

ON INJURIES OF THE CAUDA EQUINA.

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THE series of cases upon which the conclusions drawn in the present paper are based, appear to the writer to form a clinical picture the import of which has not hitherto been fully recognised, although its features are sufficiently marked and the symptoms described have been noted by more than one observer. They present instances of very different lesions, all of which, however, agree in the production of pressure on the cauda equina, and although they are not all injuries, it has appeared advisable to place side by side with traumatic cases, those due to other causes, but resembling them in the locality of the lesion and the nature of the symptoms. All these cases have been treated in the Manchester Royal Infirmary, to the courtesy of whose physicians and surgeons I have again to express my indebtedness for permission to use the material under their care.

I shall in considering these cases first relate their clinical histories, drawing attention to the salient points of each, and shall then proceed to draw certain conclusions, and to compare the facts observed with the experience of previous writers.

CASE I.—Dislocation of the First Lumbar Vertebra.—Compression of the Cauda Equina.

P. S. attended as an out-patient in Dr. Ross's clinic during the month of June 1886, and was admitted to the wards on the 7th of the following month. He gave a history of having been a heavy smoker and drinker, of an attack of syphilis twelve years ago, and of pneumonia five years ago. On Jan. 31st, 1886, he fell from a scaffolding and injured his back. For five days he was un-

conscious, and has since then had paralysis of the lower limbs with retention of urine, requiring the constant use of a catheter.

On examination, he presented a distinct deformity of the lumbar spine, there being a wide interval between the first and second spinous processes with prominence of the latter. There was slight pain in the affected region, but no tenderness. (The exact position of the deformity was verified by repeated examinations, by various gentlemen.)

The lower limbs presented complete paralysis of all the muscles below the knee, and of the flexors of the knee, and there was weakness but not entire loss of power in the extensors of that joint. Flexion of the thigh could apparently be performed without difficulty; the power of adduction was slight, and that of abduction almost, but not quite entirely lost. The buttocks and lower extremities were wasted throughout. Electric examination of the affected region gave contractions with the following currents:—

	RIGHT LIMB.			LEFT LIMB.		
	Cathodal Closure.	Anodal Closure.	Faradic Current.	Cathodal Closure.	Anodal Closure.	Faradic Current.
	cells.	cells.		cells.	cells.	
Rectus . . . . .	..	..	No effect	..	..	No effect
Sartorius	35	30	..	25	20	..
Vastus Externus . . .	25	20	..	25	30	..
Vastus Internus . . .	35	30	..	30	30	..
Gluteus maximus . . .	No contraction with 50 cells.	..	..	No contraction with 50 cells.	..	..
Biceps . . . . .			..			..
Semimembranosus . . .			..			..
Semitendinosus . . .			..			..
Adductor Longus . . .	..	..	..	..	..	..
Adductor Magnus . . .	..	..	..	..	..	..
Gracilis . . . . .	..	..	..	..	..	..
Gastrocnemius	40	40	..	35	30	..
Tibialis Anticus . . .	25	20	..	25	20	..
Extensor Proprius } Pollicis . . . . . }	..	..	..	..	..	..
Peroneus Longus . . .	25	25	..	30	30	..

The knee-jerk and plantar reflexes were absent; but the cremasteric reflexes were normal.

The urine was retained, and had to be drawn off by the catheter; fæces were passed involuntarily.

Sensation was normal on the upper part of the buttocks, that is, in the region supplied by the last dorsal, ileo-hypogastric and external cutaneous nerves, and was little if at all diminished on the front of the thighs and the anterior halves of their inner and

outer aspects, or on the inner sides of the legs; but there was complete anæsthesia of the backs of the thighs, of that part of the buttocks not included in the above limits, of the outer sides of the legs and of the feet. The perineum, the penis, and the scrotum were also quite anæsthetic, with the exceptions of the root of the latter, and the catheter was not felt in the urethra. The patient was, however, aware when the bladder was full, and when he wished to empty the rectum, but had no control over the latter, and could not feel the passage of fæces. At times he would have pricking sensations in the toes and some pain in the thighs.

The lower limbs presented no obvious change of temperature. Since the accident he had had no erections of the penis. On both heels were bedsores of large size. The urine was alkaline, containing large quantities of pus and phosphates.

The patient remained under observation and treatment for some time; but, with the exception of amelioration of his cystitis and bedsores, underwent no change. On leaving, he was instructed to return, with a view to trephining the spine, but has not since been heard of.

The explanation of the above case is sufficiently obvious. There is sensory paralysis of all the nerves of the sacral plexus and possibly of the obturator, but not of the anterior crural or other lumbar nerves: the perineum, penis, scrotum and urethra, being supplied by branches of the pudic, are anæsthetic, but the root of the scrotum retains sensation, owing to the presence of twigs of the ileo-inguinal nerve, which, however, only descends to a very short distance.

As regards motion, we find complete paralysis with the "reaction of degeneration" of the muscles supplied by the nerves of the sacral plexus. Those supplied by the anterior crural, although presenting the reaction of degeneration, are only weakened, and the adductors, supplied by the obturator, appear also to retain some power.

Again, the cremasteric reflex remains, but below this point reflex action is lost.

CASE II.—*Spina Bifida*.—*Cure*.—*Cauda Equina in Cicatrix*.

F. H. W. has been several times admitted into the Manchester Royal Infirmary, under the care, successively, of Mr. Lund, Mr. Whitehead, and Dr. Ross. He is a clerk by occupation, is 24

years of age, and gives the following account of himself. At birth he had a swelling (*spina bifida*) of the lower part of the back, which was never larger than an orange. Very soon after birth a needle was thrust into this, but he does not know whether any effect resulted. When two years of age he was said to have had a fit, followed by paralysis, and subsequently wasting of the muscles below the knee on both sides. He also states that there was some contraction of the calf muscles, causing drawing up of the heel, which on two occasions required division of the tendo Achillis, followed by the use of a metal boot. The deformity was thus eventually overcome. When about fifteen years of age he began to be troubled by an ulcer on the outer side of the right foot, which resisted all treatment, until in 1883 the little toe with its metatarsal bone was amputated by Mr. Lund. The wound thus caused remained open for nineteen months, at the end of which time its upper end had again formed an ulcer. This ulcer still remains, and is his chief trouble; it improves when he is confined to his bed, but soon breaks down again when he tries to move about.

The condition of the patient never varied very materially at the various times, extending over a period of some eighteen months, during which he was under observation, and he presents the following points.

On the back, opposite to the last lumbar or first sacral vertebra, is a flattened swelling about the size of a hen's egg, but of lenticular shape and covered with hair. At its centre is a depression, into which he states that a stocking-needle was passed at birth; but he also says that the depression was congenital, and that the needle was used only to probe its depth. The swelling is of an elastic consistence, and gentle manipulation caused sensations which the patient says are pleasurable but indescribable. Firm pressure causes passage of urine, defecation and strong sexual desire: a blow upon it causes some rigidity of the legs. Over the swelling is a luxuriant growth of hair, which is also well-developed on the lower limbs.

Both the lower limbs show distinct wasting, which is more marked on the right than on the left side, the circumferences being: right calf, 8 inches; left calf, 11 inches; right thigh, $14\frac{1}{2}$ inches; left thigh, 17 inches; while the right is half an inch shorter than the left limb. On the right side, the fifth toe and its metatarsal bone were removed, and on the outer side of the foot over the fourth metatarsal is an oval ulcer about one inch long and half an inch wide. The ulcer shows a clean-cut margin, which is raised, horny and thickened, with slight undermining of the edges and

pale granulations at the base. Between the second and third toe on the same foot was a second small ulcer which recovered with rest. The arch of the foot is exaggerated, the toe pointed, and there is no power of movement about the ankle-joint.

The lower limbs are partially paralysed, with weakness and wasting of most of the muscles, and especially of those below the knee, the leg muscles of the right side being completely paralysed. The knee-jerk, ankle-clonus, and the plantar reflex are absent on both sides; the cremasteric, abdominal, and epigastric reflexes normal. The electric reactions of the muscles were as follows:—

	RIGHT SIDE.		LEFT SIDE.	
	K. C. C.	A. C. C.	K. C. C.	A. C. C.
	cell.	cells.	cells.	cells.
Sartorius	40	40	35	40
Adductor Magnus	25	30	35	45
Gluteus Maximus	nil	nil	50	nil
Vastus Externus	25	40	40	50
Vastus Internus	45	40	45	nil
Gastrocnemius	45	50	25	40
Peroneus Longus	50	nil	40	35
Tibialis Anticus	45	45	40	nil

Hence they did not present the "reaction of degeneration." To the faradic current they reacted with difficulty on both sides, the anterior muscles of the left thigh acting most readily, those of the right foot not at all. He has difficulty in walking, being always afraid of falling, and in the dark he staggers and has to grope his way. The walk is characteristically "pseudo-tabetic," the toe dropping at each step. At times, especially if he is tired, there are slow fibrillar movements of the muscles of the right thigh and gluteal region, with occasional choreiform movements of the right foot.

As regards sensation, he states that he cannot judge of the position of his right lower limb, and that the ground does not feel solid under his feet. At times the limbs feel "as if they did not belong to him, but were some distance off." He occasionally has pain in the dorsum of the right foot, the knees and hips, and intense tickling sensation in the sole of the right foot. On examination, there was found to be extensive anæsthesia of the lower limbs, of similar distribution on both sides. The affected area was not quite sharply defined, but had the following general outline as represented in the accompanying diagrams, where the

anæsthetic portion is shaded. Commencing above at the side of the tumour and almost at its centre, the boundary-line runs downwards and outwards, across the upper limit of the gluteal region, thence over the great trochanter down the outer side of the thigh to the apex of the line leading to the external condyle; it now tends forward, somewhat to the front of the condyle, and then down along the line of the fibula for about half its length; after which it comes forward and inward across the shin, ending about the middle

FIG. 1.

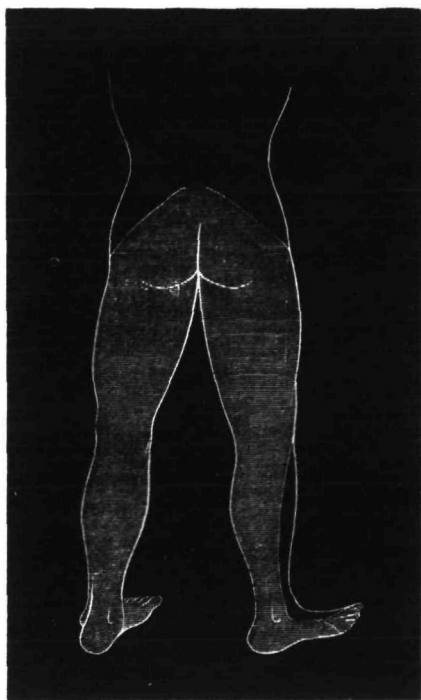
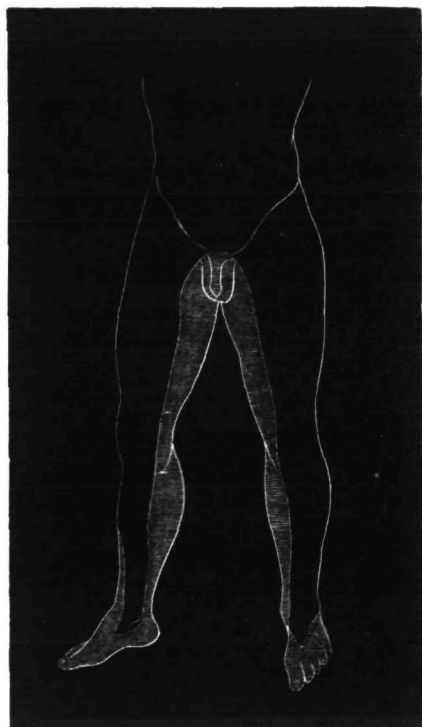


FIG. 2.



of the first metatarsal bone. The inner boundary commences about the external inguinal ring, passes outward towards Poupart's ligament; thence slightly backwards for a short distance; again down the inner aspect of the thigh to the back of the internal condyle; thence down the inner side of the leg, curving below the internal malleolus and running forwards to join the former line over the metatarsal bone of the great toe. It will be noted that these limits include the gluteal region, back of the thigh, the back

and partially the outer side of the leg, and the whole of the foot, except a small area on its inner aspect. Further, the perineum is included in these boundaries, being absolutely anæsthetic. The penis also is anæsthetic, except at its extreme root, as is the scrotum, except along a line, too small to represent in the diagram, extending forwards and downwards from the external ring for about two inches, and corresponding apparently to the distribution of the ileo-inguinal nerve. Although the scrotum is thus anæsthetic, testicular sensation on deep pressure is normal.

At one period he states that he passed urine involuntarily, and had to wear a bag to catch it; but he can now retain it, and indeed only passes it with difficulty and much straining. He knows when the bladder is full. The bowels are usually relaxed, and at times he has involuntary evacuations. He is not always able to tell whether he has or has not passed urine or fæces. He has sexual sensations and enjoyment, but states that on connection the semen is usually ejaculated before intromission, but that on a second coitus he can perform the act as usual. When under the influence of drink he says that he can both pass his urine without difficulty and complete the sexual act on the first attempt.

He is subject to attacks of lymphangitis and swelling of the inguinal glands in the right lower limb, which attacks he believes to have a tendency to monthly periodicity, and to be brought on in many instances by drinking or by sexual excitement.

This case resembles the first very closely, differing mainly in the less complete paralysis and in the partial reaction of degeneration replacing the complete degeneration shown by Case I. The distribution of the anæsthesia is similar to that of Case I. An interesting point is the retention of sexual desire and enjoyment in spite of the complete anæsthesia of the penis, and the evidence of persistence of sensation in the testicles which derive their sensory nerves from some point higher in the cord than does the scrotum. The paralysis is again seen to affect mainly the branches of the sciatic, gluteal, and pudic nerves, sparing the anterior crural and obturator with the upper lumbar branches. That the lesion is an involvement of the cauda equina in the cicatrix of the spina bifida there can, I think, be no doubt. The trophic lesion of the right foot is interesting, and is similar to that seen in a case reported by Ogston¹ of old spina bifida with perforating ulcer of the left foot, anæsthesia

¹ 'Lancet,' 1876, vol. ii. p. 13.

of the outer side of the leg, and dorsal and plantar aspects of the foot and diminished faradic contractility of the muscles of the foot, all on the same side. Indeed Ogston's case is clearly of the same nature as the above, differing only in that the cicatrix had, in his case, involved but a portion of the fibres of the sciatic of one side only.

Another case of the same nature is reported by Brunner¹ as an instance of *spina bifida occulta*. The patient had a depression over the spine from the first to the fifth lumbar vertebra, excessive growth of hair over that region, and a perforating ulcer on the outer side of the right foot. The right lower limb was wasted, especially below the knee, and there was some loss of power in it: there was anæsthesia of the sole and outer side of the foot; the knee-jerk was lost.

The next case which I shall quote presents similar symptoms arising from the pressure of a tumour on the cauda equina.

CASE III.—*Tumour of Cauda Equina.*

Joseph Davies was admitted under the care of Dr. Ross on May 12th, 1882. His previous history presented nothing of interest. About five months before admission he began to suffer from pains shooting from the small of the back down the backs of the thighs and legs to the feet, which gradually increased until he was unable to bend his back and could hardly walk.

On admission he complained of the above pain, and of great pain in the buttocks when sitting down. He could hardly walk, dragging the legs along the ground slowly and with difficulty, and the lower limbs were much wasted. The patellar reaction was increased on both sides. The urine was retained, and had to be drawn off with a catheter. Pupils presented no abnormality. He was treated with strychnia and iron.

The notes at this period are very imperfect, but there seems to have been little or no change for a long time. On July 5th he was ordered gr. 5 doses of pot. iod. On July 13th it was noted that pain was greatest about the ankles and outer sides of the feet. There was no staggering in the gait, nor did he sway when standing with the eyes closed, but the movements of the lower limbs were very feeble, especially those of the gluteal muscles. The plantar and cremasteric reflexes were well marked, but the gluteal was sluggish. The patellar tendon reaction was lively (? exag-

¹ Virchow's 'Archiv,' 1887, p. 494. See Appendix.

gerated) on both sides. On both sides the muscles of the lower limbs were markedly atrophied, and with the exception of the gluteus maximus of the left side, had lost their faradic contractility, this muscle also only reacting to strong currents. Analgesia and diminution of tactile sensibility was present over the back of the sacrum, extending thence to the perineum, the left side of the scrotum, the backs of both thighs, and down the calves in the form of a triangle with the apex downwards.

Four days later the anæsthetic area was found to have extended, so as to involve the buttocks up to the level of distribution of the ileo-hypogastric nerves, the backs of the thighs, and the bulk of the leg, omitting, however, the knee-joint, inner border of the tibia and foot, and the great toe (i.e. the distribution of the internal saphenous nerve). The anæsthesia was less perfect in the legs than in the thighs and buttocks. His urine was still retained, but he drew it off himself with a catheter. On going to stool, he could not pass a motion until he had pressed upon the perineum, but very light pressure—even merely wiping the anus—was sufficient, so that the action was probably not entirely mechanical. Pain in the lower limbs was very severe, especially on movement, and he had often much pain about the anus; those symptoms being so severe as to necessitate hypodermic injections of morphia.

A month later he could still move the lower limbs in all directions, but only with the greatest difficulty, and apparently somewhat better on the right than on the left side; there was also extreme wasting of the limbs, but it was difficult to say that one group of muscles was more affected than another. The plantar and cremasteric reflexes were exaggerated, the gluteal absent on both sides. The knee-jerk was, as before, well marked, but there was no ankle clonus. With the faradic current the gastrocnemius and glutei gave no reaction; the anterior leg muscles and all those of the thigh reacted to a current of medium strength. The following table shows the number of cells required to produce contraction with the constant current:—

	Cathodal Closure.	Anodal Closure.
	cells.	cells.
Biceps (right)	30	30
„ (left)	35	30
Gluteus maximus (right)	20	20
„ „ (left)	15	25
Extensors of foot (right)	40	40
„ „ (left)	40	40
Extensors of knee (left)	30	45
Gastrocnemius (right)	30	35
„ „ (left)	45	45

FIG. 3.

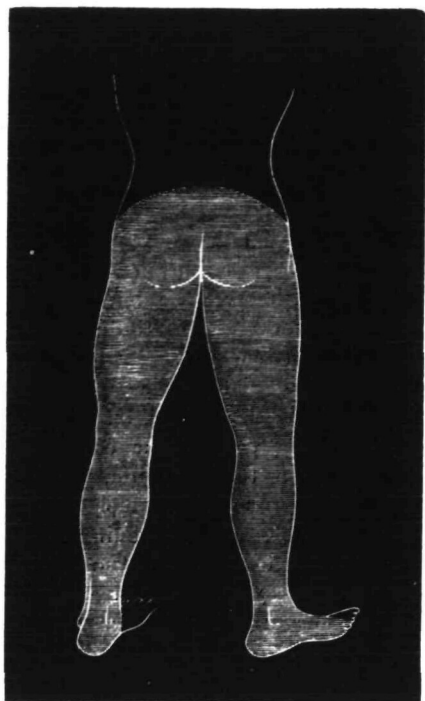


FIG. 4.

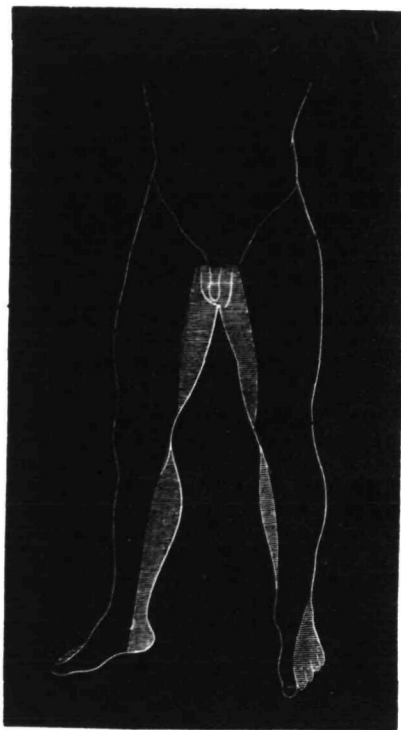


FIG. 5.

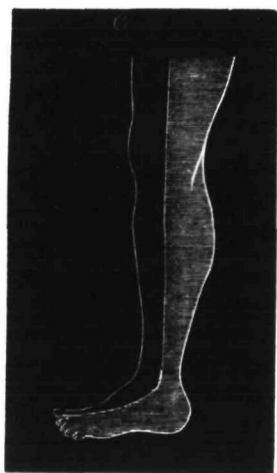


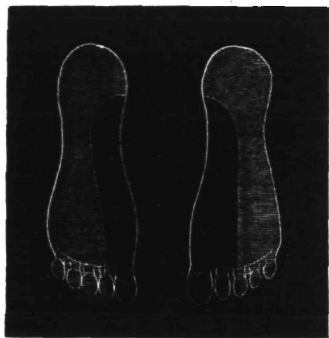
FIG. 6.



The distribution of the anæsthesia at this date is indicated by the accompanying diagrams (Figs. 3-7). Pain was still very great, but the general health remained fairly good. There was some redness over the trochanters and sacrum.

From this time the patient lost ground rapidly. The skin was sore at several points, an abscess formed over the right trochanter major, the pain was intense, the appetite failed, and the temperature became hectic, varying from 97° in the morning to $103^{\circ}\cdot6$ in

FIG. 7.



the evening. On Sept. 11th he was ordered drachm doses of liq. hyd. perchlor. with grs. ij of pot. iod. three times a day, but no improvement followed. Morphia had to be used constantly.

On Nov. 1st a bed sore formed over the sacrum, and on Nov. 15th he had convulsions and died in the afternoon.

No notes were taken of the post-mortem examination, but Dr. Ross, who was present, and Prof. Young who was at that time Pathologist to the Infirmary, remember that there was found only a very small tumour—a fibro-sarcoma about the size of a hemp seed—situated on one of the nerve cords of the cauda, with no signs of diffused infiltration or inflammation. It is, however, obvious that there must have been some lesion of more than the one nerve root, and no microscopic examination was made of the others. The spinal cord itself was perfectly normal.

We have here the same distribution of anæsthesia as in Cases I. and II., but the notes contain no reference to the relative power of the thigh muscles. The reaction of degeneration was again absent. Owing to the nature of the lesion the anæsthesia was preceded by intense pain, and the symptoms were at first more marked on the left than on the right

side. The retention of the knee-jerk and plantar reflexes is remarkable, but some exaggeration of reflex action is by no means rare in the earlier stages of peripheral nerve lesions, before irritation has given rise to complete annihilation of function. The nature of the lesion was here placed beyond any possible doubt by the post-mortem examination, which showed that the cauda equina and not the spinal cord itself was the region involved.

A closely similar case is mentioned and figured by Gowers,¹ who notes that tactile sensibility was impaired "chiefly in the region supplied from the sacral plexus;" and that although the lower limbs were paralysed, "a little power in the flexors of the hips and extensors of the knees persisted almost to the last." Hence, in Gowers' case also, the anterior crural nerve was less profoundly affected than the branches below it. His figure shows a tumour of the cauda equina immediately below the termination of the cord.

CASE IV.—*Dislocation Forwards of the Second Lumbar Vertebra.*
—*Compression of the Cauda Equina.*

R. M. C., aged 15, male, a collier by occupation, was admitted to the Infirmary under Mr. Jones's care, on December 31st, 1886.

About the end of the previous August, while he was in the pit, and probably in a stooping posture, a stone weighing 5 or 6 cwts. fell from the roof—a distance of about 5 ft.—on to his shoulders, bending him forwards with his head between his knees, and his right leg under him. On being extracted, he was found to have a fracture of the right femur, and this was apparently the only injury diagnosed at that time; but he had much pain in the lower part of the back, and in both hips, and was unable to sit up in bed. Some nine weeks later, he could sit in a chair. He was never able to move his feet after the accident, and not for a fortnight had he any power over either thigh. He had never any pain or other unusual sensations in the lower limbs. For six weeks after the accident his urine had to be drawn off systematically with a catheter, and from about the third week he had symptoms of cystitis, which still continued on admission. Since the sixth week no catheter has been used, and he has been able to pass water, nor has he ever had any incontinence; but micturition is very slowly

¹ 'Diseases of the Nervous System,' vol. i. p. 420.

performed. Constipation has been present throughout, but there has never been any involuntary defecation.

On admission we found a prominence of one of the lumbar spinous processes (the third) one inch above the level of the posterior superior iliac spines. Above and below this were depressions, and to the left of, and a little above it, another bony prominence, due apparently to the displaced transverse process of the second lumbar vertebra. There was slight pain and tenderness in this region.

The lower limbs presented partial paralysis. The hips could be moved in every direction, but adduction was more powerful than any other movement; extension and flexion were about equal, and abduction very weak; at the knee extension was more powerful than flexion. In the ankle and foot no movements could be produced. The muscles of the buttocks and lower limbs were wasted, especially below the knees; none of them contracted with a faradic current of such strength as the patient could bear, and we were unable to test satisfactorily the galvanic reactions. The knee-jerk was absent, as was the plantar reflex, the cremasteric and gluteal being well marked and apparently exaggerated.

There was nowhere absolute anæsthesia, but sensation was obtuse over a region fairly well defined by the following boundaries:—above the upper part of the gluteal region, thence down the back of the thigh, leg and sole of the foot, the front of the leg, and the dorsum of the foot. It was much less imperfect on the front of the thigh than elsewhere in the lower limbs, and was better on the inner than on the outer side of the leg. Over the genitals also sensation was much blunted but not absent, and a catheter was felt along the whole of the urethra. The passage of fæces was also felt. He states that sensation had gradually improved since the accident. The feet always felt cold, but there was no pain or hyperæsthesia.

The skin of the lower limbs presented no abnormalities. Priapism was common; the urine was alkaline, containing some pus and phosphates, and he had pain over the pubes, and smarting on micturition.

On January 15th—a fortnight after his admission—Mr. Jones proceeded to “trephine” the spine in the affected region. Chloroform having been administered, the patient was turned on his face, and an incision four inches in length was made in the middle line, with its centre over the prominent spine. From either end of this an incision of some three inches was carried at right angles to it, and to the left. The superficial structures were thus dissected up in a flap, and the muscles were drawn aside from

the vertebral groove, and held back by retractors. It was now clear that the arch of the second lumbar vertebra was displaced forwards, the prominent spine being that of the third. Thus the displacement was that most commonly met with—dislocation forwards of the upper part of the spine; at the same time the spine of the second lumbar was broken off and isolated, and the prominence above mentioned as lying to the left of the middle line proved to be the articular process of the third lumbar, its articular surface being exposed by the dislocation forwards of that of the second. The detached spine of the second vertebra was removed, and showed a gap between the arches of the second and third, filled with dense cicatricial tissue. By means of bone forceps, the arch of the second lumbar was now almost entirely removed, exposing the membranes of the cord which had obviously been compressed by it. Around these membranes there was also cicatricial tissue, which was not interfered with. The flap was replaced and sutured, a drainage tube being placed at its lower angle, and the wound dressed with wood wool.

No trouble followed the operation, and the wound healed well, but rather slowly, the temperature being more or less raised for about a fortnight afterwards. Five days later the patient stated that the sensation of coldness in the feet had disappeared. After a week the faradic current was used to the muscles, and caused slight contractions in the posterior thigh muscles, a more marked effect in the anterior muscles and adductors, but none in the legs. The galvanic current was never used, as the patient could not bear it, and struggled when it was tried. Sensation improved somewhat, and the thigh muscles became much stronger during the ensuing two months, but no power of motion returned in the leg muscles. In this condition he was sent to the convalescent hospital at Cheadle, on April 2nd, two months and a-half after the operation.

A month later, when I saw him at Cheadle, he could stand up, and could, by means of chains, &c., walk a little; the thigh muscles were fairly developed, and moveable in all directions, but the leg muscles remained atrophied, and he could not move the ankles or toes. The thigh muscles reacted to the faradic current, but those of the legs did not; it was not possible to obtain accurate galvanic observations, but apparently the ascending and descending currents were equally effective in producing contractions of the thigh muscles, and equally unable to affect those below the knees. Occasionally he had muscular tremors. Sensation appeared to be everywhere normal, but was perhaps a little more acute on the inner than on the outer side of each leg. The superficial reflexes

were well marked, the knee-jerk absent. A small quantity of pus still remained in the urine, but there were no subjective symptoms connected therewith. A fortnight afterwards, when I saw him again, he could walk with the aid of one stick only, but with marked dragging of the toes. There was no other change.

The relationship of this case to the three first cited is obvious, and the localisation of the lesion indubitable. The most interesting point in the symptoms is the slight interference with sensation as compared with motion.

We are now in a position to compare the above four cases, which, although differing somewhat in their details, resemble one another sufficiently in their broad outlines to form a distinctly marked group. For this purpose, I have arranged the leading symptoms in the form of a table, showing the similarities and points of difference in each case (p. 396).

It is to be remembered that the spinal cord terminates at the level of the lower border of the first lumbar vertebra, whence the nerves of the lumbar and sacral plexuses descend to pass out from the spinal canal, each immediately beneath the vertebra from which it takes its name. Hence, in all of these cases the lesion was so situated as to compress the cauda equina and the cauda equina only; and further, in Case I., the whole of the lumbar and sacral nerves pass out beneath its level, while in Case IV. it involves all but the ileo-inguinal and ileo-hypogastric; in Cases II. and III. the exact level of the pressure cannot be ascertained, but must clearly have been almost the same as in Cases I. and IV.

In all of these cases the salient point is that, although the whole or almost the whole of the nerves of the cauda pass the level of the lesion, those which escape from the spinal canal lower down are more seriously injured by the pressure. Why this should be so is not clear. Those nerves which come out lower down are, in the cauda, situated nearer the middle line than those which pass out above them, and hence they would appear to have more room to escape from pressure, and we might expect them to suffer less rather than more; but that the contrary is the case is an established fact, and we are able definitely to conclude that, *in a pressure lesion of the entire cauda*

	CASE I.	CASE II.	CASE III.	CASE IV.
Lesion	Dislocation of 1st lumbar vertebra.	Spina bifida	Tumour	Dislocation of 2nd lumbar vertebra.
Paralysis	Complete in distribution of sciatic and pudic nerves. Partial in anterior crural and obturator.	Complete in distribution of tibial branches of sciatic. Partial in anterior crural, obturator, sciatic (and pudic).	Partial in all muscles of lower limbs.	Complete in tibial branches; almost complete in upper branches of sciatic. Well marked in anterior crural; less marked in obturator.
Reaction of degeneration.	In distribution of anterior crural, obturator, sciatic (and pudic) nerves.	Partial in distribution of anterior crural, obturator, sciatic (and pudic).	Absent	Doubtful.
Reflexes	Patellar and plantar lost. Cremasteric normal.	Patellar and plantar lost. Cremasteric normal.	Patellar, plantar, and cremasteric marked. Gluteal absent.	Patellar and plantar absent. Gluteal and cremasteric present.
Anæsthesia	In distribution of superior gluteal, sciatic, and pudic nerves, and in posterior sacral branches. Slight if at all in external cutaneous, anterior crural, or obturator.	In superior gluteal, sciatic, pudic, and posterior sacral.	In superior gluteal, sciatic, pudic, and posterior sacral.	Partial in distribution of superior gluteal, sciatic, and pudic.
Bladder and rectum	Retention of urine. Incontinence of feces.	Partial retention of urine, preceded by incontinence. Partial incontinence of feces.	Retention of urine. Retention of feces.	Retention of urine. Constipation.
Vaso-motor and trophic.	No erections. Temp. normal. Bedsores on heels.	Erections normal. Temp. normal. Perforating ulcer.	Bedsores at various points.	None.

equina, those nerve roots which emerge lower down are more seriously injured than those above them.

As already stated, the above-described combination of symptoms has been several times noted by former writers, but as in other cases of spinal injuries, the descriptions given are usually so meagre as to render the diagnosis anything but clear. The annexed table (pp. 398-403) gives a few instances, from several hundreds of cases of spinal injury which I have abstracted, showing more or less clearly the same group of symptoms, and indicating the various interpretations that have been placed upon it. The table does not pretend to be exhaustive, but merely illustrative.

I shall not add anything with regard to the spinal symptoms in the above, which are sufficiently similar to my own cases, but merely wish to adduce evidence in favour of their being due to the pressure on the cauda equina. Case 1 is attributed by the author to "intra-spinal hæmorrhage," but the date of appearance and the seat of tenderness appear to me to warrant the interpretation given in the table. Case 2 appears to me to be most typical, and I entirely fail to see why it should be regarded as an instance of "concussion:" the lesion was clearly below the region of the cord itself and over the cauda equina, and the symptoms are those of pressure upon or partial destruction of the latter. In Case 5 Mr. Hutchinson places the probable seat of the lesion at the fourth or fifth lumbar vertebra, a conclusion which, in view of our cases, is hardly warranted; at first all the muscles of the lower limbs seem to have been paralysed (unfortunately, sensation was not at that time accurately noted), thus indicating, I believe, an affection of the entire cauda.

The best description is that of Leyden (Case 8), but he appears to have attributed the symptoms mainly to myelitis, and not to the crush of the cauda equina. In the other cases, the localisation is as a rule clear enough, from the facts above furnished.

An important case is given by Kirchoff,¹ in which there was traumatic dislocation backwards of the first lumbar vertebra; causing paralysis of the lower limbs, retention of

¹ 'Archiv f. Psychiatrie,' Bd. xv.

No.	Reference.	Sex.	Age.	Result.	Probable Lesion.	Paralysis, &c.	Reflexes.
1.	Erichsen, 'Concussion of the Spine,' 2nd ed. p. 30.	M.	14	Recovery in four months.	Inflamma- tion around cauda equina, more marked on left side.	Came on gradually dur- ing ten days. Could then not stand, but moved legs in bed; no complete paralysis ex- cept in peronei, and ex- tensors of left ankle. Rapid wasting of left leg.	No note.
2.	Lidell, Ashurst's 'System of Surgery,' vol. vi. p. 789.	M.	19	Unknown.	Gunshot wound in lumbar region.	Paralysis below the seat of injury.	No note.
3.	Ollivier, 'Traité des Maladies de la Moelle Épinière,' vol. i. p. 358.	M.	40	Partial recovery.	Gunshot wound in lumbar region.	None.	No note.
4.	Hutchinson, 'Lond. Hosp. Rep.' vol. iii. p. 343.	M.	42	Death in five weeks.	Dislocation of 2nd lumbar vertebra.	Lower limbs were para- lysed with the excep- tion of the anterior thigh muscles.	No note.
5.	Hutchinson, 'Lond. Hosp. Rep.' vol. iii. p. 326.	M.	?	Recovery in four months.	Upper lumbar region.	Paralysis of the legs. On eighth day could draw up both legs, the right with greater difficulty than the left.	No note.

Anæsthesia.	Bladder and rectum.	Vaso-motor and Trophic.	Local Symptoms.	Post-mortem.	Remarks.
Numbness and tingling on outer side of left thigh; partial loss of sensation below left knee. Right limb normal.	Occasional loss of control over sphincters.	Coldness of extremities, especially of left foot.	Tenderness over 3rd lumbar vertebra after 10th day.	..	There were also symptoms of cervical injury.
Diminished sensation below seat of injury. Hyperæsthesia of front and inner side of thigh. Anæsthesia of ureter anterior to pars prostatica.	Retention of urine.	No note.	Gunshot wound.	..	Author regards as a case of concussion, because the retention of some sensation shows that there was no serious cord lesion (<i>sic</i>).
Absolute anæsthesia of postero-internal and anterior parts of thighs; of penis and scrotum.	Incontinence of urine.	None.	Gunshot wound.	..	Case seen nine years after injury
Complete anæsthesia of soles; partial loss of sensation of rest of limbs, except front of thighs. Sensation better on inner than on outer side of thighs. Sometimes felt passage of catheter.	At first retention, later, dribbling of urine. Retention of fæces.	Bedsore.	Absent.	Fracture of body and dislocation forwards of 2nd lumbar vertebra, the cauda equina being "lifted on a bridge of displaced bone."	
Anæsthesia of genitals, but condition of limbs not at first noted. Felt pain when catheter entered bladder. On 8th day had perfect sensation in fronts of thighs. On 39th day had sensation in front of thighs and legs, in hypogastric region and scrotum; good sensation in 1st and second toes, partial in the others. Complete anæsthesia of back and inner sides of thighs.	Retention of urine. Involuntary defæcation. Urine ammoniacal for a time. On 39th day had desire, but no power, to pass water.	No priapism.	Prominence of the spine "in the lumbar region."	..	From the distribution of the anæsthesia, and from the position of the spinal prominence, the author thought it probable that the lesion affected the 4th or 5th lumbar vertebra.

No.	Reference.	Sex.	Age.	Result.	Probable Lesion.	Paralysis, &c.	Reflexes.
6.	Hutchinson, 'Lond. Hosp. Rep.' vol. iii. p. 332.	M.	33	Partial recovery in three months.	Dislocation of 2nd lumbar vertebra.	Paralysis of lower limbs, followed by some wasting, especially of glutei.	No note.
7.	M'Donnell, 'Dublin Quart. Jour. Med. Sci.' 1866, vol. xlii.	M.	31	Partial recovery in twelve months.	Upper lumbar.	At first, paralysis of lower limbs. At end of second month, complete paralysis below the knees, and very little power in the thigh muscles except the sartorius.	No reflexes below knees. Exaggerated in thighs.
8.	Leyden, 'Klinik der Rückenmarkskrankheiten,' vol. ii. p. 143.	M.	45	Death in seven weeks.	Fracture dislocation of 1st lumbar vertebra.	Lower limbs were paralysed, but some power remained in adductors and anterior muscles of left thigh. After three weeks there were cramps.	"Not increased."
9.	Leyden, 'Klinik der Rückenmarkskrankheiten,' vol. i. p. 340.	M.	32	Death in five months.	Fracture of 12th dorsal and 1st lumbar laminae.	Lower limbs almost completely paralysed, but had some power of rotating and adducting thighs, and attempts at flexion of knees. Complete passive flexion of knees prevented by spasm of quadriceps. Adduction and inwards rotation of left thigh. Occasional cramps and tremors. Muscles of legs and back of thighs did not react to farad. current; but those of front of thighs did so readily.	No note.

Anæsthesia.	Bladder and rectum.	Vaso-motor and Tropic.	Local Symptoms.	Post-mortem.	Remarks.
<p>Anæsthesia of scrotum, penis, and urethra; partially of thighs; completely of legs. At interval of three months, anæsthesia of feet, buttocks, and perineum; numbness of penis, scrotum, and urethra; fairly good sensation in thighs; better sensation on soles than on dorsum of feet, and on inner than on outer side of leg.</p> <p>At first anæsthesia of lower limbs. At end of two months had anæsthesia of feet, obscure sensation from ankle to knee, especially on left side; hyperæsthesia of thigh, especially on right side.</p>	<p>Retention of urine and feces.</p>	<p>..</p>	<p>Projection of 3rd lumbar vertebra.</p>		
	<p>Retention of urine, followed in four or five days by incontinence. Ammoniacal urine.</p>	<p>Occasional priapism. Wasting of lower limbs. Perspiration of feet and ankles. Edema of penis and scrotum. Urethritis, cystitis. Bedsore on back.</p>	<p>An immovable projection 4 inches above level of umbilicus.</p>		<p>The spine was trephined, which was followed by some improvement in the symptoms.</p>
<p>Anæsthesia of lower limbs, except from front of left thigh to dorsum of foot, the loss of sensation extending as high as the buttocks and sacrum, affecting also the penis and urethra; but less marked on the front than on the back of the thighs. Hyperæsthesia in inguinal region, shooting pains in limbs and pain in bladder.</p>	<p>Retention of urine and feces.</p>	<p>No erections. Sweating of feet; edema of lower limbs and scrotum. Bedsores of feet and sacrum.</p>	<p>No note.</p>	<p>Fracture of 1st lumbar vertebra, the cartilage immediately below which projected backwards some $\frac{1}{4}$ in. (7 mm.). Lumbar cord swollen, soft and pale. Other secondary lesions.</p>	<p>See text. This is given by the author as a typical case of traumatic myelitis.</p>
<p>Anæsthesia not complete, but sensation almost lost in the feet, very obscure in legs, back of thighs, and buttocks; better in front of thighs.</p>	<p>Retention of urine and feces.</p>	<p>Slight edema of legs. Bedsore on sacrum.</p>	<p>Spinous process of 1st lumbar vertebra projected backwards and to the right.</p>	<p>Fracture of 12th dorsal and 1st lumbar laminae, and of body of 1st lumbar vertebra; tear of dura mater; compression of cord and cauda equina.</p>	<p>Death from uræmia.</p>
				<p>Inflammation of pia mater and softening of cord extending to upper level of lumbar regions. Secondary lesions.</p>	

No.	Reference.	Sex.	Age.	Result.	Probable Lesion.	Paralysis, &c.	Reflexes.
10.	Hamilton, 'Dublin Quart. Jour. Med. Sci.' vol. vi. 1848.	M.	25	Death in two months.	Fracture through body and laminae of 2nd lumbar vertebra.	Paralysis of lower limbs.	No note.
11.	Hutton, 'Dublin Jour. Med. Sci.' vol. xxi. 1842.	M.	..	Death in six weeks.	Fracture of 1st lumbar vertebra.	Loss of power of the lower extremities.	No note.

urine, and involuntary defecation. In about six months the paralysis passed off, but the retention of urine was followed by incontinence, which, together with the rectal trouble, persisted. After death there was found some compression of the lower part of the spinal cord, and therefore necessarily of the surrounding nerve roots. The affected region of the cord showed degenerative changes. On these grounds the author concluded that this terminal portion of the cord contains the ano-vesical centre: a conclusion which appears not entirely warranted, in view of the fact that the cauda must have been somewhat compressed and that, as shown by our cases, the bladder troubles would then probably be the most persistent. We cannot, therefore, be certain that the case was purely one of cord lesion, uncomplicated by injury to the cauda.

In conclusion, I would draw attention to certain points in the diagnosis of those cases of pressure upon the cauda equina.

1. From locomotor ataxia. In a traumatic case there is

Anæsthesia.	Bladder and rectum.	Vaso-motor and Trophic.	Local Symptoms.	Post-mortem.	Remarks.
At first there was anæsthesia, except on the front of the thighs. In a few days this region was also affected, but again recovered.	Retention of urine, followed by symptoms of cystitis.	..	Projection of 2nd lumbar spine.	Fracture through upper part of body of 2nd lumbar vertebra and its laminae, with compression of the cord "just above the cauda equina."	Death from erysipelas.
The "external parts of the lower limbs were quite insensible, the internal still retaining a considerable share of sensibility."	Retention of urine and fæces. Cystitis.	Bedsore on left buttock. The right tibia and fibula were also broken and united readily. Temp. of lower limbs was "at first" 62°, afterwards 95°.	Interval between last dorsal and 1st lumbar vertebrae.	An oblique fracture of the body of the 1st lumbar vertebra, with compression of the cord and cauda equina, which were bathed in pus.	

little likelihood of confusion, although even here it might possibly be regarded as ataxia consequent upon an injury. But in a case of tumour, or spina bifida, &c., the occurrence of a perforating ulcer, pains in the limbs, patches of anæsthesia, loss of knee-jerk, and some difficulty in walking, with or without bladder troubles, might well mislead the unwary. We must then note the absence of pupil symptoms, of girdle-pains, gastric crises, &c.; on the other hand, we shall find the peculiar distribution of the anæsthesia as above described, the affected muscles will be more wasted than in ataxia, and may present the reaction of degeneration, and there will be loss of power as well as inco-ordination. The gait differs from that of ataxia, and is characteristic, there being not only clumsiness and sprawling, but marked dropping of the toes.

2. From injury or disease of the lower part of the spinal cord. Here we must be guided by the exact site of the local symptoms, if any be present, remembering that the cord does not extend below the lower border of the first lumbar vertebra.

Also, if the cord be there injured, there will probably be some anaesthesia or hyperæsthesia of the last dorsal or first and second lumbar nerves; and again we may expect more rapid trophic lesions than in injuries of the cauda. If the symptoms be asymmetrical, we have probably to do with an affection of the cauda rather than of the cord. Whether in a partial crush above the level of the last dorsal vertebra, the damage done to the anterior crural nerves bears the same relation to that done to the sciatics as in a crush lower down, I have at present no evidence to determine.

3. From extra-spinal nerve diseases and injuries. We have here several difficulties to contend with, but in most instances a careful consideration of the case will lead to a correct conclusion. The only disease liable to be mistaken for an affection of the cauda equina is some variety of multiple peripheral neuritis, and here we may usually decide the point by finding some affection of the upper limbs, by the marked preference of that disease for the extensor surfaces and by the slighter sensory symptoms. In cases of injury the difficulty is greater. Even the limitation of symptoms to one side of the body is not an absolutely pathognomonic sign, as is indicated by Mr. Erichsen's case (No. 1, table). Nevertheless, complete unilateral distribution or perfect symmetry would be strong arguments for the lesion being respectively outside or inside the spinal canal. We are again aided by the seat of any local signs of injury; and finally we might with certainty pronounce the case to be an affection of the cauda, if we found the distribution of the sensory and motor symptoms to accord closely with the above-described types.

I have but one more remark to make here, and that is with regard to treatment. In cases of paralysis from pressure upon peripheral nerves, it is now an established rule of practice to free the nerve by a suitable operation, and in cases of division to place the separated ends in suitable position for re-union. Success is almost invariably the result of such action, and perfect recovery has followed after periods so prolonged as eighteen months.¹ Now the cauda equina is simply a bundle of peripheral nerves. Hence then, if it be compressed, or even

¹ Reg. Harrison, 'Brit. Med. Jour.,' 1886. vol. i. p. 443.

partially torn, by an injury to the bones of the vertebral column, we may expect to relieve or cure our patient if we can take off pressure and remove any cicatricial tissue in which the nerves may be involved. So much must, it appears to me, be granted by all, for whatever view may be taken of the power of regeneration of the spinal cord, there can be no two opinions of that of peripheral nerves. Again, we may probably assume that, where an injury to the cauda equina is followed by persistent symptoms, there is persistent pressure either by means of displaced bone or cicatricial tissue. Hence, in these cases there is a removable obstacle to recovery. If there were no such "gross" obstacle, recovery should occur, as in injuries of other peripheral nerves. It has been very properly urged that, in injuries of the spinal cord itself, we cannot distinguish the effects of a transient from those of a permanent crush, and that we should not "trephine," because we can rarely be sure of finding any bone pressing upon the cord. But this objection does not apply to injuries of the cauda equina, because the mere fact of recovery not ensuing in the course of some weeks is evidence of continued pressure.

Thus then we may say that, in injuries of the cauda equina which do not spontaneously recover, there is probably either a cicatrix or a piece of displaced bone which is keeping up the mischief, and that if we remove this noxious agent we may very confidently hope for a cure. Are we then justified in operating for its removal? I am strongly of opinion that we are. The operation itself is certainly not to be compared in difficulty with many which are daily undertaken without hesitation. The only special danger is that of meningitis, and with modern antiseptic precautions I see no reason to fear this, especially if we delay operating until there has been time for the formation of meningeal adhesions around the seat of injury. In most cases it will be found unnecessary to open the meningeal sheath at all, the source of trouble being merely a fragment of bone, or, as in Mr. Jones's case, an extra-dural cicatrix.

On such *à priori* grounds I would advocate trephining in cases of injury to the cauda equina, always bearing in mind the following conditions.

1. We must be sure of the localisation.

2. We should, if possible, wait for a reasonable period—say six weeks, before operating, and should then do so only if the patient shows no signs of spontaneous recovery.

3. Should the paralysis of the bladder be early followed by severe cystitis, and should we suspect secondary renal troubles, what are we to do? On the one hand, not to operate probably means death; and on the other, the risk of operation is enormously increased. Further experience may enable us to settle this problem, but at present the outlook appears to be sufficiently gloomy. A third course has suggested itself to me, but I have had no opportunity to test its results, viz. to drain the bladder by means of a supra-pubic cystotomy. The object of draining the bladder is obvious, and the supra-pubic appears preferable to the perineal route, because we are thereby enabled to construct our fistula through parts which are not anæsthetic and predisposed to slough.¹ If we could thus prolong life for a time, we might afterwards proceed to operate upon the spinal column, with fair hopes of a successful result, and encouraged by the great improvement effected in the case of R.M.C. and the cure obtained in a case recently published by Lauenstein,² in which there was complete paralysis of the lower limbs, etc., from a dislocation of the twelfth dorsal vertebra, and where a perfect cure resulted from the removal of the displaced arches. It would appear, therefore, that whether “trephining the spine” is or is not justifiable in cases of injury of the cord, it is certainly the proper treatment to pursue in those of the cauda equina, and hence the importance in such cases of making an exact diagnosis.

POSTSCRIPT.

The above paper was written in June 1887, since which date there has appeared in the ‘Lancet’ for July 2nd, 1887, a most interesting article by Mr. Bland Sutton on “Spina

¹ It is hardly necessary to point out that, in an injury to the cauda equina when the symptoms of shock, &c., have passed off, the chief danger to life lies in the occurrence of bedsores or urinary troubles.

² ‘Centralblatt f. Chirurgie,’ 1886, No. 51.

Bifida Occulta." The author quotes one case of his own and others, previously published, illustrating the relationship of this affection with perforating ulcer and pes varus; but as there is no complete account of the nervous symptoms in these cases, I can only suggest, without being able to demonstrate, that they are probably similar to those above described.