A CASE OF FRIEDREICH'S HEREDITARY ATAXIA: WITH NECROPSY,

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THE number of cases of Friedreich's hereditary ataxia, with necropsy, is still limited. Mackay, in *Brain*, Part 84, has collected the records of 18 genuine cases and 4 doubtful cases. The following case is interesting, from the fact that the duration of the disease from the time the symptoms were said to have been first noticed until the patient's death was only fifteen months. It is most probable, however, that the disease was really of much longer duration. The patient, together with his younger brother, who was suffering from the same disease, was admitted to Prince Alfred Hospital, Sydney, in May, 1895, under the care of Dr. Scot Skirving, and I am indebted to him for permission to make use of the notes and publish the case:

M. K., aged 12 years, a native of Singleton, N.S.W., was admitted to hospital complaining of inability to walk properly, and a tendency to fall when his eyes were shut. These symptoms were first noticed twelve months before admission, and had been increasing since then.

Family History.—There was no history of any nervous affection in the family, with the exception of a younger brother aged 10, who is affected in the same way as the patient. There is a history of alcoholism in the father, but nothing else of note.

Previous Health.—He had measles and whooping-cough in infancy and scarlet fever eighteen months before admission to hospital.

Condition on Admission.—He is a well-nourished lad, bright and intelligent. When sitting at rest, curious jerking movements of the head are observed, and also irregular alternate contractions of the corrugator superciliorum, and at times slight twitchings of the lips and of shrugging of the shoulders. He has no headache or pain anywhere; no fits, no spinal curvature; but there is a tendency to stooping when he walks. His speech is slow, and the individual words are jerked out.

Special Senses are all intact. His pupils are equal, and react to light and on convergence; there is slight nystagmus on lateral movement. All other cranial nerves are normal.

Motion.—Movements at all joints in all limbs are perfect, and his grasp fairly good in both hands. He cannot co-ordinate the finer movements of the fingers, as, for example, in buttoning his coat. When about to drink he lifts the cup to his mouth with a certain amount of tremor, but the range of movement does not increase at the end of the act. He maintains the erect posture with some difficulty with the eyes open, and falls when they are closed. He walks with a staggering gait, throws out the legs, lifts his feet high and comes down on his heels. When walking the phalanx of the big toe is over-extended, and the tendons are tremulous.

Sensation.—There is no loss of sensation anywhere. Tactile, painful, and thermal stimuli can be accurately defined and localised, and there is no delay in response. There appears to be some hyperæsthesia over the lower third of both thighs and also over the trunk. Muscular sense is somewhat impaired.

Muscular System.—There is no muscular wasting and no talipes. No affection of the sphincters.

Reflexes.—Abdominal and epigastric are absent; cremasteric active; plantars are diminished. Knee-jerks are absent, and there is no ankle clonus.

The other systems were all healthy until a few days before death, when the signs of broncho-pneumonia appeared, and he died from that cause in July, 1895.

NECROPSY.

Post-mortem examination was made two and a-half hours after death. The lungs presented the usual appearances of broncho-pneumonia, the other organs being all healthy.

The brain weighed 56 oz., and showed no macroscopic signs of disease. It and the spinal cord were removed and hardened in Müller's fluid. Portions of the cord at different levels were embedded in celloidin, cut and stained by Schäfer's modification of Pal's method. Some sections were counter-stained with eosin, and others were stained with aniline blue black. I cannot say that the cord as a whole appeared any smaller than normal, though on microscopical examination there is a general excess of neuralgia. As in all the recorded cases, the stress of the disease has fallen on the posterior columns. In the sacral region, while there is no marked degeneration of the posterior columns, the number of healthy fibres is diminished, and this diminution is continued round the margin of the cord to just a little external to the posterior cornua on each side. In the lumbo-sacral region, while there is distinct degeneration in Goll's columns in their posterior three-fourths, a large number of normal fibres are found in their anterior fourth, immediately adjacent to the posterior commissure, representing the cornu-commissural tract. Posteriorly, the degeneration in Goll's columns merges into that of Burdach's columns, the two columns not being differentiated at this level. The degeneration is continued through the posterior root zones, posterior roots, and round the margin of the cord for a short distance external to the posterior roots. There is no obvious degeneration in any other part of the cord at this level; the nerve cells of the anterior and posterior cornua appear normal. The pia mater is somewhat thickened, and the central canal is filled up with proliferated epithelium.

In the lumbar enlargement (see Fig. 1), in both posterior columns we

find almost complete degeneration extending not quite up to the posterior commissure. In Burdach's columns there are as before a small number of healthy fibres along the inner border of the posterior cornua. Posteriorly, the degeneration is still present in the root zones, and extends only for a short distance external to the posterior roots.

In the lateral columns in the region of the crossed pyramidal tract there is some wasting of nerve fibres, but no very marked degeneration. In the mid-dorsal region (see Fig. 2) there is almost complete degenera-

Fig. 1.—Lumbar enlargement.

tion of the whole of both Goll's and Burdach's columns, though there are still to be seen some normal fibres internal to the posterior cornua. The posterior roots are degenerated, but now the degeneration is seen to be sharply limited to the posterior columns, and does not extend round the margin of the cord beyond them. Both direct cerebellar tracts are affected, and there is a faint indication of degeneration in the region of the crossed pyramidal tracts. The cells of Clarke's column are atrophied, otherwise the grey matter is normal, and the central canal is lined by a layer of columnar epithelium.

Fig. 2.—Mid-dorsal region.

In the upper dorsal region (see Fig. 3) the degeneration is still well marked in both Goll's and Burdach's columns, and now there is to be seen some differentiation between the two, Goll's being more degenerated than Burdach's. A few healthy fibres are seen in the posterior roots; the direct cerebellar tract on each side is degenerated, and there are some signs of the crossed pyramidal tracts being similarly affected. In the cervical enlargement (see Fig. 4) there is a well-defined differentiation between Goll's and Burdach's columns, but the degeneration is not quite so well marked as in the dorsal region. In Goll's column the degenera-

tion extends right up to the posterior commissure, where these columns open out. In Burdach's column there are a fairly large number of healthy fibres adjacent to the posterior cornua. The posterior roots still show some degeneration, but there is an increasing number of healthy fibres. There is also to be seen some marginal degeneration in the lateral and anterior portions of the cord, and again there are indications of slight degeneration in the lateral columns, in the region of the crossed pyramidal tracts.

Fig. 3.—Upper dorsal region.

In the upper cervical region (see Fig. 5) the degeneration in the posterior columns becomes less marked, though it is still quite obvious. It is most marked in the posterior three-fourths of Goll's column, the anterior one-fourth showing a fairly large number of normal fibres; and in Burdach's columns it is most intense in their inner portion about the middle third, the extreme anterior portions and those immediately adjacent to the posterior cornua being much less affected. There is also now more obvious degeneration in the lateral columns, but this is somewhat diffuse, and not sharply limited to the region of the crossed

Fig. 4.—Cervical enlargement.

pyramidal tract. There is also faint indication of degeneration in the direct pyramidal tract in the anterior columns, and a marginal zone of degeneration in the region of Gowers's antero-lateral ascending tract. The other portions of the cord are normal. In the higher regions of the cord, at the decussation of the pyramids, the degeneration in the posterior columns is still well marked, and this can be traced to the termination of these tracts in the floor of the fourth ventricle. The brain and cerebellum were normal.

To sum up, we find in this case well-marked degeneration

of the posterior columns throughout their whole length; of the posterior root zones, and also of a large number of posterior root fibres; much less marked degeneration in the lateral columns, in the region of the crossed pyramidal tract; some scattered marginal degenerations at different levels; distinct degeneration of the direct cerebellar tract with atrophy of Clarke's column.

These findings correspond pretty closely with those previously recorded, and are generally recognised as the typical lesions of Friedreich's ataxia. It is interesting to note how well defined the lesions were, though the duration of the disease was stated to be only about fifteen months; while in all the other necropsies reported the disease had lasted several years. The disease is apparently a primary nerve degeneration grafted upon an imperfectly developed spinal cord, such imperfect development being due to unknown hereditary influences. This view is supported by the fact, to which Newton Pitt has drawn attention, that the degenerations attack by preference the parts which are developed late. These parts have also the least important functions, and, according to Hughlings Jackson's law, these are the first to degenerate. Further, the sclerosed regions correspond to the tracts, the nerve filaments of which receive their myeline sheath after the fifth month of foetal life.

Fig. 5.—Upper cervical region.

Three features in the clinical picture of Friedreich's ataxia are deserving of some further consideration in view of the anatomical substratum of the disease. First, in the textbook description of this affection, the rarity of sensory disturbances is noted. Gowers states that "sensibility has been quite normal in many cases; in others there has been slight anæsthesia in the legs, early in some instances, late in others. Sensibility to pain and temperature is very rarely impaired. Sense of posture of the limbs has been found normal in several cases in which it has been examined." Friedreich himself notes the absence of sensory disturbances as one of the distinguishing features of the disease; and the same thing has been observed in most recorded cases since. This is in marked contrast to what is found in tabes. There, as Gowers remarks, "sensory symptoms are prominent in most cases." In speaking of the pathology of tabes, he says: "There may be an interruption of the sensory path in one or both of two places—in the peripheral nerves, and in the posterior root fibres as they enter the cord; and an interruption of the fibres in either place will explain the loss of sensibility, which is so frequently present." In only a few of the necropsies on cases of Friedreich's ataxia have the peripheral nerves been examined. In some of these the nerves are reported to be normal, in others degenerated; but, in all, the posterior roots have been found much atrophied.

In the case reported by Mackay, in *Brain*, Part 84, the peripheral nerves appear to have been examined more extensively and carefully than in previous reported cases, and were all found extremely degenerated, yet clinically it was noted that there was no anaesthesia. In referring to this point he says: "The fact, moreover, frequently recorded, that the patient's sensibility to touch, pain, and temperature remains unimpaired throughout, suggests that it is the afferent nerves from muscles that chiefly suffer. This agrees with Guizetti's conclusions, who was of opinion that, in his own case, there existed a systematic atrophy of sensory fibres." But if this were so, we should expect to find in every case clinical evidence of the loss of sense of posture, or loss of muscular sense; but this has often been proved not to be the case. In some cases the spinal ganglia have been examined, and in all there was evidence of degeneration in the nerve cells, with hyperplasia of the connective tissue. Further complete investigation, both clinical and pathological, of cases of this disease are needed before we can explain the apparent discrepancy between the clinical signs and *post-mortem* findings.

Secondly, in the majority of cases there is no sphincter trouble; and even when such does exist, it is no more than some little delay in beginning the act of micturition. Sphincter trouble may arise either from motor or sensory disturbance. In tabes, for example, when there is affection of the sphincters, it will be found that there is some anaesthesia of the urethra, bladder, or rectum. In disseminated sclerosis, on the other hand, where there is, as a rule, no sensory disturbance, the sphincter trouble depends upon some derangement of the motor innervation of those parts. The absence of sphincter trouble in Friedreich's ataxia is probably due to the absence of anaesthesia of the excretory passages.

Thirdly, I would call attention to the condition of muscular hypotonia which is present in most cases of this disease to a greater or less extent; and this in spite of the contractures of the leg muscles which produce the deformity of the foot. The occurrence of this condition in Friedreich's ataxia is interesting, since it is now a well-recognised feature in tabes, and appears to be associated in some way or other with the degeneration of the posterior roots. It is probable that the absence of all the so-called "deep reflexes" is, in part at any rate, to be ascribed to this condition of the muscles.

A CONTRIBUTION TO THE STUDY OF THE POSTERIOR COLUMNS OF THE SPINAL CORD.*

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THE structure of the posterior columns of the spinal cord is as yet so dubious that the following result of an investigation of a case of tabes dorsalis will be of interest. In this research Pal's modification of Weigert's hæmatoxylin method was used.

I am aware of the possibility that nerve fibres may be present in patches of sclerosis and yet not be picked up by hæmatoxylin, and that Marchi's method would have been a better one upon which to base the conclusions I have come to in this case. Before I got hold of the cord and nerves, however, they had had the Muller's fluid washed out of them, and had been placed in alcohol, thus precluding the possibility of a reliable Marchi's stain. But I think I may safely claim that by having stained and examined some five hundred sections from all levels of the cord, I have obviated any error that was possible as the result of using the above-mentioned method.

As the nutritional condition of the posterior roots between their trophic centres in the posterior spinal ganglia and the cord—that is, the root trunk according to P. Marie—is an important factor in this case, because they are so largely

concerned in the structure of the posterior columns and grey matter they may be described at once.

In all root trunks below the first lumbar there is total atrophy of nerve fibres. In the first lumbar root trunks a few attenuated nerve fibres are present. Above the latter point to the upper part of the thoracic region the root trunks acquire a slightly increased number of nerve fibres. In the upper two segments of the thoracic region and in all levels of the cervical cord the fibres are numerous; many of them, however, are in a state of chronic wasting, and there is little doubt that a number of them have disappeared.

These facts were determined by examination of all the lumbo-sacral root fibres, and every second thoracic and cervical at three different parts, namely, close to the cord, close to the ganglia of origin, and midway between these parts.

Accepting in a limited sense the Wallerian orthodoxy of degeneration, it is to be expected, first, that that part of the posterior columns traversed by the central continuations of those posterior root fibres shown to be degenerated will be in a state of fibrosis; and, secondly, that all fibres not direct continuations of the roots but derived from the grey matter (that is, endogenous fibres of the comma tract, Marie's cornu-commissural zone, Fleschig's median triangle and posterior internal root zone, or, as it is named by Marie, to prevent any association of it with the afferent root fibres, the postero-internal zone; and, lastly, Gombault and Philippe's endogenous fibres of the sacral region) will be intact unless the grey matter can be shown to be unsound.

The first expectation is justified by the present state of the posterior columns. Not so, however, is the second, for there is an anomalous state of affairs in the endogenously-derived tracts, one having almost wholly disappeared while the other three or four have persisted. This anomaly may, I think, be explained by a certain degeneration of the grey matter, which is probably the seat of origin of the affected endogenous fibres.

First of all those parts of the posterior columns now widely recognised to be composed of the centripetal continuations of the afferent roots will be disposed of. I find that the posterior columns in all planes are marked by a somewhat triangular area of absolute sclerosis roughly corresponding to the track of the lumbar and sacro-coccygeal root fibres of the normal cord. Throughout the whole length of the posterior columns this area of scar tissue contains no sign of nerve fibres whatever, except a few fibres of the lumbar region in the position of the median triangle (Figs. 1 to 4).

Thus the path of the lower thoracic, lumbo-sacral, and coccygeal fibres in the columns of Goll coincides with the state of the same fibres exterior to the cord. If the claim that Goll's columns are amplified in their whole upward extent by fibres originating in successive levels of the grey matter is allowed, this total fibrosis will appear strange. Still it is a fact, and seems to dispose of such a contention.

It may, however, be urged in favour of the above-mentioned claim, first, that the trophic centres from which the supposed endogenous fibres take origin are atrophied and along with them their extensions into the postero-median columns; or, secondly, that the pressure exerted by the scar tissue which has replaced the wasted exogenous fibres was cause enough to set up a retrogressive atrophy in the endogenous feeders of the columns as far forward as the antero-lateral limit of the scar tissue, or even to the grey matter itself.

The second contention, however, is effectually disposed of by reference to the lumbar posterior columns. In this region (see Fig. 5 a) there is to be seen a small group of fibres in the middle third of the posterior columns in and about the position of the median triangle. This is one of the tracts of intracordal origin, and will be referred to more fully later on. If this tract, whose fibres beyond a doubt come from the grey matter, can persist in a plane of the cord, whose posterior columns are densely fibrosed, and whose posterior horns show the greatest wasting of grey matter (see Fig. 1 a), it would not be too much to expect a like persistence of endogenously derived fibres in higher related parts of Goll's columns the associated grey matter of which, except Clarke's columns, is almost normal.

The first claim—namely, that the trophic centres of the fibres of endogenous origin are atrophied, and along with

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