tion, that those cases of ataxy which are preceded by sclerosal changes in the optic nerve are frequently cases of abortive general paralysis, and which are decidedly cerebro-spinal, rather than purely spinal; and, furthermore, when the acute symptoms set in, they become more or less rapidly fatal. When the sensory division of the fifth nerve is involved in association with amaurosis due to sclerosal atrophy of the optic nerve and other signs of tabes dorsalis, we must be guarded in making a diagnosis and in giving a prognosis. Now, in making a diagnosis, we have to study very carefully the head-pains, which are very diagnostic in the general paralysis of the insane, as they differ from those of tabes dorsalis, which are equally diagnostic. In the former case, the headache is primarily of medullary origin, is more diffuse, and invariably associated with marked elevation of temperature; but it may appear and disappear suddenly; and it differs altogether from the chronic form of headache which supervenes and becomes more localised and persistent as organic changes ensue in the later progress of the disease. In tabes, when the fifth nerve is involved, the pains are rapidly migratory, and resemble more the pains of neuralgia; and, what is most important to remember, they are not accompanied by an increase of temperature of the head. The fifth nerve is more frequently implicated in the general paralytic than in the tabetic; hence we find disturbances of sensation in those parts supplied by the sensory division of this nerve more frequent in the former than in the latter. I have seen patients with commencing general paralysis who have stated that their teeth felt like so much India-rubber; and I have also found that, throughout the whole distribution of this nerve, there has been a decided retardation in the conduction of sensations as well as of the sense of pain.

It is generally considered that the seventh is, of all the cranial nerves, the first nerve to be objectively involved in general paralysis, and especially those branches which serve for the mimetic movements of the mouth and lips; and this is unquestionably true as far as the objective signs are concerned; but more recent observation has led me to conclude that the deficiency in normal sensation of those parts supplied by the fifth nerve precedes the exaggerated and inco-ordinate movements of the lips in articulation, which are strikingly characteristic of general paralysis, and which distinguish this condition of disease from tabes dorsalis; and the same may be said of an associated lingual tremor and muscular inco-ordination. The special senses of taste and hearing are more defective in the general paralytic than in the tabetic. The varying morbid reflex actions and trophic disturbances which produce the different crises in tabes are for the most part of spinal origin, and are common to other degenerative changes in the spinal cord, and cannot be said to be due entirely to sclerosis of the posterior columns; at all events, they are not found to exist in the primary stages of the general paralytic. In tabes dorsalis, ataxy, and not paralysis, is the essential and characteristic disturbance. This disturbance is usually first manifest in the lower extremities.

In the general paralysis of the insane, the first sign of ataxy is usually seen in some derangement of those complicated and combined movements of the tongue and lips in articulation; but we find more than mere disturbance in the co-ordination of these movements, for there is, in addition, actual muscular paresis; and the power for the engenderment of individual and simple movements is greatly lessened, and no sustained muscular effort can be supported.

THE PHYSICS OF NERVE-STRETCHING.

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ON the 15th May 1878, I read a paper on the above subject before the Medico-Chirurgical Society of Edinburgh. At that time, the operation of nerve-stretching was chiefly resorted to for severe and intractable cases of sciatica. Having seen the greater sciatic nerve stretched by several of the Edinburgh surgeons, and the limb with part of the trunk lifted from the table by the nerve, I thought it would be useful to ascertain the amount of force that could be applied to the nerve without any liability of rupturing it.

On consulting the various text-books of anatomy and physiology, little or no information could be obtained. Thus Hermann, in his *Human Physiology*, translated by Gamgee, dismisses the subject with the remark, that "the mere mechanical properties of nerves have, as a rule, no interest, physiologically speaking;" but, in view of the operation we have mentioned above, they would appear to have some interest surgically. In Valentin's *Physiology*, translated by Dr. W. Brinton (page 20), there is a table, showing the relative cohesion of the tissues of the body. These are stated as follows, in kilogrammes, per square millimetre of section: muscle, .06; arteries, .14; veins, .23; nerves, .96; tendons, 5.3; bone, 8.0. It will be noticed that tendons are

given as about six times as strong as nerves. In the *Annales de Clinique et de Physique*, for 1847, is a valuable "Memoire sur l'élasticité et la cohésion des principaux tissus du corps humain," by Wertheim. At the end of his paper, he gives, in a tabular form, the result of his experiments upon various tissues. In the list of nerves, there are four great sciatics. The following was the method he employed, and the result obtained. As long a portion of the great sciatic nerve, presenting a tolerably uniform size, as could be obtained, was removed from the body, measured and weighed. One end of it was then fixed, and a weight attached to the other; the increase in the length of the nerve was observed; and, the weight being removed, its length was taken immediately, and again after a short interval. This process was repeated, the weight being gradually increased each time, until the nerve was broken. This was accomplished in a man, aged 35, by 47 lbs., and in one aged 74 by 51 lbs.; in two females, aged respectively 21 and 60, by 59 lbs. and 39 lbs. From experiments on various nerves, he came to the conclusion that, in proportion to their size, the branches of a nerve were stronger than the main trunk. These experiments of Wertheim did not appear to give the surgeon a reliable guide to the amount of force he might safely apply in the ordinary operation of nerve-stretching; and that mainly for two reasons.

1. His experiments being made chiefly with a view to ascertain the elasticity of the nerves, these were subjected to a considerable amount of stretching for some time before a force sufficient to rupture them was applied; and, as is well known, *time* is an important factor in testing the cohesion of a substance.

2. The nerves being first removed from the body, his experiments afford no information as to the strength of the upper and lower attachments of the nerve.

In order to obviate these objections, I made a series of experiments, in which the force was applied, as nearly as possible, in a manner similar to that in the operation of nerve-stretching. The subject being placed on its face, the nerve was exposed at the point where it is usually stretched—viz., at the lower border of the gluteus maximus. One end of a strong S-shaped hook was passed beneath it, special care being taken to include the whole of the nerve. The body was then turned on its back, and the buttocks supported on one table and the knees upon another. To the lower curve of the hook, weights were then rapidly attached until the nerve gave way. By this means, the force was applied at right angles to the thigh, as in the operation when the limb is lifted by the nerve; and, by the rapid addition of the weights until the nerve ruptured, the force acted only, as in the operation, for a short time.

EXPERIMENTS.

Experiment 1.—Male, aged 37, well-developed, but lower limbs oedematous; heart and lungs healthy; liver markedly cirrhotic; a clot in left iliac vein. During life, the left limb had become dropsical before the right one. Right sciatic: 100 lbs. failed to break, even after it had been on for fifteen minutes; had no heavier weights at this time. Left sciatic: 100 lbs.; the nerve came away, with its connections to the spinal cord, in less than one minute.

Experiment 2.—Female, aged 50, of average size and muscular development; aortic disease; lower extremities slightly oedematous. Right sciatic: 100 lbs.; came away from spinal cord in less than a minute. Left sciatic: 100 lbs.; came away as on right side, but almost immediately.

Experiment 3.—Male, aged 22, well developed. Right sciatic: 126 lbs.; failed to break. Left sciatic: 126 lbs.; failed to break. I had no more weights, but turned the body, and lifted the lower extremities and as much of the trunk as I could by the nerve, and I failed to break the nerve.

Experiment 4.—Female, aged 17, small for her age and ill-developed. Died of phthisis, waxy disease, etc. Right sciatic: 98 lbs.; gave way in less than a minute from spinal cord. Left sciatic: 84 lbs.; same result as above.

Experiment 5.—Male, aged 36, well developed; aortic disease; slight dropsy of lower limbs. Right sciatic: 158 lbs.; nerve broke across immediately at the point of attachment of the hook. Left sciatic: 154 lbs.; same result.

Experiment 6.—Female, aged 60. Died from fracture of skull. Right sciatic: 140 lbs.; broke as in Experiment 5. Left sciatic: 126 lbs.; the same result.

Experiment 7.—Female, aged 36, well developed. Died of cardiac disease. Right sciatic: 145 lbs.; immediately broke from the spinal cord. Left sciatic: 160 lbs.; same result as on right side.

Experiment 8.—Male, aged 40, very muscular; height, six feet. Died from injury of head. Right sciatic: 176 lbs.; broke immediately at the point where the hook was applied. Left sciatic: 170 lbs.; same result.

Experiment 9.—Female, aged 35, very well developed. Right sciatic : 160 lbs.; detached from the spinal cord in less than a minute. The left sciatic could not be tested at the time.

In all these cases, the experiments were performed from one to three days after death. In applying the weights, an amount rather less than it was considered probable would be needed to rupture the nerve was first attached to the hook; and then, with the help of assistants, small weights were rapidly added until the nerve gave way. Excluding Experiment 4, all the subjects were adults; and in these, the average weight required to rupture the nerve was 140¾ lbs. In Experiment 1, the nerve gave way with an exceptionally small force—viz., 100 lbs.; but, in the other two male subjects (Experiments 5 and 8), the average weight required was 164½ lbs. On an average, a loop of the great sciatic would, I think, bear for a short time nearly the entire weight of the body.

Even more interesting than the amount required to rupture the nerve, was the position at which it gave way. Out of the fourteen cases in the table, six broke at or near the point where the hook was applied. In the other eight cases, the nerve itself did not break; but its connections with the spinal cord and its membranes were detached. All the specimens thus obtained presented essentially the same appearance, and consisted of the nerve-roots of the last lumbar and first and second sacral nerves. These were torn at the point where they joined the spinal cord. Tracing these nerve-roots downwards to the dura mater, a small portion of this membrane was found connected with each pair of spinal nerve-roots, a short time before the latter joined. The dura mater, in fact, was torn near the point where it is prolonged from the main sheath on to each nerve. Then, the anterior primary divisions of the last lumbar, and two upper sacral nerves, could be traced down to the point where they become continuous with the great sciatic. The branch from the fourth lumbar, to join with the fifth to form the lumbosacral cord, was always present. The posterior primary divisions, and other small branches, were broken near their origin.

REMARKS.—The experiments detailed above were not published at the time the paper was read, as I intended, before doing so, to conduct a more extensive and carefully planned series of experiments. Circumstances have hitherto prevented me from working much further at the subject. As, however, the operation of nerve-stretching is now becoming a comparatively common one, both for central and for peripheral nervous affections; and as I believe the results I obtained may prove, not merely useful to the surgeon, by affording him some guide to the amount of force he may safely apply, but also because I think they have a value in connection with the question of nerve-stretching in central lesions, I venture to lay them before the profession.

My experiments clearly show, that the great sciatic nerve is able to withstand a considerable strain; but they also indicate the necessity for caution; more especially in the downward traction of the nerve. I have several times attempted to break this nerve in the dead subject, but have invariably failed, although the nerve was greatly stretched, and I sometimes heard suspicious crackling noises. The suggestion of Dr. John Cavafy, in the JOURNAL (December 17th, 1881), that surgeons should come to some more definite idea of the amount of force employed, should certainly be acted upon. There are several points in connection with the operation of nerve-stretching, which have not apparently been sufficiently considered. If a nerve, such as the great sciatic, having an almost direct origin from the spinal cord, be pulled downwards, an anatomical examination will show at once that almost the entire strain is borne by the dura mater. If the vertebral canal be opened from behind, so as to expose the spinal dura mater, and at the same time the great sciatic be stretched, a slight downward movement of the lower part of the dura mater is at once visible. By careful measurement, however, I find that it is not displaced more than an eighth of an inch. The dura mater possesses very little extensibility; and, further, the nerve-roots piercing it nearly opposite the intervertebral foramina, the stretching of the great sciatic rather tends to displace the dura mater laterally. Even a cursory examination will at once show that this cannot occur to any appreciable extent. If the dura mater be opened in the lumbar region, and the roots examined, it will be evident that the slight displacement produced by the stretching of the dura mater can have no appreciable effect in increasing their tension, and thus enabling them to act directly upon the spinal cord. The dura mater thus serves as a very efficient protector of the delicate spinal nerve-roots; but, should it be torn, an extremely small force would suffice to detach them from the spinal cord. It therefore appears evident that stretching a nerve, such as the great sciatic, produces no direct mechanical action upon the spinal cord. Stretching a nerve less directly connected with the spinal cord, such as the median, is still less likely to affect directly the spinal cord; and, of course, there is no danger, in case of rupture, of its being detached from the cord. In the few experiments I have

made upon this nerve, it always broke at the point where the force was applied.

The manner in which a beneficial effect is produced by the operation of nerve-stretching is very obscure. In some cases of sciatica, it may be due to the breaking up of adhesions, etc., pressing injuriously upon the nerve. In cases of central lesions, it probably acts upon the same general plan as other counter-irritants.

There is abundant clinical evidence to show, as one would expect, that the operation of nerve-stretching produces a powerful local action—not unfrequently being followed by temporary paralysis. Then, again, it produces a marked effect upon distant nerve-centres, such as the respiratory and cardiac, as is shown in Langenbuch's cases. As a counter-irritant, it stimulates, not merely the nerve, but also its connecting trunk and branches.

In the operation, many surgeons attach special importance to the downward traction of the nerve—apparently believing that, by this means, they produce some direct mechanical action upon the spinal cord. This appears to me, as I have before stated, to be an erroneous idea: the nerve-fibres, as far up as the dura mater, being put upon the stretch, but not the spinal nerve-roots beyond.

Dr. John Cavafy, in the BRITISH MEDICAL JOURNAL (December 17th, 1881, page 974), objects to the "nerve-stretcher" of M. Gillette, partly on the ground "that the extension must affect the peripheral and central portions of the nerve itself." If my view be correct, this is rather an advantage than otherwise, as a longer tract of nerve-fibres is thus stimulated. Furthermore, by stretching a loop of the nerve, the force is divided between the peripheral and central ends—so that there is less liability to rupture. Traction upon the peripheral end of the nerve can be employed with more safety than upon the central end, the former being the stronger; and the nervous stimulation would probably be as great, if not greater.

CASES BEARING ON CEREBRAL LOCALISATION.

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CASE 1. *Idiocy with Congenital Aphasia, Dextral Hemiplegia, and Contracture and Atrophy of Right Limbs. Destructive Lesion and Atrophy of Left Cerebral Hemisphere.*—H. C., admitted April 21st, 1879, aged 10, was described, in the statement appended to the "order for admission", as an epileptic whose insanity was congenital. The "medical certificate" stated that he was quite incoherent and unintelligible; dirty and destructive in his habits; idiotic in appearance and manner; easily excited, when he tore his skin with his nails.

On April 24th, he was observed to be a deformed lad. He squinted slightly inwardly with the right eye. The right side was chiefly affected, both arm and leg being as stiff as if the joints were ankylosed. He had an idiotic expression of countenance, and did not seem to have any intellect; and was very wet and dirty in his habits. He had had several fits since admission. His appetite was good, and he was fairly nourished. July 22nd. He had a prolonged attack of syncope after an epileptic seizure a few days ago. The fits increased in frequency and severity. The condition on February 22nd, 1880, was as follows. His chest was deformed, narrow, and projecting; his head very large, twenty-three inches in circumference, and of the hydrocephalic conformation. He knew those about him, took notice of them, and evinced a considerable amount of jealousy, joy, grief, anger, etc. On February 23rd, 1881, his right arm was paralysed and contracted; the elbow bent and stiff; the hand bent back on the arm; the wrist stiff; the fingers were flexed on the palm of the hand. The right leg was paralysed and contracted, and strongly flexed at the knee-joint. The ankle was stiff, and the sole of the foot turned in. The right arm was atrophied; the right leg also, but not so much. He moved the left arm, hand, and fingers freely. He moved the left leg, and could stand when supported on the right side. He displayed some pleasure by his facial expression when spoken to, and screamed when annoyed, but had never been known to utter any articulate sound. On March 1st, he was paler and thinner and did not take food well. On March 10th and 11th, he had a series of severe and prolonged epileptic seizures, in which the convulsions were bilateral, and the eyes turned upwards and to the left. He died March 12th, 1881.

Necropsy.—An abnormally large quantity of serous fluid was found in the cranial cavity. The right lateral ventricle was greatly dilated. A gelatinous-looking mass was found attached to the left cerebral hemisphere laterally and inferiorly; this proved to be an enormous cyst containing serous fluid. The convolutions of the region over which the cyst was situated were completely destroyed, and the portion of the centrum ovale underneath was represented by a thin lamina, in