disease completely upsets him. The whole spinal disorder is often purely reflex, and we must not overlook the rectum and genito-urinary organs as aids to diagnosis and localization.

Let us now outline the motor and sensory symptoms to be noticed in focal disease of the cord in various regions.

In the cervical region lesions above the fourth segment cause death by involvement of the phrenic nerve. Upper-arm motor symptoms, with disturbances of sensation of the entire trunk and arm, characterize involvement of the fifth and sixth cervical segments. Lower-arm motor symptoms, with disturbances of sensation of the trunk and inner surface of the arm and portions of the hand, denote involvement of the seventh and eighth cervical segments. The dorsal region gives the "girdle sensation" when the lesion is transverse, and this locates the level and determines the segment involved. The various levels are well outlined—the

third rib corresponds to the third segment, the nipple to the fourth, while the sixth and seventh are regionally located by the distribution of nerves to the epigastrium; the tenth segment distribution is near the umbilicus, etc. The motor symptoms to be noticed are paralysis of the intercostal muscles in the upper dorsal lesions and the abdominal muscles in the lower.

Lumbar lesions may or may not involve the entire lumbar enlargement. When total anesthesia of the legs, thighs, and buttocks prevails, then the entire lumbar segment is involved. But if the upper portion is alone involved, then we find anesthesia of the thigh, outer portions of the groin, part of the scrotum, and paralysis of the muscles which flex the thigh, including also the sartorius muscle.

If the middle lumbar segments are alone involved, then we have anesthesia of the thigh and paralysis of the muscles which extend the knee and adduct the thigh. The sacral region is indicated by paralysis of the bladder and rectum in lesions extending as high as the fifth sacral segment. When the fourth and fifth sacral segments are involved we have paralysis of the peroneal muscles, and muscles of the leg and foot when higher. Herter says the area of anesthesia in sacral lesions is characteristic, extending from slight anesthesia about the coccyx in the fifth sacral involvement to the saddle-shaped area of the fourth segment, while in the upper segments strips of anesthesia on the back of the thigh, leg, and ankle to the sole and dorsum of the foot are noticed. Lesions of the cauda equina are diagnosed by outlining the anesthesia, looking for deformities, and in the examination of the cord for purely cord symptoms.

Lesions in this region are due to pressure from fracture of the spine or dislocation, etc. As these cases are of surgical importance, localization should be carefully observed, so that the lesion may be removed. I recently

saw a gentleman who had a fractured coccyx, causing pressure on the cauda equina. For eight years he went from sanitarium to sanitarium, seeking relief for spinal irritation and neurasthesia. He did not find relief until his case was found to be a surgical one; operation relieved him.

Again, I would call your attention to Starr's table in localizing the lesions, for by it and with the use of electricity you can closely define regional location of the lesions in spinal-cord disease.

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