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Three Cases of Brown-Séguard
Paralysis, with Remarks on
the Sensory Tract in the
Human Spinal Cord.

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THREE CASES OF
BROWN-SÉQUARD PARALYSIS,
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THE SENSORY TRACT IN THE HUMAN SPINAL CORD.*

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Of the three cases here detailed, one, which I am able to report through the courtesy of Dr. Fisher, I have seen constantly in the neurological division of the Almshouse Hospital on Blackwell's Island. The two others have been at the Vanderbilt Clinic in the course of the past two years. Dr. Starr has kindly permitted me to look them up and examine them :

CASE I. *Right*.—Diminution of tactile sensibility; analgesia; thermo-anæsthesia; all reflexes present; no clonus; no loss of muscular sense.

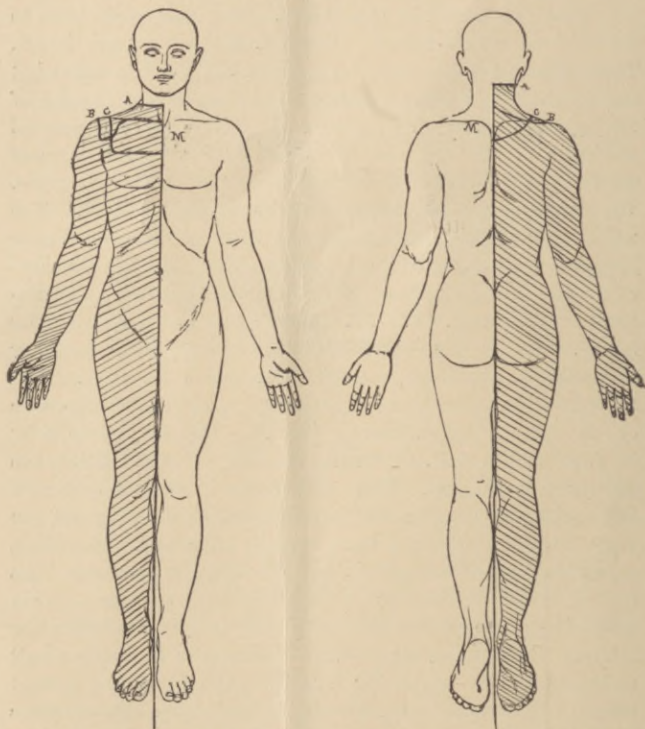
Left.—Stab wound of neck; myosis; cilio-spiral reflex absent; paralysis, with contractures, of arm and leg; wrist, elbow, and knee jerks exaggerated; clonus; crenaster reflex diminished; abdominal reflex absent; no loss of muscular sense.

* Read before the New York Neurological Society, January 8, 1895.

The patient, a Norwegian, aged forty-seven years, first found his way into the Almshouse Hospital last October for a malarial fever, which yielded quickly to quinine. His nervous condition being recognized, he was transferred to the Hospital for Incurables. I wish to take this opportunity to thank Dr. Witmer, the house neurologist, for his efficient assistance in the report of the case. The history which he tells is as follows: That soon after his arrival in this country, twelve years ago, he was stabbed in the back of the neck close to the skull on the left side. His history, both personal and that of his antecedents, previous to this time is of no medical interest. He was unconscious for three hours after receipt of this injury, and was removed to Chambers Street Hospital. On regaining consciousness he found himself hemiplegic on the left side. The fact that he was hemi-anæsthetic on the right side was not noticed until some time later. His head hung limp upon his right shoulder, and for five weeks he was in bed with his head in supports. At the end of that time the power began to return to the leg, and still later to the arm. Complete return of muscular strength has not occurred in either, and, though the leg is better than the arm, both are stiff. Sensations in these limbs were normal. On the right side tactile sensibility was but slightly affected, while sensation for pain and temperature was so much impaired that ordinary cuts, bruises, etc., caused no pain unless very severe. He could hold a piece of ice in his right hand indefinitely, and could not distinguish between hot and cold water. A bedsore developed over the right buttock, and there was a temporary paralysis of the bowels. All the improvement which occurred was complete in eight months. Since then his condition has been what it is at present. He has been subject to ulcerations on the right leg, and had incontinence of urine for one year after the injury. After that time the urine passed involuntarily if the patient were on his left side; now, if asleep on his left side, it passes involuntarily. He is a man of medium frame and fairly well nourished. On the right leg are numerous scars, results of local suppuration which has occurred since the injury. Examination of the vegetative organs is negative; mentality is unimpaired, and he is a man of

fair intelligence. On the left side of the upper part of the neck, in front of the anterior border of the trapezius and about an inch from the median line, is a scar which is the result of a punctured wound. On palpation over this scar the finger comes upon the posterior arches of the atlas and axis. There is no pain on pressure in this region. The head is deviated to the right to a slight degree. All the cranial nerves are intact. There is slight hypermetropia, and the left pupil is somewhat smaller than the right. There is also a slight internal squint of the right eye, dating from childhood. While there is general weakness of the arm and leg on the left side, this is most marked in the muscles of the shoulder and in all the extensors. The finer movements of the left hand are impaired. The movements of the spinal column are natural. The left finger joints are stiff, owing to the tense condition of the flexor muscles. There is also stiffness of the joints in the left leg, dependent on a like cause. The left trapezius is more tense than its fellow. The muscles around the left shoulder joint are smaller than those on the right, but this difference is not too marked to be accounted for by a disuse atrophy. The circumference of the middle of the left arm is less than that of the right by an inch and a half. Between the left and right thigh the difference is an inch. These differences in size agree almost exactly with those of several cerebral hemiplegias of about ten years' duration which I have recently examined. The chest expansion is two inches and the diaphragm acts normally. As regards motion in the right hand, the patient says there is no actual loss of power, but it is not so strong as it was before the injury. The dynamometer shows a difference of nearly a half on the two sides—right, 65; left, 35. In walking, the patient makes a mowing movement with his left leg in characteristic hemiplegic style. There are slight fibrillary twitchings of the muscles of both shoulders, running down into the arms. These also are more marked on the left. All muscles respond readily to mild faradaic currents. The right knee jerk is active and the left considerably exaggerated, and a clonus may be easily elicited on the left side. While the superficial reflexes on the right side are preserved, on the left the cremasteric reflex is dimin-

ished and the abdominal could not be obtained. The left wrist and elbow jerks are active and are obtainable on the right. The right pupil dilates slightly on irritation in the supraclavicular fossa; on the left not at all. There are no sensory changes



CASE I.—Below the line A M, diminished tactile sensibility; below the line B M, analgesia; below the line C M, thermo-anæsthesia.

whatever on the left. The muscular sense, as determined by distinguishing similar objects of different weights by assuming certain muscular positions at command and by telling in what position the muscles are, is everywhere intact. The following

description, amplified by the charts, applies only to the right side, including right side of genital organs. The sense of touch and pressure is impaired below a line drawn horizontally from the lower border of the thyreoid cartilage in front to the fifth cervical spine behind. The impairment of tactile sensibility is so slightly marked that it gives but few subjective symptoms, and in fact the patient's first knowledge of sensory involvement was his inability to distinguish between hot and cold water. The localization of touch is everywhere good. The loss of temperature sense extends below a curved line drawn from the third rib up over the shoulder, which descends again on the back to the third dorsal spine. This loss is well marked, and has become but little less since the injury. Analgesia, which is fairly complete, has still another distribution. It is present below a line which, beginning at the inner border of the clavicle, runs parallel with this bone for a third of its length, and then dips down for one or two inches and then ascends again over the shoulder and continues to the sixth cervical spine. The change in these anæsthetic areas, although present at the limits given, becomes most marked about an inch and a half below the superior boundary. There is not now, nor has there ever been, any hyperæsthesia. The absence of all atrophy, other than a disuse atrophy, indicates that the anterior horn is but little, if at all, involved. The absence of inco-ordination and presence of muscular sense would seem to indicate that the posterior median columns were intact. The motor change—viz., hemiplegia with contractures, increase of deep reflexes, and diminution of superficial reflexes—points clearly to a descending degeneration in the pyramidal tract. In fact, the motor symptoms are identical with those that might be furnished by a cerebral hemiplegia, even to the extent that the leg recovered more completely than the arm.

This case makes an interesting contribution to the localization of sensation of the cervical segments. Injury of the entire cord above the fifth cervical segment is immediately fatal. Gowers's* case (with autopsy), in

* Gowers. *Clin. Soc. Trans.*, xi, p. 24.

which a pistol bullet lodged between the atlas and axis and contused the right anterior half of the third cervical segment, is the highest lesion of the spinal cord reported in which examination of the various resulting symptoms had been made ante mortem. But in his case, while there followed a right spinal hemiplegia, the resulting left sided sensory symptoms were incomplete. In the absence of recognizable injury to the anterior horn in my case there is some difficulty in determining the exact segment implicated. The knife blade entered, however, pretty surely in the immediate region of the atlas and axis; these vertebræ surround the second, third, and fourth cervical segments. From the fact that in lesions of the fifth cervical segment, hyperæsthesia extends over the top of the shoulder and in the region of the supraclavicular nerves, Starr * infers that this area represents the sensory distribution of the fourth cervical segment. The anæsthesia of this case corresponds very closely to these limits, and so furnishes additional evidence for the correctness of Starr's inference. Certain peculiar symptoms in Gowers's case led him to think that the sensory fibers have a different arrangement in the cervical cord than in segments lower down. In his case there were nowhere observed any diminution of tactile sensibility or any impairment of muscular sense. The sense of pain was diminished, but only below the left nipple. From this Gowers concludes: † "It is to be assumed, therefore, that the sensory path from middle and upper cervical nerves only crosses at the highest point of cord, above level of (present) injury." Turner, ‡ from his experiments on monkeys, was led to believe that the course of tactile sensation for the arms passed up both

* Starr. *Brain*, 1894.

† Gowers. *Diseases of the Nervous System*, 1892.

‡ Turner. *Brain*, 1891.

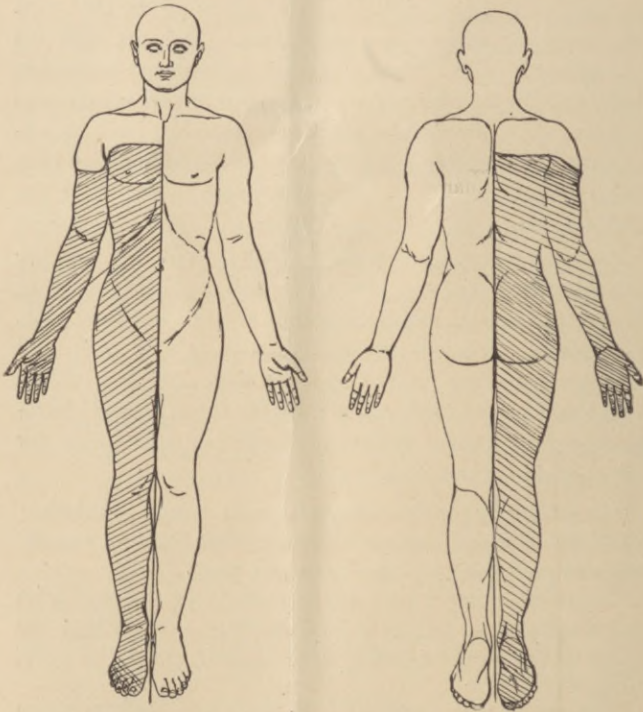
sides of the cord, while the fibers for pain and temperature sense decussated entirely on entrance. In support of this view he adduces some of Brown-Séquard's cases of injury to the cervical cord, where there was a bilateral anæsthesia, and one of Hoffman's cases, where there was loss of tactile sensation on the paralyzed side as well as on the side with the analgesia and thermo-anæsthesia. Now the different experiments on the sensory tract of animals are contradictory, and Brown-Séquard's cases appear to me hardly conclusive, while Hoffman's case was evidently (and so explained by himself) one where the posterior columns of both sides were involved. In the case which I have just described, where the lesion is certainly as high as the fourth cervical segment, the resulting hemianæsthesia has the characteristics of a clinical hemisection of the cord at lower levels—viz., intact sensation of the paralyzed side, diminution of tactile sensibility, with loss of pain and temperature sense on the opposite side. So the evidence that the fibers for tactile sensibility for the arms and clavicular regions have a different arrangement than those for lower areas appears insufficient.

CASE II. *Right Side.*—Diminution of tactile sensibility; analgesia; thermo-anæsthesia; deep reflexes present; superficial reflexes active; no loss of muscular sense.

Left Side.—Stab wound of the neck; myosis; loss of cilio-spinal reflex; paralysis, with contractures of arm and leg; loss of superficial reflexes; exaggeration of deep reflexes; no loss of muscular sense.

The second case, a patient of Dr. Morrell, of Yonkers, whom he has very kindly allowed me to examine, is very similar to the one just described. This man was stabbed in August, 1892, in the left side of the neck, well up. He recovered quickly from the traumatism, and shortly afterward commenced to regain power in the left side, which had been paralyzed. The leg recovered more than the arm. He now presents a left spinal spast

hemiplegia, with loss of superficial reflexes on paralyzed side, but with activity of these reflexes on the other side. There is left myosis and loss of left cilio-spinal reflex. There is no loss of muscular sense on either side, and no sensory symptoms have ever been observed on the left side. On the right side there



CASE II.— Upper limits of anaesthesia indistinct.

is diminution of sense of pain and temperature. This analgesia and thermo-anaesthesia is marked in the leg and abdomen—much less so on the arm and trunk. There is also some diminution of tactile sensibility. Owing to the slight impairment on

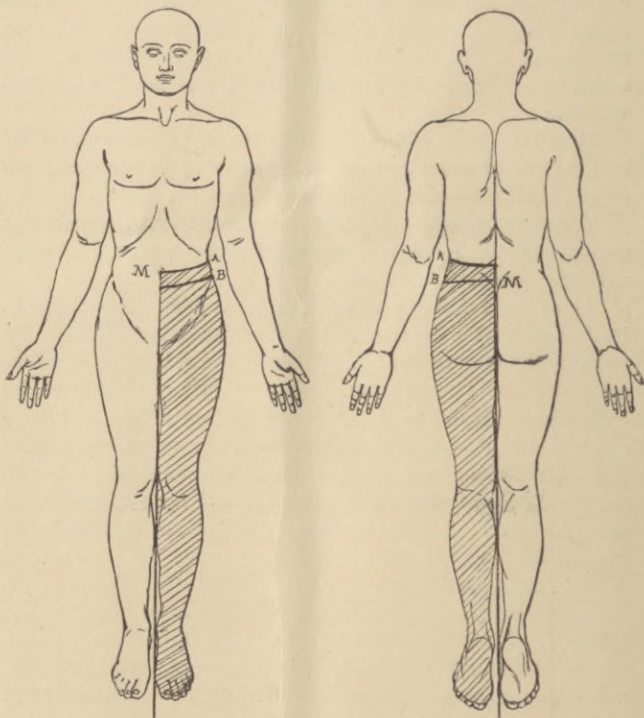
the upper extremity of these three forms of sensibility, it is impossible to define exactly the superior limit of involvement. However, the impairment for all three begins at about a line drawn from a point in the middle of the sternum, two inches above the nipple, which ascends over the shoulder and then descending slightly continues to the vertebra. This area of sensory loss corresponds to the distribution of the fifth cervical segment.

CASE III. Right Side.—Paresis, with slight contractures of leg; no loss of muscular sense; cremasteric reflex present; abdominal reflex absent; knee jerk exaggerated; clonus.

Left Side.—No loss of touch; analgesia; thermo-anæsthesia; no loss of muscular sense; cremasteric reflex present; abdominal reflex present; knee jerk absent.

This case is that of a man whom I saw about a year ago in Professor Starr's department at the Vanderbilt Clinic. He presents the symptoms of a right-sided lesion in the lower dorsal and upper lumbar cord. His own history or that of his antecedents throws no light on the ætiology. He is thirty-seven years of age, a machinist, married, and a resident of Newark. He is a man of temperate habits and more than ordinary intelligence. He denies syphilis, and no evidences of it are to be found. The disease commenced about a year and nine months ago and has been slowly progressive. He is a man of robust frame, well nourished, and symptoms of disease of his vegetative organs are not obtainable. He is more irritable than formerly. The only evidences of nervous disease are found in the lower part of the abdomen, and in the legs. The motor disturbances consist in weakness with some stiffness of the right leg. His gait, as observed in the right leg, is parietic rather than spastic. There are no hypertrophy or atrophy, no fibrillary twitchings, no inco-ordination, no pains or hyperæsthesia. On the left side, below a line drawn almost horizontally from the umbilicus to the vertebral spine behind, exists a well-marked analgesia, and below a line about an inch inferior to this one there is well-marked thermo-anæsthesia. On neither side is there any impairment of sensation for contact or localization of touch, and muscular sense is everywhere normal. (Muscular sense was

tested by simply having the patient determine with closed eyes the position of the limb.) The cremasteric reflexes are present on both sides, and while the left abdominal reflex is present the



CASE III.—Below the line A M, analgesia; below the line B M, thermo-anæsthesia.

right is gone. The left knee jerk is gone while the right is active, and there is a slight clonus on the right side. There is some loss of bladder control and some lessening of sexual power. The bowels are somewhat constipated. The case appears to me as one of right unilateral gliosis of the lower dorsal and upper lumbar region.

These three cases of unilateral lesion of the spinal cord agree in most respects with the cases, about seventy-five in number, which have been reported since Brown-Séquard's first description. The motor disturbance has generally been one indicative of degeneration in the pyramidal tract—viz., paralysis, with spastic rigidity, but no marked atrophy. In some cases the anterior horn escapes injury; but from the now established fact that most muscles have a cellular representation in more than one segment, and as only a small portion of any one segment would be injured by a knife blade, it is fair to suppose, at least in cases resulting from stab wounds, that even if the anterior horn is involved, the functions of the destroyed cells are assumed by the uninjured cells of the affected segment, together with the cells of the other segments which are together devoted to any one muscle or muscle group, and so prevent recognizable symptoms of cell death in the anterior horn. There is on the side of the lesion an increased excitability of the deep reflexes while the superficial reflexes are diminished or lost.

In both of my cervical cases, in common with most reported cervical cases, there is myosis on the injured side, and in neither is a cilio-spinal reflex obtainable on the affected side. Hyperæsthesia and pain on the paralyzed side, a common and puzzling symptom, was present in but one of these three. The fact that fibers for touch, pain, and temperature decussate at slightly different levels is illustrated in the accompanying charts. Köbner* observed that tactile sensibility was involved higher than that for either pain or temperature. In my cases this difference is notable, the order of involvement being, from above downward, touch, pain, and temperature. In a case of spondylitis involving half of the cord, Rosenthal† found thermo-anæsthesia two

* Köbner. *Deutsch. Arch. für klin. Med.*, 1877, p. 19.

† Rosenthal. *Wien. med. Presse*, 1887.

spaces higher than analgesia. His patient finally recovering, the restoration of sensation, in point of time, was touch, pain, and temperature.

These unilateral lesions of the spinal cord prove, with a fair degree of certainty, that the fibers for pain and temperature undergo complete decussation immediately on entering the cord, and proceed uninterruptedly upward on the opposite side. The conduction of sensation of temperature, as the early loss of this sensation in syringomyelia indicates, takes place probably in the gray matter. Painful impressions may be transmitted in this part also. Gowers* infers from his case that they go in the ascending lateral tract, but as in this case the gray matter, as well as the ascending lateral tract, was involved, it can not be excluded as a means of conduction of this form of sensation. The loss of muscular sense is the most uncertain of the symptoms of Brown-Séquad paralysis. It is retained in all of our cases, and in only a few of the reported cases has its loss been satisfactorily recorded. Its loss is generally believed to occur on the paralyzed side. Ferrier† reports a case of syphilis in which loss of muscular sense occurred opposite the paralyzed side and on the same side as complete tactile anæsthesia and diminution of the sense of pain and temperature. The value of this observation appears to me to be invalidated by the fact that a temporary paresis as well had preceded the sensory loss on this side. Also the complete loss of touch is so extremely rare in unilateral lesions that it of itself would suggest a bilateral involvement.

From this case, together with the results of experiments on animals, Ferrier believes that the muscular sense fibers undergo an immediate decussation on entering the cord.

* *Loc. cit.*

† Ferrier. *Croonian Lecture*, 1890.

The correctness of this view, in man at least, is hardly upheld by the reported cases of unilateral lesion. From the pathology of tabes we infer that the muscular sense, at least in so far as the sense of posture and co-ordination is concerned, is transmitted by the columns of Goll. This is generally believed for man, although the experiments of Ferrier and Bechterew* seem to prove that it is not true for monkeys. These results, however, do not agree with the earlier researches of Schiff, nor entirely with those of Gotch and Horsley.† Between the fibers for muscular sense and those for tactile sensibility there seems also to be a very close relation. While in unilateral lesions of the cord both of these sensory functions are often unimpaired when the muscular sense remains intact, I find but one case‡ in which the muscular sense was interfered with without disturbance of tactile sensibility. This also was a case of sclerosis, a form of growth in which the fibers of ordinary sensation are often left unimpaired. Also the fact that in uncomplicated tabes there is so frequently a loss of ordinary sensation in the legs lends force to the theory that the columns of Goll transmit some sensory impressions. This view is strengthened by the two following cases.

Hoffman# reports a case in which he inferred from the direction of the wound that the posterior columns of both sides and the white matter of the left side of the cord were involved. The sensibility to touch was diminished in the left leg and there was a right-sided impairment of this sense. Müller|| also reports a case quoted in Kōbner's article, in

* Bechterew. Quoted by Ferrier, *loc. cit.*

† Gotch and Horsley. *Croonian Lecture*, 1891.

‡ Charcot and Gombault. *Arch. de phys.*, 1873, p. 145.

Hoffman. *Deutsch. Arch. für klin. Med.*, 1886.

|| Müller. *Beiträge zur path. Anat. und Phys. des Rückenm.*, Leipzig, 1871.

which a complete hemisection of the cord, together with division of the posterior columns of the other side, resulted in complete loss of touch. Edinger believes that the sensations transmitted by the columns of Goll undergo decussation in the medulla. That all the fibers for tactile sensation do not cross in the cord, at least at levels of recorded injuries, the cases of Brown-Séquard paralysis would seem to prove; for when, in lesions of the cord, this function is entirely lost, there has been a bilateral involvement.

I can find no cases in which this sense was more than impaired, where the injury was certainly limited to one side; and, in fact, from the want of cases of complete cerebral hemianæsthesia there is no proof that a complete decussation of them occurs anywhere. The fibers which cross immediately on entrance are probably somewhere in the white matter of the lateral columns outside of the pyramidal tracts.

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