ON LOCOMOTOR ATAXY.*

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I HAVE a few remarks to make on the *pathological physiology* of locomotor ataxy—that is, on those *abnormal* actions of the spinal cord and voluntary muscles that are productive of incoordinate movements. These incoordinate movements have been, by different writers, attributed chiefly to cutaneous and muscular anæsthesia, as well as to loss of the so-called muscular sense; and different authors have given different degrees of prominence and importance to one or other of these morbid conditions. But the lesions of the spinal cord peculiar to locomotor ataxy induce, in some of the voluntary muscles, a certain abnormal condition which seems to have been entirely overlooked, but which appears to be really one of the chief causes of muscular incoordination. It is the opinion of some physiologists, that the loss of muscular coordination depends on the loss of reflex action in the spinal cord; and, since the posterior columns of the spinal cord are more or less damaged in locomotor ataxy, it has been inferred that spinal reflex action is dependent on the proper fibres of the posterior columns. But reflex action really depends on excitation of the grey substance by the posterior roots of the nerves, and the reflexion of the nerve-force so generated on to some of the motor nerves. Now, before I began my researches on the structure of the spinal cord, it was universally taught, both in England and abroad, that the posterior roots of the spinal nerves are attached *exclusively* to the lateral columns of the cord; whereas I showed—what is now universally admitted—that they are attached immediately to the posterior columns, and *not at all* to the lateral. The importance of this fact, in both a physiological and a pathological point of view, and especially in its relation to locomotor ataxy, will be presently made evident. In Fig. 2, which represents a transverse section of the left

Fig. 2.—*l*. Posterior roots of spinal nerves; *a*. Posterior white column; *b*. Antero-lateral column; *c*. Anterior fissure, at bottom of which is the decussation of anterior commissure; *d*. Posterior median fissure; *e*. Anterior motor roots.

lateral half of the lumbar enlargement of the cord, the posterior nerve-roots (*l*) are seen to enter the whole breadth of the posterior horn of grey substance, through nearly the entire breadth of the posterior column (*a*); and in Fig. 3, which represents a longitudinal section of the cervical enlargement of the cord, we see the course of the roots of four consecutive nerves (*p p, p, p,*) within the cord. These roots are of three kinds. The first kind (*a a a a*) enter the cord transversely, and pursue a very remarkable course. Each bundle, after traversing the longitudinal fibres of the posterior column (*p c*) in a compact form, and at a right angle, continues in the same direction to a considerable but

variable depth within the grey substance (*G*), dilating, and again contracting, so as to assume a fusiform appearance. It then bends round upon itself, at a right or more obtuse angle; and, running for a considerable distance in a longitudinal direction *down* the middle of the

Fig. 3.

cord, sends forward, at short intervals, into the anterior grey substance, a series of fibres, some of which mingle with those of the anterior roots (*A*), while others enter the anterior white column (as at *A C, A C*), in which they run longitudinally both upwards and downwards.

The second kind of posterior roots (*b, b, b,*) also traverse the posterior column transversely, but sometimes a little obliquely from without inwards. Their component fibres are finer than those of the other bundles, measuring about the 1-7000th of an inch in diameter. Some of their fibres cross over transversely to the grey substance of the opposite side, through the posterior commissure behind the canal; others extend into the posterior and lateral white columns of the same side; while the rest may be traced deeply into the anterior grey substance (*G*, Fig. 3), where they diverge in different directions, and are ultimately lost to view.

The bundles forming the third kind of posterior roots (*c c c*, Fig. 3) enter the cord obliquely. A few of their fibres proceed near the surface of the posterior column, both upwards and downwards; and pass out again with roots above and below them. The rest cross the posterior column obliquely, and chiefly upwards; a small number, only, running downwards. Interlacing at the same time with each other and with the roots already described, these fibres diverge, and for the most part reach the grey substance at points successively more distant from their entrance into the cord in proportion to the obliquity of their course; the most divergent and superficial taking a longitudinal course, at least for some distance, with the fibres of the posterior column, amongst which they are lost. From these investigations (*Phil. Trans.*, 1853), I inferred that the posterior white columns of the spinal cord cannot be the only channels for the transmission of sensory impressions—an inference which was verified two years later by the experiments of Brown-Séquard (*Gazette Médicale*, 1855).

Such being the anatomical connexion of the posterior nerve-roots with the posterior columns of the cord, it is evident that scarcely any part of the length of those columns can be damaged, either by injury or disease, without involving destruction of a corresponding number of those roots; and, since reflex action of the cord requires that impres-

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sions be conveyed by nerve-roots to the grey substance, the diminution of reflex action, in cases of injury to the posterior columns, is thus readily explained. But it is only occasionally, and to a certain extent, that reflex action, *in the ordinary sense of the term*, takes any part in the performance of voluntary movements. There is, however, a physiological state of the muscles dependent on reflex action, that is absolutely essential to the proper coordination of voluntary movements—I mean their tonicity, or that moderate but constant state of contraction which keeps the antagonist muscles, or those that are variously opposed to each other, in equilibrium or static tension. In the performance of voluntary movements, a constantly varying number of muscles, each of which differs more or less in *force* and in the *particular direction* which it gives to the limb or part, are associated together in action in an endless variety of ways. Each of the muscles that compose these varying groups must contract, either simultaneously or successively, to a certain *particular extent*, with a certain *degree of force*, and with a certain *degree of rapidity*, in relation to the actions of the others, according to the resultant direction desired in the voluntary effort; and this endless variety of ways in which a constantly varying number of muscles are balanced against each other in contraction, for the performance of constantly varying and complicated voluntary movements, affords the most exquisite and beautiful example of what in physical science is termed the *composition of forces*. In this balancing of muscular force, we have to learn by experience, and to remember, the exact voluntary effort required to contract each muscle to its proper *extent*, with its proper *force*, and with its proper *degree of rapidity*, in relation to the action of the others that complete the group employed. Now, it is evident that, if some of the muscles of the group employed have lost their normal tension or tone, they will not properly respond to the intentions of the voluntary stimulus, and will fail to perform their proper part in balancing the effects of the other muscles of the group that retain their tension, in the execution of any given movement. In proportion, therefore, to the exact *amount* of tension lost by any muscle or muscles of the group, and the *number of muscles* that have lost that tension, there must necessarily be a proportionate amount of *disorderly* movement or incoordination. But it appears to be satisfactorily proved by the experiments of Brondigeest, Rosenthal, and others, that this constant tension or tone of the voluntary muscles is due to a constant reflex action of the cerebro-spinal centres, and is immediately dependent on impressions conveyed from the muscles to those centres by the posterior roots of the nerves. Now, I have shown how these posterior spinal roots are spread out through the *posterior* columns of the cord; how impossible it is for these columns to be destroyed to any great extent without involving destruction of those roots; and how constantly these columns *are* so destroyed in locomotor ataxy. But, except in the very last stage of this malady, *all* the posterior roots are not injured by disintegration, and *some* of them are still competent to convey impression to the grey substance of the cord; so that *some* of the muscles retain their tone, while others lose it to a greater or less extent. Here, then, we find that actually the morbid condition of the spinal cord necessarily induces that partial loss of muscular tone which I have shown to be necessarily productive of muscular incoordination.

In the first volume of *St. George's Hospital Reports*, I have shown that, in locomotor ataxy, the voluntary movements are at first simply unsteady, like those of a man partially intoxicated; and that it is only later in the disease that the movements become jerking or spasmodic. Now, these two different kinds of movement admit of explanation by the progressive destruction of the posterior roots within the posterior columns; for at first, when the roots are only slightly damaged, and the tone or tension of some of the muscles is therefore only slightly impaired, these muscles oppose, although imperfectly, the force of their antagonists, and the movement will be tottering, or simply unsteady; but, later in the disease, when some of the posterior nerve-roots are completely destroyed, and the tone of some of the muscles is therefore entirely lost, while that of others is retained either wholly or in part, it is evident that the sound or sounder muscles will be unopposed by their lax antagonists, and will, therefore, contract to their full extent, and with a rapid jerking action.

There are two other points capable of explanation by this disintegration of the posterior roots in the posterior columns: I mean the numbness and loss of sensibility experienced in different parts of the body, which at the same time are the seats of the most excruciating pains. It is evident that, when the nerve-roots are severed by disintegration in the posterior columns, their peripheral ends can no longer transmit impressions to the cord; but their central ends may still be connected with the grey substance of the cord, and may, therefore, convey to it those irritating impressions that are caused by the process of their disintegration.

[To be concluded.]

CASE OF SPINA BIFIDA SUCCESSFULLY TREATED BY LIGATURE.

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I WAS summoned on September 8th, 1866, to attend Mrs. Dewsnap, of Hollingworth, in her third confinement, who, after a long and tedious labour, was delivered of a fine full-grown male child, about the usual size and weight, apparently healthy and strong. I soon discovered that the infant was suffering from a bifid spine in the lumbar region, the tumour being about the size of an orange, tense, fluctuating, and of a pale purple colour.

I made known to the parents the danger attending such cases, and suggested that I might resort to some operation for the removal of the tumour, or try the ligature. I came to the conclusion to adopt the latter course, and in two days after its birth I placed a ligature of silk thread round the neck of the tumour, tightening the ligature only slightly. The second day I passed another (also of silk thread) without removing the first; this appeared to produce a good deal of irritation, causing several clonic convulsive attacks for several hours during the day, but which passed off in the evening. The next day I passed a third ligature (silk thread), not disturbing the two former ones, and using more constriction, still without causing more convulsions, but leaving the child fretful. The three ligatures were all kept on until the tumour sloughed off, which did not happen for three weeks, leaving only a very small wound, over which I applied a piece of dry lint, using gentle pressure. In three days the wound had perfectly healed, leaving the child's lower extremities partially paralysed. After a few days, cold water was applied by means of a sponge along the whole course of the spine daily with marked benefit, the paralysis disappearing by the end of three months.

The reason that I have not reported this case sooner, is simply that I might watch my little patient for some time to see if any new symptoms should develop themselves; but, now that three years have elapsed, I consider him out of danger. The little fellow is strong and healthy, and can run about as well as any boy of his age. In the course of my obstetric practice I have had many cases of spina bifida to which I have, in some cases, used the remedies generally recommended, such as support by trusses, bandages, and puncturing the tumour; others I have left to nature, some of which lived a few months, and one five years; but I must confess that for many years I have had the idea that ligaturing the tumour in certain cases might be of service. I have often mentioned it to many of my medical friends, from whom, however, I have met with but poor encouragement; but the nearly always unfavourable result of repeated puncturing, pressure, etc., and in this case the child being well nourished and strong, led me to adopt this plan of treatment, which I am happy to say has proved a perfect success. Forester, in the first instance, and Benjamin Bell more recently, advised the application of ligature round the base of the sac, provided the disease be local and a mere distension by fluid in consequence of the imperforation of the bones, and not a disease of the spinal marrow or membranes, and provided it be not complicated. It does not appear that either of them tried it. Erichsen (vol. 2, page 215) says he has "never known any but a fatal result follow the removal of these tumours by ligature, scissors, or knife." Gross (vol. 2, page 188) speaks equally discouragingly of the result; and I cannot find a case on record which has been treated successfully by this method. Dr. Nevins mentioned at the Liverpool Pathological Society in 1850 three cases in which puncture had been tried; one case was cured, the gentleman being then 40 years of age; the second died; and the third was quite well at the end of three or four months, with the sac contracted. Dr. Hana has related a case in which spontaneous rupture of the sac took place after measles, and the child recovered. Cases have been cured by puncture followed by injection of iodine, as proposed by Dr. Brainerd. The present case was doubtless one in which the spinal cord had no, or only slight, connection with the sac. Ollivier states that, when the disease is not complicated with hydrocephalus, he has generally found the spinal marrow traversing the sac unaltered; but if coexistent with hydrocephalus, or if the canal of the spinal marrow be distended with fluid, the cord may be flattened out, as it were, so as to apparently line the sac. The gradual compression by the tightening of the ligatures may have contributed a little to the favourable result in this case; and, should another opportunity present itself to me, I shall not hesitate in adopting the same course.