

## A CASE OF CIRCUMSCRIBED UNILATERAL, AND ELECTIVE SENSORY PARALYSIS.

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By elective sensory paralysis is to be understood one in which certain only of the functions of the sensory nerves are abolished. The observations which are to be briefly reported here have been made upon my own left arm, and in large part by myself. The anamnesis is as follows: I am at present twenty-eight years old, and, as far as I remember, aside from the ordinary diseases from which children suffer, I have always been tolerably healthy. For the past nine or ten years I have noticed at times along the inner (medial) side of the left arm radiating pains, which are prone to appear on standing for a long time or after a long walk, especially when I am overtired or a little run down in health. For about the same length of time, sensations of numbness and formication have made themselves noticeable. These have been referred to the same area, and have affected also, in a slight degree, the little finger and the ulnar side of the ring finger of the left hand. The pains, which, as a rule, are not very severe, can be quickly stopped, or essentially relieved, by lying down or by elevating the left shoulder. Beyond these symptoms I have nothing to complain of, and during the past two or three years unpleasant sensations of any kind have rarely existed. The motility of the left arm is in no way diminished or interfered with. This arm is slightly weaker than the right, which is easily to be explained by the fact that it has been used less. Alterations in the muscles or the skin have never been perceptible. The secretion of sweat is normal, and goose

skin occurs on the left as often and to the same extent as on the right side.

About a year ago the arm was examined by my friend Dr. H. M. Thomas, neurologist at the Johns Hopkins Hospital, and the presence of a sharply circumscribed zone of anæsthesia for temperature and pressure was demonstrated in the area mentioned.

The last cervical vertebra shows on the left side a rigid, bony process apparently firmly attached to it. This process projects above the clavicle in front where it can be easily seen and felt. It is extremely little if at all movable, and it accompanies the first rib for a short distance, lying directly above it. This process is probably to be looked upon as a cervical rib.

Being in Leipsic during the spring and summer of 1895, at the suggestion of Prof. v. Frey, in the Physiological Laboratory there, I undertook an exact investigation of the conditions in the arm, in order to determine the extent and the kind of disturbance of sensibility qualitatively, and, as far as possible, also quantitatively. Unfortunately, my time did not permit me to make the study complete for all parts of the arm, and the investigations were therefore limited to the changes in the forearm, an attempt being made to establish with extreme care the character of the anæsthesia in this region. Although the working out of the whole zone must be deferred until later, I am already in a position to state that the sensory changes in the anæsthetic areas of the upper arm and of the hand (the deviations from the normal in the latter are very slight) resemble exactly in all essential points those in the forearm.

#### METHODS.

The sensation for cold, warmth, pressure, and pain was examined, and for these four sense-qualities the limits of the anæsthetic areas were at first tolerably accurately established by quick methods of examination, and later the distribution of the different sense-points and their threshold-stimuli (*Reizschwellen*) were carefully determined, with exact methods of localization and measurement.

I. *Cold-sensation*.—For quick limitation, metal rods with an end surface of one square centimetre or a camel's-hair brush moistened with ether were used. To localize the individual cold-points there were employed metal rods with conical ends, as in Goldscheider's thermæsthesiometer,\* and fine steel pens moistened in water at the room temperature; finally, for extremely exact localization, pieces of copper wire of 0.2 millimetre diameter were used. I prepared a large number of such bits of copper wire, varying in length from a half to six millimetres, mounted on little sticks of wood surrounded, except at one free end, by sealing-wax. By means of these the investigator is in a position to make quantitative examinations by which the more or less accurate estimation of threshold-values in "heat-quantities" is rendered possible. If the temperature of the skin is known, through the application of water which is felt neither as warm nor as cold, and also the temperature of the room in which the wires are used, one can obtain the "heat-quantity" which a given bit of wire can yield to the skin or take from it by multiplying together (1) the difference between the above temperatures; (2) the "heat-capacity" of copper; and (3) the "mass" of the piece of wire.

II. *Warmth-sensation*.—The hot tube of Blix,† provided with a thermometer, was used almost exclusively, since either the broad surface or the fine point, as desired, can be applied to the skin. An attempt was also made to stimulate the warm points with known "heat-quantities," the pieces of copper wire previously described being heated to 40° C. in an air-bath.

III. *Pressure-sensation (Druckempfindung)*.—For the first examination a soft pencil, or, still better, a little wad of absorbent cotton, was drawn over the skin, especially over the hairs. For finding the pressure-points, and particularly for determining their threshold-values, we used punctiform faradic stimulation as well as the test-hairs (*Reizhaare*), finely graded, according to the pressure they

\* Du Bois' *Archiv., Suppl.*, 1885, p. 2.

† *Zeitschr. f. Bio'ogje*, Bd. xx, 1884, p. 153.

exerted. These test-hairs were first devised and used by Prof. v. Frey.\*

IV. *Pain-sensation*.—For this purpose also test-hairs similar to those used in examining the pressure-sense, only of higher pressure-values, were employed, but an extensive use was also made of other mechanical as well as of electrical and thermic stimuli.

Since an alteration of the sensory conditions during the course of the investigation was not to be expected, and, as a matter of fact, could not be demonstrated, the test was carried through in a systematic way for each single one of the sense-qualities under examination, after which the next kind of sensation was taken up for study. The examination of each kind of sensation was divided into three stages. At first the limits of the anæsthetic area for the sense-quality concerned were broadly determined by one of the investigators named below and marked by coloured lines. After this, in numerous sittings, the sense-points were carefully sought out one by one and marked by myself. Finally, the results were confirmed, for the thermic sensations by Dr. F. Kiesow, for pressure- and pain-sensation by Prof. v. Frey. It is a great pleasure to me to heartily thank once more both these gentlemen for the repeated and most painstaking confirmatory tests which they so cheerfully made.

Every one who has had any experience in seeking out sense-points knows that the examination even of small areas of the skin, if it pretend to completeness, can not be terminated in one sitting. Estimations of the number and position of sense-points are also the more reliable the less the stimuli exceed the threshold-value; if one acts accordingly, the testing makes such claims on the attention that the examiner is incapable of making any one sitting very prolonged. Inasmuch as the examination in this case had to include tolerably large areas of the skin, it became necessary to establish the position of the sense-points which had been sought out and confirmed in some more permanent way than could be arrived at by any kind of colour-

‡ Beiträge zur Sinnesphysiologie der Haut, i, ii, iii, Leipzig, 1894-'95. Aus den *Berichten der math.-phys. Classe der K. Sächs. Gesellsch. der Wiss.*, July 2 and December 3, 1894, and March 4, 1895.

ing of the point upon the skin. This problem was solved in the following manner: The skin was divided into a number of fields according to the course of the visible cutaneous veins and also with regard to certain irregularities, which have yet to be mentioned, in the lines limiting the anæsthetic zone. As soon as the determination of the sense-points of one quality for such a cutaneous field had been completed, a piece of gelatin-paper was laid upon the skin and the sense points and the limits of the area were accurately copied and transferred to a plaster-of-Paris cast of the whole arm. For each quality of sensation examined a special plaster cast was made. This method of keeping track of the topographical relations of the investigation proved to be particularly serviceable. With the help of these casts it has been possible to find again very quickly any desired single sense-point.

#### GENERAL RESULTS.

It appears to me desirable to state first generally the main results of the investigation, and later to refer more in detail to the experiments which bear on the single sense-qualities.

1. The disturbance is limited to the domain of the *nervi cutanei brachii et antibrachii mediales* of the left arm.

2. In this area the sensation for warmth, cold, pressure, and touch (*Druck und Berührung*) are absent. In addition, no tickling sensation can be called forth in the cutaneous region concerned. The sensation for pain is apparently intact on superficial examination, but with accurate testing a slight diminution in the number of pain-points can be demonstrated.

3. The limit of the area of sensory disturbance on the flexor surface of the forearm is sharply and regularly defined, and is situated almost exactly in the middle between the radial and ulnar side. On the extensor side the limit is not sharply defined, and indeed is very irregular—i. e., the anæsthetic zone invades by deep indentations the normal area, and the transition from regions where the three sense-qualities are entirely absent to areas where sense-capacity is complete is very gradual. These findings can also be described in the follow-

ing way: On the *flexor surface*, passing from the radial to the ulnar half, the sense-points for warmth, cold, and pressure, which on the radial side are present in normal numbers, suddenly cease when we advance beyond the above-mentioned line.\* In passing over the ulnar margin of the forearm *to the extensor surface*, single sense-points here and there again appear, increasing gradually in numbers toward the radial margin, but not being present in normal numbers until this margin is nearly reached.

4. The limits described, although they hold in general for each of the sense-qualities which are disturbed, show in detail many variations. These are in part to be accounted for by the fact that the distribution of the sensory points within the partially anæsthetic area follow the same rule as on the normal skin, namely, that of the three kinds of sense-points—pressure-points, cold-points, and warm-points—the pressure-points occur in greatest and the warm-points in smallest numbers. In addition to this, single sense-points or groups of sense-points of one kind are to be found located in places where none of the other sense-qualities is represented.

5. The sense-points of the partially anæsthetic area, whether they are isolated or mixed with others, as well as the points on the border of the normal and anæsthetic skin, react to normal threshold-stimuli. I can assert this absolutely for the pressure- and pain-points from numerous determinations of threshold-stimuli. The individual cold-points and warm-points show considerable differences in excitability, but these differences do not appear to be more marked than in normal areas.

#### SOME SPECIAL OBSERVATIONS.

A. *Regarding Temperature-sensations.*—The excitability of the cold- and warm-points is, when fatigue is completely excluded, distinctly dependent upon the absolute temperature of the skin; with higher outside temperatures, after bodily exercise, and after meals, the excitability on previously clothed portions of the skin is greater, and the localization of the sense-points is made easier. Strong tem-

\* Compare below the results regarding the pressure-points.

perature stimuli, even when they are of small area—the so-called punctiform stimuli—spread out to a considerable distance beyond the direct spot of skin to which they are applied. In the anaesthetic zone single demonstrable sense-points can be excited from a distance, although not with equal ease from all directions. One can probably accept the view that the direction of the blood stream and the course of the blood vessels in the skin are of essential significance as regards this point. The response to the stimulus in such cases occurs relatively late. The smallest amount of heat, the subtraction of which I have found could lead to the reaction of a cold-point, was 0.0024 calorie, or the same amount of heat by means of which the temperature of 2.4 cubic millimetres of water can be raised through 1° C. In this test direct mechanical excitation of the cold-points, which had previously been most exactly located, was excluded. Of twenty cold-points examined, there were eighteen threshold-values which lay between the amount of heat just mentioned and an amount twelve times as great. I have made determinations of the threshold-stimuli for the warm-points only in single instances. These in relation to those of the cold-points are relatively high—a fact which may stand in some relation to the long latent period which is, as is well known, characteristic of the warm-points. The question needs and deserves a much more thorough study than I could devote to it in view of the work which had to be done in connection with the main portion of this investigation.

The paradoxical cold sensation (v. Frey\*) was examined on some fifty cold-points by Dr. Kiesow; the majority of these yielded, on the application of temperatures of from 40° to 50° C., exclusively the sensation of cold. In some few, cold and warmth were felt at the same time; in the case of some others, cold was felt at first, and after some time the sensation of warmth appeared. In the latter instances warm-points were always demonstrable in the immediate neighbourhood of the cold-points. The paradoxical excitation appeared even at temperatures which were absolutely unassociated

\* Cf. v. Frey, *op. cit.*, iii, p. 172.

with any painful quality, a point upon which especial emphasis must be laid.

The reverse experiment—the stimulation, by the application of bits of ice, of isolated warm-points lying in the anæsthetic zone—never succeeded. If one allowed, however, a drop of ether to evaporate over such a warm-point, after some time a slight feeling of warmth resulted. Here we had to deal probably with a reaction on the part of the blood vessels. I have convinced myself many times of the electrical and mechanical excitability of the temperature-points, although these modes of excitation were not made the subject of an especial study. I have, however, confirmed the results of Blix and Goldscheider in this connection.

B. *Pressure-sensation*.—The area of complete anæsthesia to pressure is smaller than that to thermic stimuli; it never reaches beyond the ulnar margin of the forearm on the flexor surface. As Prof. v. Frey\* has found, the spots where the pressure-threshold is lowest (*Orte niedrigster Druckschwelle*) exhibit a very definite relation to the hair follicles. There is no perceptible difference in the number or in the development of the hairs on the anæsthetic and the normal skin, although in the former almost all the hair follicles are non-responsive to stimuli of pressure or touch. Between the completely anæsthetic and the normal area lies a transitional zone in which some of the hair follicles are still sensitive. The transitional zone is, on the flexor side, scarcely one centimetre in width, whereas on the ulnar side it includes the ulnar margin and the greater part of the extensor surface. That these more or less isolated pressure-points possess normal threshold-values has already been mentioned. The hair follicles which do not react to pressure fail to yield the characteristic oscillatory or buzzing sensation on faradic stimulation. (Cf. v. Frey, ii, p. 291.) As a special peculiarity of the isolated pressure-points I might state that with increase of the mechanical stimulus the sensation gains only a little in intensity. This would appear to show that the deformation of the skin increasing with the stimulus is recognised more by the number of the

\* Cf. v. Frey, *op cit.*, i, p. 190; ii, p. 287.



sensory points affected than by the intensity of the excitation of the single-points.

While stroking the hairs of an uninjured spot of skin calls forth intense sensations of touch or even of tickling, within the anæsthetic area such a stimulus is not perceived at all. Mechanical influences which affect the skin itself become recognised as soon as the deformation, displacement, or pulling of the skin extends beyond the limiting lines into the area in which the pressure-points are sensitive.

C. *Pain-sensation*.—Pain-sensation can be called forth within the anæsthetic zone on very many spots. However, exact investigation shows that the points especially set apart for this sensation, the pain-points, do not everywhere lie so closely together as in normal areas. One can find on stimulation with the very finest needles or by punctiform faradization painless spots of the extent of more than several square millimetres; areas of this size not sensitive to pain do not occur normally in the region under examination. Nevertheless, the disturbance of the pain-sense is everywhere but little marked, as compared with that of the other sense-qualities, so that on superficial testing one might arrive at the conclusion that he had to deal with an anæsthesia of all the qualities of sensation with the exception of pain.

A series of influences which in normal regions at first evoke other sense-qualities and only subsequently give rise to pain-excitation, here are felt exclusively as painful. Pricks with a fine needle excite only a feeling of pain without calling forth previous touch- or pressure-sensations, and are answered by lively reflexes. A small piece of ice laid on the anæsthetic zone is at first not felt at all, and only after the lapse of a certain time excites a sensation of pain. Metal at the temperature of 47° C. and upward very quickly causes pain, though there is absolutely no accompanying sensation of warmth. Here the opportunity is offered of observing the so-called "temperature-pain" wholly independent of the temperature-sensations which on the normal skin accompany it or precede it.

As to the "heat-pain," it was shown that the threshold-stimulus

for it lies at a different level in different places. On some points a painful response was obtained to a temperature of 46° C.; this, however, was rare. For the most part, pain was felt first at higher temperatures, and hardly ever under one of 50° C. These experiments are all in favour of the view that the painful sensations which under similar conditions are felt on normal portions of skin have their origin in the stimulation of the organs directly concerned in pain-sensation. Under ordinary conditions the sensations of pressure, heat and cold, which are normally always previously evoked, act to a certain degree as protective mechanisms which very often suffice to enable one to avoid the pain-sensation. Within my anæsthetic zone these introductory sensations are absent, and I became, so to speak, surprised by the unannounced appearance of pain when efficient stimuli, though not strong enough nor so widespread as to involve the area which possesses normal sensation, were applied. This may perhaps afford an explanation of the fact that I have throughout life preferably used the right arm relatively more than most right-handed men, since there has been a partly conscious and partly instinctive attempt to protect the left arm.

The threshold-stimulus for mechanical excitation of pain I have found, by testing with Prof. v. Frey's test-hairs in the anæsthetic area, to vary within the same limits as in normal areas. For the "heat-pain" I found the region of the wrist and the ulnar border of the forearm more sensitive than those areas which lie toward the fossa cubiti. In addition, it must be remarked that exactly in the last-mentioned region the diminution of the pain-points is most distinctly to be made out.

The capacity to localize is very incomplete within the area where pain exclusively is felt. The exact situation of compass points is appreciated only very inaccurately. In applying the compass test of Weber the neighbourhood of the normal domain must be avoided, and in addition one must have made sure that the spots of skin struck by the two points actually possess pain-sensation. One finds then that pain-points which are separated from one another by as much as 10 centimetres can often not be distinguished.

D. *Motility*.—In conclusion I desire also to mention the results of an examination of the motility of both my arms which Privat-docent Dr. Windscheid was good enough to make for me.

*Circumference in Centimetres*.—The middle of the upper arm, R. 25 ; L. 24. The middle of the forearm, R. 21 ; L. 20.

Crude strength of left biceps and muscles of forearm weaker than right. In the faradic and galvanic excitability of the biceps as well as in conduction-resistance no distinct difference can be made out between the right and the left side. The contractions are never sluggish. Atrophy of single muscles is nowhere demonstrable.

#### EPICRISIS.

In reviewing the disturbances described, they are seen to be essentially "phenomena of absence," a number of nervous functions which are peculiar to the normal skin not being present. Irritation-phenomena, as far as they can be observed, are by no means prominent. With this conforms the observation that an alteration of the threshold-values of the retained functions in the partially anæsthetic area could nowhere be distinctly demonstrated.

One will find, in considering the etiology, in the purely unilateral seat of the disturbance and in the definite limitation to two cutaneous nerves, strong ground in support of the view that the cause of the disturbance is peripheral, and it is probably to be sought in the cervical rib, which is almost certainly present. Quite recently attention has been several times drawn to the fact that the presence of a cervical rib through pressure on the brachial plexus can give rise to disturbances of sensibility and motility. The cases in which the symptoms have disappeared after resection of the rib are most convincing in this connection.\* Since in the case just described a loss in motor capacity is not demonstrable, the disturbance appearing to be much more of a purely sensory nature, one might be inclined to look for the seat of the lesion in the nerve roots or in the spinal cord. In opposition to this, however, it may be pointed out that at the site of

\* The literature will be found appended to the article by Tilmann in the *Deutsche Zeitschrift für Chirurgie*, Bd. xli, S. 330.

the disturbance the sensory paths must already be arranged with regard to the peripheral distribution, if one is to explain the fact that the two above-mentioned cutaneous nerves alone have been injured. Now, according to Henle, the *nervi cutanei brachii et antibrachii mediales* arise from the lower cord of the plexus brachialis which represents a continuation of the eighth cervical and first thoracic nerves, and thus it is at any rate possible that the nerves mentioned could be affected by a cervical rib.

Most interesting in the case before us is the slight amount of disturbance of pain-conduction as compared with that of the other sensory functions. However, even this finding represents only one of the numerous variations which are possible in elective injuries of peripheral nerves. As regards this point, numerous experiences could be referred to, more particularly the newer observations of Cavazzani\* and the younger Charcot.† In Charcot's case, which is antithetic to mine, the individual, as the result of a scar in the cubital region, suffered from a paralysis of temperature- and pain-sensations in a large part of the hand, while the sensations of pressure and touch were retained. The loss of temperature- and pressure-sensations was unequal in the case observed by Cavazzani. These two cases, to which others might be added, are the more convincing in that after excision of the scar in the one instance and the healing of the wound in the other the sensory disturbances disappeared. As physiological experiments have shown that the nerve fibres of one portion of a limb—for example, those for the flexors and extensors—are not evenly distributed within the nerve trunk leading to it, but are already arranged according to their functions, so it would appear that a similar arrangement may hold also for the sensory nerves with regard to the different paths which they are to follow within the spinal cord. Thus, whereas in the motor nerves the fibres appear to be arranged according to the muscles to which they are to be distributed, for the sensory fibres we may have to consider rather

\* *Archives ital. de Biologie*, t. 17, p. 413.

† *Comptes rendus de la Soc. de Biologie*, December 10, 1892.

the different paths which they have to follow on entrance into the spinal cord.

In accordance with these views the case just described would have to be looked upon as one in which the majority of the pain-conducting fibres have been retained, while the others in great part have disappeared, for some areas of skin even completely. In any case it appears to me that this view agrees better with the facts than the other that the nerves are retained, but that their excitation is no longer felt except in giving rise to pain. When one sees that in the periphery certain only of the sense-points have disappeared—for example, the pressure-points arranged in connection with the hair follicles, while the far more numerous pain-points are present in normal or in only slightly diminished numbers—one can scarcely avoid the conclusion that there are specific nerve-endings and nerve-paths involved, which have actually disappeared.

Further, the irregular limitation of the anæsthetic area and the occurrence of sense-points singly or in groups on the extensor surface of the forearm, seems to be worthy of mention. From this alone one might almost conjecture that, even normally, the endings of different sensory nerves are associated with one another in the skin in the most complicated manner. It is true, however, that one might think also of regenerations, and more especially since such have recently been observed by Fedor Krause \* in the distribution of the trigeminus. But the adoption for the present case of either of these views would be associated with difficulties, considering the relatively very sharp limitation of the anæsthetic area on the flexor side.

In conclusion, I beg to tender my most sincere thanks to Prof. v. Frey, at whose suggestion and under whose supervision this research was carried out. Without his assistance I could hardly have appreciated fully the physiological bearings of the results obtained.

\* *Münch. med. Woch.*, 1895, Nos. 25–27.