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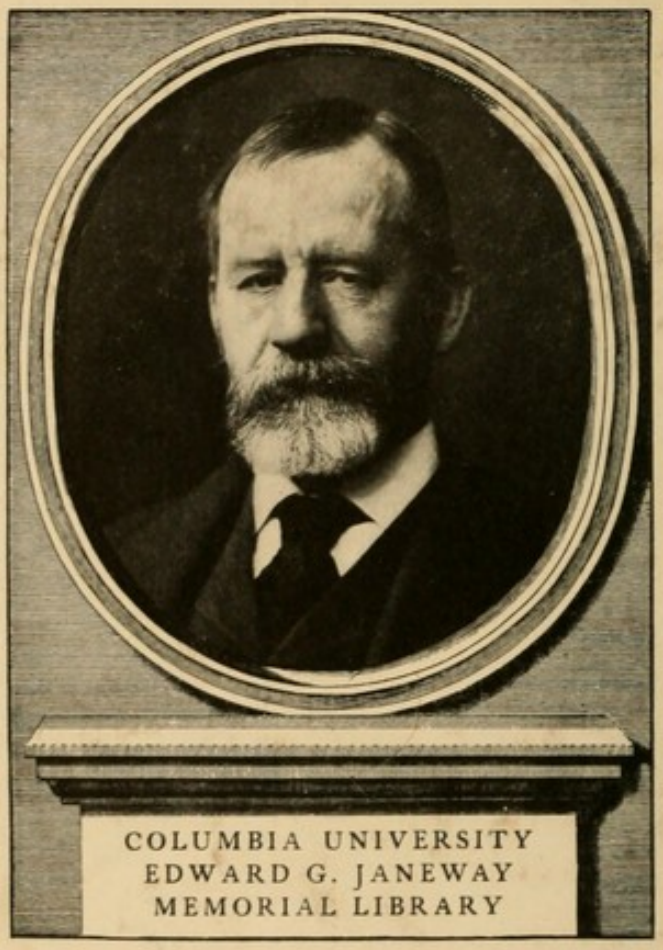

A CONTRIBUTION

TO THE

SURGERY OF THE SPINAL CORD.

BY

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With Diagrams, Illustrations, and Tables.

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INTRODUCTION.

In the following pages will be found recorded a number of clinical observations, chiefly upon injuries of the spinal cord, and certain other traumatic affections, formerly supposed to be of organic and spinal origin, but now generally attributed to a totally different form of nervous disturbance. Although many of these observations have been already published in various medical journals, yet the present book is by no means a mere reprint, inasmuch as the arrangement adopted, and the connecting links of thought here supplied, not only render the result an extension of previous work, but give to it a coherence and unity which was not attempted in the original papers. It is, however, hardly necessary for me to say that the work lays no claim to be a systematic treatise, or even an exhaustive monograph, upon the above important subjects, but that it is merely a record of personal observations and deductions.

Two considerations have chiefly led to the production of this book. In the first place, it must be generally admitted that, until very recent years, the published descriptions of the symptoms of spinal injuries have, except in the hands of a few such observers as Ollivier and Mr. Jonathan Hutchinson, been so vague and indefinite, as to be almost valueless for the purpose of throwing light upon the more obscure questions of spinal pathology and physiology, or even of permitting an accurate diagnosis of the cases themselves. And yet we have in such injuries a perfect mine of wealth, which, properly utilised, can hardly fail to advance our knowledge of the normal and diseased action of

this portion of the nervous system: and there cannot be a doubt that the "experiments" provided for us by traumatic lesions of the spinal cord must, in their turn, illuminate those other branches of physiological and pathological science to the growth of which they owe the attention now bestowed upon them.

The second consideration to which I refer is that, acting under strict antiseptic precautions and aided by modern knowledge, surgeons will probably, in the near future, open the spinal canal with as little danger and as little hesitation as they now operate upon the cavity of the cranium; but that in order to permit of such an extension of therapeutic art it will be necessary still further to increase the accuracy of our diagnostic methods.

On these grounds, then, I feel that no contribution, however slight, which may aid in the elucidation of the points referred to, ought to be withheld from the medical public, and the only question with me is whether the importance of the following observations is sufficient to justify their collection in the present form. Whether this is so or not must now be left to the judgment of the reader; but, whatever this judgment may be, at least I cannot plead that my opportunities for undertaking the work have not been ample. Having entered upon my medical education just at the time when the diseases of the nervous system began to be studied in Manchester, with an enthusiasm which has made itself widely felt, I have from the first been thrown under the influence of teachers and friends for whose assistance and advice I cannot sufficiently express my gratitude; and further, during the last four years my position as Surgical Registrar to the Manchester Royal Infirmary has given me access to an almost unrivalled field for clinical observation, in which I have had the singular good fortune to work under a staff, who have not only afforded me every opportunity for observing their cases, but have also given me permission to publish them as freely as if they were my own. To the large-minded generosity of these gentlemen—the Physicians and Surgeons of the Manchester Infirmary—I am unable adequately to express my obligation.

If, where I have received so much and such general kindness and assistance, any selection be permissible, I would tender my

especial thanks to Dr. David Little, whose ready assistance in controlling my observations upon morbid conditions of the optic discs endows them with the stamp of his high authority. But above all, I am indebted to two gentlemen, whose constant assistance and advice have been of an absolutely inestimable value to me—my former teacher, Dr. James Ross, to whose inspiration must be attributed whatever is of value in this book, and my colleague, Mr. Alexander Wilson, who has ungrudgingly lent me his aid in the preparation of the work for the press.

W. T.

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SURGERY OF THE SPINAL CORD.

CHAPTER I.

INJURIES TO THE CERVICAL REGION OF THE SPINAL CORD.

SINCE January 1885 there have been admitted to the Manchester Infirmary twenty-one cases of injury to the cervical region of the spinal cord, from an examination of which I have been able to arrive at certain conclusions as to the exact distribution of the motor and sensory functions of the brachial enlargement. As none of the injuries occurred higher than the origin of the fourth pair of cervical nerves, I have nothing to add to our previous knowledge of the functions of the upper portion of the cord, but shall proceed at once to the consideration of that section comprised between the third cervical and second dorsal roots. Before doing so, it will, however, be convenient to summarise the results, as regards localisation, obtained by previous observers: results derived from evidence of three classes—experimental, clinical, and anatomical.

Drs. Ferrier and Yeo[1] have investigated, in the monkey, the effects of irritation of each of the cervical roots, and, on the basis of these researches, Ferrier[2] has assigned certain muscles to each root, which, inverting the original arrangement, we find to be as follows, from above downwards:—

Fourth cervical type:—Deltoid, rhomboid, supra- and infra-spinatus (teres minor), biceps, brachialis anticus, supinator longus, extensors of wrist and fingers, diaphragm.

Fifth cervical type:—Deltoid (clavicular portion), biceps, brachialis anticus, serratus magnus, supinator longus, extensors of wrist and fingers.

[1] Proc. Roy. Soc., No. ccxii. p. 12.

[2] Brain, vol. iv., 1882, p. 226.

Sixth cervical type:—Latissimus dorsi, pectoralis major, serratus magnus, pronators (flexor of wrist ?), triceps.

Seventh cervical type:—Teres major, latissimus dorsi, subscapularis, pectoralis major, flexors of wrist and fingers (median), triceps.

Eighth cervical type:—Long flexors, ulnar flexors of wrist, intrinsic muscles of hand, extensors of wrist and phalanges, long head of triceps (pectoralis major ?).

First dorsal type:—The intrinsic muscles of the hand, viz., muscles of the thenar and hypothenar eminences and interossei.

Two objections may be taken to this classification: (1.) that it is difficult, if not impossible, in irritating certain nerve-roots, to be certain that the irritation has not spread to adjacent fibres; and (2.) that the conclusions may be inapplicable to man, in view of the fact that in him the motor functions are more specialised and less associated, and that the spinal nuclei may, therefore, be more concentrated, so that the entire nerve-supply for a given muscle may originate in a smaller area, and may be distributed by a smaller number of roots. It is certainly obvious that, whether it be due to one of these reasons or not, we do, as a matter of fact, find much overlapping in the series of muscles assigned to each of Ferrier's root-types.

It has, however, been ascertained that clinical observation coincides closely with the results thus obtained, and that in cases of polio-myelitis and root-paralyses the affected muscles form very similar groups. Cases capable of demonstrating such points are comparatively infrequent, and the subject has thus had to be worked out, not by one, but by several observers, but the following summary given by Dr. Gowers[1] represents the general conclusions:—

Motor.	Roots.	Motor.	Sensory.
Upper part of trapezius	Fourth cervical	Diaphragm	Shoulder
	Fifth cervical	Serratus; Flexors of elbow; Supinators (Shoulder muscles)	
	Sixth cervical	Extensors of wrist and fingers	Arm
Lower neck muscles	Seventh cervical	Extensors of elbow; Flexors of wrist and fingers; Pronators	
Middle part of trapezius	Eighth cervical	Muscles of hand	Hand (ulnar n. lowest)
	First dorsal		

[1] Diseases of the Nervous System, vol. i. p. 142.

Herringham,[1] examining their relations from a purely anatomical point of view, has in the human subject carefully dissected the cervical nerve-roots through the brachial plexus, and has obtained the following results as to their distribution :—

Fifth cervical root :—Biceps, brachialis anticus, subscapularis, deltoid.

Sixth cervical root :—Pectoralis major, biceps, brachialis anticus, pronator teres, flexor carpi radialis, superficial thenar muscles, subscapularis, teres major, deltoid, supinator longus et brevis, extensor carpi radialis longior et brevior.

Seventh cervical root :—Pectoralis major et minor, coracobrachialis, flexor sublimis, latissimus dorsi, triceps, extensor carpi radialis longior et brevior.

Eighth cervical root :—Pectoralis major et minor, flexor sublimis, latissimus dorsi, triceps.

First dorsal root :—Pectoralis major et minor.

This anatomical method of investigation would appear to be less open to objection than any other, and the general conclusions will be found to accord fairly well with those previously obtained ; the most important difference being that the intrinsic muscles of the hand are assigned a higher level of origin than in the experimental and clinical observations. The result is, however, not a perfect clinical guide, inasmuch as the connections are too minute, branches evidently being traced into muscles for which they do not contribute any important path of voluntary impulses, and the paralysis or irritation of which will, therefore, not be productive of any symptoms.

An accurate knowledge of these localisations being of the greatest importance to the surgeon who would operate for the relief of pressure lesions of the spinal cord, I have endeavoured to work out an independent scheme by observing in detail the extent of the paralysis and anæsthesia in cases of injury, both at an early period, and also during the progressive ascending myelitis which usually ensues. The extent of the paralysis has been deduced partly from the obvious loss of voluntary control over the muscles, partly from the positions assumed by the limbs, and partly from the electric reactions. The exact site of the lesion has generally been subsequently confirmed by post-mortem examination.

Following out this method, I have been led to arrange the

[1] Proc. Roy. Soc., No. ccxliii., 1886, p. 255.

various spinal muscular nuclei in the following order, from above downwards, assigning each to the nerve-root by which its efferent fibres probably leave the cord :—

Supraspinatus and infraspinatus Teres minor (?)	*Fourth cervical nerve.*
Biceps Brachialis anticus[1] Deltoid Supinator longus Supinator brevis (?)	*Fifth cervical nerve.*
Subscapularis Pronators Teres major Latissimus dorsi Pectoralis major Triceps Serratus magnus	*Sixth cervical nerve.*
Extensors of the wrist	*Seventh cervical nerve.*
Flexors of the wrist	*Eighth cervical nerve.*
Interossei Other intrinsic muscles of the hand	*First dorsal nerve.*

In endeavouring to elucidate this matter, I have entirely ignored the results arrived at by other methods, and have confined myself entirely to the evidence yielded by the cases referred to, the more so as the conclusions are consistent with the majority of previous observations.

It will be obvious that the method adopted, relying, as it does, principally upon the position and mobility of the limbs, indicates only the chief point of origin of the motor nerve-fibres for each muscle, and that where muscles are supplied from more than one level or root, the minor connections are disregarded. Thus, in the case of the pectoralis major, there is no doubt that several roots supply the muscle, but of these one only could be identified. The conclusions, however, although probably thus wanting in minute accuracy, will obviously be of the more value as clinical data, and are not open to the objections presented by Herringham's more complete scheme. Time alone will explain the minor discrepancies between my arrangement and those of others.

While narrating the following cases in the order best suited to illustrate the above table, I shall refer from time to time to other points of interest which they present.

[1] I have not identified the brachialis anticus, but, from well-known clinical facts, assume it to be in close connection with the biceps.

CASE 1.—*Fracture-dislocation between the fourth and fifth cervical vertebræ—Complete paralysis of limbs and trunk—Death.*

The following case was under the care of Mr. Heath. The notes were taken by the dresser, Mr. W. H. Iddon.

M. L., male, aged forty-five, was admitted to the Manchester Infirmary on March 27, 1886. He had fallen from a scaffolding some forty feet in height. In addition to three lacerated scalp-wounds, he presented the following symptoms. There was severe pain in the back of the neck. All four extremities were "completely paralysed," as were the muscles of the trunk and abdomen. The limbs and trunk were absolutely anæsthetic below a line running across the thorax at the level of the second intercostal space, and thence across the deltoids at the junction of their upper and middle thirds; above this line sensation was normal, the transition being quite abrupt. The pupils were equal, and were thought to be of normal size. There was no mental affection. Respiration was diaphragmatic; the urine was retained; priapism was constant. Death took place a few hours after admission, apparently from dyspnœa.

The temperature was taken several times, but was unfortunately not recorded. The house-surgeon assures me that it was certainly not, at any time, far from the normal.

At the post-mortem examination there was found a fracture through the body of the fifth cervical vertebra and the inter-vertebral disc immediately above it. The spines of the third, fourth, and fifth vertebræ were broken off. Around the dura mater at this point was a very slight effusion of blood. The cord was much lacerated, being almost torn across opposite the seat of fracture, and was very soft for a distance of nearly 1½ in., being reddened by extravasated blood. The skull and its contents were uninjured. The lungs were œdematous.

Here we have a lesion affecting the junction of the fourth and fifth cervical vertebræ, so that the fifth root, which escapes from the spinal canal above the fifth vertebra, would be injured together with the cord itself below this point. Hence we get complete paralysis of sensation and motion in the upper extremity, the whole of the brachial plexus being cut off from the brain, with the exception of its branch from the fourth cervical nerve. The present case unfortunately yields no evidence as to the distribution of this branch, the condition of the posterior scapular muscles not having been specially noted.

CASE 2.—*Dislocation between the fourth and fifth cervical vertebræ —Complete paralysis of limbs and trunk—Death.*

C. D. was admitted under the care of Mr. Hardie, the notes being taken by Mr. Benson, house-surgeon. The patient, a carter, thirty-nine years of age, was admitted on August 3, 1886, having fallen from a van, of which the wheels had passed over his shoulders.

On admission he complained of great pain at the back of the neck. All four limbs were completely paralysed, and there was anæsthesia below the level of the descending branches of the cervical plexus. Respiration was diaphragmatic. The fæces were passed unconsciously. Both pupils were contracted, the palpebral fissures narrowed, and the eyeballs presented a remarkable sensation of softness owing to paralysis of the posterior orbital muscles. The pulse was full, of low tension, and beating at the rate of 60 per minute. The temperature on the evening of admission was 96.8°.

He passed a restless night, and on the next morning the following additional symptoms were noted. There was constant priapism. The urine was retained, and upon being withdrawn by the catheter, was examined for sugar and albumin, with negative results. The face was much congested; the pulse remained full and soft, beating at the rate of 130 per minute. The temperature at 8 A.M. was 102.2°. When the patient was told to take a deep breath, he contracted the levator anguli scapulæ muscles, which could be distinctly felt beneath the trapezius, thus indicating an attempt to fix the scapula, and bring into play the extraordinary muscles of inspiration.

At 10 A.M. the patient's temperature had risen to 103.6°; at midday to 105°; at 2 P.M. to 106°. At 4 P.M. it was 107.8°. He now became insensible and livid, and the breathing was more shallow, the whole body being covered with a profuse hot sweat. At 5 P.M. he died, the temperature having risen to 108°. The temperature after death was not recorded.

At the post-mortem examination there was found a rupture of the cartilage between the bodies of the fourth and fifth cervical vertebræ, these two bodies being so widely separated behind that a finger could be introduced between them. They thus formed an obtuse angle posteriorly, pressing on the contents of the spinal canal. At this point there was marked post-mortem staining of the meninges, but decomposition was so far advanced that it could

not be ascertained whether they were inflamed. The cord itself was here compressed, through a vertical extent of three-quarters of an inch, into a narrow band, and was very much softened, there being no distinction between the grey and the white matter. Elsewhere the cord showed only post-mortem softening.

The posterior parts of both lungs were much congested, and in the brain were numerous puncta cruenta. There were no other changes of interest.

This case is similar to the last, the lesion again involving the roots of the fifth cervical nerves and all parts below them, and the symptoms being the same. Both cases are of value mainly as contrasting with those which follow.

CASE 3.—*Fracture-dislocation between the fifth and sixth cervical vertebræ—Complete paralysis of all nerves below the fifth cervical—Death.*

L. F. was admitted to the Manchester Royal Infirmary under the care of Mr. Jones on June 5, 1886. The patient was a man, aged sixty-eight, a labourer by occupation. On June 1, four days before admission, he was standing on a short ladder whitewashing, when, two of the rungs of the ladder giving way, he fell backwards in such a position that while his feet remained caught in the ladder, he first struck the back of his neck against a bench some $2\frac{1}{2}$ feet above the ground, and then fell head first to the ground. At the same time he thinks that his bucket of whitewash fell upon him.

He at once became unconscious, remaining so for several hours. On regaining consciousness, he found that his legs were quite immovable and his arms partially so, while there was loss of sensation in the lower portion of the body, coupled with a dull aching pain. There was also great pain in the head, neck, and shoulders. The urine had to be drawn off twice daily. He remained in this condition until his admission to the Infirmary on the fourth day after the accident.

When admitted, he was found to present complete paralysis of the lower limbs and of the abdominal and thoracic muscles. All the muscles of the arms were paralysed, with the exception of the biceps, brachialis anticus, supinator longus, and deltoid; the consequence being that the elbows were flexed, the shoulders abducted and rotated outwards, and the hands and arms fell into the

position indicated in the annexed engraving (fig. 1), taken from a photograph. There was no power of extension of the forearm, but a fair degree of power of flexion. Some external rotation of the humerus could be effected by the supra- and infra-spinati. The pectoralis major and latissimus dorsi were paralysed. The lower limbs and trunk were completely anæsthetic as high as the level of the second rib in front—*i.e.*, as high as the descending branches of the cervical plexus—and apparently to the third dorsal vertebra (?) behind. Above this point sensation was normal. The upper extremities were anæsthetic, with the exception of the radial side of the forearm and hand and the balls of the thumbs. All the cutaneous reflexes and tendon reactions were absent throughout. Breathing was entirely diaphragmatic.

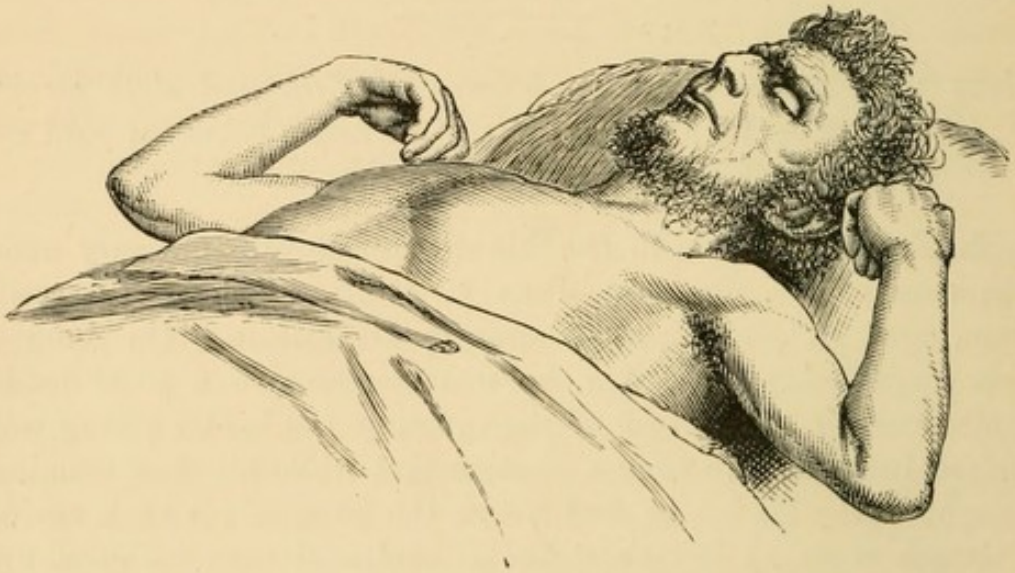


Fig. 1.—Position occupied by the limbs in a case of complete transverse destruction of the spinal cord immediately below the level of origin of the fifth cervical nerves.

The urine was retained, and the bowels had not been moved since the accident. The penis was subject to frequent erections with seminal emissions; on the back were several bed-sores. The pulse was slow and full; the temperature 98°. The pupils were both somewhat contracted. Over the fifth and sixth cervical vertebræ was a slight prominence, which was very tender on pressure. The only treatment adopted was complete rest on a water-bed, catheterisation at intervals, and some simple dressing for the bed-sores.

During the progress of the case there were not many very important deviations from the symptoms above described. The urine, which was at first healthy, became turbid and alkaline a few days after admission. After this the bladder was washed out daily with boracic acid lotion. Priapism became more constant. The

bowels were never moved except after the use of an enema or of croton-oil. On June 9, four days after admission, the arms had become completely anæsthetic, and they thereafter remained so. The temperature was generally slightly below the normal; the pulse was often 50, never above 60. Respiration was rapid throughout, being usually about 20, sometimes 30 per minute.

The patient's strength failed steadily, and at times there was confusion of thought, with low muttering delirium at night. He complained mainly of pain in the neck and of cold feet.

On June 15 he had lost all power of rotating the humerus on both sides, any passive movement of the shoulder-joints being very painful. The cheeks fell in and out very markedly on respiration. Although the power of the voice remained good, speech was almost unintelligible; he could not protrude the tongue beyond the teeth, nor freely open the mouth. There was marked fibrillar trembling of the masseters, and much accumulation of tenacious saliva about the mouth. Bed-sores had formed over the sacrum, on the inner side of the right thigh, and on the inner side of the left knee, these having hardly changed since admission.

On June 17 the contraction of the deltoid muscles, which had maintained the abducted position of the arms, ceased, and the elbows fell to the sides, the elbow-joints themselves remaining flexed.

From this date the patient gradually sank, respiration becoming more laboured, and the countenance dusky, while there was increased apathy. On June 25 the pupils were noted as being dilated and unequal, the right being the larger; there was a commencing "bed-sore" on the chest; on washing out the bladder there came away shreds of what was thought to be mucous membrane. On June 26 he died exhausted.

At the post-mortem examination the disc between the fifth and sixth vertebræ was found to be broken across, the lower part of the body of the fifth vertebra being tilted forwards. The laminæ were uninjured, but the right superior articular process of the fifth vertebra, and the corresponding transverse process of the sixth were broken off. At this point the cord was compressed, being flattened for a distance of about a quarter of an inch. The dura mater was here yellowish and opaque, the arachnoid and pia mater healthy. The cord was much softened for a distance of two or three inches above and one inch below the seat of injury, especially around the central canal, where it was quite diffluent and of a yellowish colour, showing under the microscope numerous granule-cells. The rest of the cord was healthy. The bladder

contained a quantity of blood-stained turbid fluid, its mucous membrane hanging in shreds, beneath which the wall was dark and livid; inflammation had extended to the pelvic cellular tissue and the peritoneum. The kidneys were congested, and presented numerous scattered points of suppuration; there was no dilation of nor suppuration in their pelves. The other organs presented nothing of interest.

This case is a sufficiently typical example of injury to the spinal cord above the origin of the sixth cervical nerves. Thus we find that, with the exception of the biceps, brachialis anticus (?), and supinators, there was absolute paralysis of the intrinsic muscles of the upper extremity. Of the extrinsic muscles of the upper limb, the only ones not paralysed were the deltoid and the external rotators of the humerus—the teres minor and spinati. The case is thus an exact counterpart of the so-called Erb's paralysis, in which we meet with paralysis of the same muscles which were here spared; and it enables us to confirm previous researches as to the distribution of the fifth cervical nerve-root. From the unopposed action of the above-mentioned muscles there resulted the characteristic position represented in the figure, but how far this contraction was due to mere *tonus*, and how far to pathological spasm, it is impossible to say.

The characteristic position of the limbs observed in this case has been previously noted, but its import has not, I believe, been hitherto fully explained. Thus, in the London Hospital Reports for 1866, Mr. Jonathan Hutchinson mentions a case in which a man had partial paralysis of the right arm, but could raise the limb, although he could not grasp; and the position is still more clearly indicated in another case, recorded in the same paper, of a crush opposite the fifth cervical vertebra, in which the arms were raised to a level with the shoulders, and the forearms flexed by the biceps.

Again, in the St. Thomas's Hospital Reports for 1870, Mr. Churchill describes a case of fracture of the fifth cervical arch, with crushing of the cord, in which the patient could move the shoulders and upper arms only. In the latter paper is also described a case of dislocation forwards of the sixth cervical vertebra, in which there was impaired movement of the arms, attributed to a desire to keep the spine immovable: the upper arms are described as being raised to a right angle with the body, and "the forearms were flexed so as to relax the muscles and to support the head;" the same case apparently presented hyper-

æsthesia of the radial side of the upper limbs. Clearly, then, this was an example of irritation of the region of origin of the fifth roots, with paralysis below that level.

Besides illustrating the functions and distribution of the fifth cervical root, our case suggests that the deltoid nuclei are situated below those for the biceps, the former having first yielded to the ascending myelitis. This suggestion will be found to be confirmed by other cases mentioned below.

As regards sensation, we find that a cord lesion which cuts off the origin of all the nerves of the brachial plexus below the fifth cervical causes anæsthesia of the entire upper limb, except the outer side of the arm and forearm, and the radial border of the thumb, *i.e.*, a part of the region supplied by branches of the musculo-spiral nerve.

The affection of speech and other symptoms noted in the progress of the above case at first gave rise to the supposition that there might be some extension of myelitis to the medulla oblongata; but as no further symptoms of bulbar paralysis developed themselves, and as the intermediate cervical muscles were unaffected, these phenomena would appear to have been due to the general debility only.

CASE 4.—*Fracture-dislocation between the fourth and fifth cervical vertebræ—Partial paralysis of right upper limb—Total paralysis of other limbs and trunk—Death.*

T. L. was admitted under the care of Mr. Heath on September 7, 1886. He was thirty-six years of age, and a carter by occupation. While attending to his horse the animal had fallen against him, crushing him against the manger, the corner of which struck his back between the shoulders. He immediately fell down paralysed.

On admission, there was found no external bruise or other evidence of injury, except a sense of soreness and stiffness in the lower cervical spine; no irregularity of the spinous processes could be detected. The lower limbs and trunk muscles were entirely paralysed, as was also the left upper extremity; the right upper extremity was paralysed, with the exception of the deltoid and biceps (the condition of the brachialis anticus and supinator longus is not noted). The bladder and sphincter ani were also paralysed, and there was priapism.

There was anæsthesia of the lower limbs and trunk, and of the upper limbs with the exception of the radial side of the hand, fore-

arm, and arm on both sides. Breathing was entirely diaphragmatic. The pupils were widely dilated. The temperature was 100.6°. The treatment consisted in the use of a water-bed with ice-tubes to the spine, doses of ext. ergot. liq. three times daily, and catheterisation.

At 8 A.M. on the following day the temperature had risen to 105.2°; at noon it was 104°; and then again gradually rose, reaching 105.6° before death, which occurred on the second day. Breathing became more difficult, with accumulation of mucus in the bronchial tubes, and the face grew very livid. The man died asphyxiated about thirty-six hours after admission, the heart continuing to beat for some ten minutes after respiration had stopped.

At the post-mortem examination there was found a rupture of the cartilage between the fourth and fifth cervical vertebræ, "which fracture had extended across posteriorly, involving the laminæ of the fourth or fifth vertebræ," but was unaccompanied by any displacement. The spinal membranes were healthy. The cord opposite the seat of fracture was not at all compressed, but was for a distance of about an inch very soft and pulpy, containing numerous punctiform hæmorrhages, which were most marked in the central grey matter. The other organs were not examined.

This case presents an interesting comparison with Case 3 on the one hand, and with Cases 1 and 2 on the other. The lesion of the spine itself was less severe, and there was less displacement of the bones, which consequently did not cause permanent compression of the cord. There was, however, ample evidence of a temporary crush of the spinal cord, received, no doubt, at the time of injury, the bones afterwards partially recoiling to their normal position. Such, doubtless, is the explanation of many cases (as, for instance, those referred to in the following chapter), in which there is little or no evidence of bone-lesion, but in which the cord itself has sustained a severe injury. An accident causes an acute bend of the vertebral column, which at once rights itself, but not before great or irreparable damage has been inflicted upon the contained organ; and many of these cases have been regarded as instances of "concussion of the spinal cord," the possibility of a gross mechanical lesion being overlooked. Another point which is here exemplified, but which is more fully demonstrated in Case 16, is the tendency for hæmorrhage into the spinal cord to affect mainly its central portions, where its substance is softest, and where the large branches of the central spinal artery have their distribution.

As regards the distribution of the paralysis and anæsthesia in this case, we find that there was not complete annihilation of the functions of the two fifth cervical nerves, their roots not having been severely nipped between the affected bones, although the cord below their origin was crushed. On the left side the upper limb was completely paralysed, as in Cases 1 and 2, but on the right side some of the muscles supplied by the upper root of the brachial plexus had partially escaped, the biceps and deltoid not being paralysed. The supinators were, however, paralysed on this side also, a result perfectly explicable on the supposition that, occupying the lowest nucleus connected with the fifth root, they would most readily come within the sphere of pressure due to the central hæmorrhage immediately below. Further, we find that, as in Case 3, so here, sensation was retained on the outer border of the arm, forearm, and hand of both sides, the sensory conducting paths of the left side having been destroyed up to a rather lower level than were the motor functions. Such damage as was done to the area of the fifth roots must therefore be ascribed to the central hæmorrhage rather than to injury of the roots themselves.

CASE 5.—*Comminuted fracture of fifth and sixth cervical vertebræ —Partial paralysis of left upper limb—Total paralysis of other limbs and trunk—Death.*

W. H. was admitted to Mr. Whitehead's wards on April 30, 1886. He was twenty-eight years of age, a wine merchant by occupation, and of intemperate habits. When admitted, he was intoxicated, and had, while in that condition, fallen over the railing of a staircase, the distance not being ascertained. He complained of great pain at the back of the neck, but there were no external signs of injury. There was complete paralysis of both lower extremities and of the right upper limb, but on the left side he could bend the elbow-joint. Respiration was diaphragmatic. The cutaneous reflexes and tendon reactions were abolished. Anæsthesia was complete below the distribution of the branches of the cervical plexus, except over a portion of the left upper limb. The pupils were moderately contracted, the contraction—or rather imperfect dilatation—showing best, as is usual in these cases, in diffused light; the palpebral fissures were small. The pulse was slow and compressible. The temperature was not recorded, but was below the normal. The urine was retained, and the penis large and turgid.

A more complete examination showed that although there was absolute loss of motion and sensation in the right upper extremity, the paralysis had on the left side spared the deltoid, biceps, brachialis anticus (?), and supinator longus; the pectoralis major and latissimus dorsi, and all the muscles below the shoulder, with the exception of those mentioned, were paralysed. The limb occupied exactly the position assumed by those of Case 3, being slightly abducted at the shoulder, rotated outwards, with the elbow flexed and the forearm and hand supine, the contrast between this position and the complete flaccidity of the right upper extremity being very striking. This was the first case in which this remarkable position of the limb was noted in the Manchester Infirmary, the detection of its significance being due to Mr. Collier, then resident surgical officer. Anæsthesia extended over the whole of the left upper extremity, except a strip of skin, some three inches wide, extending downwards from the shoulder along the outer side of the limb to a point about three inches below the level of the elbow-joint.

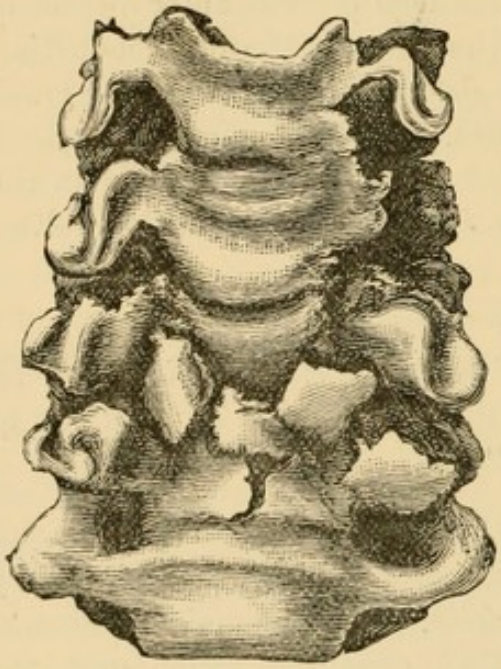


FIG. 2.—Third, fourth, fifth, sixth, and seventh cervical vertebræ from Case 5, seen from the front, showing a comminuted fracture of the bodies of the fifth and sixth vertebræ.

The patient complained much of difficulty of breathing, which increased rapidly, and he died asphyxiated about forty hours after the accident. Before death the temperature became very high.

At the post-mortem examination, which was made by Dr. Bury, then medical registrar, there was found a complete crush of the body of the fifth cervical vertebra, that of the fourth being displaced downwards and forwards, and having its left transverse and articular processes broken off, and that of the sixth being split vertically. The condition of the bones is shown in fig. 2. In front of the bodies of the injured vertebræ was some extravasation of blood. On opening the spinal canal, the cord was found to be obliquely compressed by the bony fragments in such a way that the upper limit of the flattening was above the fifth cervical nerve-root on the right side, but between that and the sixth nerve-root on the left, as shown in fig. 3, a small piece of the body of the

fifth vertebra pressing upon the origin of the fifth root of the right side. The lungs were intensely congested, and portions of the left lower lobe sank when thrown into water. The other organs presented nothing of interest.

This case, like the preceding one, is an instance of oblique injury to the cord, the direction of the obliquity being reversed, and the fifth root escaping on the left side only; and it thus offers another illustration of the distribution of the motor and sensory branches of this root. The area in which sensation was retained was less than in Cases 3 and 4, owing possibly to some of the lower sensory fibres of the left fifth root being also involved in the lesion.

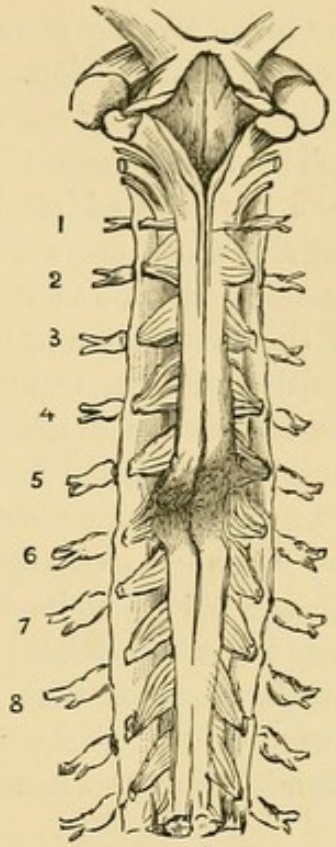


FIG. 3.—Spinal cord from Case 5, seen from behind, showing compression, extending obliquely from above the origin of the sixth cervical nerve on the left side, upwards, so as to intercept the fifth nerve-root on the right side.

CASE 6.—*Injury to upper part of brachial region—Paralysis below deltoid nuclei—Death.*

A man aged thirty-five was admitted under Mr. Heath's care on June 18, 1887. He had the night before admission fallen down about ten steps on to his head, as evidenced by bruises on the left side of the cranium. As he died in a few hours, I was obliged to obtain my information from Mr. Thompson, the house-surgeon.

At the back of the neck was a large amount of effused blood, but the spines of the vertebræ were distinctly felt, that of the sixth cervical being apparently displaced slightly to the right. Beyond this there was no deformity, nor any difficulty in movement, and the man complained of but slight pain in the back of the neck.

The lower limbs and trunk were completely paralysed; the arms were held rigid with the elbows abducted, and the hands lying on the epigastrium extended and prone. Anæsthesia was complete below a point about two inches above the nipples, being also complete over the shoulders and in the upper limbs. The pupils were reduced to fine points. The urine was retained and the penis turgid.

As the man was being placed in bed, respiration became slow and gasping, with distinct action of the scaleni and sterno-mastoids; the patient grew cyanotic and respiration then stopped, the pulse ceasing about half a minute later. There was no post-mortem examination.

The above case carries us but little further, but it is clear from the facts adduced, and especially from the anæsthesia affecting the whole surface of the upper limbs, that almost the entire brachial region was affected. With the exception of the abduction of the shoulders and flexion of the elbows, the arms were in the position of rest, resulting from complete paralysis. Hence then the biceps and deltoid had escaped, but the supinators and all muscles mentioned below them in our table were paralysed—that is to say, the hæmorrhage resulting from the crush of the cord had extended partially into the territory of the fifth root, destroying the nuclei, at its lower part, for the supinators, but sparing the biceps and deltoid above. This, and other cases, such as our fourth, indicate that the branches to the supinators have the lowest origin of the "fifth root group" of nerves, these being often implicated when the remainder of the root escapes paralysis.

CASE 7.—*Injury to upper part of brachial region—Paralysis below biceps nuclei—Death.*

A. B., aged twenty-three, was admitted to the Manchester Infirmary under the care of Mr. Jones on April 7, 1888. He was playing football, and, while stooping forwards with his head thrown up in order to "tackle" an opponent, came into violent collision, his head being jerked backwards. He was immediately paralysed.

On admission, the spine of the seventh cervical vertebra was felt to be distinctly depressed, but with little or no lateral displacement. There was a good deal of swelling about the back of the neck, and the patient complained of great pain. The lower limbs and trunk were completely paralysed, respiration being diaphragmatic. In the upper limbs the only muscles not paralysed were the flexors of the elbow. The limbs at first lay extended and close to the body, but when told to try to move them, the patient bent the elbows so as to bring the hands up to the shoulders. The pupils were slightly contracted.

An attempt was at once made to reduce the dislocation by

extension, followed by flexion, of the neck, and a distinct jerking was felt by the assistants who were steadying the trunk. The patient expressed himself as feeling his pain relieved, but no other change was produced. Later, another attempt at reduction was made under chloroform, but with equally little success. The patient was now put to bed, the head being steadied by pillows and sandbags. At this time the temperature was below 95°, and the skin felt cold; the pulse was strong and regular; the penis was turgid, the urine retained.

About 4 A.M. on the following day the temperature began to rise rapidly; the skin was hot, flushed, and perspiring; and the patient became delirious. At 6 A.M. the temperature had risen to 106.6°, at 8 A.M. to 108°, and at 9.30 to 110°, at which time the man died comatose.

There was no post-mortem examination. For notes of the above I am indebted to Mr. Stocks, the house-surgeon.

This case is also somewhat unsatisfactory, as the accident happened on Saturday night, and the man died on the Sunday morning, so that it was not very fully observed. It indicates the high position of the nucleus for the flexors of the elbow, and shows that the deltoid and supinators, also supplied by the fifth root, were paralysed. Thus, then, as in Case 3, we are led to place the deltoid nucleus below that of the flexors of the elbow. Hence we find that of the four motor nuclei comprising the "fifth root group," the lowest is that for the supinator longus (and brevis ?), paralysed in Cases 4 and 6; and that next to this comes that for the deltoid, paralysed throughout in Case 7, and as a result of ascending myelitis in Case 3. Thus the flexors of the elbow would appear to occupy the highest position of the segment—a result which, although it appeared to me improbable, I cannot but accept on the evidence of these and other cases, such as the following, in which again the flexors of the elbow were alone spared in the left upper limb.

CASE 8.—*Fracture of fifth cervical vertebra—Paralysis below biceps nucleus on right side and pronator nucleus on left—Trephining—Death.*

R. R., aged thirty-three, was admitted to the Manchester Infirmary, under the care of Mr. Hardie, on November 21, 1888.

Four days previously he had been struck on the back of the neck by a weight, which he estimated at 3 cwt., and which was hanging from a chain. The head was forced forwards on to the chest. He did not lose consciousness, nor present any signs of cerebral concussion or other head-injury, but he became immediately paralysed. Subsequently to the time of the accident he did not think any change had occurred in his condition.

He complained of pain at the back of the neck, but no local deformity could be detected. The lower limbs and trunk were completely paralysed and anæsthetic below the descending branches of the cervical plexus. Respiration was diaphragmatic.

The left upper limb lay with the humerus straight by the side, and the forearm across the epigastrium. The only movement which could be effected was flexion of the elbow, which was accompanied by a readily-felt contraction of the biceps. The right upper extremity had no fixed position, and presented a greater range of movement, flexion of the elbow and abduction of the humerus being readily performed, while there was slight power of adducting the humerus, and of supinating and pronating the wrist. Sensation was much better on the outer border of the left upper limb than in any other portion of it, and was almost entirely lost on the inner aspect, but there was no defined limit; the hand was completely anæsthetic except along its outer border and over the root of the thumb. In the right upper limb the limits of sensation were similar, but the anæsthesia was less complete.

The plantar and cremasteric reflexes and the knee-jerks were absent.

Both palpebral fissures and pupils were small, and the latter did not dilate on pinching the skin of the neck.

The urine, which was retained, was neutral (sp. gr. 1023), and contained no sugar, albumin, or other abnormal constituent.

The temperature was 99.6°. The penis presented no turgidity. The pulse was 96, small and soft. The skin felt dry and warm, and presented several superficial suppurating sores on the feet, thighs, and abdomen, the former due doubtless to the use of hot bottles, the latter admittedly the result of turpentine stupes.

On November 22, five days after the injury, Mr. Hardie proceeded to trephine the spine. The back of the neck having been shaved, and the patient lying on his face, with the head over the end of the table, and supported by an assistant, a median incision was made over the cervical spinous processes, and carried down to the bones. The soft structures were reflected to either side, partly by the knife and partly by the raspatory. Hæmorrhage

gave a little trouble, but was soon checked by the pressure of sponges. On exposing the vertebral arches, the fifth cervical spinous process was found to be loose, and after some trouble it was wrenched away in one piece with the left lamina. When this fragment of bone had been taken away, the dura mater was partly exposed, and the right lamina of the sixth cervical arch was also found to be fractured. With a Hey's saw, supplemented by the bone-forceps, the left lamina of this arch was divided, and the posterior portion of the arch thus entirely removed. The exposed dura mater appeared perfectly normal, and was now obviously free from compression at any point. A large drainage-tube was therefore placed in the wound, which was sutured and dressed with iodoform and wood-wool pads. The spray was used throughout. During the operation respiration ceased, and the patient's condition became very critical, requiring him to be turned on to his back for a time, with the use of artificial respiration and inhalation of nitrite of amyl.

No improvement followed the operation, and very shortly after recovery from the chloroform the patient passed into gradually deepening coma. The temperature rose to 101° on the evening of the day of operation, and reached 103.8° the following morning. It then again fell rapidly to 99.4° in the evening, and to 98° on the second day, when the patient died comatose and cyanotic. He thus survived the operation by forty-eight hours.

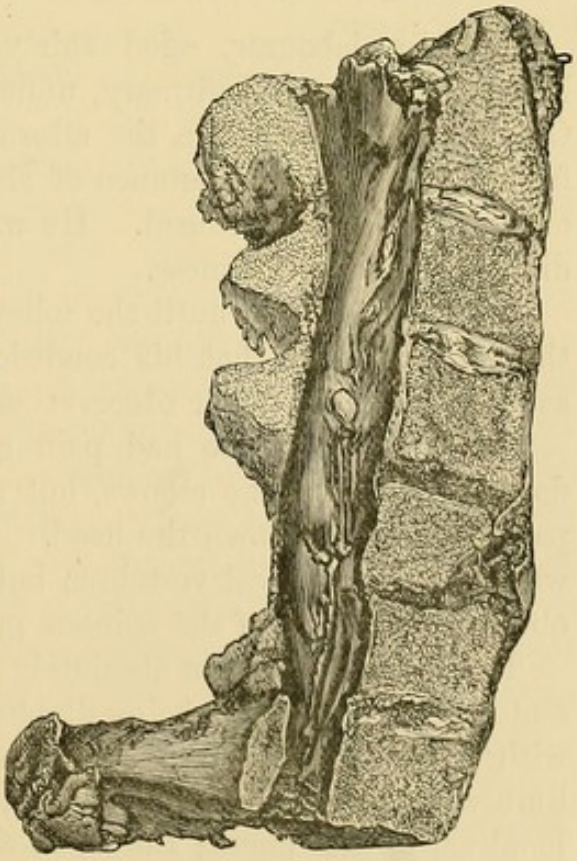


Fig. 4.—Section of second to seventh cervical vertebræ, the arches of the fifth and sixth being removed, and the body of the fifth fractured.

At the post-mortem I removed only the affected region of the spine, the condition of which is fully explained by the accompanying illustration (fig. 4), taken from a sagittal section previous to removal of the cord. The body of the fifth cervical vertebra is completely smashed, and projects backwards, distinctly compressing the cord. The membranes were uninjured.

The right upper limb of this patient had suffered less severely that the left, and it is obvious that some of the muscles supplied by the sixth cervical root had escaped paralysis. We shall refer to this root more fully directly, but may note in passing that the muscles here spared were the adductors of the humerus and pronators of the wrist, a condition corresponding with the high position given to their nuclei in our Table.

The following is another instance of an oblique lesion of the cord, including in the damaged area the origin of the sixth cervical root on the left side, and extending upwards on the right so as to involve that of the fourth and fifth roots. The reason of this obliquity was not noted at the post-mortem examination, but it was probably due to a higher extension of the central hæmorrhage on the right side of the grey substance of the cord.

CASE 9.—*Dislocation of fifth cervical vertebra—Complete paralysis of right upper limb; paralysis below fifth root nuclei on left —Trephining—Death.*

J. C., a labourer, aged thirty-eight, was admitted to the Manchester Royal Infirmary, under the care of Mr. Hardie, on October 25, 1887. On the afternoon of this day he had fallen from a waggon for a distance of about six feet, striking the back of his shoulders and head. He was immediately paralysed, but did not lose consciousness.

I did not see him until the following day, but am informed by the house-surgeon that his condition on admission was the same as when he came under observation.

On October 26 he had pain across the shoulders, shooting down the arms to the elbows, but no tenderness of the spine or pain on pressing down the head. There was some arching backwards of the cervical vertebræ, but no lateral deviation, and no obvious deformity of the spinous processes.

The lower limbs were absolutely paralysed, as were the abdomen and thorax, respiration being diaphragmatic, jerky, 18 per minute, with subjective sense of dyspnœa and cough. The left upper limb was abducted at the shoulder, with the elbow flexed and the hand across the chest; the right was completely flaccid. On the left side the patient retained the power of voluntary contraction of the supra- and infra-spinati, biceps, deltoid, and supinator longus, but not of the other limb-muscles, whereas on the right side all the muscles were paralysed. The neck-muscles were

normal on both sides. Both palpebral fissures and pupils were smaller than usual, but not so markedly so as in many cases.

Anæsthesia extended as high as the level of the third ribs in front and the sixth cervical spine behind, but on the right side sensation was retained over the region of the deltoid and slightly beyond it, and on the left side it extended over the area of the deltoid, and thence down the outer side of the limb to about the root of the thumb, becoming, however, very vague at the lower part. The anæsthetic boundary was not very sharply marked, and had no adjoining hyperæsthesia.

The knee-jerk and plantar, cremasteric, gluteal, and epigastric reflexes were absent. The skin felt dry and warm, although the temperature was normal. Urine was retained. The penis was turgid, but less so than on the previous day. Pulse 66, feeble, and with a very marked respiratory wave, being full and soft towards the end of inspiration, and very small towards the end of expiration.

The man's condition being clearly otherwise hopeless, Mr. Hardie determined, after consultation with several of his colleagues, to trephine the spine, which was done at 4.20 P.M. on the afternoon of the day after admission, about twenty-four hours after the injury. For the subsequent notes I am indebted to Mr. Bannister, the house surgeon.

Chloroform having been administered, a vertical incision about four inches long was made over the cervical spinous processes, having its centre opposite the fifth. The muscles being cleared from the laminæ, an interval of about a quarter of an inch was found between the fifth and sixth spines, and the fifth vertebra appeared to be slightly displaced forwards. The laminæ of the fifth and sixth vertebræ were now removed by bone-forceps, when the dura mater was exposed, presenting a perfectly normal appearance without any trace of hæmorrhage. As nothing further could be done, the dura was not opened, but the muscles were brought together by deep catgut sutures, a large drainage tube inserted, and the wound closed over a smaller superficial drain. The carbolic spray was used throughout, and wood-wool pads used as a dressing. After the operation brandy was given at frequent intervals.

At 6 P.M. the pulse was 54 and feeble; temperature 96°; respirations 13, and still purely abdominal. At 10 P.M. pulse 74; temperature 98.6°, respirations 16. The patient passed a fairly good night, but in the morning the temperature was 103.4°. On the afternoon of the 27th he became suddenly much worse;

the respirations became very feeble and then stopped; the heart-beats, which were very feeble and infrequent, continuing for about ten minutes longer. A few minutes after death the temperature in the mouth was 104°.

The post-mortem examination was made by Dr. Harris. The disc between the fifth and sixth cervical vertebræ was found to be ruptured, the former bone projecting very slightly forwards. No fracture was discovered. The dura mater was uninjured, but the cord was flattened opposite the seat of injury, and was much contused for about an inch above and below, containing hæmorrhages in its substance and in the central canal; elsewhere its structure was normal. The first and second bones of the sternum were also partially separated, and the lungs much congested.

Having thus illustrated the functions of the fifth cervical root, we may now pass to the consideration of cases in which the lesion is situated at a lower level.

CASE 10.—*Fracture-dislocation of fifth cervical vertebra—Partial destruction of brachial region of cord—Death.*

J. E. C., aged thirty-three, was admitted into Mr. Heath's wards on March 25, 1887, at 2.30 P.M. He had shortly before been "larking" with some friends, and had another man seated upon his shoulders, when he was pushed in the face backwards against a high counter. The result was that his neck was twisted backwards, the man falling from his shoulders. For the first few minutes he only noticed pain in the back of the neck, but then his legs began to feel weak, and he lay down: within ten minutes the lower limbs were completely paralysed and insensitive, and he found that he could not straighten the left forearm.

When admitted, there was paralysis of the lower limbs, and the left upper limb was only partially movable, being flexed at the elbow and somewhat abducted at the shoulder. The right limb appeared to retain more power. The temperature at 4 P.M. was 94.2°, at 8 P.M. 97.6°, and at midnight 99.2°, near which point it remained for some days. He was placed in a water-bed, and the urine withdrawn by the catheter.

On the following morning he complained of pain in the back of the neck, but there was no local deformity, and no pain on pressing down the head. The lower limbs were absolutely para-

lysed, as were the abdominal and thoracic muscles, respiration being diaphragmatic.

The left upper limb lay with the fingers partially flexed, the wrist straight, hand prone, elbow flexed, and the humerus abducted to an angle of about 45° with the body: he often raised the humerus above the shoulder, otherwise retaining the same position, except that the wrist became semi-prone. He could not extend the elbow, nor flex nor extend the fingers, but on attempting to flex the fingers there was slight extension of the wrist; he had also slight power of flexion and extension of the wrist, but this movement was extremely limited: pronation and supination were fairly good: the pectoralis major, latissimus dorsi, and apparently the subscapularis contracted very feebly; the biceps, deltoid, and supinator longus were but little if at all impaired.

On the right side the condition was practically the same, except that there was rather more power in the wrist. On taking a deep breath, the sterno-mastoid, trapezius, and levator anguli scapulæ contracted very distinctly on both sides.

As regards sensation, there was a subjective "feeling of heat" in the left palm and forearm. Anæsthesia was nowhere complete, but was almost so below the level of the third ribs, and in the upper limbs internally to a plane running down the centre of the arms and forearms to the styloid processes of the ulnæ, both before and behind. Below these limits there was absolute analgesia, but a vague sensation was conveyed by tickling. The limit was very ill-defined, and above it was an indistinct hyperæsthetic zone.

There were no superficial reflexes nor tendon reactions.

Urine was retained, and had to be drawn off by the catheter; its sp. gr. was 1024; it was neutral, and contained neither sugar, albumin, nor any deposit. The bowels had not been moved since admission. The respirations were at the rate of 19 per minute, with no sense of dyspnœa, but slight cyanosis. Pulse 69, full and soft. Skin dry and warm. The penis was turgid. Both palpebral fissures and pupils were small, and there was no dilatation of the pupils on pinching the neck.

Two days later, the paralysis of the upper limbs was of equal extent on both sides. There was complete loss of power in all the intrinsic and extrinsic muscles except the biceps, deltoid, supinators, and subscapularis, the elbows being flexed, the humeri abducted but not rotated outwards, and the hands thus lying across the chest. The pectoralis major, latissimus dorsi, and teres major had become quite flaccid. The region of anæsthesia in the upper limbs had also extended. The temperature was normal. The

optic discs were examined, but presented no abnormality. Priapism was less marked.

On the fourth day the urine contained a little pus (and therefore albumin), but no sugar. Its reaction was acid.

On the fifth day the optic discs appeared less well defined than before, and presented some venous congestion.

On the sixth day the subscapularis and supinator longus could no longer be felt to contract, but the arms usually occupied the same position as before, although during sleep they were often raised above the shoulder. He complained much of a sense of pain and stiffness in the upper limbs. The optic discs were more vascular, and were hazy—an observation which was confirmed by Dr. Little, who held, however, that there was no neuritis.

For a few days sensation in the trunk and lower limbs now seemed to improve slightly, but the patient became weaker, and was frequently somewhat delirious at night. The temperature ranged from 100° to 101°.

On the eleventh day were noted tremors of the paralysed muscles of the upper limbs. A day later, the deltoid and biceps of the left side were found to be beginning to fail, and the humerus was less abducted than formerly. At the same time sensation began to fail again.

On the fourteenth day the left upper limb was absolutely paralysed and anæsthetic, the humerus lying by the side, the elbow at a right angle. On the right side, the only muscle whose contraction could be felt was the deltoid. Ecchymoses had formed on the heels, toes, and malleoli.

On the fifteenth day a distinct knee-jerk could be obtained on the right side, and on the left a slight reaction was present.

A few days later he developed symptoms of pneumonia, and the condition of the urine became much worse. The temperature, which had regained the normal on the fifteenth day, again began to rise on the twenty-third, keeping a fairly steady upward curve until the twenty-ninth day, when it reached 104.6°, and death ensued. During the later period there was obviously more rapid wasting in the forearms and hands than in other parts of the body. On several occasions also it was noted that the passage of the catheter was accompanied by reflex contractions of the sartorii.

At the post-mortem examination I found some separation of the fifth and sixth cervical spinous processes. The body of the fifth was partially dislocated forward, forming a very obtuse angle with that of the sixth, and overlapping the latter anteriorly by

about a line. The articular processes were in contact, but were partially slipped off one another. The upper and anterior margin of the body of the sixth vertebra was very slightly ground off, but there was no other fracture. The vertebral canal contained a little dark clotted blood at the seat of the lesion. The cord was here partially compressed and very pale, all distinction of white and grey matter being lost. This condition extended only for about an inch, and elsewhere the cord presented no macroscopic abnormality. No nerve-roots were crushed. There were marked cystitis and double pneumonia.

We have here another case in which, after the cord had been crushed below the fifth cervical nerve-roots, the muscles supplied by these escaped paralysis for a considerable time. The case differs, however, from those previously mentioned, in that the annihilation of the functions of the cord below the lesion was less complete, as evidenced by the fact that anæsthesia was not absolute, and that some power remained in many of the muscles supplied by nerve-roots distinctly below the lesion. The examination on the second day showed that whereas the flexors of the elbow, deltoid, and supinators retained a very fair amount of power, the other muscles of the limb were paralysed to a varying extent. Thus, next to the "fifth root group" in order of power we find the subscapularis, pronators, pectoralis major, and latissimus dorsi, between which no distinction could be drawn, and we find also that the extensors of the wrist still retained a little power. On the fourth day we have paralysis of all the muscles supplied by the brachial plexus, except the "fifth root group" and the subscapularis, the retained tonus of the latter preventing such outward rotation of the humerus as is seen in fig. 1. Again, on the sixth day the subscapularis and supinators fail, and later the deltoid and biceps begin to do so. As there can be little doubt that myelitis was extending upwards, we may then accept as indicating the arrangements of their nuclei from below upwards the order in which the muscles here lost their power, viz. :—

1. *Intrinsic muscles of the hand* and *flexors of the wrist and fingers* immediately completely paralysed.

2. *Extensors of wrist* almost absolutely paralysed on second day.

3. *Pectoralis major*, *latissimus dorsi*, *teres major*, and *pronators* following before fourth day.

4. *Subscapularis* retaining power longer than any muscles but those of the fifth root.

The high position of the subscapularis is partially confirmed by Case 8, already referred to; and in the latter we find evidence that the pronators are supplied from a neighbouring point. Thus, although several muscles have not yet been localised, the arrangement of our Table is so far perfectly illustrated.

CASE 11.—*Diastasis in cervical region—Partial paralysis—Trephining—Death.*

J. H. M., a railway porter, aged thirty-nine, was admitted to Mr. Jones's wards on September 22, 1888. He had been hurt a few hours before by a bale, weighing some $7\frac{1}{2}$ cwt., falling from the second floor of a building on to his head and knocking him backwards, so as to cause the back of his head and neck to strike against a waggon. He did not lose consciousness, but experienced immediate paralysis of sensation and motion in the trunk and limbs.

He complained of pain in the back of the neck, the shoulder-blades, and "all the joints of the upper limbs," with cramps in the arms, but had no sensation in the trunk or lower limbs. The back of the neck was very tender, and the fifth cervical spine could not be felt, those of the sixth and seventh cervical vertebræ being prominent, with a gap above them. Pressure downwards upon the head caused pain in this region.

He lay with the right humerus abducted almost to a right angle, the elbow fully flexed, and the wrist supine, the hand lying on the pectoralis major. The left humerus was less markedly abducted, and the elbow was flexed to about a right angle, so that the left hand lay on the right side of the chest. Hence we had the position characteristic of a lesion of the cord below the fifth cervical nerve-roots. On examination, it was found that he had slight power of moving his lower limbs; respiration was entirely abdominal; in the upper limbs all the intrinsic and extrinsic muscles were paralysed except the supra- and infra-spinati, biceps (brachialis anticus?), deltoid, and supinator longus.

The knee-jerk and plantar reflex were increased; the cremasteric and abdominal reflexes could not be elicited.

Anæsthesia extended up the trunk as high as to the level of the sixth dorsal nerve, and above this sensation was very deficient until the area supplied by the descending branches of the cervical plexus was reached. In the upper limbs there was sensation only over the deltoid, down the outer side of the upper arm and forearm,

and very slightly in the hands. On the boundary-line of the anæsthesia was slight hyperæsthesia.

The pupils and palpebral fissures were contracted. Urine was passed unconsciously, and the bladder was empty. He had never any priapism. The pulse was 60, full and soft; temperature normal.

On the following day the urine was found to be faintly alkaline, with a sp. gr. of 1008; it contained no albumin or sugar, but gave a deposit of phosphates and mucus.

On the third day the wrists were distinctly less supinated, the left humerus was rather more and the right rather less abducted than on admission, so that the two upper limbs were now in the same position. The urine had a sp. gr. of 1023, and contained a heavy deposit of urates; it was still voided unconsciously, without distending the bladder. He mentioned that he had had a free flow of "salty water" from his eyes, and the face was a good deal congested. The pulse was 48, with an occasional intermission; temperature normal.

On the fourth day the arms lay closer to the sides, and the elbows were less flexed, so that the hands lay near the umbilicus. Sensation in the trunk and lower limbs was unaltered, but slight sensation now existed in the whole of the upper limbs. The knee-jerks were still exaggerated, the plantar reflex of about normal vigour. During the previous day Mr. Giles, the house-surgeon, had noticed that in the morning the left hand was warmer and redder than the right; in the evening the condition was reversed. On this day, I again found the left redder and congested. The pupils and palpebral fissures were small but equal. The profuse lachrymal secretion had ceased. The urine was ammoniacal (sp. gr. 1023).

Three days later the arms lay straight by the sides; the man could flex his elbows and rotate the humeri, but could not perform any other movements. He had slight sensation in the lower limbs, especially in the feet. The right knee-jerk had now disappeared and the left was much diminished. The formerly exaggerated plantar reflexes could no longer be obtained.

On the eleventh day he felt very ill and was much weaker; the knee-jerks were again well marked.

On the thirteenth he had ceased to have any power of moving the upper limbs. At this time there came on very painful feelings of cramp in the upper limbs and stomach, and he was hardly able to obtain any sleep on account of the pain.

Four days later he had much more power in the biceps and

deltoid, and slight power in the left triceps. The knee-jerks were now and hereafter exaggerated. The optic discs were hazy, and their vessels slightly congested.

On the nineteenth day pain in the limbs persisted as before. Considerable power was manifested by the biceps, deltoid, and supinators; on supination, contraction could be readily felt in the supinator brevis, as well as in the longus. The lower part of the pectoralis major and the subscapularis could be felt to be tonically contracted (the arms as before lying by the sides), and he could still further contract them voluntarily. No contraction could be felt in the teres major and latissimus dorsi; there was very slight power in the triceps. Hence he could—

1. Flex the elbow by the *biceps* powerfully.
2. Abduct the humerus by the *deltoid* powerfully.
3. *Supinate* the wrist.
4. Adduct the humerus by the *pectoralis major* and *subscapularis.*
5. Extend the arm by the *triceps* feebly.
6. *Pronate* by the action of gravity only, *i.e.*, by so rotating the humerus that the hand fell into the prone position.
7. He had no power over the forearm or hand-muscles.

Sensation was unaltered. The right optic disc now presented no abnormality, the left was still hazy.

On the twentieth day the optic fundi were examined by Dr. Little, who reported that the right was perfectly normal; the left, however, was hazy, with some distension of the vessels and a little haziness along their course; hence there was a distinct pathological change, indicated especially by the differences between the two eyes.

On the twenty-sixth day the patient had rather more power in the triceps, and appeared to have a little in the pronators. There was little, if any, anæsthesia of the upper limbs, but that of the trunk was unaltered.

On the thirty-fourth day the pronator teres could be distinctly felt to contract, and there was the slightest possible power of flexing the fingers of both hands, but the wrists remained immovable. The limbs could be placed and would lie in any position. Cramps were much less severe, but the lower limbs were drawn up at the hips and knees. The knee-jerks were very slight. Both optic discs were again alike, the right being more hazy than before, the left less so. The urine was very foul. The temperature generally remained normal.

In the beginning of November, five weeks after the injury, the

discs were quite clear, and healthy-looking, Dr. Little's report at this time being "both optic nerves quite healthy and alike, well defined, and no haziness whatever."

The patient could feebly flex or extend the wrist and adduct the thumb. The lower limbs were in a condition of strong tonic spasm with flexion of all joints, and any attempt at moving them caused much pain. Neither superficial nor deep reflexes could be obtained.

From this time forward there was no change of importance, except that the temperature became irregular, as a result probably of the cystitis. Pain continued to be very severe, and there was steady emaciation. It was now decided to trephine the spine.

On November 17, 1888, *i.e.*, fifty-six days after the injury, the back of the neck having been shaved and carefully washed, chloroform was administered. Mr. Jones made an incision about five inches long in the middle line, from the tip of the third to that of the seventh cervical spinous process. This incision was at once carried down to the supra-spinous ligament, and the soft parts reflected to either side by means of the knife. Very slight hæmorrhage was caused. The fifth cervical spinous process was found to be broken off and displaced forwards, and its vertebra slightly rotated to the left, the left transverse process being on a plane posterior to that of the right. The fifth spinous process was first extracted, and then by means of a chisel, followed by the use of ordinary bone-forceps, the laminæ of the fifth vertebra were divided on each side, so that the posterior part of its arch could be removed. In the same way the arch of the sixth was taken away. This proceeding exposed the posterior aspect of the dura mater, which was smooth and of a normal colour, but projected somewhat backwards, as if distended. All pressure being thus apparently removed, the wound was washed out with a solution of perchloride of mercury (one part in 3000), and dusted with dry boracic acid. A large drainage-tube was inserted, the wound sutured, and dressed with dry carbolised gauze and wood-wool pads. The spray was not used. When the man was returned to bed, his head was supported between sandbags.

In the evening the temperature was 99.8°, but the patient appeared perfectly well. For the next three days there was no apparent change, and the temperature gradually returned to the normal.

On November 20 the morning temperature was 97.8°. The arms had returned to the characteristic position of abduction of the humeri and flexion of the elbows, but adduction of the humeri

could still be effected by voluntary effort. In the evening the temperature rose to 100.4°.

November 21.—The wound was dressed, and very little discharge found. Except at the lower end, where the drainage-tube projected, its surface was healed, and all sutures were now removed, the drainage-tube being left. The temperature continued to rise, reaching 103.2° in the evening. Pain in the limbs was much less than before the operation.

November 23.—The temperature still remained high. The arms were motionless and had fallen to the sides, the elbows being flexed. Contractions could be felt distinctly in the biceps only, and very slightly in the deltoids.

From this time the man grew rapidly worse, becoming cyanotic, and finally comatose. The temperature rose to 105°, and he died at midday on November 25.

In making the post-mortem examination, I removed only the spinal cord and a part of the spine. The condition of the latter will be best understood from the following engraving (fig. 5), taken from a photograph of a sagittal section. The cartilages between the second and third and the third and fourth cervical vertebræ were broken, and there had evidently been severe over-flexion in this region, causing some compression of the upper anterior edge of the body of the third cervical vertebra, but no fracture. The bones had then returned to their positions, leaving the spinal canal free from any permanent compression. The spinal membranes were much congested throughout their whole extent. The cord itself was soft and diffluent opposite the fourth, fifth, and sixth cervical vertebræ. From these appearances it will be obvious that there had been over-flexion of the cervical region of the spine, and that although the greatest damage to the vertebral column was situated opposite

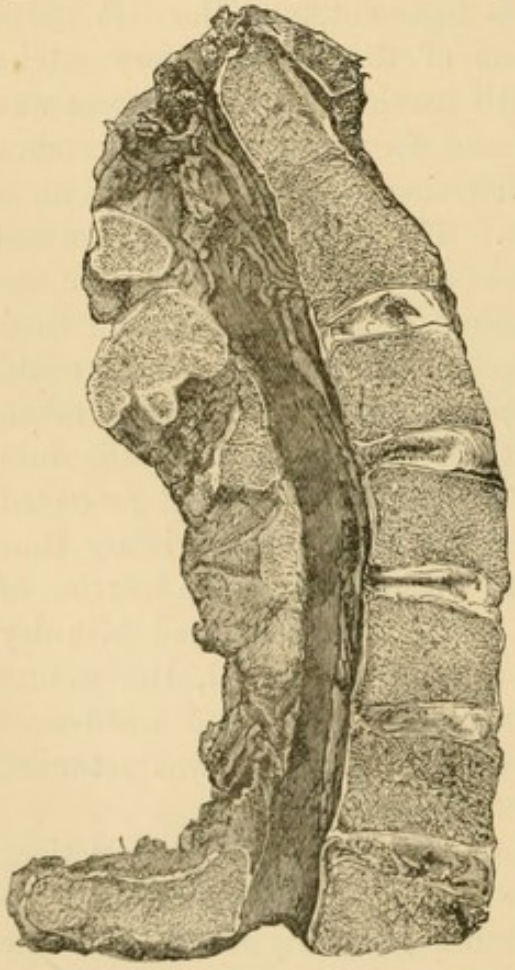


Fig. 5.—Section of second to seventh cervical vertebræ, the arches of the fifth and sixth being removed.

the third cervical vertebra, the cord had suffered mainly from hæmatomyelia opposite the fifth.

In this case we find, on admission, the condition, already fully described, in which the nuclei of the fourth and fifth cervical nerve-roots are spared, but those of the sixth and inferior roots are compressed by hæmorrhage. Shortly afterwards myelitis ensues, and on the second day we have paralysis of the supinators; on the fourth, of the deltoids; and on the eleventh, of the flexors of the elbows and muscles supplied by the fourth root. Recovery then commences, and there is some absorption of the hæmorrhage into the cord, which appears to restore the functions of the nuclei in order from above downwards. Thus the fifth root group of muscles is the first to recover; then follow the adductors of the humerus, and to a less extent the extensors of the elbow, the forearm and hand-muscles remaining paralysed on the eighteenth day. The only deviation from the order of our Table is the continued paralysis of the pronators; but the contractions of these muscles are among the most difficult to identify, owing to the interference of gravitation in the position of the hand, and I could not be sure of their paralysis. A few days after the stage above referred to they undoubtedly regained power. Lastly, the extensors and flexors of the wrist and fingers and the adductors of the thumb regain slight power. In this condition the patient remained until the operation, after which myelitis was re-established, and the nuclei below those of the fifth root were again rapidly paralysed, leaving us finally with a lesion of the same extent as on admission.

CASE 12.—*Fracture-dislocation of seventh cervical vertebra—Crush of cord in region of lowest brachial nuclei—Ascending myelitis —Death.*

J. S. was admitted to the Manchester Royal Infirmary under the care of Dr. Morgan on February 5, 1887, about 10.30 P.M. He had been at a place of entertainment, and when drunk had fallen from a gallery some ten feet in height, but it was not known how he struck himself.

It was nearly twenty-four hours after his admission when I first saw him, and when he presented the following symptoms. The lower limbs and trunk were completely paralysed, respiration being diaphragmatic. In the upper limbs movements were nor-

mal, with the following exceptions:—The intrinsic muscles of the hand were paralysed, the fingers being flexed and their extensors (*i.e.*, the interossei and extensor communis digitorum) paralysed, whilst any attempt to completely flex them caused slight extension of the wrist; the wrist was held straight, both its extensors and flexors, but especially the latter, being very weak. On the right side the extensors of the wrist were weaker than on the left. The lower limbs were completely anæsthetic, as was the trunk, as high as the level of the second rib in front and the spine of the seventh cervical vertebra behind. In the upper limbs anæsthesia was limited with the greatest accuracy to the inner side of the arm and forearm, being bounded in front by a line running vertically from the front of the deltoid opposite the second rib, down the centre of the biceps and forearm to the middle of the wrist; similarly behind the boundary was a vertical line down the centre of the triceps and back of the forearm to the centre of the wrist. In the hand the limiting line sloped, both in front and behind, from the centre of the wrist to the cleft between the fourth and fifth fingers, the little finger being completely anæsthetic, the others not at all so. There was no trace of hyperæsthesia.

Superficial and tendon reflexes were all absent. Both palpebral fissures were distinctly small, as were the pupils, the diminution of the latter being, as usual, especially notable in a dim light. The pupils, moreover, did not dilate on pinching the skin, but they showed very marked dilatation on each inspiration. Urine was retained. Penis turgid. Pulse 80. Temperature, *mane* 98°, *vesp.* 99.4°.

On the following morning some additional points were noted. The patient had no pain anywhere, but described a sense of stiffness in the upper limbs, and no pain was caused by pressing or jerking the head downwards. The seventh cervical spine was thought to be rather more prominent than usual. Respiration was mainly diaphragmatic, aided by the upper scapular and sterno-mastoid muscles; it was at the rate of 24 per minute, without sense of dyspnœa. He had slight cough and some collection of mucus in the bronchial tubes. The plantar, cremasteric, abdominal, and epigastric reflexes, and the tendon reactions at the ankle, knee, wrist, and elbow, were all absent. The urine had a specific gravity of 1028, and contained neither sugar nor albumin. The pulse was 80, soft, and feeble; sphygmographic tracings taken from the radial and the posterior tibial arteries showed nothing unusual in either vessel. The heart was normal.

The skin felt dry and warm, although at this time the axillary temperature was only 96.2°, but the chest and abdomen were moister than the limbs; there was no redness or trace of soreness.

On the third day the patient felt better, especially as he had been troubled with vomiting, which had now ceased. He had less power over the fingers and wrist, the former being flexed, the latter extended and without power of movement. Dr. J. C. Thresh, the clinical clerk, called my attention to the fact that the urine (specific gravity 1031) completely solidified with cold nitric acid, owing to the formation of nitrate of urea. The optic discs were a little hazy, with slight venous congestion. On February 10 the discs were again examined by Dr. Little, who noted these symptoms, but could not definitely assert that there was any pathological change.

These symptoms continued without any important change until the seventh day, when it was found that on both sides the patient had lost the power of rotating the wrist or extending the elbow, and that no contraction could be felt in the triceps muscles. The fingers and wrists were flexed and completely paralysed. The pectoralis major on either side was also now paralysed, but the latissimus dorsi, teres major, and subscapularis could be felt to contract on voluntary effort. The position of rest of the upper limbs was now as follows: the humerus abducted almost to a right angle and slightly rotated inwards, the elbows fully flexed, the wrists prone, and the hands across the chest with the wrists and fingers flexed. Breathing was much more difficult; he presented some signs of mental hebetude: the whole body was dry and cold, and the urine was still loaded with urea and phosphates (in solution), having a specific gravity of 1033.

On the following day the subscapularis could no longer be felt to contract, and the latissimi were weaker, the teres major remaining about the same as the day before. The humerus was now rotated *externally* more readily than *internally*, thus differing from the condition of the previous day, and it was a greater effort to bring it towards the side. A little redness had appeared over the malleoli.

On the ninth day we found that the boundary of absolute anæsthesia was the same as on admission, but some dulness of sensation extended further outwards on the limb. The motor symptoms were unaltered. The optic discs had become more indistinct than before, and the small vessels were quite obscured. Dr. Little concluded that there was now definite optic neuritis.

During the evening of this day he vomited freely both food and

"coffee-grounds," and, becoming delirious, died about 1 A.M. on February 15, the tenth day after the accident.

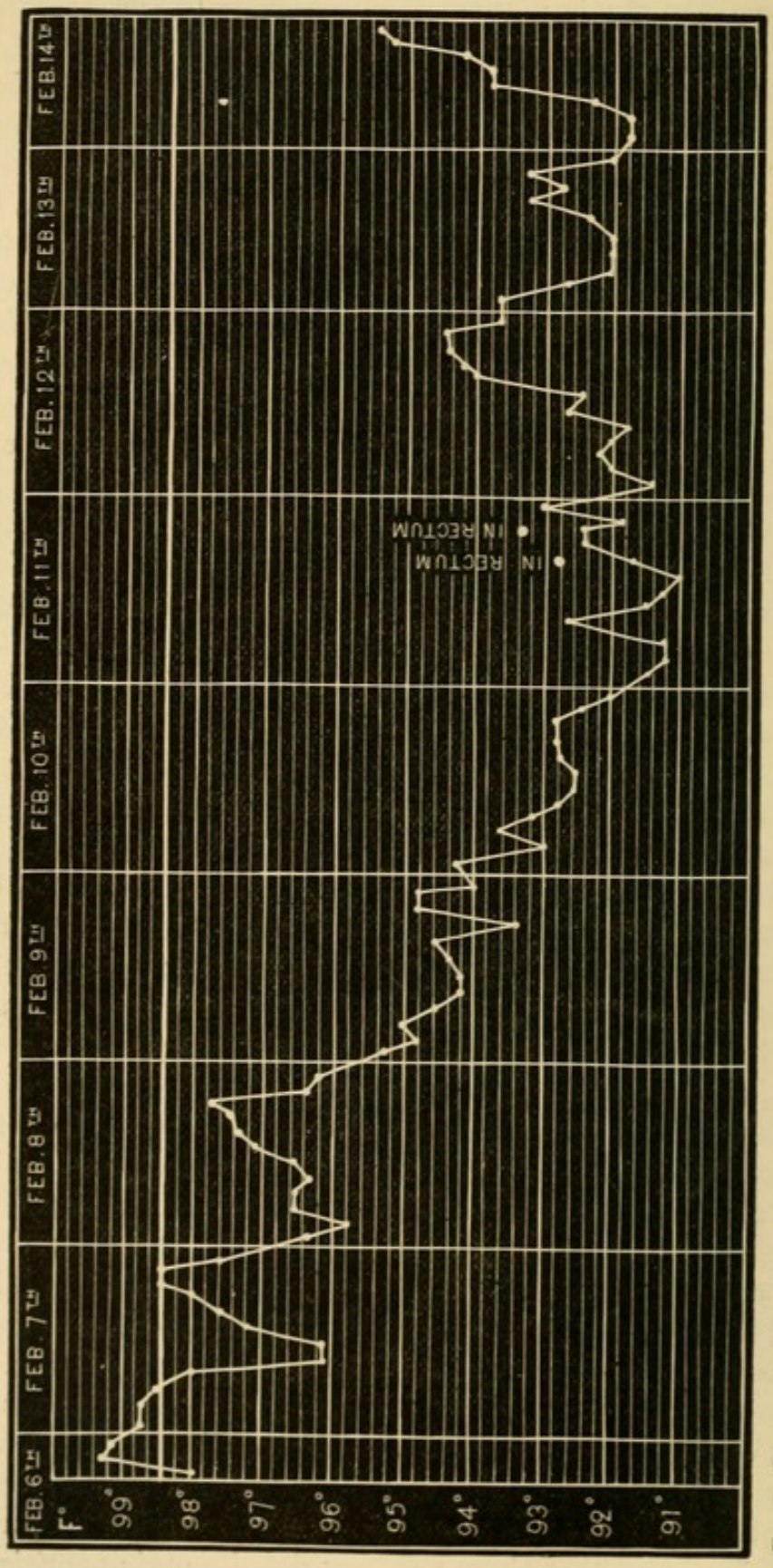


FIG. 6.—Temperature Chart in a case of fracture-dislocation of the seventh cervical vertebra. The temperatures were registered every two hours; at 12, 2, 4, &c., till February 9th; at 1, 3, 5, &c. till the 13th at noon; then every three hours. The thermometer was carefully tested and found to be practically correct.

The above chart shows the very low temperature which was maintained during the entire duration of the case.

At the post-mortem examination was found a fracture of the anterior and upper part of the body of the first dorsal vertebra, a small portion being chipped off and remaining attached to the disc above. The seventh cervical vertebra was displaced forwards, carrying with it the above-mentioned fragment of the first dorsal. The laminæ of these two vertebræ were separated behind, the articular processes of the first dorsal being posterior instead of anterior to their fellows of the seventh cervical. On opening the spinal canal, there was found slight effusion of blood between the bone and the dura mater. The cord was compressed at the level of the first dorsal vertebra, and softened for a short distance above and below the site of compression, its centre being occupied by an effusion of blood reaching as high as the fifth cervical nerve-roots, in the form of a narrow cone. There was some suppuration between the anterior common ligament of the spine and the fifth cervical vertebra, and at exactly corresponding points on the anterior and posterior walls of the pharynx.

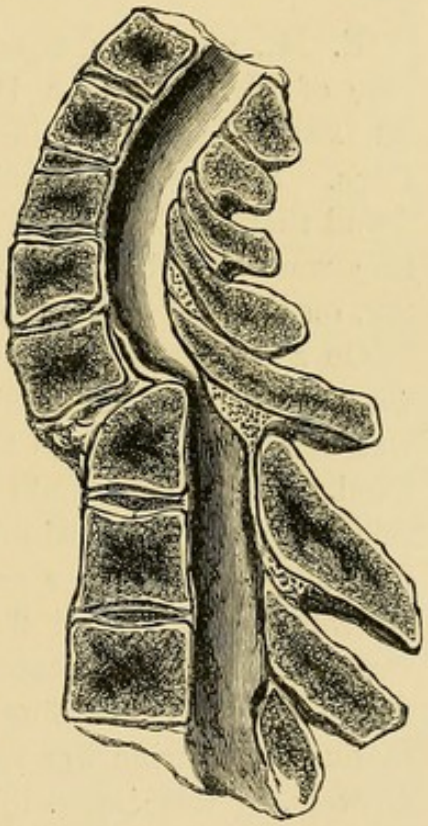


Fig. 7.—Sketch of section of spine in case of J. S., showing fracture-dislocation of the seventh cervical vertebra.

This interesting case is in itself almost a demonstration of the greater part of our Table. The injury was at the extreme lower part of the cervical region, and must at first have involved the origin of the first dorsal nerves, and probably to some extent that of the eighth cervical. Thus at first we had paralysis only of the intrinsic muscles of the hand and the interossei, but thereafter from day to day we were able to watch the extension upwards of myelitis, picking out muscle by muscle in the following order :—

1. The flexors of the wrist.
2. The extensors of the wrist.
3. The triceps and pectoralis major.
4. The latissimus dorsi.
5. The teres major and subscapularis.
6. The deltoids, flexors of the elbow, and external rotators of the humerus (supra- and infra-spinati) remained until the last.

The dates at which the pronators failed could not be obtained.

In conclusion, we may refer to two more cases, completing the series of fatal fractures in the cervical region which have come under my observation. Both these cases are characterised by the fact that extensive hæmorrhage into the cord caused the paralytic symptoms at once to extend higher than the level of the crush, an occasional result which makes it necessary to avoid too hastily diagnosing the site of a fracture from the extent of nervous symptoms only.

CASE 13.—*Fracture-dislocation of sixth cervical vertebra—Extensive hæmorrhage into cord—Death.*

E. M., a woman, aged forty-three, was admitted under the care of Mr. Heath, on December 5, 1886, on which day, about 11 A.M., she had, while intoxicated, fallen down some twelve steps. She was unconscious for a short time, and on recovering found that she had lost all power of moving the trunk and limbs. She was brought to the Infirmary, and admitted about 5.15 P.M. on the day of the accident.

On admission she was very drunk, and a complete examination was impossible. The skin felt very cold, and the temperature was below 95°, but no thermometer of a lower register was at hand. The pulse could not be felt. There was no sweating. She complained of pain behind the shoulders, but there was no deformity. The lower extremities and the left upper limb were entirely paralysed and flaccid. On the right side the shoulder was abducted, and rotated somewhat outwards, the elbow being flexed, the wrist and fingers flaccid. Respiration was diaphragmatic. The urine was retained. Owing to the vagueness of her answers, it was impossible to ascertain the limits of sensation, but there appeared to be anæsthesia below the neck. The right pupil was small, distorted, and immovable, owing to posterior synechia; the left was small, but responded both to light and accommodation.

When I examined her on the following morning, the patient presented the following symptoms:—The intellect was perfectly clear, and she gave rationally the above account of her accident. She presented total paralysis of all four limbs, and of the muscles of the chest and abdomen. She had no power of moving even the shoulders; the pectoralis major, deltoid, supra- and infra-spinatus, latissimus dorsi, and subscapularis, as well as the intrinsic muscles of the upper limb, being quite flaccid on both sides. There was no tendency to rotation of the humerus, either inwards

or outwards. On the other hand, the trapezii and sterno-mastoids were tonically contracted.

Respiration was diaphragmatic, but there was no indication of dyspnœa, and the voice was not weak. The urine had to be drawn off by means of the catheter, and the bowels had not been moved since admission. The palpebral fissures were smaller than usual, giving the patient a sleepy look. The right pupil was as described above, but presented some further contraction on exposure to light.

She complained of a sense of coldness in the left foot, and of great pain in the back of the neck and across the shoulders, pain being aggravated by any movement of the shoulder-joint. The limbs and trunk were completely anæsthetic, there being a band of hyperæsthesia about $1\frac{1}{2}$ inches wide extending across the chest in the form of a collar, at the level of the second ribs, and thence outwards across the deltoids. Above this line sensation was normal. It was not possible accurately to define the limit of sensibility behind, owing to the necessary movement causing great pain in the neck. The firmly-contracted trapezius was painful on deep pressure. No pain was caused by very firm downward pressure on the head.

The plantar reflex was exaggerated, the slightest tickling of the soles causing clonic spasms of the limb. No abdominal cutaneous reflex could be obtained, and there was no knee-jerk nor ankle clonus.

The cranial nerves presented no abnormality. The right optic disc was normal; the left could not be seen, owing to a commencing cataract.

The pulse was very irregular and intermittent, full, soft, and beating at the rate of 108 per minute. The heart-sounds presented nothing abnormal.

Respirations were 28, and, as above stated, entirely diaphragmatic, the chest falling in on inspiration.

The temperature at 8 A.M. was 95°. When examined at noon, it was 97°, but the skin of the trunk and lower limbs felt warm and somewhat dry.

The urine had a sp. gr. of 1024, was acid, contained no albumin and no deposit. It decolorised, but did not precipitate Fehling's solution. The nurse afterwards informed me that there had been a considerable amount of vaginal discharge.[1]

[1] Not having become aware of the condition before death, I am unable to ascertain whether the discharge was of leucorrhœal or other nature, or whether it may have been a paralytic secretion from the vaginal mucous membrane.

The temperature now began to rise steadily, and at 9 P.M. on the same day reached 101.6°, at which it remained until death, which occurred at about 3 A.M. on the following day; that is, about forty hours after the accident. Death resulted from failure of respiration.

At the post-mortem examination we found a separation between the laminæ of the sixth and seventh cervical vertebræ, the whole of the ligaments uniting the arches being ruptured, and the sixth vertebra being carried forwards and to the right. On removing the bones *en masse*, the left inferior articular process of the sixth was found completely slipped off the superior articular process of the seventh, whereas on the right side it was only displaced forwards to a slight extent. There was an obliquely horizontal fracture across the body of the seventh vertebra, extending from the cartilage above it, forwards and slightly downwards, to a line about one-fourth of the distance from its upper to its lower border in front. The piece of bone thus separated was, with its adjacent cartilage and the sixth vertebra, carried forwards and somewhat downwards and to the left. On opening the spinal canal, there was found extravasated and coagulated blood external to the dura mater throughout the entire distance from the sixth cervical vertebra to the inferior termination of the canal. The disc between the sixth and seventh vertebræ had been crushed and forced backwards into the spinal canal, forming a shelf about one line in depth, which pressed upon the cord, but not to any great extent. The roots of the seventh nerves were crushed. The cord was slightly pressed upon by the above-mentioned projecting disc, but was nowhere compressed by the extra-meningeal hæmorrhage. Opposite the body of the sixth vertebra it presented a slight swelling of a bluish colour, its substance being here quite diffluent and full of dark blood. From this point upwards as high as the origin of the third cervical nerves the cord was very soft, and contained small extravasations of blood, mainly in the grey matter, and especially in the central canal, these appearances being less marked at the upper than at the lower part. Below the sixth intervertebral disc the cord was slightly softened for the distance of about an inch. Elsewhere it presented no abnormality to the naked eye. The membranes appeared normal.

In this case no information of value is to be obtained as to the question of localisation, for the hæmorrhage into the cord extended so rapidly as almost at once to paralyse the cord throughout the

entire brachial region, although the lesion of the vertebræ was at the level of exit of the seventh cervical nerves. For a short time after admission the nuclei of the fifth cervical nerve escaped paralysis on the right side, but these also were destroyed before I saw the patient, and death soon followed. The extensive central hæmorrhage found at the post-mortem amply explains this condition, and the case is chiefly of use as showing that the damage to the cord may almost at once extend to a considerable distance above the vertebral lesion.

CASE 14.—*Dislocation of seventh cervical vertebra—Hæmorrhage extending to nuclei for triceps muscles—Death.*

W. T., aged twenty-eight, a labourer, was admitted to the Manchester Royal Infirmary under the care of Mr. Wright on October 3, 1887. Two days previously he had been at work on the roof of a house, when he fell a distance of about eleven feet on to a block of stone, which struck him just between the shoulder-blades, causing his head to be jerked backwards. He felt very sick, but did not vomit, and then found that he was powerless to move either his arms or his legs. During the two days for which he remained at home, no change can be ascertained to have occurred in his condition.

On admission, he presented complete paralysis of the lower limbs and of the abdominal and chest muscles, respiration being diaphragmatic. There was pain over the first dorsal vertebra, but not elsewhere, and no pain on pressing down the head. The upper limbs lay across the chest with the elbows close to the sides, and flexed, as in the annexed sketch, made by the house-surgeon, Mr. Bannister. On both sides the flexors of the wrist and fingers were completely paralysed, and he had no power of grasping; on the right side the extensors were also paralysed, but on the left they retained very slight power. The triceps, serratus magnus, and pectoral muscles could be felt to contract, but only very feebly so. The biceps, deltoid, and

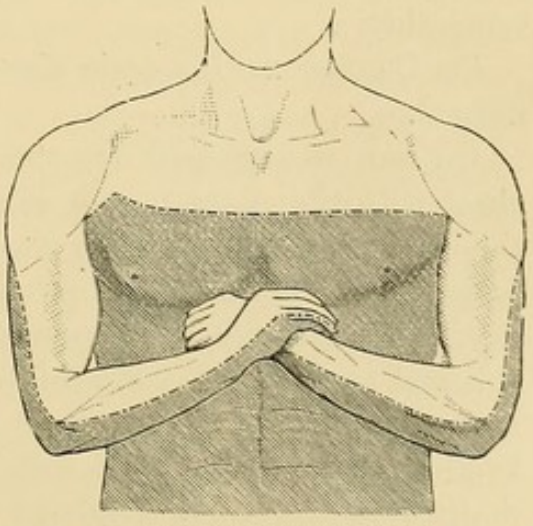


FIG. 8.—Position occupied by the limbs in a case of complete transverse destruction of the spinal cord immediately below the nuclei for the subscapularis muscles.

supinator longus were more powerful than any of the other muscles of the upper limb, but were also weak.

Anæsthesia was very clearly defined, extending over the lower limbs and up the trunk as high as the level of the second rib in front, and to the second dorsal spine and spines of the scapulæ behind. In the upper limbs it affected the little finger and inner part of the ring-finger, the ulnar side of the hand and forearm, and the intero-posterior aspect of the arm, as shown in the shaded portions of the sketch. The rest of the upper limbs was sensitive. About the boundary of the anæsthetic region was slight hyperæsthesia, more marked in some parts than in others.

Both palpebral fissures and pupils were small, the right being more markedly so.

The bladder was much distended, and on passing a catheter a large amount of normal urine was drawn off.

The penis was semi-erect. Temperature 99.8°.

On the following day the urine was ammoniacal, and of a deep purple colour from admixture of blood. This profuse hæmorrhage from the kidneys continued for some days, during which time the patient became gradually weaker, but it ceased on the eighth day; the urine continuing, however, to be ammoniacal and containing some pus.

On the seventh day the temperature in the right auditory meatus was found to be 101.2° as against 100.2° on the left side, this observation coinciding with the more marked diminution of the pupil and palpebral fissure on that side, due to paralysis of the sympathetic.

On October 20 the optic discs were examined and found to be normal.

On the twenty-third day the right upper limb lay across the chest with the elbow to the side, the hand on the upper part of the sternum and the fingers closed. When asked to move it, the patient only rotated the humerus outwards, and as he did so the supra-spinatus and infra-spinatus could be felt to contract. He still had very feeble power of flexing the elbow, but neither the biceps nor the supinator longus could be felt to contract, and he had lost all power over the deltoid. All the other muscles of the limbs were absolutely paralysed. On the left side the elbow was also close to the chest, but less flexed, so that the forearm was at about a right angle to the upper arm. On this side he had more power of flexing the elbow, and could abduct and adduct as well as rotate the shoulder, there being obvious contraction of the deltoid, biceps, and spinati muscles; he had also some feeble power

of pronation. On breathing deeply, the levators of the angles of the scapulæ could be felt to contract. Anæsthesia was the same as on admission.

On the twenty-ninth day he was much weaker, and it was found almost impossible to draw off the urine, owing to the catheter continually becoming blocked with stringy mucus. Severe vomiting and hiccough also troubled him greatly, and he refused all food. The temperature throughout the case varied from about 99° to 101°. Two days later he died exhausted, having survived the accident by thirty-one days.

At the post-mortem examination, which was made by Dr. Harris, there was found rupture of the disc between the last cervical and first dorsal vertebræ, the parts being very movable, but no fracture was detected, and when the post-mortem was made there was no displacement. The cord opposite the seat of injury was almost diffluent, and softening extended throughout almost the whole cervical region and for some short distance below, but the remainder of the dorsal region showed no abnormality. The bladder was much enlarged and its walls thickened; on its mucous membrane was a thick, gritty, yellowish-white membrane, which came away as a distinct cast; the peritoneal surface was inflamed and adherent to the sigmoid flexure and omentum. In the kidneys were the appearances of acute parenchymatous nephritis.

Here, as in Case 13, we find the cord-lesion extending above the site of dislocation before the patient came under observation. As before, we have the biceps, deltoid, and supinator fairly powerful. The triceps, serratus magnus, and pectoral muscles also retain a fair amount of power, and appear to have received about an equal amount of damage, justifying their being placed near together in our Table. It will be noticed that the attitude shown in fig. 8 differs from that of fig. 1, owing to the adductors (chiefly the pectoralis and subscapularis) of the humerus not being completely paralysed. At the end of three weeks we find on the left side that the supra-spinatus, infra-spinatus, biceps, deltoid, and apparently the supinators, subscapularis, and pronators retain some power; whereas on the right side the supra-spinatus and infra-spinatus are the most powerful muscles, and the flexors of the elbow are not quite paralysed, as are the remaining muscles. Again, therefore, the relative strength of the muscles confirms the arrangement of as much of our Table as is here illustrated.

We have thus, by comparing these fourteen cases of fracture-dislocation of the spine, been able to establish on a fairly secure basis the conclusions set forth in the original Table. A few gaps and a few discrepancies remain, but considering the nature of the investigation, these do not appear to be numerous or important. In the following chapter we shall find not only a confirmation of our results, but an illustration of their importance for the purposes of accurate diagnosis.

The distribution of the anæsthesia in the above cases is of interest equally as great as that of the paralysis. In a most interesting and important paper, Dr. Ross [1] has fully demonstrated the nature of the distribution of the sensory nerves of the upper limb. Regarding the limb in its embryological position, we find that it is projected as a bud from the trunk, the hand being supine and the radius upwards, with the palmar surface anterior. In this position the bud carries out with it branches of the anterior primary divisions of the spinal segmental nerves from the fifth cervical to the first dorsal inclusive; and as these nerves maintain their embryological relations in the adult, we have the several roots supplying the limb in numerical order from the radial to the ulnar side. Hence, then, the higher the mischief extends in the cord through the brachial region, the further will the anæsthesia extend from the ulnar towards the radial side. This arrangement is fully demonstrated by our cases. It is unnecessary to refer again in detail to this distribution, which will be obvious upon reading the reports. It will be found that the fifth root supplies the region overlying the deltoid muscle, and the outer aspect of the arm and forearm as far as the styloid process of the radius or base of the thumb, and that the eighth cervical and first dorsal supply the little finger and inner side of the hand, forearm and arm, the remaining roots providing for the central parts of the limb on both anterior and posterior aspects. The exact lateral extent of the bands of skin thus supplied by each root can hardly be determined, and is indeed probably not a fixed quantity; the boundaries are usually ill-defined, and there can be little doubt that vicarious conduction of sensory impressions readily arises, as in other varieties of anæsthesia.

[1] The Segmental Distribution of Sensory Nerves. *Brain*, January 1888.

CHAPTER II.

INJURIES TO THE CERVICAL REGION OF THE SPINAL CORD—*Continued.*

We have so far referred only to cases of severe crushing of the cord, in all of which (except Case 11) the transverse lesion has been complete, and has entirely annihilated the functions of the cord below its level. Moreover, in all of the above cases the termination has been death, and in the majority a post-mortem examination has confirmed the diagnosis of the site of injury.

We pass now to the consideration of a series of less severe injuries, which will best illustrate the value of the above conclusions for purposes of localisation, and will at the same time serve to confirm the results arrived at.

Case 15.—*Lateral dislocation of fifth cervical vertebra—Injury to left fifth cervical nerve-root and hæmorrhage into cord at level of origin of sixth roots—Reduction—Recovery.*

R. M., aged fifty-five, a labourer, was admitted to the Manchester Royal Infirmary on April 27, 1887, under the care of Mr. Whitehead. He stated that, about 10 or 11 P.M. on the previous night, he had fallen, head first, down some seven or eight steps, and being able to move his right arm only, he had remained as he fell until 7 A.M.

On admission he presented the following symptoms:—The lower limbs appeared to be quite paralysed, but were said to have been moved once or twice during the morning; they were very rigid; the knee-jerks were much exaggerated, and the cremasteric reflexes absent. On respiration costal movement was slight, but quite distinct. Anæsthesia extended as high on the trunk as the level of the second ribs, but was not quite complete.

Urine was retained; the penis was not turgid. The condition of the upper limbs was more interesting. The left was completely paralysed, lying by the side. The right was abducted at the shoulder, with the elbow strongly flexed, so that the hand lay above the shoulder with the palm backwards, *i.e.*, in a state of supination, the fingers and wrist being slightly flexed. He could raise and rotate the shoulders, but had no other power of movement in the limb. There was almost absolute anæsthesia of the left upper limb, but on the right side loss of sensation was limited to the ulnar aspect. Both pupils and palpebral fissures were small. The head and neck were markedly bent to the right, and there was a distinctly-felt lateral curvature in the cervical region.

Having concluded that there was a dislocation, probably unilateral, of the fifth cervical vertebra, and having in view the otherwise inevitably fatal termination of the case, we resolved to attempt immediate reduction. This was performed as follows:—The man lying on his back in bed, I seized him firmly by the shoulders, and Mr. Collier, then resident surgical officer, grasping the head, drew it upwards and to the right, then bringing it over to the left. A slight snap was felt, and the position of the head was rendered more nearly, but not yet quite straight. The same proceeding being repeated, a snap was again felt, and the head came into its normal position. At this movement the patient screamed with pain shooting down the left arm, and situated, he said, on the side further from the thumb. This pain lasted only for a minute or two. Within half-a-minute he flexed the left elbow, and then again kept the limb quiet with the elbow flexed. On re-examining the sensation of the left upper limb, we found partial sensibility on the ulnar side, but the radial side remained anæsthetic as before. At the same time we noticed a diffused swelling in the left posterior triangle of the neck, due doubtless to effused blood, which subsided in a few days without giving any trouble. Finally, we adapted to the patient's head, neck, and shoulders a felt casing, designed to keep them in position. No deformity of the head or neck remained. At 2 P.M.—an hour later—the patient could move the elbow and fingers on the left side, and sensation, as before, was absent only on the radial aspect of the limb. There was no marked rise of temperature either now or at any subsequent period in the course of the case.

On the following day a large amount of urine was passed, and the catheter was not required after this date. The urine had a sp. gr. of 1024, contained a large quantity of urates, with some

albumin, and decolorised Fehling's solution without giving a precipitate. The penis was slightly turgid. There was a good deal of pain between the shoulders, but no other change.

On April 29, the third day, sensation was more acute in the lower limbs, especially on the right side, and in the anæsthetic portions of the upper limbs. The patellar reflexes were less exaggerated than before, and the limbs less rigid. The right upper limb presented, as before, the symptoms of complete paralysis of motion and sensation below the distribution of the fifth cervical root; on the left side the fingers, wrist, and elbow could be feebly flexed and extended; the wrist could be pronated and supinated, and the humerus slightly abducted and adducted. The urine was now alkaline, very fœtid, and contained pus. The optic discs were normal. A day later the patient had more power in the left upper limb, and anæsthesia was nowhere complete. On the right side he had gained some power of pronating the wrist and of extending the elbow, and the area of sensation was extending. The knee-jerks were about normal; the contraction of the pupils less marked. The annexed illustration (fig. 9), taken from a photograph obtained for me by Mr. Sidley at about this period, shows the position of the limbs, and indicates the marked abduction of the humerus and flexion of the elbow on the right side.

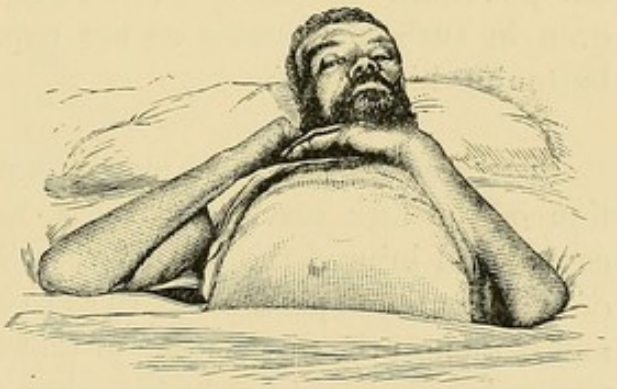


FIG. 9.—From a photograph of Case 15, showing the position of the limbs where the fifth cervical nerve-root was injured on the left side only.

From this point it is unnecessary to give a daily record, and it will suffice to note merely a few of the more important changes. Sensation very gradually returned throughout, being preceded, as usual, by a sense of tingling in the limbs; the right lower limb recovered more quickly than the left. Traces of albumin and sugar (?) disappeared from the urine within a week, as did the pus and the alkaline reaction. For a long time there was some difficulty in passing urine, but this gradually passed off. The pupils returned to their normal condition in about a month, the right doing so the more slowly, and even as lately as January 1888 being smaller than the left. The knee-jerks had quite disappeared by May 5, and, after being absent for some time, gradually returned in the exaggerated form of spastic paralysis,

which they still retain, and which is more marked on the right side. On May 11 the patient could move the lower limbs about the bed very fairly. In about six months he could walk. In the upper limbs return of power was equally slow, and there is here a good deal of atrophy, this atrophy and weakness being even now more marked on the right than on the left side. In August all the muscles of the left upper limb reacted well to the faradic current, whereas on the right side only the biceps, deltoid, and supinator longus did so, so that on that side the "reaction of degeneration" was present below the fifth root. After the accident the nails of both hands grew in a markedly clubbed form.

Since he left the Infirmary this man has frequently reported himself to me, and when I last saw him, in August 1888, he could walk well, but with the usual spastic gait, and complained only of a feeling of numbness in the lower limbs, abdomen, and hands. His upper limbs are a good deal wasted, but he has very fair power throughout, and can do light work, having no difficulty even in such movements as are required for lacing his boots or buttoning his clothes.

In this case I think we may assume that there was a dislocation of the fifth cervical vertebra, and that the traction thereby caused had injured the left fifth cervical nerve-roots at their point of exit from the spinal canal, so as to completely paralyse sensation and motion in the distribution of that nerve, but that the cord itself was not completely crushed, having only sustained hæmorrhages into its substance of slight extent as compared with those in the cases reported in the last chapter. As shown in the accompanying diagram (fig. 10), the right fifth cervical root would escape —the cord below this region would be affected by partial destruction (which was more complete on the right side)—and the left fifth cervical root would, as already stated, be partially torn or greatly stretched, so as to suffer temporary total paralysis.

Hence, we have on the right side partial paralysis of the upper limb, the biceps, deltoid, and supinator longus escaping as in other cases in which the fifth root is spared, together with retention of sensation on the outer side of the limb supplied by the same nerve. All sensation is lost below this root, and the pupil is smaller in size upon this side of the body than on the other, coinciding with the greater amount of damage done to the cord. This is also evidenced by the fact that anæsthesia was more marked on the left than on the right side in the lower part of the body, and that the paralysis of those muscles

of the upper limb supplied from below the fifth root was more marked on the right side, as was the exaggeration of the tendon reflexes. On the right side, also, we have the "reaction of degeneration" resulting, whereas on the left it did not do so. On the left side, on the other hand, we find that the movements of reduction, by irritating the over-stretched fifth root, caused some of the muscles supplied by it to contract during the manipulation, but that both motor and sensory paralysis were more marked

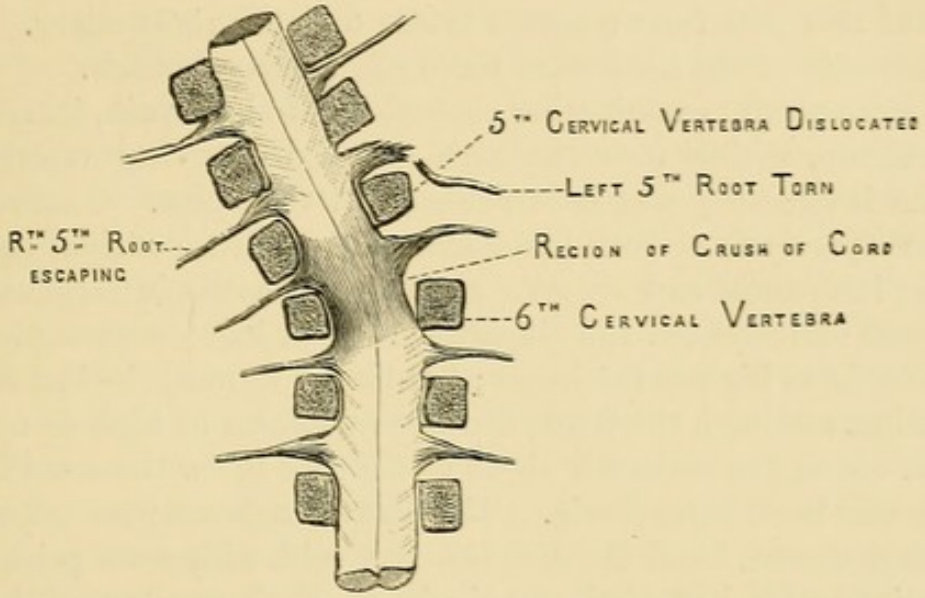


FIG. 10.—Diagram of the supposed nature of the lesion in the case of R. M. The left fifth cervical nerve-root should appear as crushed or stretched rather than completely torn.

and enduring in this root than elsewhere. The vesical and other symptoms are compatible with a partial destruction of the cord, and passed off to a large extent as repair ensued. One point in this case is quite unusual, namely, the early exaggeration of the patellar reflexes, these being as a rule lost, owing to the shock of the injury; whereas here, as in Case 11, they were increased, probably owing to irritation; as the irritation subsided they disappeared, and then at a later stage reappeared in an exaggerated form—the usual result of an old transverse lesion.

We may now refer to five cases of hæmatomyelia unaccompanied by any severe lesion of the vertebral column, which present numerous interesting points.

CASE 16.—*Traumatic hæmatomyelia in lower cervical and upper dorsal region—Death.*

J. B., aged thirty-four years, suffering from an injury to the spine, was admitted on December 30, 1885, under the care of

Mr. Heath. He was a carter by occupation, and was hurt while loading a waggon by a "tippler" full of coal falling upon him so as to throw him upon his face, the coal striking him between the shoulders.

On admission to the Infirmary he was quite conscious, but stated that he had been rendered insensible for some time by the injury. He had complete loss of power over both lower extremities, and complained of great pain at the back of the neck and between the shoulders, which was increased by moving the head. He had also pain from a severe bruise over the right elbow. On the left side of the head were three slight scalp-wounds.

A more careful examination showed him to have pain, increased by pressure, mainly over the fifth and sixth cervical vertebræ; but no irregularity was here detected in the spine. There was absolute paralysis of both lower extremities, with deficient action of the intercostal and anterior abdominal muscles in respiration, but good movement of the diaphragm. Both legs were completely anæsthetic as high as the knees; but thence upwards he had some sensation, although there was distinct numbness as high as a line drawn round the abdomen about two inches below the umbilicus. There was no hyperæsthesia. The plantar reflexes were noted as "almost absent," and the feet felt very cold, with some prickling sensation. He had distinct priapism. Both pupils were much contracted, but equal, and contracting further on exposure to light. There was no vomiting and no mental affection. He was placed on a water-bed, the scalp-wounds dressed, and ext. ergot. liq. administered in 3ss doses. In the evening the urine had to be withdrawn.

On the following day there was still absolute paralysis of the lower limbs, but there was now no anæsthesia. The priapism had subsided, and the urine was passed without any trouble. The diaphragmatic respiration was very marked. On examining the arms, which had not been done the day before, I found marked weakness of the flexors of the wrist and fingers on both sides; the grip was very feeble, but the power of extension against resistance was little if at all diminished. The superficial reflexes and tendon reactions were everywhere absent. The left pupil was somewhat contracted, but the right one very much more so; both contracted further on exposure to light. The patient had some vomiting during the night, and there were râles all over the chest. The temperature was 98.6° F. in the morning, and 99.8° F. in the evening.

On the following day, January 1, 1886, the fæces were

passed involuntarily. There was severe and painful cough, and all over the chest loud crackling râles; the countenance was cyanotic. No other change had occurred. Temp., morning 99°; evening, 100°. The cyanosis and difficulty of breathing now rapidly increased, and there was dulness at the bases of both lungs, but no crepitations were heard. Without further symptoms, the man died on the night of January 2, 1886.

The post-mortem examination revealed engorgement of the bases of both lungs and of the right side of the heart; but the other organs were healthy, with the exception of the spinal region. In the muscles over the lower cervical and upper dorsal regions was some dark effused blood, but the vertebral column presented no evidence of injury. The membranes of the cord were quite normal, as was the external appearance of the cord itself; but "on section there was found to be a dark black hæmorrhage into the central grey matter in the lower cervical and upper dorsal regions. This hæmorrhage, which measured in its vertical extent from 1½ to 2 inches, was in the greater part of its extent situated centrally, occupying the whole of the central grey matter and extending but little into the white substance, which in its neighbourhood was merely softened and of a faintly yellow tinge. At the lower part, for a very short distance, the hæmorrhage was limited to the anterior cornu of the right side, while the corresponding left horn appeared to be perfectly healthy. Elsewhere the cord was firm, and presented no abnormality."

In this case the hæmorrhage extended only into the nuclei of the nerves to the flexors of the wrist and fingers, leaving intact those supplying the muscles which, in our Table, have been placed on a higher level.

Case 17.—*Hæmatomyelia in middle cervical region—Recovery.*

J. A., a bailiff, aged sixty-two, attended as an out-patient under the care of Dr. Ross in December 1886. He told us that nine weeks previously he had fallen about nine or ten feet, and, having held out his arms to save himself, came down upon his hands. For a second or two he felt nothing, but had then great pain shooting down the arms to the hands. His upper limbs rapidly became spasmodically contracted, so that he held them with the elbows to the sides and flexed, the hands in front and partially flexed—*i.e.*, as he showed us, very much in the position in which a book might be held for reading. This

pain and spasm lasted for about a fortnight, since which time they had been gradually abating, and when he came to the Infirmary he had not much pain, and could move the arms in all directions, although they were still weak and he could not well throw them backwards. The legs had felt cold and weak since the accident.

On examination, we found hyperæsthesia, cutaneous and deep, extending across the shoulders from the sixth or seventh cervical spine to the acromia. He had no spinal pain or tenderness. On carrying the arms backwards there was pain which prevented his dressing himself. He had no trace of anæsthesia. Over the hyperæsthetic region was a slight vesicular eruption. All the arm-muscles appeared to be fairly strong. The lower limbs felt weak, and the knee-jerk was increased. There were no urinary troubles.

On January 18, 1887, I again examined him more carefully. No local signs of spinal injury could be detected. The upper level of the hyperæsthetic band was on a level with the sixth cervical spinous process, and the lower some two inches further down; the band extended outwards on either side for about three inches, *i.e.*, as far as to the distribution of the descending branches of the cervical plexus. Its boundaries were well marked, especially above. The vesicular eruption had almost disappeared, and appeared on inquiry to have been due to previous friction with acetic acid.

All the muscles of the upper limbs presented a fair amount of power, but the deltoid and biceps appeared to be relatively the strongest muscles and the retractors of the humerus (latissimus dorsi) the feeblest. The hands and flexors of the wrists were wasted to some extent. All the muscles reacted to moderately powerful faradic currents. No sensory change could be made out in the upper limbs, and there was no jerk on striking the triceps or wrist tendons.

Examined in a dim light, the pupils were distinctly smaller than normal, the change being more marked on the right side, and they did not dilate on pinching the neck. The legs were well developed, and presented no paralysis, anæsthesia, or trophic lesions; but the patient stated that they did not feel so strong as formerly, and were always either cold or burning hot. The knee-jerks were markedly exaggerated; the superficial reflexes absent. The bladder and rectum presented no abnormality.

I saw this patient again on April 28, 1888, when he told me that he was much better than he had been at first, but that he

still felt some feebleness of both arms and legs, and that occasionally the legs felt hot or cold. He presented no very marked signs of injury, being quite able to go about and perform all the usual muscular movements. His arms were, however, not very strong, and there was obvious wasting of both triceps muscles. On making an electrical examination, I found that the flexors of the wrist required a more powerful faradic current than the biceps, the extensors of the wrist a still more powerful one, and the triceps could only be got to contract with very strong faradic currents. With the galvanic current, cathodal closure in every muscle caused contractions more readily than anodal closure, so that there was no reaction of degeneration. Hence the muscles of the upper limb were partially atrophied and insensitive to the faradic current in varying degrees, the most active being the biceps, then the flexors of the wrist, then the extensors, and the weakest being the triceps. The knee-jerks were slightly, but not much exaggerated. He had no pain, anæsthesia, hyperæsthesia, or cutaneous eruption.

This case would appear to be another example of hæmorrhage into the central grey matter of the spinal cord, most severe in the neighbourhood of the triceps and latissimus nuclei, but extending into those immediately above and below. The flexors of the elbow and the shoulder muscles escaped entirely the destroying lesion, but irritation caused the spasmodic position of the limbs which he at first experienced; similarly, there was spasm below the region of the hæmorrhage, causing flexion of the fingers and wrist. Hence we have spasm in two groups of muscles—those above and those below the lesion, viz., above, the biceps, subscapularis, and others, causing the humeri to assume a position similar to that shown in fig. 8; and below, the flexors of the hand and fingers. At the stage when we saw the man, this spasm had passed away; the paralytic symptoms were most prominent, affecting the central group of muscles—the triceps and retractor muscles (latissimus and teres major), and to a rather less extent the extensors of the wrist and fingers. The region of hyperæsthesia corresponded to the posterior divisions of the central nerves of the plexus. It is remarkable that there was no sensory affection in the distribution of the anterior divisions, *i.e.*, in the central part of the arms, but, as stated on p. 42, I am inclined, from various observations, to believe that the central nerves of the brachial plexus have a comparatively narrow area of distribution in the upper limbs, and doubtless the anterior and posterior bands which they do supply

would shortly be vicariously supplied by the upper and lower branches on either side of them. The diagnosis of a central hæmorrhage rather than a meningeal lesion must rest chiefly on the rapid onset of the symptoms. Meningitis could not cause symptoms within a few minutes, and a meningeal hæmorrhage would be less distinctly localised.

CASE 18.—*Hæmatomyelia in the region of the triceps nucleus.*

R. P., aged twenty-five, a porter, was admitted to the Manchester Royal Infirmary under Mr. Hardie's care on December 19, 1887. He had on the same day been walking along the streets, which were slippery, when he fell at full length on his back. He was seized with a sudden pain at the lower part of the neck, shooting down the arms, and at once sustained complete loss of power in his legs and partial loss in his arms. He was never unconscious.

When examined, he presented severe pain in the lower cervical region, shooting thence down the arms. No deformity of the spine could be felt, but pressure caused great pain between the fourth cervical and first dorsal vertebræ, and pain was caused by pressing the head downwards or moving it from side to side. He lay in bed with the forearms folded across the chest, the elbows being a little abducted, the hands prone; abduction and adduction of the humerus were, however, fairly well performed, as were pronation and supination. Flexion of the forearm was not much impeded, but the power of extension was lost. The grasp of the hand was exceedingly feeble, and extension at the wrist resulted from the effort. The flexors and extensors of the wrist were weakened, apparently about equally so. The intrinsic muscles of the hands were very feeble. These symptoms were similar on both sides, except that on the right adduction of the humerus was less powerful than on the left, whereas the grasp of the hand was stronger on the right side, and unaccompanied by extension at the wrist. On the left side sensation was thought to be somewhat deficient in the fingers, but there was no other affection; on the right side it was normal.

The chest-movements were feeble, and the legs showed great loss of power, but sensation was unaffected. The knee-jerk and plantar reflexes were exaggerated on both sides. He had no bladder or rectal troubles; the urine was of sp. gr. 1019, acid, containing a trace of albumin, but no sugar. Temperature,

100.6°; pulse 80. Ext. ergot. liq. was administered several times.

Two days later the arms were slightly stronger, the legs decidedly so; the temperature had fallen, and shortly reached the normal.

On December 27 extension of the forearms was still weak, but the other movements much better. He had now ceased to retain the fixed position described above, except at times, and had hardly any pain. Improvement was rapid, and on January 16, 1888, he was discharged cured, except for some slight feebleness of the grasp.

The above account is taken from notes by Mr. Bannister, the house-surgeon, as I only saw the case a few days before his discharge.

This is another instance of a small hæmorrhage, mainly in the region of the triceps nucleus—a hæmorrhage confined to the anterior cornua, and affecting only the motor apparatus. It is needless to repeat the evidence, which shows that it was most severe in the region of the triceps nucleus, but extended thence to those of the extensors and flexors of the fingers, and that it was at a rather higher level on the right than on the left side, so that on the former the adductors of the humerus were also weakened.

CASE 19.—*Hæmatomyelia in middle cervical region—Recovery with persistent symptoms.*

W. H., aged thirty-six, a carter, was admitted under the care of Mr. Hardie on June 13, 1885. About half-an-hour before admission he had fallen between the shafts of a van which he was driving, and one wheel had passed over his shoulders.

On admission, he lay quite helpless, there being complete paralysis of the left arm and of both legs, while the right arm was partially paralysed, but retained some motor power, "especially at the elbow." Respiration was diaphragmatic. The reflexes were normal. There was anæsthesia below the distribution of the cervical nerves. Speech was laboured, owing to difficulty in breathing, but there was no loss of consciousness or mental confusion. The left pupil and palpebral fissure were slightly smaller than those of the right side. There was much pain in the back of the neck, but no abnormality was there detected. After the patient had been put to bed, he was able to

move the right lower extremity slightly. There was great thirst and dryness of the mouth. The urine had to be drawn off; it was acid, of a specific gravity of 1010, and contained neither sugar nor albumin. He was placed on a water-bed, the head being fixed by sandbags.

On the following morning it was ascertained that sensation was nowhere absolutely lost, but that it was impaired on both sides of the body, more markedly on the right than on the left. There was more power of moving the right leg and arm; the limbs of the left side remained completely paralysed. Other symptoms continued as before; the temperature was in the morning 100.2°, in the evening 101°. There was free perspiration; the urine was scanty and high-coloured.

When examined on June 15, forty-eight hours after the accident, the shock had passed off, and there was less pain in the neck. The right arm and leg were more powerful, and the rhomboids, posterior scapular muscles, biceps, deltoid, and supinator longus acted well, although the other muscles of this limb were paralysed. The left arm and leg remained completely paralysed. Sensation was returning on both sides, but remained less acute on the right than on the left side. This diminution of sensation extended as high as the supra-clavicular branches of the cervical plexus. The reflexes were normal. There appeared to be some slight movement of the intercostal muscles in respiration. The pulse was beating at the rate of 102; the temperature was in the morning 102°, in the evening 102.4°.

On the following day there was further gain of sensation and of power on the right side. On the left side were slight pricking sensations. The temperature had fallen to 99.4°. Other symptoms were as before. It was noted that there had throughout been no priapism.

On June 17 he passed his urine without the use of a catheter, and had no further trouble with it. His bowels were now opened for the first time since the accident. The pulse remained somewhat rapid, being 85 in the morning, and 100 in the evening; the temperature was 101°. On the 19th there was distinct costal respiratory movement. The pulse was still rapid, and the temperature 100°. On the 26th the temperature for the first time reached the normal, at which it afterwards remained, except temporarily on two unexplained occasions.

On June 24 there seemed to be little or no further change, and iodide of potassium was ordered in gr. x. doses. From this point improvement progressed very slowly. On July 4th

he was able to move both shoulders very slightly, and the intercostal muscles acted more freely on the right than on the left side; there was no other change in the paralysis. The knee-jerk was exaggerated on both sides; there was no ankle-clonus. On July 20th he was transferred to the medical wards, under the care of Dr. Ross, where very full notes of his condition were taken by Dr. Bury, then medical registrar, of which an abstract only is here given. At this time it was noted that costal respiration was still deficient, being apparently more so in the lower ribs (probably because the downward traction of the diaphragm was able to overcome the expansion).

The following was the condition of the right upper limb:— The wrist was semiflexed and somewhat inclined towards the ulnar side, having very slight power of flexion and extension. The thumb lay fully extended, but could be slightly flexed, adducted and abducted: there being, however, no power of opposition. The first phalanges of the fingers were extended, the second and third partially flexed; there was slight power of flexion of the metacarpo-phalangeal joints, but no movement at the inter-phalangeal joints. As regards lateral movement, there was slight power of abduction and adduction of the first and fourth fingers, but the second and third were immovable, having always a slight interval between them. He could pronate the wrist and then bring it half-way into the supine position, but no further. The elbow was semiflexed and could be partially flexed, but not extended, and passive extension caused the tendon of the biceps to stand out very sharply. At the shoulder-joint there was diminished movement, especially of abduction, external rotation, and flexion; he could touch the tip of the opposite shoulder, but not the head. There was marked wasting of the whole limb. A very powerful faradic current caused slight contraction of the extensors and flexors of the elbow and of the serratus magnus, but of none of the other muscles of the limb or shoulder. The galvanic current gave the "reaction of degeneration" with the pectoralis major, deltoid, supra- and infra-spinatus, biceps, triceps, extensors and flexors of the forearm, and muscles of the hypothenar and thenar eminences. On the left side the condition was similar, except that there was even less power of voluntary movement. In brief, there was well-marked "atrophic paralysis" of all muscles supplied by the brachial plexus. The movements of the lower limbs were weak, but of normal range, except for some deficiency at the left ankle, and the electric reactions were also here normal.

It was not easy to map out accurately the extent of sensory deficiency, owing to the fact that there was nowhere absolute anæsthesia, nor any defined limit. On both sides sensation was normal in the neck, and as far downwards as the lower limit supplied by the cervical plexus, that is, to the level of the third rib. There was below this limit marked diminution of sensation on the right side, extending to within half-an-inch of the middle line in front: at this point there was an area of transition, and to the left of the middle line sensation was normal. Behind, the anæsthetic area extended over the whole of the right side of the trunk as far as a vertical line midway between the posterior border of the right scapula and the spines of the vertebræ; the upper limit of anæsthesia being here the spine of the scapula. The right shoulder was not anæsthetic. There was no anæsthesia of the left half of the trunk. The right lower limb was anæsthetic, the left was not—in fact, there was partial anæsthesia of the whole of the right side of the trunk and lower extremity, with normal sensation on the left side. In the upper limbs the distribution of anæsthesia was symmetrical, affecting the whole of the limbs, excepting a strip of skin running from the shoulder along the centre of the biceps, and then straight downwards along the front of the forearm to the hand, where it spread out, so that the only part of the hand which was anæsthetic was the thumb, the rest having apparently normal sensation both in front and behind.

The knee-jerk was much exaggerated, and there was marked ankle-clonus; the superficial reflexes were absent, and there were no reflexes in the upper limbs.

The skin over the anæsthetic areas was hot and dry, the slightest prick or scratch causing a bright red spot or line. There were slight swelling and tenderness at the back of each wrist. The inter-phalangeal joints were also thought to be slightly swollen, but were probably merely rendered more prominent by the general atrophy. The finger-nails were long, the skin at their roots being red, smooth, and shining.

The left pupil was slightly smaller than the right, and the left palpebral fissure somewhat narrowed.

The patient remained under observation for rather more than three months more, taking a mixture of iron and quassia. During this time his voluntary power increased considerably in the right upper extremity, and to a slight extent in the left; when last seen, he could move the fingers of the right hand fairly well in all directions, had slight power of opposition of the thumb, could raise the elbow to the level of the shoulder, and could touch

the top of the head with his hand. Sensation had also improved. There was still some difficulty in moving the left ankle, but otherwise the movements of the lower limbs were good.

Superficial reflexes were obtained over the abdomen; the cremasteric reflexes were still absent, the plantar was got on the right side only. The knee-jerk was less marked on the right side than it had been, but was unaltered on the left. There was no other change, and the vital functions were well performed.

We have here another case of central hæmatomyelia, in which the hæmorrhage, being more extensive upon the left side of the cord, caused the paralysis of the lower limb and pupillary fibres to be greater on that side, and the anæsthesia to be more marked in the right lower limb. On the left side the hæmorrhage extended into the region of origin of the fourth and fifth cervical nerves, whereas on the right side it stopped short of that of the fifth. For some little time the distribution of the paralysis was increased by the spread of myelitis, which, like the hæmorrhage, confined itself mainly to the central grey matter of the cord, so that eventually, although the whole of the brachial motor nuclei were greatly damaged, their muscles being left atrophic and paralysed, there was but slight interference with the conducting fibres.

The sensory affection is particularly interesting. Anæsthesia clearly affected the distribution of the highest (say the fifth cervical) and the lowest (say the first dorsal) roots of the brachial plexus on both sides, together with the entire sensory tract for the right side below the level of the brachial region. This distribution can be explained by assuming a central lesion in the upper brachial region, which would involve the posterior roots of the fifth nerve as they enter the cord and penetrate towards its centre; then the immediately succeeding roots, ascending for some little distance in the peripheral white matter, as they probably do, would escape the lesion. As we proceed lower, we find the first dorsal sensory root completing its first brief peripheral course, and entering the grey matter at about the level of the lesion, so as to be involved in its effects; and finally, the greater extent of the lesion of the left side of the cord explains the damage done to the whole of the remaining ascending fibres from the right side of the body, which are again probably peripheral.

In order, therefore, to reduce the explanation of the symptoms to a single lesion, we must assume that the sensory fibres, after entering the cord, penetrate nearly to its centre; that they then ascend for some little distance in a peripheral position before

entering (or re-entering) the grey matter to decussate with their fellows, and that, finally, after a brief course in the grey matter, they once more enter the white substance, and, becoming peripheral, remain so for the remainder of their course. Such an explanation appears to be consistent with the general results of experiment as to the direction of sensory conduction in the cord, which seem to indicate that the paths enter the grey matter after a brief vertical course, but that they subsequently regain the white columns.

The record of the following case is very incomplete, but the symptoms will be found to be entirely explicable by the diagnosis of a small hæmorrhage in the upper part of the brachial region, causing but slight and temporary compression of the fibres of the cord, and unaccompanied by any serious destruction of its tissues.

CASE 20.—*Traumatic cervical hæmatomyelia—Temporary paralysis of limbs and trunk—Recovery.*

W. B., aged forty, was admitted to Mr. Heath's wards on August 15, 1885, suffering from the results of a fall, estimated at a distance of fifty feet. He was a strong, healthy-looking man, with no trace of previous illness. On the right side of the head was a deep scalp-wound, extending about four inches backwards from the forehead, and surrounded by much bruising. It may at once be said that under ordinary treatment this wound soon healed up. There was no unconsciousness, nor other trace of cerebral symptoms. All four limbs were, however, paralysed—the arms completely so; the legs could be moved in bed, but the patient could not stand. He had complete anæsthesia of the arms, abdomen, and legs, but no loss of control over the rectum and bladder. The skin over the lumbar spine showed extensive bruising. Unfortunately the notes of this case were very imperfectly taken, and there is no further information contained in them.

On the following day the temperature rose to 99.2° F. in the morning, and 100.8° F. in the evening; there was more power in the lower limbs and muscles of the neck. On August 17th he could move his legs quite easily and freely in bed, and there was no sign of paralysis of the neck, but both arms remained completely paralysed. Sensibility was improved, but there were tingling sensations in all the limbs. The temperature was lower. On the 18th sensibility appeared to have quite returned. The

fingers and thumb could be moved fairly well on both sides, and there was slight movement of the whole upper limb. The temperature had returned to the normal, at which it afterwards remained. From this time there was a slow but steady gain in power, and on August 28th the upper extremities could be moved in any direction, although only feebly so. It was, however, some time before the legs were sufficiently strong to support the weight of the body. He was first able to walk a little on October 12th, and could then use his arms for such light work as holding a book, but they were still weak; there was no distinct muscular wasting; ankle-clonus, and the patellar, triceps, and radial reflexes were exaggerated. The only affection of sensibility was some numbness of the inner sides of the calves, with tingling sensation in the fingers.

Three days later he was sent to the Convalescent Hospital at Cheadle, where the constant current was applied to various parts of the limbs three times weekly, and where strength rapidly returned.

I again saw the patient on January 16, 1886, *i.e.*, five months after his accident. He then looked very well and had returned to his work, but still felt weakly, and had the sensation of tingling in the fingers; there was, however, no anæsthesia, and no difficulty in using the hand. He stated that at times he had some girdling sensation, which he referred to the region of the lower dorsal and upper lumbar nerves. The patellar and radial "deep reflexes" were exaggerated, but there was no ankle-clonus and no jerk on striking the triceps tendon.

Owing to the want of an accurate clinical examination, we have no evidence as to the exact locality of hæmorrhage in this case, but the general course is so similar to that of our other cases of hæmatomyelia, that we can hardly doubt that the case was of the same nature, and would, if properly examined, have yielded evidence of effusion into some of the spinal nuclei. It is the absence of such examination in cases of this nature which leads them to be described as "concussion of the cord."

CASE 21.—*Gunshot injury to the spinal cord—Paralysis of limbs and trunk—Partial recovery.*

M. H., a widow, aged thirty-seven, was admitted under the care of Mr. Jones on May 10, 1886. Five weeks previously she received two bullet-wounds from a revolver, probably fired at a distance of about two yards. One bullet pierced the left

thumb and then passed through the lobe of the left ear, grazing the mastoid process, and apparently at once escaping. The other entered immediately below and behind the left mastoid process, passing downwards and to the right. She was "immediately" paralysed in all four limbs, and when seen by a medical man was found to have complete loss of sensation below the neck, diaphragmatic breathing, and incontinence of urine and fæces. An attempt was made to find the bullet, but proved unsuccessful. The wounds healed well in about a fortnight, during which time the nervous symptoms were said to have remained unchanged. Calomel was occasionally administered to regulate the bowels, and the limbs were rubbed with oil.

On admission to the Infirmary five weeks after the injury, she was found to be a well-nourished and healthy-looking woman. In addition to the scars left by the above-mentioned wounds, she presented the following symptoms:—At the back of the neck some three inches to the right of the fifth cervical spinous process, was felt a hard nodule, apparently the bullet, lying quite superficially. She felt pain on moving the head, and tenderness of the cervical spine. There were no cerebral symptoms. The upper limbs were completely paralysed. The lower extremities were less absolutely so: on the left side she had some power of extension and flexion of the ankle-joint, and could raise the limb slightly from the bed; on the right side there was somewhat less power of movement of the ankle. The abdominal and intercostal muscles were also paralysed, breathing being diaphragmatic. There was no anæsthesia, but slight hyperæsthesia about the shoulders. The superficial and deep reflexes were normal. The limbs did not appear wasted. There was incontinence of urine and fæces. The temperature was normal, and remained so throughout the patient's stay in hospital. There were no circulatory or digestive disturbances.

A few days later, Mr. Jones removed the bullet without difficulty from the site above indicated. It proved to be a conical revolver-bullet, about three-quarters of an inch long, and flattened at the apex from contact with some hard substance. The wound healed readily, and gave no trouble. The faradic current was hereafter regularly applied to the limb-muscles, the electric reactions of which were normal.

On May 19th were noted involuntary twitchings of the legs, which were very constantly present, and continued during her stay in hospital. On the 25th she was found to have some slight power of movement of the fingers of her left hand, and

increasing power in the movements of the feet. Shortly after this she commenced to move the abdominal muscles, and, to a slight extent, the intercostals, the power of all of these slowly increasing. Towards the middle of June she became able to move slightly the fingers of the right hand, but there was little improvement elsewhere. She complained a good deal of occasional wandering sensations, of "pins and needles," and of the almost constant muscular tremors. From this time until she went home on July 30th, there was no change, except a slight increase in the power of the already-acquired movements.

By kind permission of Dr. Martin, her medical adviser, I saw this patient again, at her own home, in September. As regards motor power, there was little or no change from the time of her leaving the Infirmary. The limbs were not more wasted than would be expected from her long confinement to bed, and the muscles everywhere presented normal electric reactions. The knee-jerk was much exaggerated, and there was ankle-clonus on both sides; the radial, ulnar, and triceps reactions were absent. She had complete control over the bladder and rectum. There was no anæsthesia. The pupils were normal. She complained greatly of pain in the various joints, but especially in the left elbow and ankle. The general health had remained good.

About a year later I heard incidentally of the death of this patient; but was unable to obtain any further details or permission for an autopsy.

This case presents so many points of similarity to the five which precede it, that we are naturally led to seek in the latter the explanation of the symptoms. There is the same sudden paralysis with anæsthesia, followed by spastic symptoms, the anæsthesia passing off gradually, the bladder and rectum, at first paralysed, recovering their functions. There is, however, this important difference, that whereas hitherto we have had evidence of destruction of a portion of the grey matter of the cord, generally leaving a localised atrophic paralysis and some permanent impairment of sensation, but allowing of much recovery in the case of the descending tracts, there are here no atrophic symptoms, but there is extensive and permanent injury to the descending motor tracts. Further, in the present instance the symptoms are absolutely symmetrical. We are thus led to look for some cause of general compression of the cord at a point near the upper part of the brachial region. In the earlier cases, the compressing agent was a central hæmorrhage, causing some destruction of the

grey matter in its immediate vicinity. In the present instance we can hardly assume this to have been the nature of the lesion, as, if we do so, we must suppose an effusion of blood large enough to cause continued pressure on the whole of the structures of the cord, and yet so small as not to have extended into the anterior cornua and produced any muscular atrophy. If, however, the lesion were meningeal, lying entirely outside the cord, it might very well cause such pressure without producing any serious destruction of its substance. But a moment's consideration will show that the accident was of just such a nature as to produce this injury. An examination of the neck, or of such a plate as that given on p. 302, vol. i., of Quain's "Anatomy" (eighth edition), will show that if a bullet were to enter "immediately below and behind the left mastoid process," and pursue a straight course to a point "some three inches to the right of the fifth cervical spinous process," it would cross the vertebral column about the level of the fourth cervical spine, that is, about the level of exit of the fifth cervical nerves, the upper limit of the paralysis and anæsthesia in our case. Now, the bullet was flattened at the apex, as if it had struck some bone, and as it entered below the mastoid process, the only bone in its track would be a portion of the spine. It would then appear that the bullet struck the spinal column somewhere immediately above the point of exit of the fifth cervical nerves, there injuring the cord, either by a direct wound, by an indirect wound due to bony splinters, or by causing a meningeal hæmorrhage.

In concluding a review of the above cases, there are a few points to which reference may be made, and for the consideration of which it is more convenient to regard the cases collectively.

We are at once struck by the relatively large number of cases of hæmorrhage within the vertebral canal, unaccompanied by any evidence of injury to the spine itself, constituting at least five, or, if we include the last case, six, out of a total of twenty-one cases of injury to the cervical region of the spine. The number of these cases occurring in actual practice is probably much underestimated, many of them being regarded as instances of concussion of the spine, without definite organic lesion. The symptoms are frequently complicated, and, without a careful consideration of the origin and course of the affected tracts, would appear to be inexplicable on the hypothesis of a single lesion. If, however, these symptoms be fully investigated with the assistance of an accurate knowledge of the anatomy of the cord, they will

probably in most cases be found to be clearly due to some gross local lesion. It is to be regretted that of the numerous reported cases of spinal injury, a minority only are sufficiently detailed to permit of an accurate diagnosis, it being too customary to use such loose expressions as "partial paralysis of the upper limbs."

Another cause of the comparative neglect of hæmatomyelia as a result of injuries to the spine is the relative infrequency of post-mortem examinations verifying this condition. These cases are not nearly so fatal as fractures and dislocations, and their true pathology is therefore not generally recognised. Thus we find that of fifteen cases of fracture or dislocation, all but one were fatal, whereas of the six cases of hæmorrhage only two died, and in the last, in which the diagnosis is doubtful, death followed at so long an interval, that the case had passed from under observation. Under these circumstances the only possible means of diagnosis is the demonstration that all the symptoms may be due to a single focus of injury; but where such demonstration is practicable, a diagnosis of hæmorrhage should always be preferred to the vague and unsatisfactory designation "concussion of the spinal cord."

An excellent illustration of the importance of excluding hæmatomyelia before rejecting the diagnosis of an organic lesion is referred to by Mr. Page,[1] who, criticising a case of Dumenil and Petit, suggests that the symptoms which they attribute to concussion might have been due to a gross lesion caused by bending of the spine. The case referred to is strikingly similar to the above examples of hæmatomyelia, and all the symptoms might have been produced by a central hæmorrhage at the upper part of the origin of the sixth cervical root, a diagnosis with which the post-mortem appearances are entirely consonant. A similar accurate study will undoubtedly eliminate many, at present, obscure cases of "concussion."

The tendency of hæmatomyelia to affect the centre of the cord —the grey matter, especially of the anterior cornua, and the central canal—is illustrated by all of these cases, as well as by several of those referred to in Chapter I., in which a spinal lesion was accompanied by an extensive central hæmorrhage.

The symptoms produced by such a hæmorrhage are divisible into two groups, just as are the symptoms of a cerebral hæmorrhage: we have a "destroying" and a "compressing" lesion—the former permanent, the latter more or less temporary. As a result of the destroying lesion, we find atrophic paralysis and

[1] Brain, 1886, vol. ix. p. 258.

possibly persistent anæsthesia in the distribution of some of the roots of the brachial plexus. The compressing lesion may cause more or less complete paralysis and anæsthesia below its level, with retention of urine and fæces, priapism, contraction of the pupil, and other symptoms, which, as a rule, soon subside, probably leaving only some spastic symptoms in the lower limbs.

Another important point illustrated by the above cases is the method of production of these intramedullary hæmorrhages. Two theories are possible; one, that the cord is "concussed," or jerked violently backwards or forwards against its containing canal, and thus bruised; the other, that there has in all cases been a diastasis or partial dislocation with recoil. The former view appears, however, to be untenable. Thus, in Case 16, had the lesion been due to concussion, we should have expected the post-mortem evidence of the bruise to the delicate cord to have extended over a wider and less sharply defined area than that which the hæmorrhage actually occupied; the cord must have been driven forwards *en masse*, and there is no reason why the injury inflicted should be thus localised. Similarly, in several of the other non-fatal cases, the symptoms prove the hæmorrhage to have been of small extent. An acute bend, on the other hand, might readily produce a lesion of this nature, and, in fact, we find in Cases 4, 11, and 15 a condition which is practically a hæmatomyelia, in which the injury to the cord had undoubtedly resulted from a displacement of the vertebræ, reduced in the first two cases by nature, and in the third by art.

The region in which hæmatomyelia is found to occur also favours this view of its production. In all the above cases it was located in a small area, limited by the region of origin of the four lower cervical and the first dorsal nerves, a region corresponding to the bodies of the fourth, fifth, and sixth cervical vertebræ. Above or below this section of the cord I have not met with a single instance of traumatic hæmatomyelia—a fact totally inexplicable on the concussion theory. This is, however, the summit of the arch formed by the cervical curve, and is, therefore, the region in which an acute bend of the neck would make itself mainly felt, especially if the effects of such a bend were spread over several vertebræ, straining somewhat the articulations of each without giving rise to a dislocation. In fig. 5 is illustrated the probable pathology of such a lesion; the connections of several of the cervical vertebræ have partially yielded, and the bending of the spinal tube has bruised the cord near the apex of the curve, and has there caused a hæmatomyelia.

Such facts as are obtainable regarding the exact nature of the accident are also in favour of the "flexion" as against the "concussion" theory. Thus, in Cases 16 and 20, the occurrence of severe scalp-wounds appears to indicate that the force of the blow received was in each case delivered upon the head, and would thus tend unduly to bend the cervical spine. In Case 17, the accident was a fall upon the hands, which would imply a severe jerk to the head and neck, and would thus cause sharp flexion of the latter. In Case 18, the patient fell flat upon his back, so that the affected region would be less exposed than any other part of the spine to a direct impact and to concussion, but correspondingly more liable to flexion. Finally, in Case 19, the passing of a wheel over the shoulders is an injury too slow in its action to "concuss" or jerk the cord forwards, but is one well calculated to produce bending of the spinal column.

CHAPTER III.

INJURIES TO THE DORSAL REGION OF THE SPINAL CORD.

Owing to the comparative simplicity of the distribution of the dorsal nerves, and especially to the absence of plexuses upon their course, the symptoms presented by injuries of this region of the spinal cord are much less complicated than those which arise when the cervical or lumbar enlargement has been implicated. As a result of this simplicity, the difficulties of localisation become comparatively trivial; and hence, injuries of the dorsal region illustrate more clearly than those of any other the general characters of lesions of the spinal cord. For this reason, the following cases are here recorded, and attention will be called to some of the more interesting points which they present.

As previously stated, I have not met with any cases of meningeal or intra-medullary hæmorrhage in this region; and the following examples, constituting the series of cases observed during the last four years in the Manchester Infirmary, are all doubtless instances of fracture or dislocation.

Case 22.—*Fracture-dislocation of third or fourth dorsal vertebra.*

D. E. H., a woman, aged thirty-one, was admitted to Mr. Hardie's wards in the Manchester Infirmary on April 12, 1889, having shortly before fallen backwards out of a window some fifteen or twenty feet from the ground. She was found in an unconscious condition, with an extensive scalp-wound on the back of the head, as well as several bruises on the limbs.

It was not until consciousness returned on the following day that the spinal injury was noticed. She then presented complete paralysis and anæsthesia below the level of the fourth ribs, with

a hyperæsthetic band corresponding to the third intercostal space. All the superficial and deep reflexes were lost below the site of the lesion. Urine and fæces were retained; respiration was mainly abdominal, but without dyspnœa; the pulse was 96; temperature normal. The skin of the lower limbs felt very dry, and the patient complained much of a sensation of coldness in them. The urine was neutral, of sp. gr. 1032, and free from albumin or sugar.

She had but little pain or tenderness of the back, nor any pain on vertical pressure upon the head; but one of the dorsal spinous processes—whether the third or fourth could not be accurately determined—was markedly prominent as compared with that immediately below it.

The surface-temperature was taken on several occasions above and below the lesion, the results being as follows :—

		Difference in favour of thigh.
April 15.—Surface of front of thigh	86.8°	− 2.0°
Surface of front of arm	88.8°	
Axilla	98.4°	
April 16.—Surface of front of thigh	88.4°	− 2.4°
Surface of front of arm	90.8°	
Axilla	98.0°	
April 17.—Surface of front of thigh	88.0°	− 1.8°
Surface of front of arm	89.8°	
Axilla	98.4°	
April 18.—Surface of front of thigh	87.0°	− 1.2°
Surface of front of arm	88.2°	
Axilla	98.4°	
April 29.—Surface of front of thigh	86.8°	− 1.0°
Surface of front of arm	87.8°	
Axilla	98.0°	
May 16.—Surface of front of thigh before using battery	87.7°	
Surface of front of thigh after using battery	85.2°	+0·5°
Surface of front of arm	87.2°	
Axilla	98.4°	
May 17.—Surface of front of thigh before using battery	90°	
Surface of front of thigh after using battery	89°	+1.5°
Surface of front of arm	88.5°	
Axilla	98.4°	

The optic discs were examined and found to be normal on April 16, April 23, and May 16.

These symptoms underwent very little change during the next few weeks. The bowels were moved for the first time on the eighth day, and were thereafter evacuated daily. About the fifteenth day the patient began to complain of tingling and pricking in the feet and lower limbs, which gradually increased in intensity, and then gave place to pain sufficiently severe to

interfere with sleep. No return of sensation or motion in the limbs accompanied these changes, but at the same time the patient began to be occasionally conscious that the bladder was full. If the urine was then not drawn off, it was shortly passed involuntarily.

When the last note was taken on May 16, the distribution of paralysis and anæsthesia were unaltered, but the hyperæsthesic band had entirely disappeared. A feeble jerk was obtained on percussing the ligamentum patellæ of the right side only. The superficial reflexes were still absent. The rectum appeared to have regained its functions, the condition of the bladder being as above described. On the feet were several large bullæ filled with blood, but the skin did not give way. The skin of the lower limbs still felt dry, but they often perspired freely at night.

CASE 23.—*Fracture-dislocation of fifth* (?) *dorsal vertebra.*

H. S., a slater, aged forty-four, was admitted to the Manchester Infirmary under the care of Mr. Whitehead on May 21, 1888. Shortly before admission he had fallen from a building of considerable height on to his head, finally alighting with his back on a heap of bricks. He presented a scalp-wound about the junction of the left parietal with the occipital bone, and signs of fracture of the base of the skull—bleeding from the left ear, left facial paralysis, &c. The latter need not now be further referred to, except that it may be stated that the patient became very deaf and considerably demented.

I only saw the case a few days after admission, and then found the man conscious. He complained of pain in the mid-dorsal region, and there was slight angular curvature in the region of the fifth, sixth, and seventh dorsal vertebræ, the spine of the sixth being especially prominent and also obviously detached. On admission the deformity had been more marked, but it was much reduced by the supine position. No pain was caused by pushing down the shoulders.

The lower limbs and the abdominal muscles were completely paralysed, and anæsthesia apparently extended as high as the sixth intercostal space, having a slight margin of hyperæsthesia above it; but owing to the patient's mental condition, the exact boundary (which was not sharply defined) could not be certainly identified. The urine was retained, and after May 30th became alkaline and offensive, the catheter having been used in

the meantime. For several days he had marked priapism; but after I first saw him this came on only when the catheter was passed, there being, however, persistent slight turgidity of the penis.

The plantar and cremasteric reflexes were retained, although the latter was very feebly developed; the knee-jerks were lost, as were the abdominal and epigastric reflexes.

Three weeks after admission the paralysis and anæsthesia were as before, but the hyperæsthetic zone had disappeared. The sixth rib was now definitely ascertained to be the upper limit of the anæsthesia. The plantar reflexes were much exaggerated, the cremasteric distinct, and the abdominal absent. The knee-jerk was still absent. On scratching the skin of the lower limbs flushing was readily produced. The turgidity of the penis had quite disappeared. The urine was purulent and very fœtid, although the bladder was being washed out twice daily with an antiseptic solution. The temperature was normal during his long stay in hospital, except for occasional fluctuations of no special import.

From this time until October 24, 1888, when he was discharged, the man showed no changes of consequence. The condition of the bladder gradually improved, but there was never any return of power or sensation in the limbs and trunk. Even at the end of five months the knee-jerks remained absent, and although the lower limbs became much wasted, there was no contracture. The progress of this patient's case after he left the Infirmary is unknown to me, but I hear that he died in April 1889, exhausted, and with very extensive bed-sores.

CASE 24.—*Fracture-dislocation of sixth dorsal vertebra.*

J. H. was admitted, under the care of Mr. Whitehead, on December 10, 1885. He was a strongly-built young man, twenty-four years of age, and had been injured by an iron pipe, of unknown weight, falling upon him.

In addition to simple fractures of the left tibia, radius, and ulna, he presented the following symptoms:—There was complete paralysis and loss of sensation of the lower extremities, and of the trunk as high as the eighth rib, with retention of urine and fæces. There was great pain in the lower dorsal spine, but no deformity. He complained much of difficulty in breathing, and coughed up a little blood. The temperature was 102.6°.

The notes of this case are very imperfect, but tell us that shortly after admission symptoms of pneumonia were developed, with very painful cough and sanguineous sputa. On the fifth day the urine became alkaline. The temperature oscillated somewhat, but was generally between 102° and 103°, until August 16, the sixth day after admission. On the morning of that day it was 102.2°; at 1.25 P.M. he had a rigor, and it rose to 103.8°; at 1.45 it was 106.2°; at 2 P.M. 107.6°. Breathing now became purely diaphragmatic, and he died during the afternoon.

Dr. Harris found the following appearances at the post-mortem examination:—The spines of the fifth, sixth, and seventh dorsal vertebræ were broken off, as were the transverse processes on the right side of several of the dorsal vertebræ. The cartilages above and below the sixth dorsal vertebra were both ruptured, the body of the vertebra being displaced backwards and split vertically. At this point the cord was completely divided, the two ends being separated by a distance of $1\frac{1}{2}$ inch, and the dura and pia mater stretched across from one to the other. Above and below, the cord was softened and infiltrated with blood for a distance of about two inches in each direction. The membranes were healthy, except that there was a slight laceration of the dura mater opposite the seat of injury.

Both pleura contained a large quantity of dark blood, fluid and in coagula. The lung-tissue on both sides was contused and infiltrated with blood, and the lungs œdematous.

CASE 25.—*Fracture-dislocation of seventh dorsal vertebra.*

J. S. W. was admitted into Mr. Heath's wards in the Manchester Royal Infirmary on May 17, 1887. He had been injured by a bale of goods falling upon him from a great height, and presented the symptoms of shock with complete paralysis and loss of sensation "below the level of the seventh dorsal vertebra." He died in a few hours.

At the post-mortem examination was found, in addition to fracture of the right thigh, and rupture of the stomach, spleen, and left kidney, a fracture of the seventh dorsal vertebra extending through its body obliquely from above and behind downwards and forwards. The articular processes were dislocated, and the spinal column was here movable in all directions, the bones being held in

apposition only by the soft structures. There was a large quantity of blood in the spinal canal outside the dura mater, and the cord opposite the seat of the lesion was almost torn across, only a few shreds of its tissue remaining.

CASE 26.—*Fracture-dislocation of ninth dorsal vertebra.*

J. D., a labourer, aged thirty, was admitted to the Manchester Infirmary under the care of Mr. Heath on December 11, 1888. In the previous March he had fallen about fifty feet from the top of a building, the fall being partially broken by his back striking a beam some thirty feet from the ground. He was taken to the Ashton Infirmary, where he remained until September without undergoing any improvement in his symptoms.

On admission to the Manchester Infirmary, he was found to have marked prominence of the spine of the tenth dorsal vertebra, the process immediately above being depressed. The back was straight, without angular curvature or deviation of the spines from the middle line.

The lower limbs were completely paralysed and their muscles tonically contracted, causing them to lie quite straight, with the toes pointing. The plantar and cremasteric reflexes were lost. The knee-jerk was well marked, although not much exaggerated; ankle-clonus could not be investigated owing to contraction of the calf-muscles. The faradic current caused no contraction in any of the muscles except those in the front of the left thigh, which reacted slightly to very powerful stimuli.

Anæsthesia was complete below a line corresponding accurately to the upper limit of the distribution of the last dorsal nerve.

The urine dribbled away almost constantly, bladder-dulness extending as high as midway from the pubes to the umbilicus. The urine was alkaline, purulent, and fœtid. On one occasion, when a soft rubber catheter had been half introduced, it was forced out again by a spasmodic contraction, followed by a stream of urine, which did not, however, empty the bladder. Fæces were passed unconsciously and involuntarily. The penis presented no turgidity. The skin of the lower limbs felt dry and warm, and presented patches of redness as well as a sore on the right heel: scratching it caused bright hyperæmic lines.

The surface temperature was taken on several occasions, with the following results :—

		Difference in favour of thigh.
Dec. 21.—Front of thigh	86.5°	−4.1°
Front of upper arm	90.6°	
(Axillary	97.2°)	
Dec. 22.—Front of thigh	87.8°	−1.0°
Front of upper arm	88.8°	
(Axillary	98°)	
Dec. 23.—Front of thigh (an hour after using battery)	91.6°	+4.9
Front of upper arm	86.7°	
(Axillary	97.6°)	
Dec. 27.—Front of thigh (before using battery)	84.9°	−4.5
Front of thigh (immediately after using battery)	83.6°	
Front of upper arm	89.4°	
(Axillary	97°)	
Jan. 8.—Front of thigh (before using battery)	86.4°	−3.6°
Front of thigh (immediately after battery)	83.9°	
Front of upper arm	90°	
(Axillary	97.4°)	

During his stay in hospital this patient never presented any changes of importance. His axillary temperature was throughout slightly subnormal. One other point is worthy of notice; his optic discs were carefully examined on several occasions, but revealed no abnormality.

The treatment consisted in faradisation of the lower limbs, and washing out the bladder daily with a solution of boracic acid.

On February 2, 1889, he was discharged as incurable.

Case 27.—*Fracture-dislocation of tenth dorsal vertebra.*

L. J., a collier, aged thirty, was admitted on December 8, 1888, to Mr. Whitehead's wards. Shortly before admission he had been at work in a coal-pit, when a mass of rock, weighing nine or ten cwts., fell, so that a part of it struck him in the "middle of his back." He immediately sank down quite helpless.

On admission, he presented some swelling about the eleventh dorsal vertebra, and the lumbar concavity appeared to begin too soon. On the following day, extension was made, under chloroform, by jack-towels round the waist and thighs, the spine being manipulated at the same time, and the deformity was said to have been thereby reduced.

I saw him for the first time on December 11. He had then

prominence of the eleventh dorsal spine, with a depression above it, and some swelling in the lumbar region. Crepitus could not be obtained. Any movement of the lower limbs caused much pain, but no pain resulted from jarring the spine vertically. The lower limbs were absolutely paralysed, the trunk and upper limbs being normal. The plantar and cremasteric reflexes and the knee-jerk could not be elicited.

Below the limits of the distribution of the eleventh dorsal nerve there was partial anæsthesia; but vague sensation extended rather more than a hand's-breadth beneath this point, complete anæsthesia only beginning a little below Poupart's ligament. The penis and scrotum were anæsthetic, and the passage of a catheter was not felt until the moment of its entrance into the bladder. The urine had been retained and the bowels unopened since the accident. The penis presented no turgidity. The skin of the lower limbs felt dry and cool.

The surface temperatures were as follows:—

		Difference in favour of lower limb.
Dec. 21.—Front of thigh	91°	−0.8°
Front of upper arm	91.8°	
(Axillary temperature	99.4°)	
Dec. 24.—Front of thigh	92°	+2.0°
Front of upper arm	90°	
(Axillary temperature	97.6°)	
Jan. 16.—Front of thigh	86.2°	−1.6°
Front of upper arm	87.8°	
(Axillary temperature	98.6°)	
Apr. 16.—Front of thigh	93.2°	−1.6
Front of arm	94.8°	
(Axillary	99.4°)	

The bowels continued to be very constipated, and cystitis shortly supervened, for which the bladder was daily washed out with boracic acid lotion.

On February 1, 1889, his condition was again carefully examined. The lower limbs were much wasted, and still completely paralysed and anæsthetic. The plantar and cremasteric reflexes and the knee-jerks could not be obtained. The upper boundary of the anæsthesia corresponded accurately to the lower limit of the distribution of the last dorsal nerve. After washing out and emptying the bladder, urine was retained for some two hours, after which incontinence came on, remaining until the bladder was again emptied on the following day. This incontinence consisted in a continuous dribbling with an occasional forcible and copious discharge. Even when the bladder was full,

no dulness could be obtained on percussion above the pubes. The patient was conscious of the distension of his bladder by the lotion. The urine itself remained very foul and purulent. The temperature was irregular, being frequently above normal. Bed-sores had formed on the left buttock and on both knees and heels. Scratching of the skin of the thighs, which was very dry, caused marked hyperæmic lines, lasting for some minutes. The fundi of the eyes were normal.

On April 16, 1889, when the last note was taken, the man's condition was practically unchanged. The lower limbs had wasted greatly, and were rigid and extended, with the toes pointed. The skin was rough and dry, with ulcers at various places. The superficial and deep reflexes were still absent below the injured region. The bladder had gradually acquired the power of retaining urine for a longer period, amounting to about four hours after catheterisation, and the urine was less foul and contained less pus.

CASE 28.—*Dislocation of eleventh dorsal vertebra.*

J. R., a collier, aged twenty-two, was admitted under Mr. Jones's care on July 19, 1888. A week previously he had been working in a mine, when some coal fell upon his head, throwing him forwards, after which a further quantity of coal came down on to his back. He did not lose consciousness or present any signs of cerebral concussion, but found at once that he could not move his legs.

On admission, he complained of pain in the lumbar region of the spine, and there was found a diffuse prominence, most marked over the last dorsal spine, but obscured by effusion of blood, which extended somewhat higher than this point. No pain was caused by vertical jarring of the spine. The lower limbs were completely paralysed, but the abdominal, thoracic, and upper limb muscles were unaffected. The plantar, cremasteric, abdominal, and epigastric reflexes were all absent, as was the knee-jerk. Anæsthesia had a well-defined border, corresponding accurately throughout to the lower limit of the distribution of the last dorsal nerve, and there was no hyperæsthesia; those branches of the last dorsal nerve which descend on to the upper part of the gluteal region retained their sensation, but the rest of this area was anæsthetic.

The urine was retained, fulness of the bladder causing pain, and the urine contained pus and phosphates (the patient had

previously been suffering from gonorrhœa); but no sugar and very little albumin. The bowels were very constipated. On the feet were patches of redness, and the skin about the perineum and penis was red and rather raw. The penis itself was turgid. The slightest scratch of the lower limbs produced a bright hyperæmic line, lasting for several minutes. The temperature was normal.

Treatment consisted in periodic evacuation and washing out of the bladder.

Two days later the patient was put under chloroform, and an attempt made to reduce the spinal dislocation. Jack-towels being placed round the thighs, the thorax was firmly held, and extension made upon the lower limbs, when a distinct jerk was felt at the site of the fracture, the prominence of the twelfth dorsal spine becoming less marked. On relaxing the extension, the deformity returned as before, and the process was repeated two or three times, the pelvis being also carried backwards so as to increase the deficient lumbar convexity. Permanent reduction was, however, found to be impossible, and a plaster of Paris jacket was then applied, the back being partially supported by a towel under the lumbar region until the plaster had set.

On July 31, there being no improvement, the jacket was removed with the view of trephining the spine; but there being now no deformity, the operation was not performed, and a felt jacket was reapplied.

From this point the case presents little of interest. The nervous symptoms did not improve, the only change being that in September the patient complained a few times of shooting pains in the lower limbs. When the jacket was removed six weeks after its reapplication, the twelfth dorsal spine was as prominent as ever, having a depression above it. Turgidity of the penis passed off a few days after admission. The urine continued to be very foul, purulent, and ammoniacal, and on one occasion a phosphatic concretion about the size of a hemp-seed came away in the eye of the catheter. Gradual emaciation ensued, and on October 25, 1888, the man was sent home as incurable.

The first point to be noticed is that in these, as in other published cases of spinal injuries, the level of the upper border of the anæsthesia is usually somewhat below the level of the lesion. Then, in Case 23, where, from the prominence of the sixth dorsal spine, we probably had a dislocation forwards of the fifth dorsal

vertebra, the anæsthesia only affected the intercostal nerves as high as the sixth (inclusive), and in Case 24, although the sixth dorsal vertebra was displaced backwards and divided the cord, the anæsthesia did not extend above the eighth intercostal nerve.

Similarly, it will be found throughout that the upper level of the anæsthesia is generally somewhat below the area of distribution of the nerve trunk corresponding to the injured vertebra, the only exception being Case 25. But as it is practically not possible to differentiate the action of each intercostal muscle, we can only assume that the paralysis probably reaches to the same level as the anæsthesia, and thus we conclude that the superior limit of the isolation of the spinal nervous system is generally rather lower than might at the first glance be expected. This relationship is best represented by a table giving the probable level of the crush of the cord, and the actual upper limit of paralysis and anæsthesia. The probable level of the lesion is, in the absence of post-mortem data, derived from the marked prominence of a spinous process, such prominence being taken to indicate a dislocation forwards of the body of the vertebra immediately above that of which the spine projects. We thus obtain the following results :[1]—

Case	Probable Site of Lesion relatively to the Vertebræ.	Highest Nerve whose Functions are Lost.
23.	Junction of fifth and sixth dorsal.	Sixth intercostal.
24.	Sixth dorsal.	Eighth intercostal.
25.	Seventh dorsal.	Seventh intercostal.
26.	Junction of ninth and tenth dorsal.	Twelfth dorsal.
27.	Junction of tenth and eleventh dorsal.	First lumbar.
28.	Junction of eleventh and twelfth dorsal.	First lumbar.

In order further to ascertain this relationship, I have taken from Gurlt's analysis[2] all those fatal cases of fracture in the dorsal region in which there is fairly definite information as to the exact site of the injury and the upper level of the paralysis and anæsthesia. Few of the cases are explicit upon this point, but these few I have arranged in a Table. The first column shows the probable exact site (relatively to the vertebræ) of the crush of the spinal cord; the second gives the level to which symptoms are said to have extended; and the third, the nerve which would from this datum appear to have been the highest to be affected.

[1] Case 22 is omitted, as the symptoms were too indefinite for accurate localisation.

[2] *Handbuch der Lehre von den Knochenbrüchen*, vol. ii.

No.	Site of Lesion of Cord Relatively to the Vertebræ.	Highest Level of Paralysis or Anæsthesia.	Highest Paralysed Nerve.
†1.	Second dorsal.	Third rib.	Third dorsal.
2.	Third dorsal.	Seventh rib.	Seventh dorsal.
3.	Third–fourth dorsal.	Umbilicus.	Eleventh dorsal.
†4.	Fourth dorsal.	Sixth dorsal vertebra.	Sixth dorsal.
†5.	Fourth–fifth dorsal.	Epigastrium.	Sixth or seventh dorsal.
†6.	Fourth dorsal.	Epigastrium.	Sixth or seventh dorsal.
†7.	Fifth–sixth dorsal.	"As far as the false ribs."	Seventh dorsal.
*8.	Fourth–seventh dorsal.	Nipples.	Fourth dorsal.
†9.	Sixth dorsal.	Two inches above umbilicus.	Eighth or ninth dorsal.
†10.	Seventh dorsal.	Umbilicus and eighth dorsal vertebra.	Eighth or eleventh dorsal (?).
†11.	Seventh–eighth dorsal.	Pit of stomach.	Ninth dorsal (?).
†12.	Eighth dorsal.	Three fingers' breadth above umbilicus.	Ninth dorsal.
*13.	Ninth dorsal.	Two inches above umbilicus and twelfth rib.	Ninth dorsal.
†14.	Ninth–tenth dorsal.	One inch above umbilicus.	Tenth dorsal.
†15.	Ninth–tenth dorsal.	Umbilicus.	Eleventh dorsal.
16.	Ninth–tenth dorsal.	Four inches above umbilicus.	Eighth dorsal.
†17.	Upper eleventh dorsal.	Half inch below umbilicus.	Twelfth dorsal.
†18.	Whole eleventh dorsal.	Last false rib.	Twelfth dorsal.
*19.	Middle eleventh dorsal.	Umbilicus.	Eleventh dorsal.
*20.	Eleventh–twelfth dorsal.	Umbilicus.	Eleventh dorsal.
†21.	Twelfth dorsal.	Anterior superior spine of ilium.	Second lumbar.
†22.	Middle twelfth dorsal.	Anterior superior spine of ilium.	Second lumbar.
23.	Twelfth dorsal.	Paralysis of lower limbs, anæsthesia below knees.	Motor, second lumbar sensory, fifth lumbar.
†24.	Twelfth dorsal.	Paralysis and anæsthesia of lower limbs.	Second lumbar.
25.	Eleventh–twelfth dorsal.	No paralysis, anæsthesia of sciatic nerves.	Fifth lumbar.
26.	Eleventh dorsal to first lumbar.	Paralysis of lower limbs, anæsthesia from middle of thigh and gluteal fold.	Fourth lumbar (?).
27.	Twelfth dorsal.	Inguinal region.	Third lumbar (?).

Looking now at the above Table, we find that the cases can be arranged in three groups, viz. :—

Group A. (marked *) consists of four cases (8, 13, 19, and 20), in which the nervous symptoms extend as high as the vertebral lesion. To these may be added No. 25 of my own cases, giving five instances out of thirty-three.

Group B. (marked †) consists of sixteen cases, in which the nervous phenomena find their highest level at a distance, generally equal to the area of distribution of about two intercostal nerves, below the trunk coming out under the displaced vertebra. Adding to these five of my own cases, we find in this group twenty-one out of thirty-three cases.

Group C. (Cases 2, 3, 23, 25, 26, 27, and 16 from Gurlt) contains the remaining seven cases, in the first six of which the paralysis was a considerable distance below the vertebral lesion, whereas in the last it extended above this level.

The reason of this distribution will be obvious upon looking at the diagram given by Dr. Gowers in his work on "The Diagnosis of the Diseases of the Spinal Cord." If we have a dislocation, say, between the *fourth* and *fifth* dorsal vertebræ, we have a crush of the spinal cord about the level of origin of the *sixth* dorsal nerve, with possible injury to the fourth and fifth roots, which here lie beside the cord. But the cord is a much more fragile structure than the roots, and is from its size and position more exposed to injury, so that it is constantly damaged in cases in which the roots remain intact. Hence we must expect the level of the paralysis to be lower than that of the vertebral lesion by just so much distance as is occupied by the intraspinal course of the nerve-roots at the site of injury. In this way we can explain the distribution of the symptoms in the large number of cases forming Group B. In doing so, it must be remembered that the level of origin of the nerve-roots relatively to the vertebræ varies within considerable limits, extending even, it may be, to more than the depth of an entire vertebra, a point clearly illustrated by Mr. Reid's excellent diagram.[1]

Should the crush be very severe, we may also have the roots injured, when we get the exceptional condition of Group A. Thus, in my own Case 25, which was of this nature, the spinal injury was so severe that "the spine was movable in all directions;" and in Case 16 of those quoted from Gurlt, we are distinctly told that the roots of the ninth and tenth nerves were destroyed.

In Group C. are two cases (2 and 3) which I find unintelligible. In both, the cord was said to be torn across at the site of the fracture, and in the second of them the ends were separated by more than an inch. Under these circumstances, we can hardly accept as reliable the statements that anæsthesia only commenced far below the level of the lesion. Cases 23, 25, 26, and 27 really belong to the same category as those of Group B.; they are all injuries about the twelfth dorsal vertebra, to which correspond the origins of the second and subsequent lumbar nerves and the commencement of the cauda equina, and the apparently very low boundary of the anæsthesia is a result of the long intraspinal course of the nerves in this region.

To sum up, we find that, omitting the two doubtful cases and

[1] Journal of Anatomy and Physiology, 1889, vol. xxiii. p. 341.

Case 16, which will be referred to presently, we have thirty injuries in the dorsal region, in five of which both the cord and the roots were crushed, so that the level of the paralysis and anæsthesia corresponded to that of the bony lesion; whereas in twenty-five cases, the cord only being crushed, the limit of the nervous symptoms lay correspondingly lower.

The point may appear a trivial one, but it has really a most important practical bearing in at least two directions.

1. There seems a strong probability that the operation of "trephining" the spine may shortly become not infrequent, if not for injuries, at any rate for certain other pressure lesions of the cord. It is thus of the first consequence to recognise and to recollect that the seat of compression will, in the great majority of cases, be higher than that of the anæsthesia by the length of the intra-vertebral course of the implicated nerves.

In his exhaustive paper upon the surgery of tumours of the spinal cord,[1] Mr. Victor Horsley refers in some detail to this subject, and comes to the conclusion that "the difference between the position of the growth and the localisation of the pain is clearly due to the anatomical relations of the nerve organs and roots to the vertebræ, and something more, viz., the as yet (in the human being) imperfectly known course of the fibres in the spinal cord." So far as spinal injuries throw any light upon the subject, there does not, however, appear to be any necessity, in the cases composing Group B., to assume any other factor in the determination of the level of the lesion than the obvious anatomical conditions already referred to, varying as Reid has shown these conditions to be.

2. Another important practical point which is brought out by the above facts is that where (as in cases of injury) the site of the lesion relatively to the spine is already known, and where the anæsthesia extends as high as this level, then we are in the presence of a lesion sufficiently severe to have compressed both the cord and its roots,—one, therefore, in which any operation will probably be utterly hopeless.

There remain for consideration a few cases in which the upper limit of the anæsthesia is found to be considerably below that of the lesion—much lower than can be accounted for by the intra-vertebral course of the nerves. Two cases of this nature have been recorded above on pp. 26 and 47, and these two cases probably provide the explanation of the phenomenon. In one of them (Case 16) we had a central hæmorrhage in the lower cervical

[1] Med. Chir. Trans., vol. lxxi. p. 413.

region, and the complete anæsthesia, which was transient merely, only extended as high as the knees, thence shading gradually to "as high as a line drawn round the abdomen about two inches below the umbilicus." This being one of my earlier cases, I am by no means certain that the expression "as high as the knees" correctly represents the limits of the anæsthetic region, which probably extended much higher on the posterior aspect of the limbs (*infra*, pp. 126, &c.); but the important points are that the upper level was far below that of the lesion, and that the boundary was very ill-defined. Again, in Case 11, we find that the lesion was situated about the point of origin of the sixth cervical nerves, but that complete anæsthesia extended only as high as the sixth dorsal nerves; and that again the boundary was a very ill-defined one, some impairment of sensation extending upwards to the lower cervical nerves. In both cases there was ample evidence that the functions of the cord were not entirely destroyed by the lesion, and that some of its conducting fibres had escaped complete compression.

But in the first case, it is certain that the lesion was a central hæmorrhage; and in the second, there was no persistent bony displacement, so that hæmorrhage was the sole cause of symptoms, and hæmorrhage is always most severe in the centre of the cord. It will therefore follow that in both cases the more peripheral of the descending fibres would be less subject to compression than those more centrally situated; and if the sensory fibres for the lower parts of the body be the more centrally situated, these would chiefly suffer. It would appear that this is the case, and that in these two instances the eccentric pressure was insufficient to paralyse the most peripheral fibres—that is, those which leave the cord highest. This view will explain the very gradual increase in the anæsthesia from above downwards, and the suggested arrangement is also obviously probable, inasmuch as, if the higher fibres were situated centrally to those which leave the cord below them, they would require to cross the latter in order to reach their point of exit.

Such an explanation appeared to me adequate to explain the phenomena, until I became aware, from reading Mr. Horsley's paper above referred to, that the same tendency to implicate the lowest sensory nerves first is observed also in the case of tumours whose pressure upon the cord is concentric, and which would therefore, in accordance with the above theory, appear likely to produce at first an exactly opposite condition. In the absence of any other explanation, however, I am still inclined

to regard the theory as probably correct. The central parts of the cord are the most vascular, and the nerve-fibres are here least protected by the intramedullary connective tissue, so that even in the case of a concentric pressure lesion, we can understand that they may be the most susceptible both to the direct effects of pressure and to the indirect results of any localised congestion which may be, and probably is, created thereby.

Mr. Horsley also calls attention to the fact that, in the case of tumours, the direction of invasion of paralysis is the reverse of that of anæsthesia (and pain), being from above downwards. This same tendency is illustrated in some of the above cases, especially in Case 21 (p. 59), in which, during recovery from a lesion external to the cord, power of voluntary movement was partially restored in the lower limbs first, beginning at the ankle, and in the case of the upper limbs the paralysis improved in the hands only. So also the majority of the cases of hæmatomyelia present, during recovery, a return of power from below upwards. Possibly, therefore, the motor fibres are laterally arranged in a manner exactly opposite to that of those for sensory conduction, but the present evidence upon this point is even more scanty in the case of the former than in that of the latter.

Finally, it will be obvious that if, in a case of fracture of the spine, either myelitis or hæmorrhage extend above the level of the bony lesion, the nerve-symptoms will also extend to a corresponding degree,—a condition illustrated by Nos. 13 and 14 of my own cases, and by No. 16 of those quoted from Gurlt.

The above records of the surface temperatures in the paralysed and non-paralysed regions respectively are too few in number for safe generalisation, and they are here introduced mainly as affording material which may be useful in assisting future research, it being only by collective investigation that we can obtain satisfactory conclusions upon such a point in cases of such comparative infrequency as spinal injuries.

It would, however, appear that, in a complete transverse injury of the cord, we have produced, even from an early period, some contraction of the vessels of the paralysed regions—at least this is so where the injury is below the cervical region. Corresponding with the lower temperatures thus observed is the frequently noted dryness of the paralysed limbs, resulting from a deficient secretion of sweat, and giving to the hand a deceptive sensation of warmth.

It is even more obvious that when the spinal vaso-motor

centres are left in entire control of the vascular walls, they manifest an extreme sensibility to external impressions.

Thus it has been constantly observed in the preceding cases, as well as in those which will follow, that slight irritation of paralysed parts, as by scratching, produces a temporary active congestion of the skin. It would also appear from the results obtained in Cases 22 and 26 that the immediate effect of the application of the electric current is a contraction of the vessels, but that after a lapse of some little time this contraction is followed by a dilatation. I may add that care was taken in all these observations to equalise the conditions of exposure of the parts whose temperature was to be tested, and that neither the uncovering nor the wetting of the skin which accompanied the use of the galvanic battery explains the varying temperatures which resulted.

The importance of this abnormal mobility of the blood-vessels, and of their tendency to congestion upon slight irritation, in the causation of "trophic" lesions, is perfectly obvious, and there can be little doubt that similar vascular changes produce important effects on internal organs, as is illustrated by the urinary abnormalities recorded in Chapter I.—the occasional presence of albumin, of blood, of excess of urea, &c., and of a compound capable of rapidly decolourising Fehling's solution.

CHAPTER IV.

INJURIES TO THE CAUDA EQUINA.

ALTHOUGH the subject of the present chapter is but a portion of that to be considered under the head of injuries to the lumbo-sacral region of the spinal cord, it would appear convenient to regard apart a few instances of the commonest result of an incomplete crush of the cauda equina, and I have therefore reprinted almost verbally a paper which appeared in "Brain" in January 1888, to the subject-matter of which we can refer back in considering other injuries of the lower portion of the spinal cord and its nerve-roots.

The series of cases upon which are based the conclusions drawn in the present chapter appear 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 in the nature of the symptoms.

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 29.—*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 January 31, 1886, he fell from a scaffolding and injured his back. For five days he was unconscious, and he 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 extension and 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.		
	Kathodal Closure.	Anodal Closure.	Faradic Current.	Kathodal 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.

Sensation was normal on the upper part of the buttocks, that

is, in the region supplied by the last dorsal, ilio-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 exception 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 there had been no erections of the penis. On both heels were bed-sores of large size. The urine, which was retained, 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 bed-sores, underwent no change. On leaving, he was instructed to return, with a view to trephining the spine, but he 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 ilio-inguinal nerve, which, however, only descend 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 its level reflex action is lost.

CASE 30.—*Spina bifida—Cure—Cauda equina compressed by 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 twenty-four years of age, and gives the following account of himself. At birth he had a swelling (spina bifida) which was never larger than an orange, over the lower part of the back. Very soon after birth a needle was thrust into this, but he does not know whether any effect ensued. 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 causes 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 its edges and pale granulations at its base. Between the second and third toe on the same foot was at one period a second small ulcer, which recovered with rest. The arch of the foot is exaggerated, the toes 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 plantar reflex are absent on both sides; the cremasteric, abdominal, and epigastric reflexes normal. The electric reactions of the muscles are as follows: —

	Right Side.		Left Side.	
	K. C. C.	A. C. C.	K. C. C.	A. C. C.
	Cells.	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 do not present the "reaction of degeneration." To the faradic current they react 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," resembling that of locomotor ataxia in its sprawling hesitating character, but unlike the gait seen in that disease, in that the toes drop 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, the patient 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, and in 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 general

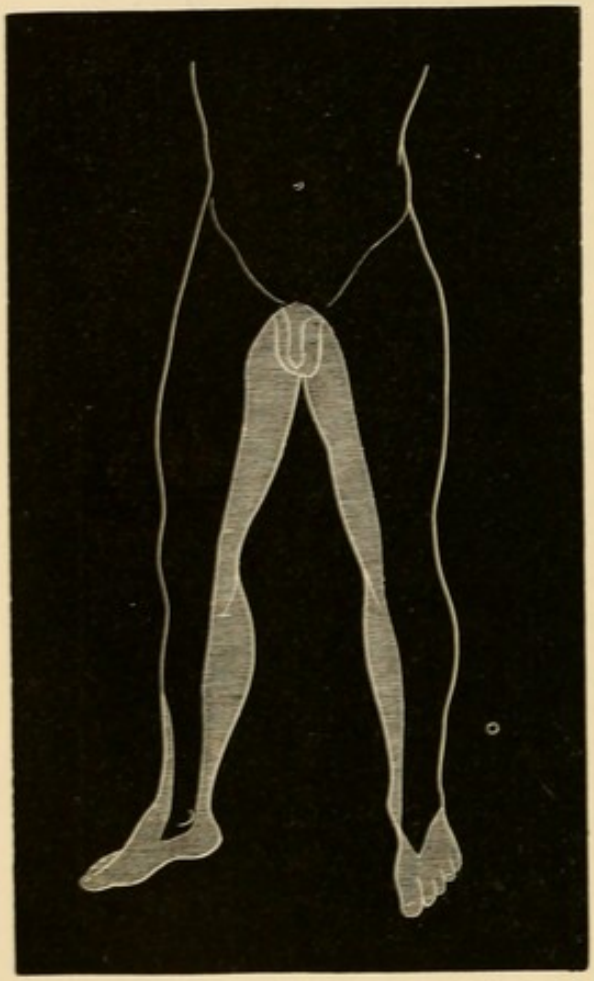


FIG. 11.

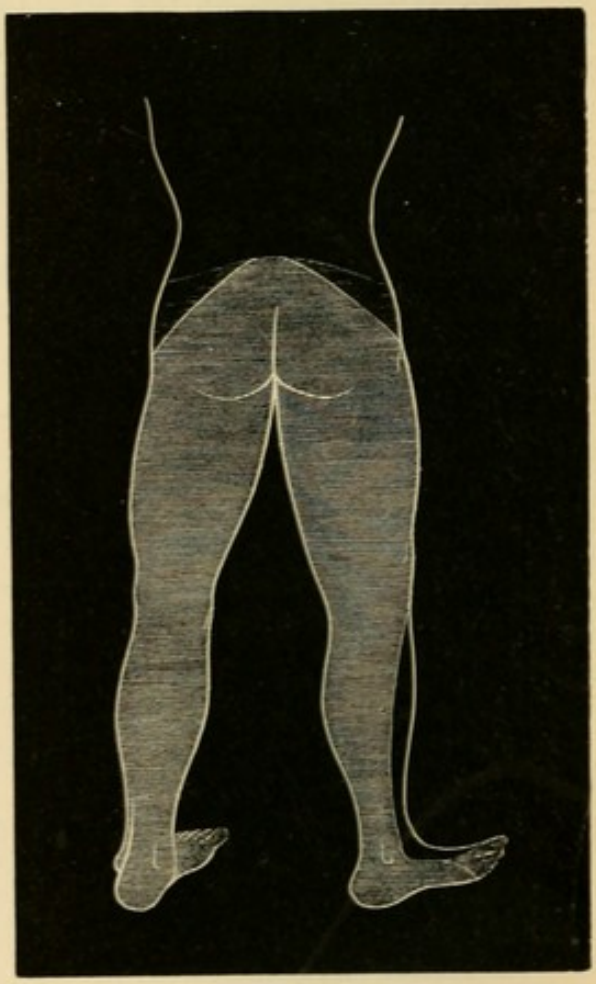


FIG. 12.

outline, 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 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 the anæsthetic area includes the gluteal region, the back of the thigh, the back and part of 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 its 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. He says that when under the influence of drink 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 last very closely, differing mainly in the less complete paralysis and in the partial reaction of degeneration replacing the complete degeneration shown by Case 29. The distribution of the anæsthesia is similar to that of Case 29. 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 a higher level of 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 a compression of the cauda equina by 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 Mr. Ogston[1] of old spina bifida with perforating ulcer of the left foot, anæsthesia 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 similar case is reported by Brunner[2] as an instance of *spina bifida occulta*. The patient had a depression over the spine extending 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.

Mr. Bland Sutton[3] has recorded another case of perforating ulcer due to *spina bifida occulta*, but we have no information as to the sensory and motor functions. He refers, further, to similar cases recorded by Recklinghausen and Fischer, the former presenting a perforating ulcer, the latter, chronic ostitis of the metatarsus, and both having anæsthesia of the feet.

The next case presents closely similar symptoms arising from the pressure of a tumour upon the cauda equina.

Case 31.—*Tumour of cauda equina.*

Joseph Davies was admitted under the care of Dr. Ross on May 12, 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,

[1] Lancet, 1876, vol. ii. p. 13. [2] Virchow's Archiv, 1887, p. 494.
[3] Lancet, 1887, vol. ii. p. 4.

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 5 he was ordered gr. v. doses of iodide of potassium. On July 13 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, those of the gluteal muscles being especially so. The plantar and cremasteric reflexes were well marked, but the gluteal was sluggish. The patellar tendon reaction was lively (? exaggerated) 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 were 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 ilio-hypogastric nerves, the backs of the thighs, and the bulk of the leg, omitting, however, the front of 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 buttocks. On going to stool, the patient 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

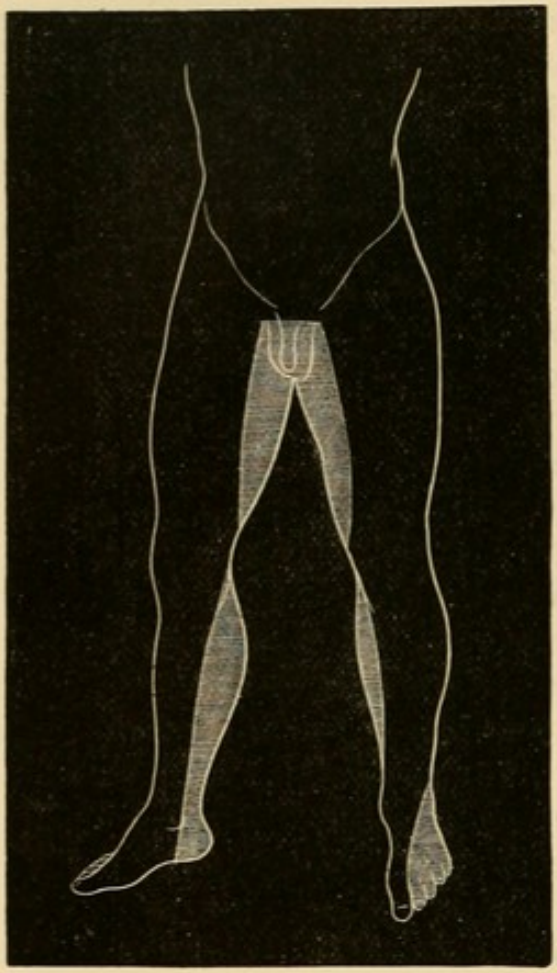


FIG. 13

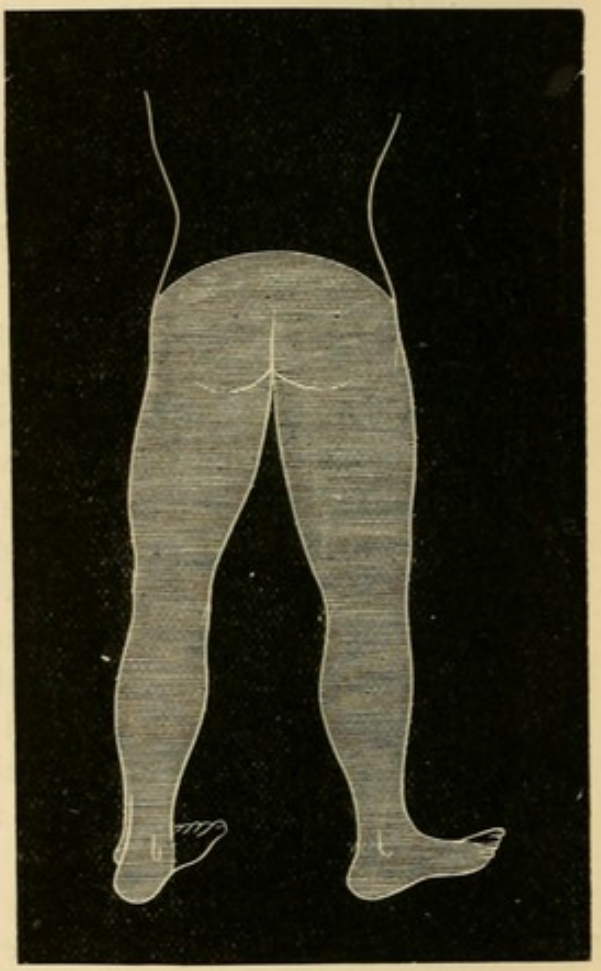


FIG. 14.

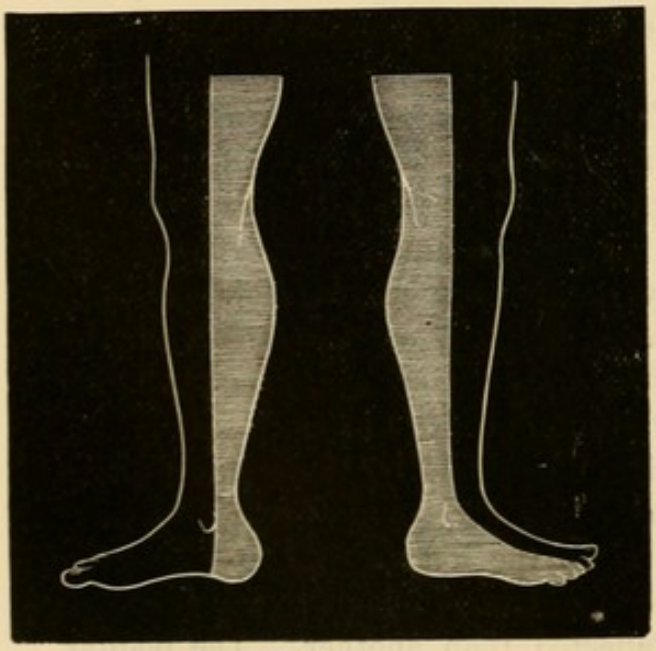


FIG. 15.

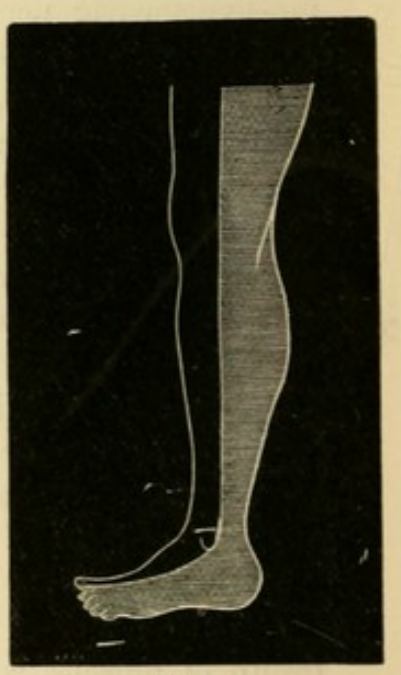


FIG. 16.

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:—

	Kathodal Closure.	Anodal Closure.
	Cells.	Cells.
Biceps femoris (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

The distribution of the anæsthesia at this date is indicated by the accompanying diagrams (figs. 13–17). Pain was still very great, but the general health remained fairly good. There was some redness over the trochanters and sacrum.

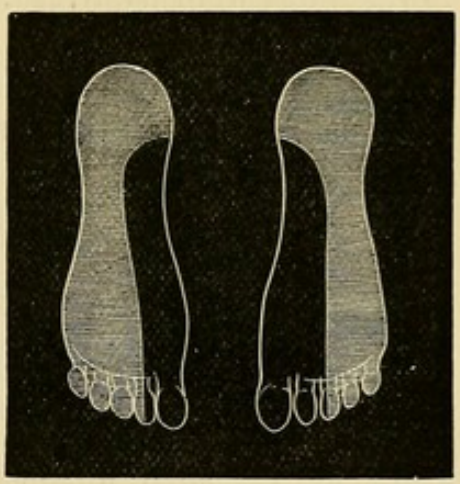


Fig. 17.

From this time the patient lost ground rapidly. The skin became 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 103.6° in the evening. On September 11 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 November 1 a bed-sore formed over the sacrum, and on November 15 he had convulsions and died in the afternoon.

No notes were taken of the post-mortem examination, but Dr. Ross, who was present, and Professor 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 29 and 30, 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 unusual, 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 Dr. 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 Dr. 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 32.—*Dislocation forwards of the second lumbar vertebra—Compression of the cauda equina.*

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

About the end of the previous August, while he was in the pit, and probably in a stooping posture, a stone weighing five or six cwts. fell from the roof—a distance of about five feet—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 fractured

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

limb, from which we may assume that it was anæsthetic. 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 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 process (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, but could be moved about the bed to some extent. The hips could be moved in every direction, but adduction was more powerful than any other movement; extension and flexion were about equally vigorous, 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, those below the knees being especially so; none of the lower limb muscles contracted with a faradic current of such strength as the patient could bear, but we were unable to test the galvanic reactions satisfactorily. 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 the lower part of the gluteal region, and thence down the back of the thighs and legs to the soles of the feet, as well as over the front of the legs and the dorsum of the feet. It was much less imperfect on the front of the thighs than elsewhere in the lower limbs, and was better on the inner than on the outer side of the legs. 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 stated that sensation had gradually improved since the accident. The feet always felt cold to the patient, 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 there was pain over the pubes, and smarting on micturition.

On January 15th—a fortnight after admission—Mr. Jones proceeded to trephine the spine in the affected region. Chloroform having been administered, the patient was turned on to his face, and an incision four inches in length was made in the middle line, with its centre over the prominent spinous process. From either end of this an incision of some three inches in length 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 then separated by blunt dissection, 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, so that 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 vertebra 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 would not submit to 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 2, 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 chairs, &c., walk a little; the thigh-muscles were fairly developed, and the hip and knee joints freely movable, 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 less acute on the outer than on the inner 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 this slight cystitis caused no subjective symptoms. 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.

About eighteen months after the last date this lad was shown by Mr. Jones to the members of the Manchester Medical Society. He was then at work as a collier, and could, with the aid of a stick, walk several miles, but the muscles of the feet and flexors and extensors of the toes remained paralysed, and there was some contraction of the posterior thigh-muscles, causing the knees to be always slightly bent.

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.

	Case 29.	Case 30.	Case 31.	Case 32.
Lesion	Dislocation of first lumbar vertebra.	Spina bifida . . .	Tumour	Dislocation of second 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 great and small sciatic and pudic nerves, and in posterior sacral branches. Slight if at all in external cutaneous, anterior crural, or obturator.	In great and small sciatic, pudic, and posterior sacral.	In great and small sciatic, pudic, and posterior sacral.	Partial in distribution of great and small sciatic and pudic.
Vesical and rectal symptoms	Retention of urine. Incontinence of fæces.	Partial retention of urine, preceded by incontinence. Partial incontinence of fæces.	Retention of urine. Retention of fæces.	Retention of urine. Constipation.
Vaso-motor and trophic symptoms . . .	No erections. Bed-sores on heels.	Erections normal. Perforating ulcer.	Bed-sores at various points.	None.

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 in order 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 entire cauda equina, and the cauda equina only; and further, in Case 29, the whole of the lumbar and sacral nerves pass out beneath its level, whereas in Case 32 it involves all but the ilio-inguinal and ilio-hypogastric; in Cases 30 and 31 the exact level of the pressure cannot be ascertained, but must clearly have been almost the same as in Cases 29 and 32.

In all of these 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 pass 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 equina, those nerve-roots which emerge lower down are more seriously injured than those above them, a conclusion the importance of which will be more obvious in the following chapter.

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. 100–105) gives a few instances, from several hundreds of cases of spinal injury, of which I have abstracted the records, showing more or less clearly the same group of symptoms, and indicating the various interpretations that have been placed upon them. The Table does not pretend to be exhaustive, but merely illustrative:—

Case	Reference.	Sex.	Age.	Result.	Probable Lesion.	Paralysis, &c.	Reflexes.
A.	Erichsen, Concussion of the Spine, 2nd ed. p. 30.	M.	14	Recovery in four months.	Inflammation around cauda equina, more marked on left side.	Came on gradually during ten days. Could then not stand, but moved legs in bed; no complete paralysis except in peronei and extensors of left ankle. Rapid wasting of left leg.	No note.
B.	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.
C.	Ollivier, Traité des Maladies de la Moelle Épinière, vol. i. p. 358.	M.	40	Partial recovery.	Gunshot wound in lumbar region.	None.	No note.
D.	Ollivier, *ibid.* p. 515.	M.	22	Partial Recovery.	Crush of cauda equina.	At first complete paraplegia. After two years could walk with assistance; ankle-joint flail-like; could flex but not extend the thigh, and extend but not flex the leg.	No note.
E.	Hutchinson, Lond. Hosp. Rep., vol. iii. p. 343.	M.	42	Death in five weeks.	Dislocation of 2nd lumbar vertebra.	Lower limbs were paralysed with the exception of the anterior thigh-muscles.	No note.
F.	Hutchinson, Lond. Hosp. Rep., vol. iii. p. 326.	M.	?	Recovery in four months.	Fracture in 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 third 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 urethra 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.
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.
After two years anæsthesia of feet, back of legs, thighs, buttocks, scrotum, and penis. Perfect sensation in front of limbs from groin to ankle.	Involuntary urination and defæcation.	No note.	Contusion in lumbar region.	...	Reported as a case of concussion.
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.	Bed-sore.	Absent.	Fracture of body and dislocation forwards of second 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 front of thighs. On 39th day had sensation in front of thighs and legs, in hypogastric region and scrotum; good sensation in first 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 fourth or fifth lumbar vertebra.

Case	Reference.	Sex.	Age.	Result.	Probable Lesion.	Paralysis, &c.	Reflexes.
G.	Hutchinson, Lond. Hosp. Rep., vol. iii. p. 332.	M.	33	Partial recovery in three months.	Dislocation of second lumbar vertebra.	Paralysis of lower limbs followed by some wasting, especially of glutei.	No note.
H.	M'Donnell, Dublin Quart. Jour. Med. Sci., 1866. vol. xlii.	M.	31	Partial recovery in twelve months.	Fracture in upper lumbar region.	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.
K.	Leyden, Klinik der Rückenmarkskrankheiten, vol. ii. p. 143.	M.	45	Death in seven weeks.	Fracture-dislocation of first 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"

Anæsthesia.	Bladder and Rectum.	Vaso-motor and Trophic.	Local Symptoms.	Post-mortem.	Remarks.
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.	Retention of urine and fæces.	...	Projection of third lumbar vertebra.	...	...
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.	Retention of urine, followed in four or five days by incontinence. Ammoniacal urine.	Occasional priapism. Wasting of lower limbs. Perspiration of feet and ankles. Œdema of penis and scrotum. Urethritis, cystitis. Bed-sore on back.	An immovable projection four inches above level of umbilicus.	...	The spine was trephined, which was followed by some improvement in the symptoms.
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.	Retention of urine and fæces.	No erections. Sweating of feet; œdema of lower limbs and scrotum. Bed-sores of feet and sacrum.	No note.	Fracture of first lumbar vertebra, the cartilage immediately below which projected backwards some ¼ inch (7 mm.). Lumbar cord swollen, soft and pale. Other secondary lesions.	See text. This is given by the author as a typical case of traumatic myelitis.

Case	Reference.	Sex.	Age.	Result.	Probable Lesion.	Paralysis, &c.	Reflexes.
L.	Leyden, Klinik der Rücken-marks-krankheiten, vol. i. p. 340.	M.	32	Death in five months.	Fracture of twelfth dorsal and first lumbar laminæ.	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.
M.	Hamilton, Dublin Quart. Jour. Med. Sci., vol. vi. 1848.	M.	25	Death in two months.	Fracture through body and laminæ of second lumbar vertebra.	Paralysis of lower limbs.	No note.
N.	Hutton, Dublin Jour. Med. Sci., vol. xxi. 1842.	M.	...	Death in six weeks.	Fracture of first lumbar vertebra.	Loss of power of the lower extremities.	No note.

I shall not add anything with regard to the details of the 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 pressure upon the cauda equina. Case A. is attributed by the author to "intraspinal hæmorrhage," but the date of appearance and the seat of tenderness would seem to warrant the interpretation given in the Table. Case B. appears to me to be most typical, and I entirely fail to appreciate the reason

Anæsthesia.	Bladder and Rectum.	Vasa-motor and Trophic.	Local Symptoms.	Post-mortem.	Remarks.
Anæsthesia not complete, but sensation almost lost in the feet, very obscure in legs, back of thighs, and buttocks; better in front of thighs.	Retention of urine and fæces.	Slight œdema of legs. Bedsore on sacrum.	Spinous process of first lumbar vertebra projected backwards and to the right.	Fracture of twelfth dorsal and first lumbar laminæ, and of body of first lumbar vertebra; tear of dura mater; compression of cord and cauda equina. Inflammation of pia mater and softening of cord extending to upper level of lumbar region. Secondary lesions.	Death from uræmia.
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 second lumbar spine.	Fracture through upper part of body of second lumbar vertebra and its laminæ, 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 first lumbar vertebræ.	An oblique fracture of the body of the first lumbar vertebra, with compression of the cord and cauda equina, which were bathed in pus.	...

given for regarding it as an instance of "concussion." The lesion was below the region of the cord itself and over that of the cauda equina, and the symptoms are those of pressure upon, or partial destruction of, the latter. In Case F. 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 by the nature of the nervous symptoms described. At first all the muscles of the lower limbs seem to have been paralysed (unfor-

tunately, sensation was not at that time accurately noted), thus, it would seem, indicating that the entire cauda equina was primarily paralysed, but that recovery of the higher roots rapidly ensued.

The best description is that of Leyden (Case K.), who appears to have attributed the symptoms mainly to myelitis, and not to the crush of the cauda equina; but although the co-existence of myelitis is proved by the post-mortem appearances, the site of the lesion and the fact that the symptoms followed immediately after the accident, appear to indicate a primary lesion of the cauda equina. In the other cases, the localisation is, as a rule, obvious enough from the facts above furnished.

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

1. From locomotor ataxia. In a traumatic case there is little likelihood of confusion, although even here the affection 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 incoordination. 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. Failing this, the diagnosis becomes one of very great difficulty, the only other differential symptom being the existence of constant pain or hyperæsthesia above the anæsthetic region, a condition which points rather to the cauda equina than to the cord itself as the seat of disease. In lesions of gradual increase, such as tumours, the rate of production of the various symptoms will assist us, as in Case 48, where a history of six years' progressive development points rather to an affection of the cauda than of the spinal cord. Asymmetry of the symptoms also probably indicates a lesion of the cauda equina.

3. From extra-spinal diseases and injuries of the nerves to the lower limbs. 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 peripheral 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 (Case A., 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 site 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.

CHAPTER V.

INJURIES OF THE LUMBO-SACRAL REGION OF THE SPINAL CORD.

As in the case of the cervical region of the spinal cord, we may, before entering upon a study of traumatic lesions of the lumbo-sacral region, recapitulate briefly the conclusions of previous observers regarding the functions of the various nerve-roots which constitute the crural plexus.

These conclusions are derived from two methods of research —the experimental and the clinical—and hitherto they have not been verified by any accurate anatomical investigations corresponding to those of Herringham upon the roots of the brachial plexus.

Drs. Ferrier and Yeo,[1] observing the effects of experimental irritation of the several roots of the crural plexus, classify as follows the muscles supplied by each :—

Third lumbar type :—Ilio-psoas, sartorius, adductors, extensor cruris.

Fourth lumbar type :—Extensors of thigh, extensor cruris, peroneus longus, adductors.

Fifth lumbar type :—Flexors and extensors of toes, tibial muscles, sural muscles, peroneal muscles, outward rotators of thigh, hamstrings.

First sacral type :—Muscles of calf (plantar flexors), hamstrings, long flexor of big-toe, intrinsic muscles of the foot.

Second sacral type :—Intrinsic muscles of the foot.

The objections to an implicit reliance upon these experimental results have been already indicated in considering the analogous

[1] Brain, vol. iv., 1882, p. 226.

observations upon the brachial plexus, but, as in the latter case, we find that they agree in the main with the results of clinical experience.

The classification of Dr. Gowers[1] is derived from a comparison with the above of such scattered clinical records as throw any light upon the distribution of functions, and the results thus obtained are embodied in the following Table:—

Root.	Motor.	Sensory.	Reflex.
First lumbar Second lumbar	Cremaster.	Groin and scrotum (front).	Cremasteric.
Third lumbar	Flexors of hip.	Thigh: Outer side.	
	Extensors of knee.		*Knee-jerk.*
Fourth lumbar	Adductors of hip.	Thigh: Front.	
Fifth lumbar	Extensors and abductors of hip.	Thigh: Inner side.	Gluteal.
First sacral	Flexors of knee.	Leg (inner side).	*Foot-clonus.*
Second sacral Third sacral	Intrinsic muscles of foot.	Buttock (lower part) Back of thigh. Leg and foot except inner part.	Plantar.
Fourth sacral Fifth sacral Coccygeal	Perineal and anal muscles.	Perineum and anus. Skin from coccyx to anus.	

Peroneus long. Flex. of ankle. Ext. of ankle.

If, now, we endeavour, as in the cervical region, to obtain from an examination of cases of spinal injury fresh data for accurate localisation, we at once find ourselves confronted by several difficulties which render useless the method pursued in the earlier investigation. In the first place, death comparatively rarely follows injuries in the lumbar region, so that we have not the advantage of an absolutely accurate localisation. The cases also which are met with in an individual experience are too few for generalisation. Again, owing to the fact that the whole of the nerves of the lumbo-sacral plexus originate from the spinal cord within the short vertical extent of the last dorsal and first lumbar vertebræ, it is practically impossible to find spinal injuries which accurately cut off their separate levels of origin. And, finally, most important of all, is the fact that the nerve-roots of the lower portion of the cord have so extensive an intraspinal course that they are generally implicated together, and, owing to the solidity of the sacrum, do not become separately cut off by lesions near their points of exit.

But, in spite of these difficulties, it is possible, by a careful comparison of cases, to obtain, from the evidence supplied by

[1] Diseases of the Nervous System vol. i. p. 142.

spinal injuries alone, a fairly accurate conception of the functions of each of the nerve-roots which enter into the lumbar and sacral plexuses. The following cases, partly original and partly quoted, are intended to illustrate these functions, and will be found to supply a tolerably complete picture of the effects produced by their loss.

As in nearly all these cases the lesion was so situated that all the nerves of the cauda equina might possibly have been affected, it will be necessary to make certain assumptions, viz., first, that if after a crush of the cauda, certain fibres are injured and others not, the injured nerves originate lower that those which are spared; and second, that where destruction of certain functions is partial only, then, the more complete such destruction, the lower is the nerve whose injury has given rise to it. The ground for these assumptions is that, as a matter of fact, we seldom find nerves, known to arise high up in the crural region, injured whilst those below them have escaped,—a general proposition for which the evidence will be found in the preceding chapter (p. 99).

It will again be convenient first to present in tabular form the results at which I have arrived, and then to consider in detail the evidence upon which the conclusions are based. In the Table thus given, it is to be distinctly understood that I have inserted only so much of the distribution of each root as is illustrated by the following cases. Thus, although there is no doubt whatever that the second lumbar root supplies muscular branches, these are here ignored because the cases yield no evidence of the same. The separation of some of the roots will be seen to be, to a certain extent, arbitrary, and it is not improbable that, owing to the physiological requirements of the lower limb, the specialisation of the spinal nuclei and the concomitant isolation of their efferent motor fibres are less marked than in the case of the upper extremity, and that I may thus have ignored minor nervous connections running in roots other than those which supply the chief motor branches to each muscle; but, as already suggested, it is probable that this very absence of accurate detail itself renders the results of the more value as a practical clinical guide, for which purpose we require to know only such relationships as will influence the production of symptoms.

Root.	Motor Distribution.	Sensory Distribution.
First lumbar . . .	None.	Ilio-hypogastric and ilio-inguinal.
Second lumbar . .	None.	Outer (?) and upper part of thigh.
Third lumbar . . .	Sartorius. Adductors of thigh. Flexors of thigh.	Anterior aspect of thigh below second lumbar root.
Fourth lumbar . .	Extensors of knee. Abductors of thigh.	Anterior and inner part of leg.
Fifth lumbar . . .	Hamstring muscles.	Back of thigh, except in distribution of first, second, and third sacral.
First sacral . . .	Calf muscles. Glutei. Peronei.	A narrow strip on back of thigh, back of leg, and ankle ; sole ; part of dorsum of foot.
Second sacral . .	Extensors of ankle.[1] Intrinsic muscles of foot.	
Third sacral . . .	Perineal muscles (erector penis, transversalis perinei, accelerator urinæ, &c.). (Nervi Erigentes.)	Perineum, external genitals, "saddle-shaped" area of back of thigh.
Fourth sacral . . .	Bladder and rectum.	

CASE 33.—*Fracture of first lumbar vertebra—Crush of conus medullaris.*

One of the least extensive lesions produced by injury to the lumbar cord is that found in the following case, recorded by Kirchhoff.[2]

A man, aged thirty, fell sideways from a horse on to his nates. As a result of this accident, he was at first unable to walk, and was confined to bed for three months. During the first three weeks he had retention, and thereafter incontinence of urine, with cystitis. He suffered also from involuntary and unconscious defæcation. After some nine months he grew gradually better, until he could remain on his legs all day, but there was no material change in the condition of his bladder and rectum. At the end of eighteen months he was seen by Kirchhoff. At that period he presented tenderness and some deformity over the first

[1] Here, as elsewhere, the term "extensors of the ankle" is used in reference to the *anterior* muscles, *i.e.*, the extensors in a morphological sense.

[2] *Arch. für Psychiatrie*, vol. xv. p. 607.

lumbar spine. The walk was slow and straddling (*weitbeinig*), motor and sensory power were preserved throughout the body, but all four limbs were weak. The patellar reflexes were a little exaggerated. With these symptoms he had loss of control over the bladder and rectum. After complete emptying of the former (by the catheter), urine was retained for some two hours, but incontinence then ensued. If the fæces were fluid, they could not be retained at all; but if solid, he could hold them until the bed-pan was brought. Cystitis was followed by pyelitis, secondary abscesses, and death.

At the autopsy was found a crush of the first lumbar vertebra. The discs above and below it met in front, and the body was driven backwards in the form of a triangle, which projected about 1 cm., compressing the lower end of the cord some 3 cm. above the filum terminale. The conus medullaris was also forced to the right of the displaced bone. Microscopical examination showed degeneration of the conus medullaris and ascending degeneration of the cord, but no injury to the fibres of the cauda equina. Besides these changes, there were the ordinary appearances of pyelitis and metastatic abscesses.

In the above case we find a practically uncomplicated lesion of the termination of the spinal cord, whose nerves appear to supply the bladder and rectum only. True, there would seem to have been originally some slight injury to other nerves going to the lower limbs, but the effect of this general pressure on the cauda was almost entirely transient, and the only definite result was paralysis of the sphincter ani and of the detrusor and sphincter vesicæ, both doubtless due to the mischief done to the termination of the cord. That the detrusor was paralysed is shown by there being pure retention of urine for the first three weeks, followed by incontinence when partial recovery permitted of some return of function. It is impossible to derive any information as to the relative vertical arrangement of the reflex centres.

Now the absence of any anæsthesia about the perineum, penis, or scrotum, and the negative evidence that there is no note of any interference with the sexual functions, such as would arise from paralysis of the muscles of this region, sufficiently indicate that the majority, at any rate, of the fibres of the pudic nerve had escaped injury, and that the other chief branches of the sacral plexus had done so is obvious. We are thus driven to localise the lesion, in this case, immediately above the fourth sacral nerve or its point of origin, because the pudic and the

nerves for the lower limbs receive such large reinforcement from all the roots above this point, that we can hardly imagine a lesion involving the third sacral, and yet giving rise to such slight symptoms. For the present, therefore, we may assume this to be illustrative of a lesion of the fourth and fifth sacral and the coccygeal nerves only. The small patch of anæsthesia (in the region of the tip of the coccyx) and the paralysis of the levator ani, which might be expected to result from injury of the two latter branches, would readily escape notice.

CASE 34.—*Fracture of last lumbar vertebra—Compression of cauda equina by callus.*

Strikingly similar to the foregoing is the following case, which was treated in Mr. Whitehead's wards in the Manchester Infirmary.

D. E., a collier, aged forty-nine, was at work in a coalpit towards the end of October 1885, and was standing upright when an unknown weight of coal fell from the roof, striking him across the back of the hips. He became immediately paraplegic, and afterwards remained in bed, without, he said, undergoing any improvement, up to the date of his admission to the Infirmary, some seven weeks after the accident, viz., on December 24, 1885.

On admission, he appeared very ill, and the whole body was much wasted, the muscles of the upper limbs being as atrophic as those of the lower, except that the nates had perhaps chiefly suffered. He presented no cerebral symptoms. The spine showed no deformity, and could not be said to be tender at any point, although there was vague soreness over the sacrum. He complained of severe neuralgic pains, shooting down the backs of the thighs and legs to the heels, and at times extending from the bladder to the end of the penis, or referred to the sacrum. Pressure on either sciatic nerve, between the tuber ischii and the great trochanter, caused intense pain. The bladder was much distended, and there was a constant dribbling flow of urine, accompanied by much pain, but he retained some power of voluntarily increasing the flow by great efforts. He was greatly troubled by constipation, and had no control over the passage of his fæces. Without support he could not stand at all, but, with very slight assistance, he could walk with a sprawling, hesitating gait, and in bed he could move his lower limbs in all directions.

All the muscles reacted readily to the faradic current, and presented no abnormality with the galvanic; tactile, thermal, and muscular sensibility were normal everywhere; the super-

ficial reflexes were normal, the knee-jerks slightly exaggerated, but there was no ankle-clonus. The skin of the whole body was covered with a sour perspiration, and that over the sacrum was red and inflamed. The temperature was normal; pulse 78, full, regular, and rather compressible. Urine acid, clear, of sp. gr. 1020, and without albumin. He suffered much from thirst. No inquiry was made as to the sexual functions.

Treatment consisted in complete rest in the supine position, with periodic evacuation of the bladder.

On the evening of December 31, a week after admission, the temperature, which had hitherto been normal, rose suddenly to 103.2°, and it thereafter remained high. At the same time the urine became alkaline and foul, and he suffered from constant nausea and vomiting, with foul tongue. These symptoms were followed by fibrillar tremblings in the muscles of the trunk and limbs, by rapidly increasing and intense emaciation, obstinate insomnia, fœtid sweating, and a very frequent (180) intermittent pulse. On January 18 he became violently delirious, and lapsed into a "typhoid" condition, with a running uncountable pulse, and two days later he died.

The post-mortem examination was made by Dr. Harris, then pathologist to the Infirmary, whose report states that on opening the spinal canal there was found on its anterior aspect, projecting from the posterior part of the body of the last lumbar or first sacral vertebra, a disc-shaped bony prominence about the size of a marble. Although no other signs of fracture were to be found, this was taken to be probably due to callus. This nodule compressed the entire cauda equina opposite to it—that is, some $4\frac{1}{2}$ inches below the conus medullaris—through a vertical extent of about half an inch, the component nerves being united by a delicate and vascular newly-formed connective tissue. The spinal membranes themselves and the cord were healthy throughout, there being no meningeal thickening even opposite the bony nodule. Above and below the latter the nerves of the cauda equina presented no abnormality, nor was any change detected in the sciatic nerves, either with the naked eye or with the microscope.

The bladder cavity was abnormally large, although not very markedly so, its walls of normal thickness, its mucous membrane pale and smooth, except at the posterior part, where there was a small recent hæmorrhage in the submucous tissue. It contained a large quantity of pale slightly turbid urine. The ureters were not dilated. Both kidneys were much enlarged—the right weighing nine, the left ten ounces; their capsules peeled readily, but

were thickened, and throughout their substance were numerous minute abscesses, each surrounded by a dark zone of hæmorrhage; the pelves were normal. The aortic valve of the heart was thickened and incompetent; both this and the mitral valve showed evidences of recent endocarditis; the walls of both ventricles were of normal consistency, but thickened, the entire heart weighing 13½ ounces. The other organs of the body were healthy.

Here, then, we have a case in which the cauda equina was partially compressed about the level of the last lumbar vertebra. From this resulted severe neuralgia in the sciatic and pudic nerves, and weakness of some of the muscles of the lower limbs, but no complete paralysis and no anæsthesia of the limbs. Following the rule to which we have already referred, that the lowest branches of the cauda suffer most in a general pressure lesion, we find a complete paralysis of the sphincter ani and of the nervous mechanism of the bladder. The paralysis was here evidently due to interference with the peripheral fibres, and not with the nuclei. The power of expelling some urine by voluntary straining was probably due solely to action of the abdominal muscles. As in Kirchhoff's case, there is a possible doubt whether (ignored on examination) the region between the coccyx and anus, usually supposed to be supplied by the coccygeal nerve, may not have presented a small patch of anæsthesia, but certainly there was no loss of sensation in the perineum or limbs. Hence, then, this case further indicates that the branches for the sphincter ani and the bladder muscles have a lower origin than those supplying the skin and muscles of the perineum. There are several points in the case not inquired into so fully as might be wished, due to the fact that in 1885 my attention had not been directed to the details of the subject.

CASE 35.—*Injury to cauda equina (?)—Paralysis of bladder and sphincter ani.*

On March 16, 1887, I saw, with Mr. George Thomas, of Bradford, T. O., thirty years of age, who sustained an accident on December 29, 1886. On that date he was standing up in a cart, when a van ran into the latter from behind, throwing him out in such a way that he fell upon his back on the road, striking the lumbar region against the curbstone of the pavement. He was able to get up at once and to walk, but says that his legs felt stiff and trembled. Shortly afterwards he walked up some stairs to the top of a warehouse, and he drove home.

On reaching his home he went to bed, and during the day the lower limbs became partially paralysed, as they have since remained. From that time until I saw him he had been bedridden, but had undergone little or no change except general loss of flesh from confinement. At first he had severe pain in the lumbar region, but in a few weeks this diminished, and in March 1887 he had only some aching, mainly when sitting up.

On examination, he was found to present partial paralysis of the lower limbs. He could get out of bed and across the room by means of supports, but could not stand if unaided. When lying down, he moved the limbs at every joint, but only with great effort and to no very great extent. There was no marked wasting of the muscles. He stated that ten years previously he had had a fall, ever since which his right foot had "dropped a little." He believed the weakness of the limbs to be increasing.

There was nowhere any anæsthesia. The knee-jerk and ankle-clonus were much exaggerated, the plantar reflex normal, the cremasteric absent. He complained of his legs occasionally "jumping" at night.

His urine ran away from him almost constantly, but was not fœtid; bladder dulness extended from the pubes to the umbilicus. He knew when he was about to pass his fæces, but could not retain them, and must at once obey the call to stool. He had no priapism, nor any trace of trophic lesions, and erections of the penis occurred as usual.

Locally there was no deformity, but some tenderness of the spine, most marked opposite the level of the posterior superior iliac spines. The general health had remained fairly good.

Mr. Thomas has kindly endeavoured to obtain some information for me as to the subsequent progress of this case, but has been unable to hear anything very definite. The bladder and rectal symptoms appear to have undergone no improvement, but the paresis passed off, and no further troubles have supervened. In the summer of 1888 he was farming near Chester, and "looked fairly well."

Hence in this case also the entire cauda equina would seem to have been temporarily injured as regards the motor power of its nerves, but the only permanent trouble was, as in Kirchhoff's case, the interference with the bladder and rectum, supplied by the lowest roots. The case is, however, not satisfactory evidence, as the lesion may have been a slight transverse myelitis in the upper lumbar region.

We may next refer to a group of cases in which the above-described symptoms were present, but were accompanied by other phenomena, indicating a somewhat higher lesion.

CASE 36.—*Injury of the cauda equina involving the third sacral nerves.*

Huber[1] reports the following case:—

A man, aged twenty-four, fell some six yards on to a paved street, alighting in a sitting position. He immediately felt great pain in both tubera ischiorum, in the lumbar region, over the sacrum and along both sciatic nerves, and he could not stand. From the moment of the accident he had retention of urine, with involuntary evacuation of fæces, accompanied by obstinate constipation. He could hardly move his legs, and had a feeling of numbness in them. The sacral and gluteal regions were very tender. After about a month he could stand and walk, and at that time he came under Huber's observation. He then complained of retention of urine, incontinence of fæces, slight weakness of both lower limbs, and numbness in the soles of the feet. Great flexion of the hips caused pain from the exit of the sciatic to the middle of the thighs. There was no paralysis of either limb, and the reflexes (superficial and deep) were all normal. He was found to have anæsthesia about the anus and seat, in the perineum, scrotum, and penis, and on part of the posterior surface of the upper part of the thighs. The boundaries of this region were not sharply defined, and will most readily be understood from the accompanying representation of Huber's diagram (fig. 18), which by the degree of shading indicates the varying intensity of the anæsthesia. Although the scrotum was anæsthetic, the testes were not. There was very dull sensation on passing the catheter or introducing the finger into and pressing upon the rectum. An ill-defined sensation was noticed before fæces were passed. The walk was normal and without pain. He could bend the back, but on bending the knees had slight pain in the calves. There was no deformity of the back. Some three

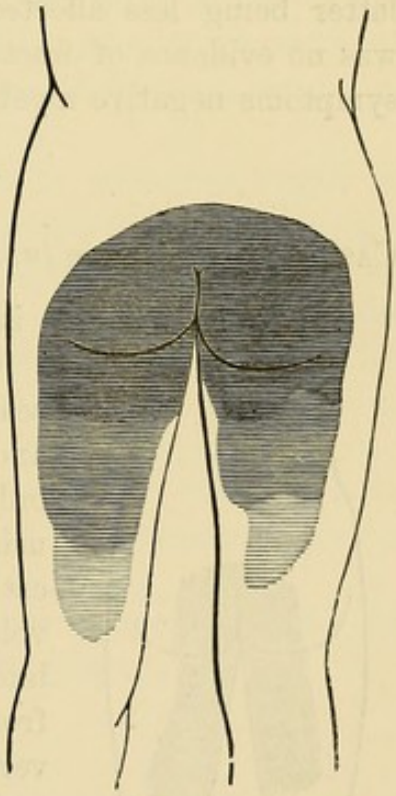


FIG. 18.

[1] *Wiener medizinische Wochenschrift*, 1888, Nos. 39 and 40.

months after the accident it became unnecessary to use the catheter, as the patient could by strong pressure on the bladder cause the urine to flow slowly. He had sometimes partial erections of the penis—not, he thought, sufficient for copulation—and two or three times there was an escape of semen with slight voluptuous sensation, there being no ejaculation, but only a slow escape from the urethra.

Huber's diagnosis is intra-meningeal hæmorrhage below the lumbar enlargement, which for a short time compressed the cord itself, causing the paralysis, and is still pressing on the roots of the pudic and coccygeal nerves, as well as on the lower roots of the sciatic nerve, which furnish the small sciatic branch, the latter being less affected than the pudic and coccygeal. There was no evidence of fracture, and the immediate onset and other symptoms negative myelitis.

CASE 37.—*Injury in lumbar region, involving the third sacral roots.*

A very similar case is related by Bernhardt:[1]—

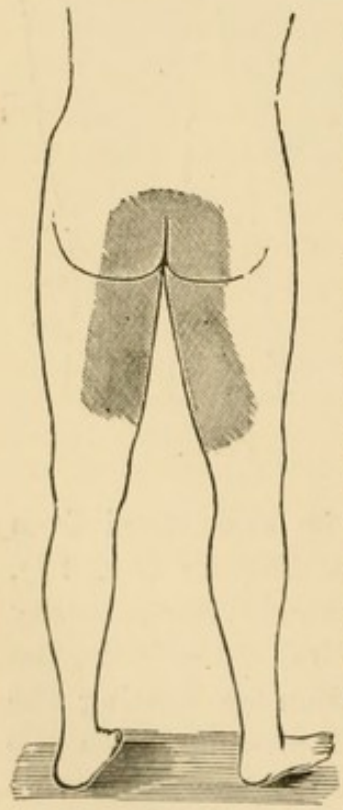


FIG. 19.

On January 10 a patient fell on to his seat from the second floor of a building, and, not losing consciousness, complained only of pain in the back and retention of urine. On the following day he had to be catheterised, and he passed his fæces involuntarily and unconsciously. Nine days later he could stand alone, but had pain from about the seventh to the twelfth dorsal vertebra, where there was some swelling and tenderness. He had still retention of urine and unconscious defæcation. There was no paralysis of the lower limbs, the superficial and deep reflexes were normal, and, except in one region, sensation to all varieties of impression was normal. Anæsthesia was, however, complete in the perineum, scrotum (but he could feel pressure on the testicles), penis, over the lower part of the sacrum and coccyx, and thence outwards for about a hand's-breadth, as well as down a strip on the inner and posterior aspect of the thighs, indicated in the accom-

[1] *Berliner klinische Wochenschrift* August 6, 1888.

panying figure (fig. 19). The patient continued to use the catheter, but had no sensation of the bladder being full. He could feel by abdominal movements when he passed fæces, but did not feel their course through the rectum or anus. He had sometimes erections, and once a pollution, and in February he performed coitus. By May he could sometimes pass a little urine, but never completely emptied the bladder, and if he was not catheterised the latter would ultimately become over-full, and urine would flow. On the 12th of May he found that on coitus the act was normally performed, except that the semen was retained in the urethra, and only escaped in drops some time afterwards. An electric current was not felt in the perineum, urethra, or rectum, nor could any contractions be felt by the finger in the levator ani or perineal muscles. After continued electrisation of these parts there was some improvement in the power of passing urine and retaining fæces.

What the exact nature of the lesion in this case might be could not be ascertained without a post-mortem examination. Bernhardt insists mainly on the fact that while the nervous supply to the bladder and rectum was almost absolutely destroyed, that of the genital system was but little affected. The nervi erigentes were uninjured, and so perhaps was the nerve to the erector penis; sexual pleasure was also retained, but impotence resulted from the loss of expulsive power—that is, from paralysis of the accelerator urinæ and transversalis perinei muscles.

Two other cases, recently published by Oppenheim and by Osler, still further illustrate this group of symptoms.

CASE 38.[1]—*Fracture of first lumbar vertebra—Crush of cord about level of origin of third sacral roots.*

A man, aged twenty-four, fell from the second floor of a house on to his sacrum. After a brief period of unconsciousness, he noticed numbness and paralysis of both lower limbs, both of which symptoms rapidly passed away. He had immediate retention, followed by complete incontinence of urine and fæces, with unconsciousness of their passage. Neither erections nor passage of semen ever occurred after the injury. At the region of the first and second lumbar spinous processes was some angular curvature. Of the muscles of the lower limbs, those of the calf

[1] Oppenheim, *Archiv für Psychiatrie*, Band xx. Heft 1.

only showed very slight weakness; otherwise there was no loss of power, and no atrophy or electrical change. The knee-jerk was exaggerated, but there was no ankle-clonus. Anæsthesia affected the region of the anus, buttocks, perineum, scrotum, and penis, and a small strip on the inner and posterior aspect of the upper part of the thighs: above, it was limited by a line about half-way down the sacrum, and externally it extended to midway between the tuber ischii and great trochanter. Cystitis and fever supervened, the patient dying about three months and a half after the injury.

At the post-mortem examination was found a fracture of the first lumbar vertebra. The terminal portion of the conus medullaris was compressed, showing the histological appearances of myelitis with hæmorrhages, and the lowest sacral roots were degenerated. The remaining roots of the cauda equina were almost absolutely normal.

CASE 39.[1]—*Injury in lumbar region involving third sacral roots.*

A man, aged forty-seven, fell from a bridge into a sitting posture, and at first sustained paralysis of the legs, bladder, and rectum, the paralysis of the lower limbs passing off gradually. Sixteen years after the injury he had slight weakness and atrophy of the left lower limb. The spine presented no local signs of injury. He had no control over the bladder and rectum, and was impotent. The gluteal and cremasteric reflexes and the knee-jerk remained. Anæsthesia is represented in the annexed copies of Osler's diagrams (figs. 20 and 21), and affected the lower gluteal regions, posterior aspects of the thighs, perineum, scrotum, and penis as far as its root. The urethra was also insensitive.

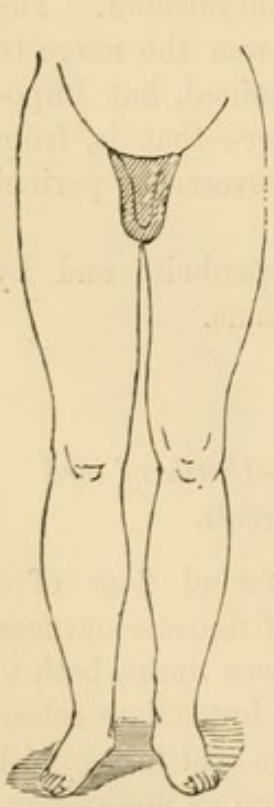


FIG. 20.

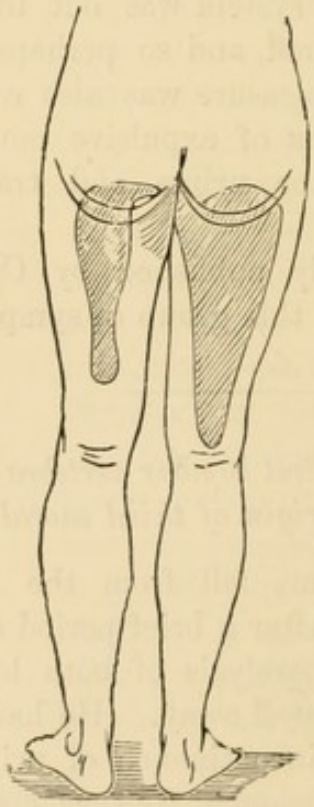


FIG. 21.

[1] Osler, Medical News, December 15, 1888.

It will thus be seen that, just as our three first cases represent a group in which the injury is of the slightest nature, and probably affects only the terminal roots of the cord, so also the last four form another group in which we have the same vesical and rectal troubles *plus* paralysis (in the male) of the ejaculatorates seminis, with anæsthesia of the perineum and genital organs and of a patch in the thighs, which, from the obvious coincidence with those parts of the thigh which come first into contact with a small saddle, we may perhaps call the "saddle-shaped" type.

We find then in our second group destruction of function of the fourth and fifth sacral and of the coccygeal nerves, together with anæsthesia of the entire cutaneous distribution of the pudic nerve, and of part of that of the small sciatic (especially its inferior gluteal branch), and paralysis of some, perhaps all, of the muscular branches of the pudic (running to the transversalis perinei, erector penis, accelerator urinæ, and compressor urethræ). May we not then venture to assume that this second group of cases represents the effects of injury to the third sacral and subjacent nerves, the third thus being the root which supplies the bulk of the pudic trunk, and a portion of the sciatic, devoted apparently to such of the cutaneous distribution of the small sciatic nerve, as has been fully described?

In these cases we find also an interesting condition of the nervi erigentes. In Case 36 these nerves were apparently partially paralysed; in Case 37 they had entirely escaped injury; and in Case 38 they were totally paralysed (in Case 39 we have no precise information). Dr. Gaskell has localised these nerves in the second and third sacral roots, a conclusion which perfectly explains the varying extent of the injury done to them in a lesion of the third.

Thus far we have referred only to injuries of the extreme lower roots of the sacral plexus, but owing to the obscurity of the few recorded cases of injury or disease immediately above this region, it will perhaps be better now to turn to the upper limits of the lumbar plexus, and to trace *downwards* the connecting links which lead us to the previous groups. I have no instance of a lesion immediately below the first lumbar root, but it is not necessary to adduce evidence that that root supplies the ilio-hypogastric and ilio-inguinal nerves. To what extent it provides fibres of the genito-crural I am unable to say.

CASE 40.—*Dislocation of last dorsal vertebra—Paralysis below second lumbar nerve-roots.*

T. H. was admitted into the Manchester Royal Infirmary, under the care of Mr. Hardie, on January 16, 1888. He was a labourer, aged thirty-nine, and was loading a cart when a bale of cloth fell upon his shoulders, doubling him up. For the first few minutes he was unconscious, and then found that he had lost both motion and sensation in the lower limbs. On admission, he complained of pain in the lower part of the back and the right side of the

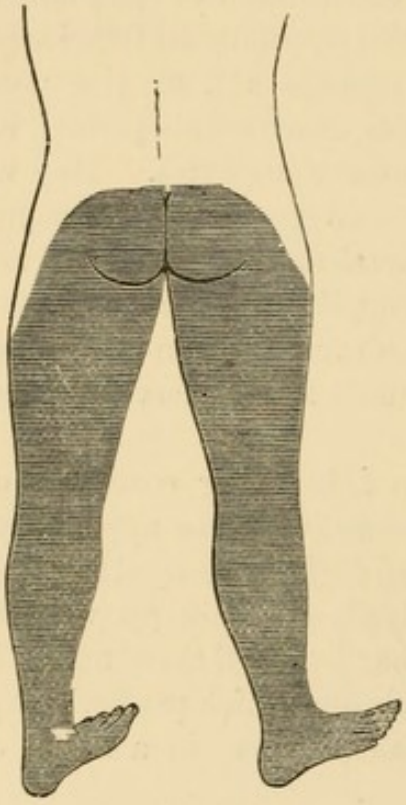


FIG. 22.

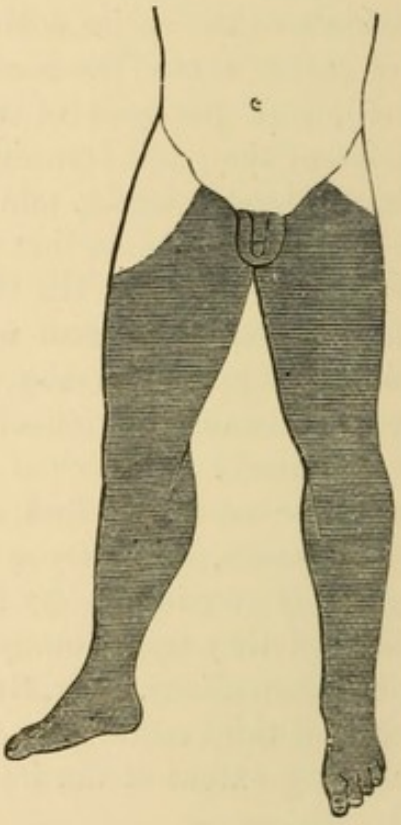


FIG. 23.

chest, pain being also caused in the lumbar region of the spine on pressing down the shoulders. Two of the lower spinous processes were somewhat prominent. The lower limbs were entirely paralysed, but there was no affection of the trunk or upper extremities. He had anæsthesia of the lower limbs, with the following boundaries:—In front, sensation extended accurately to the line of Poupart's ligament, except that on the outer side of the left thigh there was a patch of sensation extending downwards, and of about the size and shape of the hand with the fingers held downwards. On the right side was a patch of similar shape, but about twice the above size, and extending more to the front of the thigh.

The penis and scrotum were also anæsthetic, except at the upper part of the latter, *i.e.*, in the distribution of the ilio-inguinal nerve. Behind, anæsthesia was limited by a line extending from the upper part of the great trochanter to the posterior superior spine of the ilium, and thence to the middle line. The annexed diagrams best illustrate the boundaries of the affected region (figs. 22, 23).[1]

The plantar and cremasteric reflexes were absent, as were also the knee-jerks. The penis was turgid, urine was retained, and had to be drawn off by the catheter; it had a sp. gr. of 1014, was acid, and contained no albumin or sugar, but gave a deposit of phosphates. The pulse was feeble, 96 per minute; temperature 99°; respiration somewhat abdominal, with bronchitis, due to a cold which had existed before the accident.

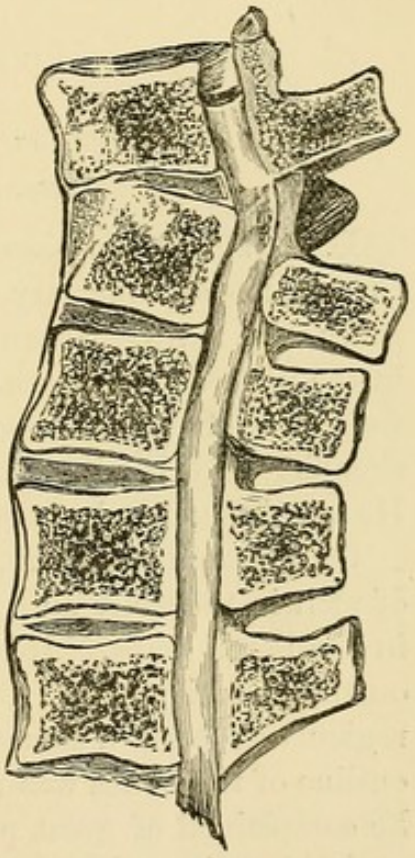


FIG. 24.—Fracture of first lumbar an dislocation of last dorsal vertebra.

Three days after admission the urine became alkaline and fœtid and contained blood, which was present for a day or two only, and was then replaced by pus. For several weeks thereafter no change of importance occurred, and the general condition improved, the bronchitis passing off, and the cystitis varying in severity from time to time. Wasting of the lower limbs came on gradually, and two months after the accident their muscles were all found to be insensitive to the faradic current. The feet also became somewhat œdematous. Turgidity of the penis still continued, but appeared to be due to irritation from use of the catheter. About this time the patient complained of great loss of sight in the right eye, but repeated examinations made both by Dr. Little and myself failed to show any abnormality, either organic or functional, with the exception of myopia. During the next month this symptom gradually improved.

On May 16th, when I last saw him, he had been very ill for several days, with much vomiting, and was very thin; his nervous symptoms presented no change of importance, the paralysis and anæsthesia being the same as on admission. The urine constantly dribbled away from him, was very fœtid, and contained much pus.

[1] In fig. 22 the unshaded or sensitive area is carried too low on the left side.

Four days later he died exhausted. The temperature throughout the case was usually slightly raised.

The post-mortem examination was made by my clerk, Mr. Hopkinson, who removed several of the vertebræ, from a sagittal section of which is taken the annexed sketch (fig. 24). The latter shows a fracture of the first lumbar vertebra with dislocation forwards of the last dorsal. The lower part of the spinal cord and the trunks of the cauda equina were, after death, not markedly compressed by the projection backwards of the former bone. In the bodies of both vertebræ were changes due to chronic osteomyelitis, but there was no trace of callus.

CASE 41.—*Dislocation of last dorsal vertebra—Paralysis below second lumbar nerve-roots.*

L. L., aged thirty-seven, a collier, was admitted to the Manchester Royal Infirmary, under the care of Mr. Heath, on February 21, 1888. Shortly before admission he had been working in the pit when a portion of the roof, of which he judged the weight to be about two tons, fell upon him, striking his left shoulder and bending him forwards, so as to double him up. He was immediately paralysed, but did not lose consciousness.

On the following day, when I examined him, he complained of pain in the belly and back, and of loss of power and sensation in the lower limbs. He had also the effects of a severe bruise on the left shoulder. Over the lower dorsal and upper lumbar region was found a somewhat extensive depression, but the exact outline of the bones was masked by effused blood. In this region he complained of great pain and tenderness, but he had no pain on jerking the spine from above. The lower limbs were absolutely paralysed, but the thoracic and abdominal muscles as well as those of the upper limbs had escaped injury. The limitation of anæsthesia was not very distinct; "it appeared to extend over all nerves below the last dorsal, except that in the distribution of the ilio-inguinal, ilio-hypogastric, genito-crural and external cutaneous there remained some vague sensation." About the level of the ilio-hypogastric and last dorsal was slight hyperæsthesia. The knee-jerk and the plantar and cremasteric reflexes were absent. All these symptoms were symmetrical.

The urine, which was retained, and had to be withdrawn by the catheter, had a sp. gr. of 1030, was loaded with urates, contained a little albumin, and gave a very well-marked sugar reaction.

The penis was slightly turgid. He had had some bronchitis before the accident, and had at this time a bad cough, the chest movements being feeble. Temperature, 100°; pulse, 80; pupils, somewhat dilated.

On the following day the line of demarcation of the anæsthesia was better marked, and its distribution was found to be on both sides almost identical with that represented on the right limb in figs. 22 and 23. The urine contained less albumin (there being a scarcely perceptible trace), and no sugar.

For some days there was no marked change. The cough improved slightly. The urine became alkaline and fœtid, and on February 28 contained swarms of micrococci, mostly in pairs and small chains, but no pus. The anæsthesia extended an inch or so upwards on the abdomen, with a hyperæsthetic band above it. On March 2 it had reached to a line $2\frac{1}{2}$ inches above the umbilicus, but was by no means complete for some distance below this level. The bowels were at first obstinately confined, but after the administration of croton oil on February 27, fæces were passed involuntarily. Pain round the abdomen was so great as to require frequent use of morphia and belladonna stupes. The temperature became daily a little higher, reaching after February 27 to about 103°, with no marked variations. On March 3 he was obviously sinking; his cough was very troublesome, the bronchial passages much obstructed, and the temperature fell three degrees. On March 4, the twelfth day, he died exhausted.

Fig. 25.—Fracture of first lumbar and dislocation of last dorsal vertebra.

At the post-mortem examination we found the disc between the twelfth dorsal and first lumbar vertebræ ruptured, and the anterior part of the latter vertebra broken away obliquely, as shown in the accompanying engraving (fig. 25). The spines of these two vertebræ were separated behind, owing to the twisting forwards of the last dorsal, but there was not at the time of the autopsy any displacement sufficient to narrow the spinal canal. The pedicles of the twelfth dorsal vertebra were also broken across, but without displacement of its arch, and its articular processes were separated from those of the first lumbar. The dura mater was intact, and the cord and cauda equina not compressed, nor

was there any hæmorrhage into the spinal canal. The cord was, however, quite soft at the seat of the lesion, and for some two inches above it.

In these two cases we have complete paralysis of the crural plexus, except that certain sensory nerves have escaped. The skin-area thus spared is represented by figs. 22 and 23, and it will be found that the nerves not interfered with are the ilio-hypogastric and ilio-inguinal, which undoubtedly arise from the first lumbar root; together with a part of the distribution of the genito-crural, arising from the first and second lumbar, and of the external cutaneous, which arises from the second and third lumbar.[1] The lesion in each case may, therefore, probably be supposed to be beneath the second lumbar nerve, which will perfectly explain the sensory effects. We should expect the testicles also to be sensitive, owing to the distribution to them of the genital branches of the genito-crural, but, unfortunately, this point was not investigated in either case. They have, however, been found to retain sensation in several cases of injury at slightly lower levels. There is no evidence that any muscles supplied by the plexus escaped paralysis, it being impossible to demonstrate the functions of the nerve to the cremaster, except by the reflex, which is here annihilated by the anæsthesia. The turgidity of the penis noticed in both cases is merely the semi-distended condition seen in most spinal injuries, and is quite different from the distension of erection such as may occur when the injury is below the level of the nervi erigentes.

We are thus brought downwards to the level of origin of the third lumbar nerve-roots. Below this region I have no cases to offer in which the differentiation of roots was produced by a localised crush of the cord, but if we grant the original postulate that in crushes of the cauda equina the most injured roots are those of lowest origin, we obtain much information from the cases related in the previous chapter.

Thus in Case 29 the distribution of the anæsthesia indicates a complete paralysis of the entire sciatic nerve, and of all the nerve-roots inferior to those from which it arises. Hence the muscles partially paralysed are presumably supplied by the third and fourth lumbar roots, the chief tributaries of the anterior crural. These muscles are, in the order of increasing severity of paralysis, as follows:—

[1] In referring to the distribution of sensory nerves, I have used Mr. Wagstaffe's edition of Heiberg's "Atlas" (London, 1885).

1. Flexors of the thigh :—psoas, iliacus, with assistance of sartorius and rectus.

2. Adductors of the thigh *and* extensors of the knee :—adductor group, rectus and quadriceps femoris.

3. Abductors of the thigh :—tensor fasciæ and fibres of the glutei.

If, again, we compare the relative strength of the muscles in Case 32, in which the lesion was similar, we have :—

1. Adductors of thigh.
2. Flexors and extensors of thigh.
3. Extensors of knee.
4. Abductors of thigh.

In both cases, then, we find the adductors and flexors of the thigh retaining more power than the extensors of the knee or abductors of the thigh, so that we may localise the nuclei of the adductors and ilio-psoas higher than those of the quadriceps, tensor fasciæ, and gluteus maximus. The considerable power retained in the extensors of the thigh in Case 32, I can—having regard to the otherwise demonstrated interference with the functions of the sciatic—only regard as probably due to an error of observation. It is an extremely difficult matter to estimate the comparative contractile power of the muscles of the lower limb, and in this instance, as the patient could only be satisfactorily examined when lying on his back, the action of gravity would assist the extensors of the thigh and oppose both the flexors of the thigh and extensors of the knee.

The cases tabulated on pp. 98, 100, bear out this arrangement, as do Cases 30 and 31, the diagrams of the distribution of anæsthesia in the two latter illustrating the sensory distribution of nerve-roots below the fourth lumbar.

On the basis of the above results, I would then assign to the third and fourth lumbar roots the innervation of the adductors, flexors, and abductors of the hip-joint, and of the extensors of the knee-joint, and would place the adductors and flexors of the thigh at a higher level than the other muscles supplied from the anterior crural, so that probably the third lumbar root supplies the adductors and ilio-psoas, the fourth lumbar the rectus, quadriceps, and tensor fascia femoris.

The position of the sartorius is perhaps determined by a case of spinal injury recorded by M'Donnell,[1] in which the muscles of the lower limb were paralysed, with the exception of those of the "front of the thigh," which were paretic only, and of the sartorius, which appeared to have entirely escaped injury. Hence it would

[1] Dublin Quarterly Journal of Medical Science, vol. xlii. *Supra*, p. 102, Case H.

appear that the spinal nuclei for this muscle must be assigned a high position in the region of origin of the third lumbar root.

The sensory distribution of the third and fourth lumbar roots is best illustrated by the diagrams of retained sensation in Cases 30 and 31, but I have no facts which assist us to differentiate the two roots satisfactorily. In Case 44, recorded below, the method of disappearance of the anæsthesia would seem to indicate that the plexus patellæ (derived from the obturator nerve), and the long saphenous, arise lower than the middle and internal cutaneous branches of the anterior crural.

The cremasteric reflex is retained when the third and fourth lumbar roots escape paralysis, but lost when the lesion extends above their level of origin.

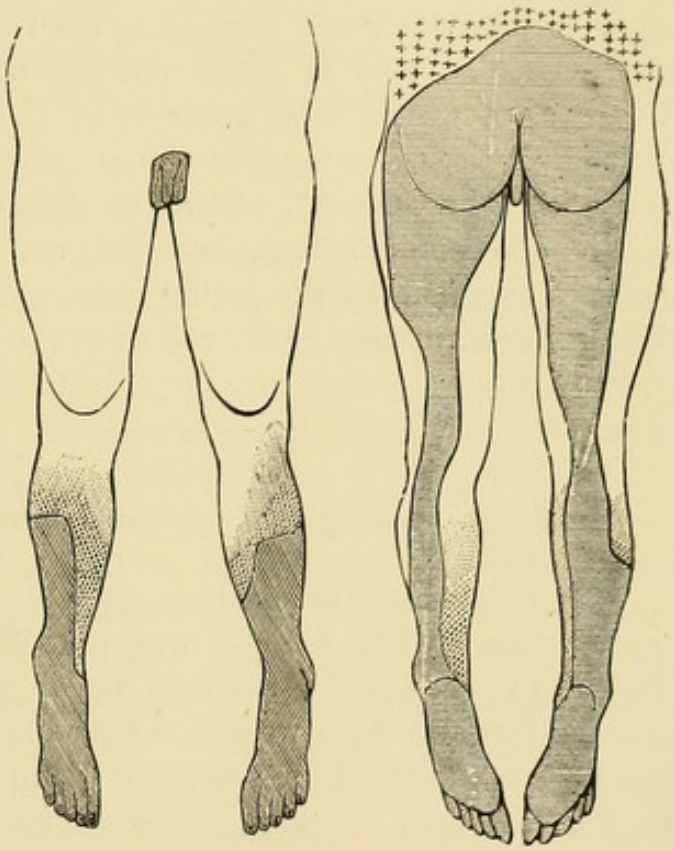
Passing on now to the consideration of roots below the fourth lumbar, we find that in Case 32, where these inferior roots had partially escaped injury, the muscles of the posterior aspect of the thigh retained more power and recovered much more thoroughly than those of the leg and buttock. We are thus led to regard the former as supplied from a higher point in the cord, and we may assign them to the fifth lumbar root, which gives a very large branch to the sciatic. This would leave us with the first and second sacral roots for the supply of the glutei and leg-muscles. Unfortunately the evidence available to enable us thus to split up the functions of these three great tributaries of the sciatic is very scanty, but, such as it is, it bears out the above view.

CASE 43.—*Dislocation of fifth lumbar vertebra—Injury to sacral nerve-roots.*

Kahler[1] relates the case of a young man who had fallen a distance of about nine yards, probably on to the buttocks. The lower limbs were at first completely paralysed and anæsthetic, but a certain amount of improvement shortly ensued, so that in seven months he could walk with crutches. After that period there was no further change. When examined after the lapse of two years, the spine showed marked lordosis, the second lumbar spinous process was in its normal position, the third was depressed, and the fourth still more so, the fifth being so deeply seated that it could not be felt. Various details given in the original paper show clearly that the fifth lumbar

[1] *Prager medic. Wochenschrift*, 1882, Nos. 35, 36, and 37.

vertebra was dislocated forwards on the sacrum. The patient had no control over the bladder, which was much distended, and emptied itself involuntarily. Defæcation was also involuntary. In the lower limbs the adductors of the thigh and the quadriceps were well developed, the tensor fasciæ, posterior thigh-muscles and glutei were much wasted, as were all muscles below the knee, those of the calf being the best developed of the latter. Both feet were pointed. Adduction and flexion of the hip were powerfully performed; extension, and especially abduction, feebly so. Extension of the knee was well performed; flexion almost impossible. Active movements of the foot and toes were totally paralysed. The peroneus longus and brevis, the tibialis anticus, and the extensor communis digitorum presented the reaction of degeneration, but the rest of the above-mentioned muscles (including the glutei and gastrocnemii) did not. The knee-jerks were retained. Slight ankle-clonus could be elicited, but the plantar reflex was lost. The sensory deficiency is best indicated by a copy of Kahler's diagrams (Figs. 26 and 27).



FIGS. 26 and 27.—The hyperæsthetic area is shaded with crosses; the region of total anæsthesia with lines; in the area indicated by large dots there was loss of the senses of pain and of temperature only; in that of the small dots, loss of temperature sense.

The temperature of the lower limbs was the same as that of the rest of the body. Over the gluteal region was a bed-sore, but no other trophic changes presented themselves.

Kahler regards this as an instance of injury to the fifth lumbar roots, at their point of exit between the last lumbar vertebra and the sacrum; but it would appear to the writer to represent rather a crush of the cauda equina at this level. The distribution of the anæsthesia corresponds to an injury involving the pudic nerves and the greater part of the area supplied by the sciatics, and the

affection of the bladder and rectum also show the lower roots to have been affected. Taking this view, we can arrange the muscles of the limb in the order in which they suffered, *i.e.*, probably in the order, from above downwards, of the origin of their nerve-fibres, thus:—

1. The adductors and flexors of the thigh uninjured.
2. Extensors and abductors of the thigh weakened and wasted.[1]
3. Glutei and gastrocnemeii paralysed and much atrophied.
4. Peronei, extensors of ankle (and intrinsic muscles of foot?) entirely paralysed, and presenting the reaction of degeneration.

This supposition is borne out by the ultimate condition of Case 32, in which, after recovery of the other muscles supplied by the sciatic, those moving the ankles and toes remained paralysed, and by Case 30, where the sensory paralysis affected the sciatic and pudic nerves, and the motor paralysis chiefly the muscles supplied by the pudic nerve and those about the ankle. Further confirmation is derived from the following:—

CASE 44.—*Injury to the lower (? second) sacral nerve-roots.*

This case was kindly shown to me by Dr. Jones, of Wath-upon-Dearne. The patient was a collier, aged forty-six. On March 15, 1887, he received an injury to his spine, being doubled forwards by a weight falling on to his back. His lower limbs were paralysed for sixteen weeks, and he had "very little" feeling in them. During the first fortnight his urine had to be drawn off by the catheter.

When I saw him, eighteen months after the accident, he complained of pain and a burning sensation in the hips. He walked with the knees bent, throwing his weight on to the heels, and he could not raise the toes of the left foot from the ground when the foot was kept firm, those of the right being moved with difficulty only. He had nowhere any anæsthesia. The plantar reflex was lost, the cremasteric retained on both sides, and the knee-jerks were absent. He required much straining to pass water, but could do so by his own efforts. There was no rectal trouble, and coitus was, he said, normally performed. The spinous

[1] The nerves to these muscles pass out of the vertebral canal above the level of the lesion, but there are several obvious explanations of an upwards extension of the pressure upon the cauda equina.

process of one of the lumbar vertebræ, apparently the first, was displaced about half an inch to the right of the middle line.

Here the only traces of paralysis were found in the extensors of the toes and in the wall of the bladder, and there was no anæsthesia.

In the following the paralysis was almost universal in the lumbo-sacral plexus, but the anæsthesia produced by injury to the lower nerve-roots of the sciatic is well indicated.

CASE 45.—*Dislocation of last dorsal vertebra—Paraplegia—Partial anæsthesia—Trephining.*

J. M., aged twenty-eight, a pattern-maker, was admitted to Mr. Jones's wards on March 9, 1888. A few minutes before he was brought in, some iron plates, which he estimated to weigh about 10 cwts., had fallen on to his shoulders, bending him forwards. He resisted their weight, but was gradually forced down until the plates were held up by some bystanders, just before he came to the ground. He was at once deprived of all power of motion and sensation in the lower limbs.

On admission, there was found a circumscribed swelling over the lower dorsal region, one of the spinous processes being unusually prominent, deflected about an inch to the left side, and movable, but without crepitus. Chloroform was administered, and traction made upon the thighs, with counter-extension from the axillæ and lateral movement of the pelvis, first to the left and then to the right side. By this means the line of the spinous processes was rendered straight, and pads and a bandage were applied to keep it so. The patient was then placed on a water-bed.

On the following day, when I first saw him, the man complained of pain in the lower part of the back and abdomen, and in the upper part of the front of the thighs. No pain resulted from vertical jarring of the spine. Owing to the bandages, the spine itself was inaccessible. The lower limbs were completely paralysed, but the muscles of the abdomen, thorax, and upper limbs had escaped. The plantar and cremasteric reflexes and the knee-jerk were absent.

Anæsthesia extended over the front of the lower limbs to as high as a point two inches above the knee-joint, the boundary-line being concave downwards, and lower on the inner than on the outer sides of the knees, as in the annexed diagram.

In front of the thighs there was some hyperalgesia. From the wish not to disturb the patient, to whom the slightest movement caused great pain, the posterior aspects of the lower limbs were not examined.

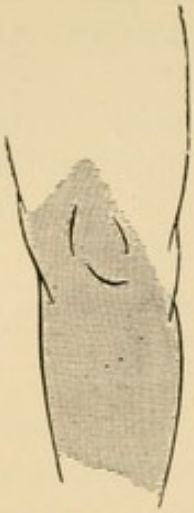


Fig. 28. — Anterior aspect of right knee of J. M., showing boundary of anæsthesia.

The urine was retained, had a specific gravity of 1026, and was faintly acid, containing no deposit, but a mucous cloud, and traces of albumen, but no sugar. The penis was not turgid. The axillary temperature was 99°, and remained near the normal throughout the progress of the case.

During the next few days the hyperæsthesia of the front of the thighs disappeared. Fæces were passed involuntarily and unconsciously. The muscles of the lower limbs became very tense, and vague sensibility was elicited by deep pressure on the legs. On the fourth day a small bulla formed on the right heel. On the sixth, the urine became ammoniacal and purulent, and on the eighth incontinence ensued. That the latter was not due to retention only was shown by the absence of defined bladder dulness, and by the fact that dribbling continued even immediately after the use of the catheter.

By the twelfth day returning sensation had extended downwards to below the patella in front of the lower limbs, but the entire posterior surfaces of both thighs as well as of the legs were now found to be anæsthetic. The bulla on the heel had healed up again.

On April 15—*i.e.*, thirty-seven days after the accident—the condition was as follows:—The lower limbs were still completely paralysed and a good deal wasted. Their muscles all presented the partial reaction of degeneration, giving no response to the faradic current, but reacting more readily to the kathodal than to the anodal closing shock. The plantar reflex and knee-jerk were absent, the cremasteric reflex normal, and the epigastric very lively. The limits of sensory affection were not very well defined, but there was slight hyperæsthesia and hyperalgesia, beginning about one inch below the umbilicus, and extending to immediately below the knees in front. Below this area was anæsthesia. Here the limit was ∧-shaped, with the apex upwards, and reaching to a little below the patella, sensibility extending about half way down the inner side of each leg, and to a much less extent on the outer side. Behind there was very obscure sensation of the outer side of the gluteal region and back of the thighs and

legs, but the inner parts of the gluteal region, the perineum, scrotum, and penis, presented complete superficial anæsthesia. Deep pressure elicited vague sensation everywhere. The testes were as sensitive as usual. Observations with the æthesiometer yielded the following results:—

Anterior aspect of	R.	thigh,	two points placed	longitudinally	felt at a distance of	4¼in.
,,	L.	,,	,,	,,	,,	5½in.
,,	R.	,,	,,	transversely	,,	1⅝in.
,,	L.	,,	,,	,,	,,	1½in.
Posterior aspect of	R.	,,	,,	longitudinally	,,	over 5½in.
,,	L.	,,	,,	,,	,,	over 3in.
,,	R.	,,	,,	transversely	,,	over 5½in.
,,	L.	,,	,,	,,	,,	over 3in.

[The instrument would not measure beyond 5½ inches, and on the backs of the thighs, when placed transversely, the points could not be separated more than three inches without passing beyond the confines of the sciatic nerve to those of the anterior crural and external cutaneous, upon doing which they were immediately distinguished. Great pressure was required over the backs of the thighs to make the instrument felt at all, and probably at no distance could the two points have been distinguished.]

We may then sum up these observations by saying that (1.) Absolute anæsthesia affected the inner part of the gluteal region and postero-internal aspect of the thigh, the perineum, penis, and scrotum, and the lower branches of the sciatic nerve, as indicated by the heavy shading in the annexed diagrams (figs. 29 and 30); (2.) Somewhat less insensitive was the remainder of the region supplied by the large and small sciatic nerves; and (3.) Sensation was still more perfect in the distribution of the obturator, the anterior crural, with its long saphenous branch, and the external cutaneous nerve; but (4.) At an earlier period (that indicated in fig. 28) the plexus patellæ of the obturator nerve was anæsthetic.

At this same period also we found the skin of the lower limbs rough and dry, yielding, on slight scratching, a well-marked hyperæmic line. About a fortnight previous to this date the patient said he had had an erection, and possibly he might have had a second, but there had been no sexual desire. His bladder was beginning to regain retentive power, and he could hold his urine for some two hours at a time, then passing it involuntarily, but not unconsciously. The fæces were still passed involuntarily and unconsciously. There was no affection of the optic discs. The back presented no pain or tenderness, the spinous processes were not displaced laterally, but that of the first lumbar vertebra was markedly prominent posteriorly, there being depression of those above it.

About May 8 the patient began to suffer occasionally from a sensation of cramps (unaccompanied by movement) and from shooting pains in the lower limbs; and about May 26 he acquired slight power of voluntarily contracting the anterior thigh-muscles. The cystitis gradually improved, and the general health remained good.

From this time there was practically no improvement beyond a very slight gain in cutaneous sensibility, appreciable only by measurements with the æsthesiometer, and it was now decided

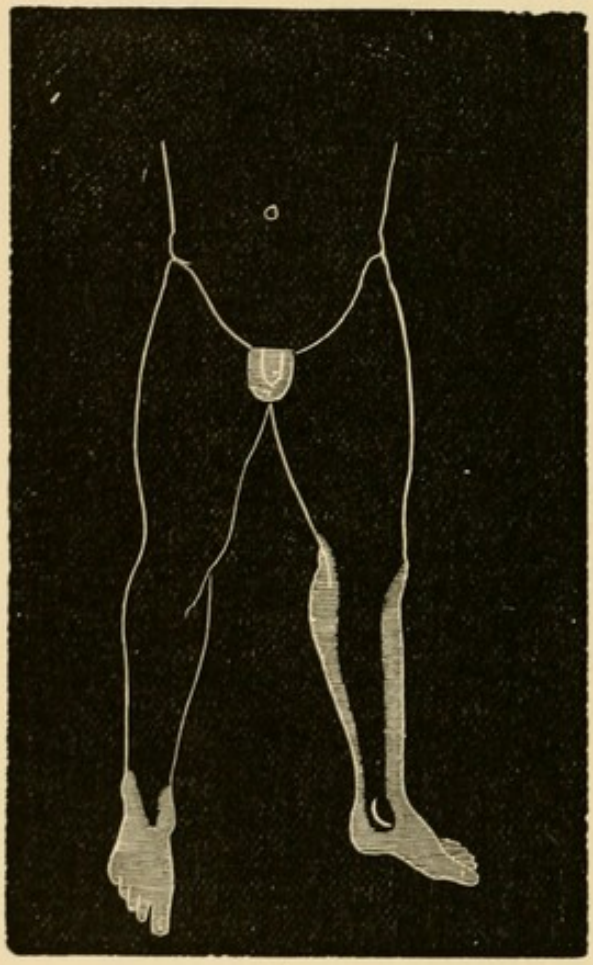


FIG. 29.

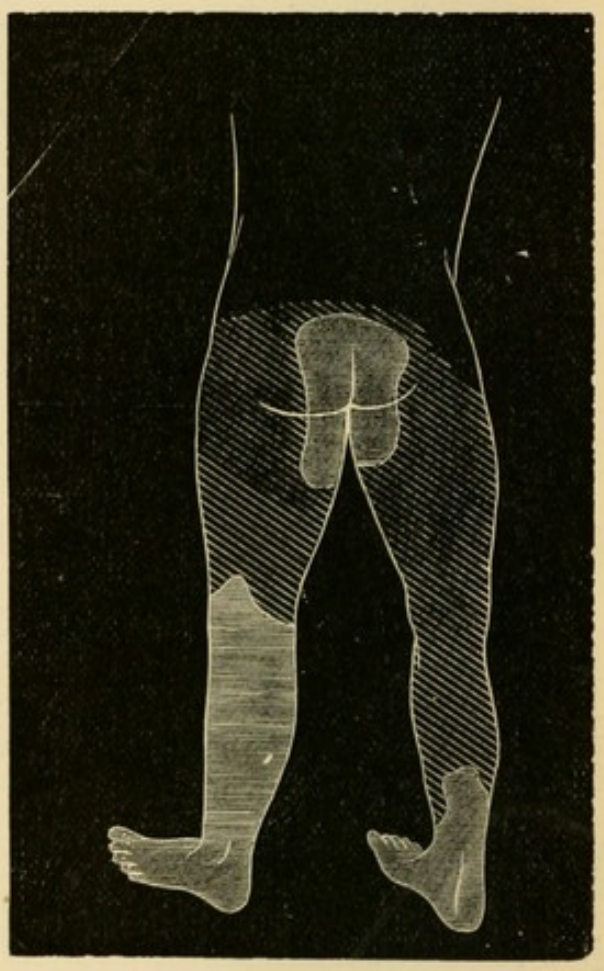


FIG. 30.

to trephine the spine, an operation which was performed by Mr. Jones on July 14, 1888, eighteen weeks after the injury.

The patient having been chloroformed, was turned upon his face, and an incision was made, some five inches in length, to the left side of the spine, and with its centre opposite the projecting spinous process of the first lumbar vertebra. From both ends of this, other incisions were carried at right angles across the spine, and a rectangular flap of skin and subcutaneous tissue was thus raised. By means of the knife the vertebral muscles were cleared and then held aside, exposing the arch of the first lumbar verte-

bra, which was removed with bone-forceps, so as to lay bare the dura mater. The latter appeared to be healthy, although protruding somewhat backwards, but between the arches of the first lumbar and last dorsal vertebræ it was compressed by a mass of soft cicatricial tissue. As much as possible of this tissue was removed, together with the whole of the arch of the last dorsal vertebra, and the theca was then found to be so much flattened that its contents appeared to have been quite cut across. Immediately above this region the dura mater bulged slightly, and a small spicule of bone having penetrated it, some cerebro-spinal fluid escaped. All pressure on the theca being now removed, the skin flap was replaced and sutured, a drainage tube having been first inserted in the deepest part of the wound. The surfaces were dusted with powdered boracic acid, and dressed with iodoform and sublimated wood-wool pads. No spray was used.

On the day after the operation the temperature rose to 100°, and there was a good deal of shock, with much pain in the back. These symptoms, however, passed off in a few days, no accident supervening, and the pain soon subsiding. On the fourteenth day the wound was healed.

Although the general health continued good, there was unfortunately no marked improvement after the operation. The anterior thigh-muscles appeared to gain a little in power, and the anæsthesia of the lower limbs diminished to some extent, but these changes were only very slow and very slight. On October 10 the patient was sent to the Convalescent Hospital at Cheadle, where he remained for some time longer, but whence he was finally discharged without marked relief.

A point of some importance in the above case is the limit of the anæsthesia on the front of the limb at an early period, as shown in fig. 28. It indicates that, of the region already described as being supplied by the anterior crural and obturator nerves (third and fourth lumbar roots), the lower portion is supplied from the lower root.

Finally, the two following records, although of old date, describe tolerably clearly the results of an injury affecting chiefly the lower roots of the sciatic trunk.

CASE 46.—*Fracture of first lumbar vertebra—Paralysis and anæsthesia involving second sacral roots.*

Cruveilhier[1] mentions the case of a woman, aged thirty-five, who, having sustained a fall of twelve feet, was rendered unable to walk, in which condition she was seen at the Salpétrière three months later. She had then "incomplete power" in the muscles of her legs and thighs, with involuntary defæcation and micturition. Sensation was lost in the feet as high as the malleoli, and was obtuse above this point, but improved higher up the limb. The toes were strongly flexed on the metatarsi, and the feet extended on the legs. At the autopsy was found a crush of the first lumbar vertebra, with a bony projection about its centre compressing the spinal cord, which was pale and degenerated. The cauda equina had escaped injury.

Here the paralysis appears to have chiefly affected the extensors of the ankle and toes, the posterior leg-muscles, by their uncontrolled contraction, giving rise to the deformity: at the same time there was anæsthesia in the region which previous cases have led us to regard as that of the distribution of the second sacral nerve-roots.

CASE 47.—*Fracture of first lumbar vertebra—Paraplegia—Anæsthesia involving second sacral roots.*

Holthouse[2] mentions a woman, aged forty-two, who dropped from the height of a third-floor window on to her feet. Complete paralysis of the lower limbs and retention of urine and fæces followed immediately. On the third day (before which no examination appears to have been made) she was found to have no sensation or reflex in the soles of the feet; micturition and defæcation were involuntary. On the sixth day is the somewhat more complete record that she had no sensation in the soles, but that there was some feeling in the calves, "and in the whole of the [? other parts of the] limb on the right side, but not on the left." Three days later she was said to have anæsthesia below the ankles. There ensued a bed-sore on the sacrum, cystitis, and erysipelas, and the patient died on the nineteenth day. At the autopsy was found a crush of the first lumbar vertebra,

[1] *Anatomie Pathologique*, tom. ii., *Maladies de la Moelle*, p. 5.
[2] Lancet, 1858, vol. ii. p. 629.

fragments of the body of which had been driven backwards, "and had crushed that part of the spinal cord just above the cauda equina;" there was no effusion of blood or inflammatory deposit.

In these two last cases, which are so closely similar in their symptoms, we should expect to find anæsthesia of the "saddle-shaped" area, which is supplied by the third sacral root; but it is exceedingly probable, especially when we consider the date of the observations and the sex of the patients, that such a condition would pass unnoted.

As a conclusion to the above series of cases, I may mention the following example of tumour of the cauda equina, recently admitted to Mr. Jones's wards in the Manchester Infirmary for retention of urine, which illustrates admirably some of the above localisations, as well as the assistance to be obtained from the same in the diagnosis of the exact seat of spinal lesions.

CASE 48.—*Tumour of the cauda equina, involving successively the various nerve-roots.*

J. D., aged thirty-one, was admitted to Mr. Jones's wards in the Manchester Infirmary on April 15, 1889. His family history is unimportant. He has had no previous illness, and presents no indications of syphilis or alcoholism. Some six years ago he began to suffer from pain in the lower part of his back, extending thence down the back of the lower limbs to the heels; at the same time he had difficulty in micturition, which, after about three months, was followed by complete retention of urine for a week. The latter condition improved a little, and for about a year he was able to pass urine, but at the end of that time he again had absolute retention for about three weeks. Coincidently with these troubles he began to suffer from obstinate constipation.

This condition of constipation, difficulty, and occasional failure in micturition, with pain in the back of the lower limbs, continued until about eight months ago. We may call this the first stage of his illness.

Eight months before admission the pain in the back of the limbs disappeared, and was gradually replaced by "numbness;" at the same time pain also began to be felt in the front of the thighs, from the hips to the knees, but no lower, and this pain has since continued. Along with this he has had marked feeble-

ness in the lower limbs, especially below the knees, and on the right side. From the eighth to the third month before admission he was unable to have connection with his wife, but had nocturnal emissions and erections. The bladder and rectal troubles continued. This constitutes the second stage of the disease.

Three months ago the pain in the front of the thighs, the numbness of the back of the limbs, and the muscular weakness became markedly worse, and he ceased to have any erections. Thus we reach a third stage.

At the present time the lower limbs are a good deal wasted; they present no paralysis, but all the muscles are weak, and the toes show a tendency to drop in walking; muscular sense is retained. The electric reactions are normal. The bowels are very constipated, and the urine is absolutely retained, the catheter being constantly required.

Over the lower lumbar vertebræ, in the middle line, there is a region which is painful on pressure or movement. Pain affects the front of the thighs in a region corresponding to the dotted area in the diagram (fig. 31), but there does not appear to be any exaggeration of sensibility to pain or touch. Anæsthesia is nowhere absolute, but there is very great blunting of sensation in the penis, scrotum (except at the upper part), perineum, gluteal region, and intero-posterior aspects of the upper parts of the thighs, this dulness of sensation extending, although in a less marked degree, down the centre of the backs of the thighs, over the calves, except on the inner side, and to the soles of the feet, where it spares the great-toe and half the second toe. Still slighter loss of sensation affects the front of the knees, the outer sides of the legs, and the outer side of the dorsum of the foot. In the leg and foot the sensory deficiency is more marked on the right side. The testicles are not anæsthetic. Some sensation is retained in the urethra, but it appears to be blunted. The annexed diagrams (figs. 31 and 32) represent these conditions roughly only, there being actually much less well-defined limits.

The plantar and gluteal reflexes are lost on both sides, the cremasteric is retained, the abdominal appear to be exaggerated. Ankle-clonus cannot be elicited; on the right side there is no knee-jerk; on the left it was slightly marked on admission, but disappeared some ten days later.

The general health remains good, except for some gastric disturbance. The eyes are normal in all respects.

There can be no doubt that we have here a pressure lesion of the cauda equina; the progress of events is too slow for us to sup-

pose that we have an affection of the spinal cord itself; the duration of the case and the course of the symptoms, to which fuller reference will be made immediately, point to a tumour rather than to meningitis; and the history and appearance of the patient contra-indicate tubercle, so that the growth is doubtless a tumour.

Taking this view, we may thus explain the symptoms, remembering always that, in pressure-lesions of the cauda equina, the lower roots almost invariably suffer more than those which arise above them, and suffer first from an increasing pressure-lesion. In the first stage we have paralysis of the fourth sacral root,

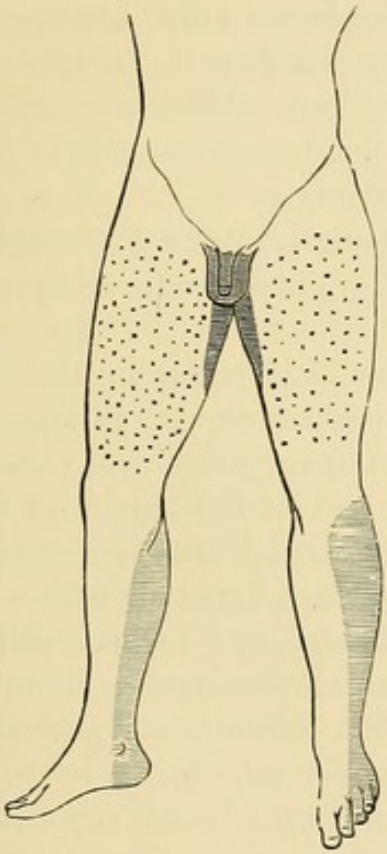


FIG. 31.

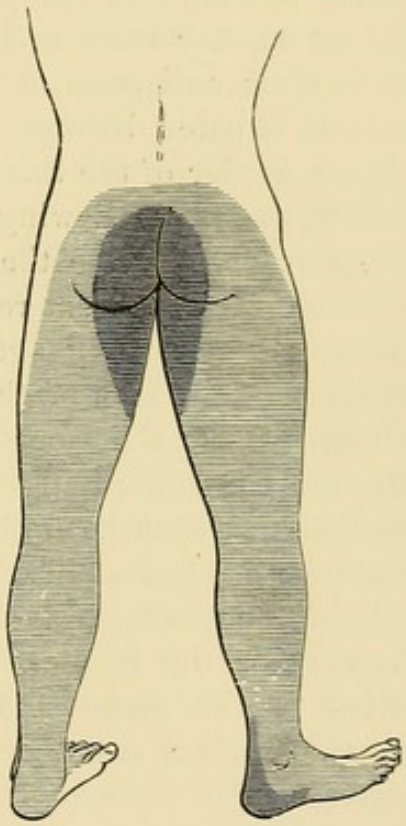


FIG. 32.

which supplies the bladder and rectum, together with irritation, causing pain in the sensory branches of the first three sacral roots. In the second stage, which came on eight months before admission, there ensued loss of power of coitus, due to paralysis of the muscles supplied by the third sacral root, and at the same time anæsthesia supervened in the previously painful areas, and the irritation was transferred to the third and fourth lumbar roots.

In the third stage, which came on about five months later, the nervi erigentes are paralysed, thus indicating pressure on the second sacral roots, anæsthesia is well marked in the cutaneous distribution of all the sacral roots, and is less obvious in that of

the fifth lumbar, and pain is confined to the distribution of the third (? and fourth) lumbar roots. Motor weakness affects most of these roots, but is fairly marked in the second sacral, which supplies the extensors of the toes, &c., and is still greater in the third and fourth sacral, which are distributed to the bladder, rectum, and perineal muscles. The two first lumbar roots entirely escape.

If now we inquire into the exact localisation of the tumour, we must place it below the upper border of the second lumbar vertebra, because here we have the termination of the spinal cord, which, from the nature and slow growth of the symptoms, is probably not affected (*cf.* p. 106). Again we must admit that the third lumbar roots are irritated by the growth, as there is pain in their cutaneous distribution. Hence then we conclude that it is situated between the upper border of the second and the lower border of the third lumbar vertebra.

Lastly, the two following cases, although both are non-traumatic, further illustrate the effects of a lesion implicating the third sacral and subjacent roots :—

A syphilitic woman,[1] aged thirty-two, suffered from absolute anæsthesia of the skin of the external genital organs, as high as the boundaries of the mons veneris, of the vaginal mucous membrane, the perineum, and the inner aspect of the thighs in the immediate neighbourhood of the perineum, and over the sacrum and gluteal region, as in Bernhardt's case. Together with this anæsthesia she had paralysis of the bladder and rectum, and a bed-sore over the sacrum, but no further paralysis or sensory affection of the limbs. A post-mortem examination revealed gummatous spinal meningitis in the sacral region, with "compression of the roots of the pudendal plexus" and superficial caries of the sacrum.

A woman,[2] aged thirty-six, suffered, as the result of a severe cold, from pains in passing urine, with numbness of the nates, shortly followed by retention of urine and fæces, and, five days later, by involuntary micturition and defæcation. At the end of seven months she presented anæsthesia of the bladder, urethra, rectum, perineum, external genitals, vagina, uterus, and lower half of the nates, with continued involuntary micturition and defæcation, but with no affection of sensation or movement in the extremities. This condition was unchanged at the end of four years.

[1] Westphal, *Charité Annalen*, Jahrgang I. Berlin, 1876.
[2] Rosenthal, *Wiener medizinische Presse*, 1888, No. 19.

CHAPTER VI.

THE INDICATIONS FOR OPERATIVE TREATMENT IN AFFECTIONS OF THE SPINAL CORD.

Omitting the suggestions of Paulus Ægineta, Fabricius Hildanus, and others, and the case in which Louis successfully extracted the fragments of a vertebral arch broken by a gunshot wound, the earliest recorded instance of a definite operation having been undertaken, for the cure of traumatic compression of the spinal cord, appears to have been the case of Cline, who, at the instigation of Sir Astley Cooper, performed this operation in 1814. During the last three-quarters of a century some sixty similar operations have been practised, but the results have so far not been sufficiently favourable to recommend the procedure to the majority of surgeons. The enormous impetus given to operative surgery by the introduction of the antiseptic system and the recent achievements of cerebral surgery have, however, again naturally raised the question of the advisability of operating for the relief of injuries of the spinal cord; and the brilliant successes of Macewen and Horsley have extended the sphere of possibly beneficial interference from the traumatic to other compressing lesions of that structure. In the following chapter I propose to collect and to criticise such evidence as we possess, bearing upon a question which will probably before long be placed upon an entirely new basis. The subject may conveniently be divided into sections.

Section I.—Traumatic Lesions.

Within the last few years five cases of spinal injury have been trephined in the Manchester Royal Infirmary, the details of which will be found recorded in the above pages. We may first consider briefly the circumstances connected with each of these.

In Case 9 (p. 20) there was no question but that the cord was completely crushed, the condition of the patient was undoubtedly hopeless, and an operation thus appeared advisable as allowing a possible chance of recovery, and as being certainly incapable of rendering matters more serious than they already were. As a matter of fact, not the slightest benefit resulted, and the post-mortem examination showed that the condition was not one

susceptible of relief, inasmuch as there was no pressure upon the cord, the bony displacement being very slight, and the damage inflicted upon the nervous structures having doubtless been entirely received at the moment of injury, when the cord had been completely crushed, and had been released only after destruction of its tissue by bruising and hæmorrhage.

In Case 8 (p. 17) the symptoms pointed to a lesion quite as serious as in the last instance, and here also the operation was a last resort in a desperate case. The result showed, however, that the spinal cord was here exposed to continued pressure from the displaced bones, and that this pressure must have been relieved by the removal of the counter-pressure due to the excised arches. In spite of this, not the slightest improvement resulted in the symptoms, and it seems not improbable that the operation may somewhat have shortened life, owing to further damage having been inflicted upon the compressed cord by the necessary manipulations, especially during the period of suspended respiration.

In Case 11 (p. 26) the conditions were entirely different. The course of the case indicated clearly that the cord was not entirely destroyed, but that at least some of its conducting fibres maintained their continuity. The spontaneous improvement, which for some time progressed very steadily, at first gave rise to hopes that extensive regeneration might result. Further, the exaggeration of the plantar and patellar reflexes, and the fact that incontinence of urine, with an empty bladder, was present from the commencement, indicated at least that the reflex centres had not suffered from the usual shock, possibly that irritation rather than paralysis was playing an important part in the production of the symptoms. When, therefore, recovery had progressed for some time, and had then come to a standstill, it appeared probable that, by trephining, it might be possible to remove any source of irritation as well as of compression, and that the favourable course might thus be re-established. Without operation the patient's life was certainly not worth living, nor likely to be much prolonged, exhausted as he was by pain, sleeplessness, and cystitis. Further, the depression of the fifth cervical spinous process, regarded in connection with the upper limit of the paralysis, appeared to indicate a dislocation forwards of the fifth cervical vertebra of the usual type, giving rise to narrowing of the medullary canal opposite the upper border of the body of the sixth. Even after the operation this view received countenance from the backward projection of the theca in this region.

The result proved that there was no persistent compression of the cord; that the lesion of the vertebral column was prac-

tically a diastasis only, and was at a higher level than had been anticipated; that the affection of the cord was the result of a merely temporary crush, with extravasation of blood; and that consequently an operation could by no possibility have been of any service. The cause of death was undoubtedly a re-establishment of traumatic myelitis, as a result of the local interference.

Case 32 (p. 94) differed materially from the last three, both in the nature of the injury and in the result. The injury did not affect the spinal cord at all, but was confined to the cauda equina, and an interval of four months and a half had elapsed between its receipt and the date of the operation. During the earlier part of this period the symptoms had improved, but, as in the last case, this improvement had ceased, and for some eight weeks there had been no change in the patient's condition. The operation revealed a large amount of cicatricial tissue compressing the nerves of the cauda equina, and on the removal of this tissue improvement recommenced, and was eventually very satisfactory.

In Case 45 (p. 131) the displacement of the spine was at the junction of the last dorsal and first lumbar vertebræ, which would probably correspond to the region of exit from the cord of the fifth lumbar nerve-roots.[1] Hence the crush would affect the conus medullaris at this level, together with the nerves of the cauda equina, which here accompany it. The functions of the latter were only partially destroyed. After an interval of eighteen weeks, and after such slight improvement as was at first manifested had entirely ceased, the operation was resorted to. As in the last case, cicatricial tissue was found to be surrounding the nervous structures, and this tissue was removed; besides which, the cord itself appeared to be almost entirely torn across. The subsequent improvement was practically nil, except for a slight recovery of function in the upper lumbar roots, which, having left the cord above the seat of the lesion, form the commencement of the cauda equina.

The above five cases constitute the whole of my own experience of the operation of trephining the spine, as performed for traumatic lesions, but I have collected in the Table which follows all the recorded cases which I can find. Excellent summaries up to date are given by Gurlt,[2] Ashhurst,[3] and Werner,[4] and these have been freely used, being checked and supplemented by reference to such of the original reports as are accessible to me.

[1] Gowers, Diseases of the Nervous System, vol. i. p. 106.

[2] *Handbuch der Lehre von den Knochenbrücken.* Hamburg, 1864.

[3] Injuries of the Spine. Philadelphia, 1867.

[4] *Die Trepanation der Wirbelsäule.* Strassburg, 1879.

No.	Operator and Date.	Reference.	Symptoms before Operation.	Period of Operation after Injury.
1	Cline. 1814.	South's *Chelius*, London, 1847. Vol. i. p. 539.	Total motor and sensory paralysis of the lower extremities.	Second day.
2	Wickham. 1819.	Tyrrell's edit. of Cooper's *Lectures on Surgery*, London, 1825. Vol. ii. p. 20.	Total motor and sensory paralysis of trunk and lower limbs: partial of upper limbs.	Eight days.
3	Oldknow. 1819.	Cooper's *Fractures and Dislocations*, London, 1822.	?	Six days.
4	Attenburrow.	Tyrrell's edit. of Cooper's *Lectures on Surgery*, London, 1825. Vol. ii. p. 20.	?	?
5	Tyrrell.	*Ibid.*, p. 11.	Motor and sensory paralysis below Poupart's ligament: involuntary defæcation and micturition: depression of twelfth dorsal vertebra.	Two days.
6	Rhea Barton. 1824.	Cooper's *Fractures and Dislocations*, Godman's American ed., or Packard's *Malgaigne*.	Total paralysis of trunk and lower limbs: incontinence of urine and fæces.	Twelve days.
7	Tyrrell. 1827.	*Lancet*, 1827.	Total paralysis of lower limbs: last dorsal dislocated backwards.	One day.
8	Alban Smith. 1828.	*North American Med. and Surg. Jour.* Vol. viii.	Paralysis of all the limbs except of muscles above the elbow.	Two years.
9	Holscher. 1828.	*Hannov. Annal. f. d. ges. Heilk.* Bd. iv. 1839.	Total paralysis of lower limbs: obvious dislocation forwards: on 13th day commencing gangrene of sacrum.	Thirteen days.
10	South.	South's *Chelius*. London, 1847. Vol. i. p. 541.	?	?
11	Rogers. 1834.	*Amer. Jour. Med. Sc.*, O. S. Vol. xvi.	Paralysis: great dyspnœa: depression of first lumbar spine.	Two days.
12	Edwards. 1838.	*Brit. For. Med. Chir. Rev.*, 1838, and M'Donnell, *Dub. Quart. Jour. Med. Sci.*, 1865.	Paralysis of lower limbs, bladder, and rectum.	"A considerable time."
13	Laugier. 1840.	*Lésions traumatiques de la Moelle épinère*. Paris, 1848.	Total motor and sensory paralysis of lower limbs: retention of urine: bed-sore.	Four days.
14	Potter. 1844 (?).	Hurd, *New York Jour. Med.*, 1845.	Motor and sensory paralysis below the breast: violent pain in neck: bed-sores: cystitis. Previous lung disease.	One hundred days.

Nature of Operation.	Subsequent Course.	Result.	Region Affected and Post-mortem Appearances.
Removal of two isolated spinous processes and one of the arches.	No effect.	Death on nineteenth day.	Fracture of twelfth dorsal, displacement of eleventh: cord almost torn through.
Removal of part of seventh cervical vertebra.	Freer breathing: distinct return of sensation.	Death in one day.	Fracture of seventh cervical vertebra.
Removal of seventh cervical spinous process.	?	Death on following day.	Fracture of seventh cervical: extensive extravasation of blood.
?	?	Death.	?
Removal of twelfth dorsal and first lumbar arches.	Immediate return of sensation on inner aspect of thigh: after one day sensation down to the toes: peritonitis secondary to bladder mischief.	Death on fifteenth day.	Fracture of last dorsal and first lumbar vertebræ: exudation on meninges: cord healthy: cystitis: peritonitis.
Removal of seventh dorsal arch.	Return of sensation after second day.	Death in $3\frac{1}{2}$ days.	Dislocation of seventh cervical, fracture of ninth dorsal.
Removal of twelfth dorsal arch.	Return of sensation in hips. Death from pleurisy.	Death in eight days.	Dislocation of twelfth dorsal vertebra.
Removal of third and fourth dorsal spines.	Healing of a gluteal bedsore: return of sensation as far as the thighs.	Incomplete recovery.	Middle dorsal spine: vertebræ ankylosed.
Removal of eleventh and twelfth dorsal arches.	Wound healed in six weeks. Return of sensation in lower limbs: slight mobility of legs: could sit up.	Death in fifteen weeks.	General œdema: hydropericardium: connective tissue masses at site of operation.
Removal of an arch which was fractured on one side.	?	?	?
Removal of twelfth dorsal and first lumbar arches.	Relief of breathing: return of sensibility in lower limbs: pain in feet. Gangrene of right foot, where there was a compound fracture.	Death in ten days.	Fracture of first lumbar vertebra: cord normal.
Elevation of one of the lumbar arches.	Lived for fifteen years: return of functions of bladder and rectum: afterwards father of children: could never walk.	Incomplete recovery.	Lumbar region.
Removal of spine of eighth and arch of ninth dorsal vertebræ.	Slight relief of respiration in two hours: pneumonia, &c.	Death in four days.	Fracture of seventh, eighth, ninth, and tenth dorsal vertebræ: cord completely torn: fractured ribs: pneumonia.
Removal of parts of four lower cervical and two upper dorsal vertebræ.	Almost immediate return of sensation: wound did well: later, respiratory troubles.	Death in eighteen days.	Lower cervical and upper dorsal regions.

No.	Operator and Date.	Reference.	Symptoms before Operation.	Period of Operation after Injury.
15	Walker. 1845.	*Catalogue of the Museum of the Boston Society for Medical Improvement*, 1847.	Motor and sensory paralysis below the breast: dyspnœa: retention of urine: incontinence of fæces: priapism.	One day.
16	Mayer. 1846.	v. Walther and v. Ammon's *Jour. der Chirurgie.* Bd. 38.	Immediately after blows from a stick, pain and distinct cracking in back: two months later, increasing weakness in back and anæsthesia of lower limbs. In five months total motor and sensory paralysis of trunk and lower limbs: incontinence of urine: difficult respiration: painful crepitus on movement.	About six months.
17	Blair. 1852.	Ballingall's *Outlines of Military Surgery*, Edinburgh, 1852.	?	?
18	Blackman. 1854.	American edit. of Velpeau. Vol. ii. p. 392.	Complete motor and sensory paralysis of lower limbs: incontinence of urine and fæces: irregularity of upper part of sacrum.	Four and a half years (?).
19	Blackman. 1854.	Hutchison, *Amer. Med. Times*, 1861.	?	Five hours.
20	Jones, G. M. 1856.	*Med. Times and Gazette*, 1856. Vol. ii. p. 86.	Motor and sensory paralysis below sternum: arms could only be moved upwards: sensation in arms, but not in fingers: excessive priapism: diaphragmatic respiration: retention of urine: cerebral symptoms.	Six days.
21	Hutchison. 1857.	*Amer. Med. Times*, 1861.	Total motor and sensory paralysis below umbilicus: no reflexes: priapism: retention followed by incontinence of urine: respiratory troubles: depression of eighth and ninth dorsal spines with crepitus.	Ten days.
22	Smith, Stephen. 1858.	Hutchison, *Amer. Med. Times*, 1861.	Motor and sensory paralysis below sixth intercostal nerve: numbness and formication in arms: retention of urine: priapism: bed-sores on second day.	One day.
23	Potter, H. A. 1859.	*Amer. Jour. Med. Sc.* N. S. Vol. xiv.	Total paralysis, except that the hands could be slightly raised.	A few days.
24	Potter, H. A. 1862.	*Ibid.*	Same case as last. Continued paralysis: general condition good.	Three years.

Nature of Operation.	Subsequent Course.	Result.	Region Affected and Post-mortem Appearances.
Removal of sixth cervical spinous process, which was broken but not depressed.	Return of sensation in three days, complete in two and a half months: later control over bladder and rectum: muscular tremors, contractures: slight atrophy: slight power in lower limbs.	Incomplete recovery.	Sixth cervical.
Resection of seventh dorsal arch, which was obviously compressing the cord.	Return of voluntary micturition. For nine days restoration of sensation in lower limbs with hyperæsthesia and tremors, but no motor power: then exhaustion, fever, and bedsores.	Death in twenty-one days.	Compression and degeneration of cord opposite seventh dorsal: impacted fracture of this vertebra without callus: fracture of several spinous processes: abscess in anterior mediastinum.
?	"A successful result."	?	?
Removal of $1\frac{3}{4}$ ins. of upper part of sacrum, which was depressed.	After some hours, consciousness of micturition, and a day later of defæcation: gradual return of sensation, and, after five weeks, of voluntary power in legs.	Incomplete recovery.	Sacrum.
	?	Death in eight days.	Fracture of upper dorsal spine.
Resection of third and fourth dorsal arches: no injury found: then resection of fifth and sixth cervical arches.	Return of sensation as far as umbilicus, and freer movement of arms on same day: return of bladder sensation: sudden death.	Death on fifth day.	Fracture of bodies of fifth and sixth cervical vertebræ: extravasation in and around cord: tearing of nerve-roots.
Removal of eighth and ninth dorsal spines and tenth dorsal arch: cord laid bare for $2\frac{1}{4}$ ins.	No improvement: respiratory failure: wound gangrenous.	Death on twentieth day.	Fracture of several dorsal spinous processes, three bodies and two ribs: cord torn: pyopneumothorax.
Resection of depressed arch of tenth dorsal vertebra.	No improvement.	Death soon after the operation.	Fracture of tenth dorsal: no dislocation: extravasation of blood from cervical vertebræ to sacrum.
Resection of fifth and sixth cervical arches: cord pulsated.	Wound healed in three months: could sit and move head: left hand freer mobility: spastic symptoms in lower limbs.	Incomplete recovery.	Fracture of sixth cervical spinous process: dislocation: arch of fifth almost divided cord.
Resection of fourth, sixth (?), and seventh cervical arches.	No effect.	Unrelieved.	Cord not united: theca thinned.

No.	Operator and Date.	Reference.	Symptoms before Operation.	Period of Operation after Injury.
25	Potter, H. A. 1860(?).	*Amer. Jour. Med. Sc.* N. S. Vol. xiv.	?	?
26	M'Donnell. 1865.	*Dublin Jour. Med. Sc.* Vol. xl.	Paralysis of lower limbs, bladder, and rectum: anæsthesia of soles of feet: loss of reflexes: bed-sores: prominence of first and depression of second lumbar spine.	Thirty-seven days.
27	Gordon. 1865.	*Dub. Journ. Med. Sci.* Vol. xlii.	Paralysis of lower limbs, bladder, and rectum: bed-sores. At end of eight weeks total paralysis of lower limbs except thigh, which was paretic only: sartorius not affected: anæsthesia in feet: above this numbness: hyperæsthesia of right thigh: no reflexes below knee.	Sixty-eight days.
28	Willett. 1865.	*Lancet*, 1866. Vol. i.	Complete motor and sensory paralysis of all limbs and trunk: threatened asphyxia on second day.	Two days.
29	Tillaux. 1865.	*Bull. gén. de Thérap. méd. et chir.*, 1866, p. 202.	Total motor and sensory paralysis of lower limbs: no reflexes: retention of urine and fæces: semi-erection: difficulty of breathing: bed-sores: depression of first lumbar spinous process.	Nine days.
30	Tyrrell. 1866.	*Dub. Journ. Med. Sci.* Vol. xlii.	?	Two days.
31	Maunder. 1866.	*Lancet*, 1867. Vol. i.	Motor and sensory paralysis (not quite complete) below nipples: diaphragmatic respiration: retention of urine and fæces followed by incontinence: prominence of seventh cervical spine.	Twenty-two days.
32	Cheever. 1867.	*First Med. and Surg. Rep. of the Boston City Hospital*, Boston, 1870, p. 577.	Paralysis of motion and sensation in lower limbs: priapism: dyspnœa: coma: crepitus at fifth and sixth dorsal vertebræ: emphysema: probably fractured ribs.	Three hours.

Nature of Operation.	Subsequent Course.	Result.	Region Affected and Post-mortem Appearances.
Resection of fifth, sixth, and seventh cervical arches: distinct pulsation of cord.	?	Death in four days.	Cord not torn: large extravasation about foramen magnum: fracture of occipital and left parietal bones.
Resection of last dorsal (?) arch: dura unopened.	On first day return of sensation in soles, and of power in thighs: fourth day, sensation normal: seventh day, return of reflexes: improvement in bed-sores and urine: some power over bladder: marked power in thighs, none below knees: then rigors, diarrhœa, sudden death.	Death on seventeenth day.	Fracture of first lumbar vertebra: dislocation forwards of twelfth dorsal: cord compressed but not inflamed: cystitis, pyelo-nephritis, &c.
Resection of first lumbar or twelfth dorsal arch: dura not opened.	Urine acid after fourth day: on twenty-sixth day normal micturition: in eight weeks return of sensation and partially of motion in lower limbs: bed-sores healed: in six months could sit up easily; still had involuntary defæcation: exfoliation of a splinter of bone.	Incomplete recovery.	Fracture of twelfth dorsal or first lumbar.
Not completed.	...	Death during operation.	Dislocation of fifth cervical: extravasation of blood.
Removal of first lumbar spinous process, which was broken off and displaced: dura not compressed.	Rigors, delirium, &c.: paralysis extended to clavicles.	Death in eleven hours.	Transverse fracture of first lumbar without displacement: dura uninjured: cord not torn, but contained effusion of blood and showed ascending myelitis: hæmorrhage in vertebral canal, but no compression: fracture of eighth and ninth ribs.
?	Wound doing well for first three weeks.	?	Injury of lower part of vertebral column.
Resection of first and second dorsal arches.	Relief of dyspnœa and cough, and of pain: death from respiratory troubles.	Death on 13th day.	Seventh cervical partially dislocated forwards: cord softened: pyæmia.
Removal of comminuted spinous processes of second, third, fourth, and fifth dorsal vertebræ, and third and fourth laminæ.	"Respiration modified by operation."	Death in twenty-four hours.	Upper dorsal.

No.	Operator and Date.	Reference.	Symptoms before Operation.	Period of Operation after Injury.
33	Cheever. 18—.	*First Med. and Surg. Rep. of the Boston City Hospital*, Boston, 1870, p. 577.	Complete paralysis below nipples: partial in upper limbs: abdominal respiration: depression opposite sixth cervical vertebra: retention of urine: tympanites: high fever.	Twenty-four hours.
34	Willard. 1871.	*Amer. Jour. Med. Sc.* Vol. lxiii., April 1872. (*Chicago Med. Examiner*, Oct. 1871.)	Motor and sensory paralysis of lower limbs: retention of urine.	A few hours (?).
35	?	*St. Bartholomew's Hospital Rep.* Vol. vi.	A man aged 30.	?
36	Nunneley. 18—.	*Med. Times and Gazette*, August 1869.	?	?
37	Nunneley. 18—.	*Ibid.*	?	?
38	Nunneley. 18—.	*Ibid.*	?	Ten days.
39	Nunneley. 18—.	*Ibid.*	?	Five weeks.
40	Stemen. 18—.	*Fort Wayne Journ. Med. Sci.* 1883 (Lidell, Ashhurst's *System of Surgery*).	?	?
41	Stemen. 18—.	*Ibid.*		?
42	Stemen. 18—.	*Ibid.*	?	?
43	Maydl. 188–.	Albert, *Lehrbuch der Chirurgie*, Vienna, 1884. Vol. ii. p. 55.	?	?
44	Lücke. 1877.	Werner, *Die Trepanation der Wirbelsäule*, Strassburg, 1879.	Complete motor and sensory paralysis of twelfth dorsal and subjacent nerves: retention of urine and fæces: tympanites: cremasteric reflex present, plantar slightly marked: depression of eleventh dorsal spine: crepitus.	Thirty-six hours.
45	Macewen. 1885.	*Brit. Med. Jour.*, 1888. Vol. ii. p. 308, Case vi.	"Absolute motor paralysis [of lower limbs], with incontinence:" hyperæsthesia: wasting of limbs: loss of electric reactions: bed-sores: cystitis: fever.	Six weeks (?).

Nature of Operation.	Subsequent Course.	Result.	Region Affected and Post-mortem Appearances.
Removal of sixth and part of fifth cervical arches.	No improvement: hyperpyrexia (110°).	Death in nine hours.	Forwards dislocation of sixth cervical.
Removal of second lumbar arch, which was fractured.	Apparently no change.	Death on tenth day.	Second lumbar.
?	?	Death.	?
[?]	?	Death.	"Injuries such as not to allow of recovery taking place."
?	?	Death.	Do.
?	?	Death.	Do.
			[Nunneley's cases are all very briefly referred to by himself.]
?	Excellent health for 2½ years after, but leg remained partially paralysed.	Partial recovery.	?
?	?	Relieved.	?
?	?	Not benefited.	?
?	?	Death.	?
Resection of two vertebral arches in dorsal region.	"The patient recovered from the operation."	?	Dislocation in dorsal region: cord was crushed.
Removal of comminuted fragments of bone pressing on the cord, and resection of entire arch and left transverse process (of eleventh dorsal): cord was somewhat flattened: extension gave more space: wound sutured except in centre: "Listerian dressing."	Several times during operation slight pressure on cord caused movements of lower limbs (in spite of deep chloroform narcosis): partial recovery of sensation in three-quarters of an hour, improved by extension: hence extension by weight of about six pounds to each leg: movements of toes on eighth day: pleurisy: cystitis: bed-sores: exfoliation of a small sequestrum: finally wound healed: complete anæsthesia and paralysis: bed-sores: incontinence of urine, &c.	Not benefited.	Probably dislocation and fracture of eleventh dorsal: cord compressed. [Slight improvement at first, from relief of pressure: then apparently myelitis.]
Removal of fractured twelfth dorsal arch, and dense connective tissue on posterior aspect of dura.	Same night limbs warmer: third day, toes movable: after a month tenotomy for contractures: then rapid gain of power: in three years could "move about with ease, but with a paraplegic gait."	Partial recovery.	Fracture of twelfth dorsal vertebra.

No.	Operator and Date.	Reference.	Symptoms before Operation.	Period of Operation after Injury.
46	Lauenstein. 1886.	*Centralblatt für Chirurgie*, 1886. No. 51, p. 888.	Could not stand, but moved legs in bed: limbs wasted and cold: reflexes slight: no anæsthesia: unconscious defæcation: retention and overflow of urine: cystitis: failure of plaster jacket: subsequent fever and general marasmus, with some anæsthesia of right thigh: angular curvature.	Ten weeks.
47	Keetley. 1888.	*Brit. Med. Jour.*, 1888. Vol. ii. p. 421.	Motor and sensory paralysis below fifth cervical nerve: priapism: depression at back of neck.	Three hours.
48	Horsley. 1887.	*Med. Chir. Trans.* Vol. lxxi., 1888, p. 400.	Absolute motor and sensory paralysis of lower limbs: loss of control over bladder and rectum: cystitis: severe bed-sore: prominence of eleventh dorsal spine.	A few days (?).
49	Horsley.	*Ibid.*	"A fracture."	?
50	Duncan. 1888.	*Edin. Med. Jour.*, March 1889, p. 830.	Complete loss of motion and sensation from the groin downwards: retention of urine: projection and mobility of eleventh dorsal spine.	A few hours (?).
51	Duncan. 1889.	*Ibid.*, p. 831.	"Complete paraplegia:" retention of urine: projection of third lumbar vertebra: extreme collapse.	One day.

Nature of Operation.	Subsequent Course.	Result.	Region Affected and Post-mortem Appearances.
Removal of twelfth dorsal and first lumbar arches—the former comminuted—and of thickened dura: careful antiseptic precautions.	Cord touched during operation, causing contraction in limb: to this is attributed temporary total paralysis in peronei: shortly severe pain in back and limbs: wound healed on fourth day: fifth day, pain and fever ceased, improvement in urine and anæsthesia: in three months could stand erect and urinate.	Completely cured in six months.	Dislocation of twelfth dorsal vertebra.
Removal of fifth and fourth cervical arches: membranes exposed, free from tension, unusually soft.	Slight improvement in sensation on second day: hyperæsthesia: respiratory troubles: wound almost healed.	Death in seventy hours.	Vertical fracture of fourth cervical: vertebral canal patent: cord completely divided opposite fifth cervical vertebra.
Removal of eleventh dorsal spine, which was depressed, and of tenth dorsal arch: dura healthy: not opened, but accidentally punctured.	Slight improvement in sensation: none in paralysis: bed-sore healed: cystitis recovered: wound healed in seven days.	Partial recovery.	Fracture of eleventh dorsal: hæmatomyelia.
?	Wound healed "without any complication whatever."	?	?
Removal of tenth, eleventh, and twelfth dorsal arches: dura not opened.	Wound healed on ninth day: no change in symptoms.	Unrelieved.	Fracture of tenth, eleventh, and twelfth dorsal arches: displacement forwards of body of tenth, not more than ¼ in.
Removal of arches of second and third lumbar: body of former displaced about 1 in. forwards: membranes blue and distended: dura opened, giving exit to blood and clots: cauda not much affected: wound in dura closed: displacement of bones reduced, and reduction maintained by pads and plaster jacket.	On following day wound doing well: sensation had returned to considerably below the knees: breathing suddenly became embarrassed: cyanosis: failure of respiration.	Death on second day.	Fracture of third and dislocation forwards of second lumbar vertebra: displacement perfectly reduced: cauda very slightly bruised: rupture of diaphragm, hernia of stomach, and great omentum into left pleural cavity, &c. Death due to other injuries.

No.	Operator and Date.	Reference.	Symptoms before Operation.	Period of Operation after Injury.
52	Duncan. 1889.	*Edin. Med. Jour.*, March 1889, p. 832.	Absolute paraplegia as high as groin: retention followed by incontinence of urine and fæces: much collapsed: great extravasation of blood in back: projection of second lumbar spine.	Thirty-six days.
53	Péan. 1889.	Hart, *Brit. Med. Journ.*, 1889. Vol. i. p. 672.	Horse-bite on back, apparently only a slight "pinch of the skin:" after some days nervous symptoms came on gradually: great pain in back: complete paralysis of lower limbs: retention of urine: prominence of sixth and depression of seventh and eighth dorsal spines.	?
54	Allingham, H. 1888.	*Brit. Med. Journ.*, 1889. Vol. i. p. 838.	"Paralysed from below the level of the ensiform cartilage;" "seemed to lose ground."	?
55	Allingham, H. 1888.	*Ibid.*	"Paralysed from a level seven inches above the umbilicus."	Six days.
56	Dawbarn. 1889.	*New York Med. Jour.*, June 29th, 1889, p. 711.	Complete paraplegia, beginning a few inches below the ribs: involuntary defæcation: retention and overflow of urine: cystitis: anæsthesia as high as umbilicus, except over toes, where was slight sensation: projection of twelfth dorsal spine, depression and deflection to left of eleventh: no improvement during one month.	Six months.

Nature of Operation.	Subsequent Course.	Result.	Region Affected and Post-mortem Appearances.
Removal of arches of first three lumbar vertebræ: parts much matted together: first lumbar displaced forwards about an inch: cord torn half through and bent twice at a right angle: sheath above and below injured region sewn together, relaxing latter portion: some cerebro-spinal fluid escaped.	No improvement up to seventeenth day: free flow of cerebro-spinal fluid, which began to diminish in a week, but was still continuing on seventeenth day.	Unknown.	Dislocation of first lumbar vertebra: fracture of second.
Exposure of the arches, which were comminuted: ten fragments removed from the spinal cord.	"Patient is now restored to almost his ordinary condition."	Recovery.	Middle dorsal.
Removal of fifth, sixth, and seventh dorsal laminæ exposing cord: antiseptic treatment.	Healing of wound in ten days: some improvement, "the level of the paralysis being brought down to the umbilicus."	Partial (slight) improvement.	Depression and fracture of sixth dorsal laminæ.
Removal of third, fourth, fifth, and sixth dorsal laminæ: dura opened.	Wound healed in about a fortnight: bed-sores: cystitis, &c.	Death in seven months.	Cord almost divided: "both ends tapering down to a fine point."
Removal of tenth, eleventh, and twelfth dorsal arches: dura not opened: cord bent at angle of 15°: anti-septic dressing.	Wound soon healed: after ten weeks, pain had ceased: more power over bladder and rectum: some return of power in sartorii: readier response of muscles of limbs to electricity: limbs became warmer in a few hours.	Slight improvement.	Junction of eleventh and twelfth dorsal vertebræ.

Such being the available clinical evidence, we are now in a position to consider the question, how far is the future practice of this operation advisable? In the first place, we may clear the ground somewhat by stating, as beyond dispute, that in cases of compound fractures of the arches (chiefly gunshot wounds), foreign bodies and bony fragments should be removed, and the wound treated antiseptically. No possible harm can accrue from so obvious a procedure, which was apparently first practised by Louis. In the above Table cases of this nature have not been included, and they need not now be further referred to.

Taking all other cases together, we may arrive at a decision after answering the following series of questions: (1.) How far are spinal injuries curable without operation? (2.) Is the operation itself necessarily fatal, or so dangerous as to be unjustifiable? (3.) If successful, is it likely to leave the vertebral column in a condition too weak to perform its functions? (4.) Does the operation hold out a prospect of improvement in all or any cases? and if the latter, in what cases? Let us take these points *seriatim*.

I. Are the results of fractures and dislocations of the spine incurable without operation? Practically, we may say that the vast majority are. Gurlt records 217 deaths out of a total of 270 fractures; but even when there is "recovery," there are usually persistent nervous symptoms which render life little but a burden, and which would warrant extreme measures for their relief. There are also among these recoveries fractures of the vertebræ, in which, owing to the cord not having been involved, no nervous symptoms are produced; but for these no one would suggest trephining, and they cannot influence the decision in cases of injury to the cord. A few cases remain, and they are very few, in which a fairly satisfactory recovery is made, and in which we should not be inclined, for the relief of such slight symptoms as remain, to subject the patient to a major operation. It will, however, be found that in all such cases recovery sets in early, probably within a few days of the accident, and that such recovery is progressive, so that when the process has once been checked, we find no further change for the better, however long the patient survive. These are obviously cases in which there is no permanent source of compression of the cord, but in which probably a diastasis or partial luxation of the vertebræ has produced a contusion of the cord or of its nerve-roots. We may conclude, then, that in a small percentage of cases, in which the symptoms indicate only a partial transverse lesion of the nervous structures, recovery may begin shortly and progress

steadily. In these cases we do not require, and therefore should not practise, an operation. In all others—in cases in which the transverse lesion is complete, in which, although it be partial only, there are no signs of improvement within a week or two, or in which improvement, after having gone on steadily for a time, comes to a standstill—recovery will not ensue. For these cases trephining *might* be practised in the absence of any other means of relief.

II. Is the operation necessarily fatal, or so dangerous as to be unjustifiable? Necessarily fatal it obviously is not, and under modern conditions it does not appear to be a very dangerous procedure. Of the above total of sixty-one cases, including five original and fifty-six quoted, only thirty-five are recorded as deaths, or about fifty-seven per cent.,—a proportion comparing favourably with the eighty per cent. of deaths in Gurlt's analysis of fractures not operated upon, and which is only raised to sixty-seven per cent., even if we regard the six cases in which the result is unknown as having all ended fatally. Such figures, however, regarded apart from contingent circumstances, hardly give us a fair estimate of the danger incurred by operating. The majority of the fatal cases were evidently doomed apart from the operation, and in but few could the latter be regarded as the cause of death. More to the point is the fact that physiologists have very frequently trephined the spines of animals, and that in such cases untoward results are unusual. As throwing some further light on the question, I have made an analysis of twenty undoubted cases of wounds, by sharp instruments, to the cord or its membranes, in human beings, and among these we find only five deaths. If we reflect that these wounds were made, not by the surgeon, but by accident, and that many were not treated antiseptically, we must conclude that the only *special* danger of the operation, septic meningitis or myelitis, has been much exaggerated. Hence it would appear that the dangers of the operation are comparatively not great, especially in view of the conditions which it is designed to relieve.

III. It has been argued that even a successful operation would leave the vertebral column so weakened as to be unable to perform its functions as a support to the body or a protection to the spinal cord. This contention is at once disposed of by the records of cases which have survived. In no single instance has such a difficulty been encountered. There is, moreover, no reason why the spinal envelope should not be strengthened by the re-implantation of such vertebral arches as have been

elevated, a procedure which has been successfully adopted by Mr. Wright in a case of spinal caries (*infra*).

IV. Does the operation hold out any prospect of recovery in all or any cases? and if the latter, in what cases? Even when we have established the incurability of crushes of the cord apart from trephining and the practicability of that operation itself, it will be necessary before adopting it to give an affirmative reply to this question; and here it is that the main difficulty arises. Post-mortem evidence shows that three conditions may be met with as the early results of a crush of the spinal cord, due to fracture or dislocation of the body of a vertebra. In many cases—I should be inclined to say in the majority of cases—there is not found any serious narrowing of the vertebral canal after death. The displaced bones commonly fall back immediately after the injury into their original position, leaving the contused cord free from pressure. In other cases the displacement of the bones is maintained, and the cord is compressed, usually between the body of the lower and the arch of the upper of the affected vertebræ. In a small minority of cases pressure upon the cord is due solely to the effusion of blood. In the first group of cases operation is clearly useless; the whole mischief is already done and the cord is in as favourable a position for repair as can be supplied to it. In the second and third groups only, can we by operation remove the source of pressure, and for the present we may neglect the few cases constituting the third group. We have, therefore, to ask ourselves what benefit is to be derived from relieving the cord from the pressure of a *permanently* displaced vertebra.

There is here a *prima facie* probability that nothing will be gained. It can hardly be doubted that, when the bones are continuing to press upon the cord, the mischief done to it will be at least as severe as, probably more severe than, it is in those cases in which they are not. But as these latter rarely recover, in spite of the comparatively favourable conditions, it is highly improbable that the former will do better after trephining. In other words, clinical evidence points to the fact that the damage done by an acute compression of the cord is usually irreparable—that the cord is incapable of repairing an extensive crush. Cases of hæmatomyelia point to the same conclusion: life may be spared, but rarely, if ever, are no permanent symptoms produced, simply because the structures immediately destroyed by the hæmorrhage undergo no regeneration; and therefore, if, as in severe crushes, there be a practically complete transverse hæmorrhage, there will result a permanent complete transverse lesion. In face of these facts it

is useless to point to experiments upon animals in which the structure and functions of the cord are said to have been more or less restored after section; the more so as the results of such experiments are still open to doubt. In human beings, as in animals, clean sections are capable of repair. Among the twenty cases of wounds by sharp instruments to which I have already referred, there are eighteen in which the cord appears to have been more or less divided. In four of these complete recovery ensued, at intervals of two months and upwards; and in six there was partial recovery; in one the record ceases on the tenth day, when improvement was clearly in progress. But there is a wide difference between a clean cut and the effects of a crush; and, as has been indicated, the latter appears to be hopeless. The fact remains that a certain amount of improvement may follow a crushing lesion, due probably to the recovery of those portions of the cord structure that have only been compressed and not destroyed by the hæmorrhage; but it appears highly improbable that any such tissue will remain to a cord permanently flattened by displacement of the body of a vertebra.

Trephining has been strongly urged by Dr. Brown-Séquard and others, on the ground that the more serious symptoms of a crush are not paralytic, but irritative, and that operation will remove the source of irritation. Into this somewhat doubtful question I do not propose now to enter, further than to say that clinical experience does not seem to confirm this view. The trophic troubles which result from those injuries in which exaggeration of reflexes and other symptoms would indicate irritation are not more severe than those found in cases in which every other symptom points to a pure paralysis, and paralytic lesions may undoubtedly give rise to the vascular changes which accompany, even if they do not cause, such trophic troubles. But even where we have evidence of irritation, we have no proof that it is due to the pressure of displaced bone. Thus in Case 11 (p. 26) there were marked evidences of such irritation, and yet the post-mortem showed that there was no bony pressure upon the cord, and that the mischief arose entirely from hæmorrhage and subsequent inflammation. As above stated, I have seen but one other case in which there was early increase in the knee-jerk, probably indicating irritation of the reflex centres, and there other symptoms showed conclusively that the injury done to the cord was comparatively slight, and recovery ensued without operation. Hence, even if we grant the lesion to be irritative, we cannot expect to remove the source of irritation of the cord by trephining the spine; both

the irritation and the paralytic effects are equally the result of a lesion of the nervous structures, which, once produced, is independent of the position of the vertebræ.

On these grounds, then, it would appear that no benefit can result from operating for most traumatic injuries to the spinal cord, and that operation is therefore unjustifiable in such cases.

We must, however, draw an important distinction between the spinal cord and its nerve-roots. The structure of the latter is very different from that of the cord itself, and they must be considered merely as peripheral nerves. As such, they are, in the first place, far more resistant to compression. An injury which would convert the cord into a mere mass of blood-stained pulp might damage a nerve-trunk very slightly. That nerve-trunks may and do recover after severe injuries is a fact capable of daily observation. Even complete division and separation of the ends of a nerve is no barrier to its recovery, unless some other tissue intervene between its separated portions or unless the latter be very far apart. And even in the latter case the removal of the obstacle may be, and generally is, followed by reunion at dates frequently very remote from that of the injury. This being the case with regard to peripheral nerves elsewhere, we must expect the same results to follow in the case of injury to the intraspinal roots.

Where the latter run in contact with the cord itself, the above considerations will have no practical bearing, as the cord lesion far transcends in importance that of its associated roots. But below the lower border of the first lumbar vertebra we have a region, frequently injured, in which the spinal roots have still a long intraspinal course, but in which the cord has no place. Here then we have a new condition—a region in which a spinal injury implicates peripheral nerves only, and in which we may on *à priori* grounds hope to do much by relieving these nerves from pressure. We may also assume that, in injuries of the cauda equina, if the symptoms be permanent, they are due to some removable source of pressure, as to displaced bone or cicatricial tissue. Were the injury a contusion merely, these roots would doubtless spontaneously recover their functions, as do other peripheral nerves so injured.

These theoretical considerations are confirmed by the statistics of recorded cases. Thus of the sixty-one cases collected, sixteen appear to have "partially" or wholly recovered, there being two complete recoveries only, viz., Cases 53 and 46. Omitting for the moment Case 53, which will be subsequently referred to, we thus find fifteen more or less satisfactory results. Of these

fifteen, one is our fourth case (p. 94), in which the lesion clearly involved only the cauda equina. The others are Cases 8, 12, 15, 17, 18, 23, 27, 39, 40, 45, 46, 48, 54, and 56 of the Table. Of these, the region of injury is unknown in Cases 17, 39, and 40, thus leaving for consideration eleven cases only from which we can derive any information of value, and of the latte again, Case 8 is a record of somewhat doubtful validity. Cases 15, 23, and 54 are injuries above the lumbar region, but in Case 15 the operation was performed the day after the accident, and there is not the slightest indication that the patient would not have progressed equally well without it, and in Cases 23 and 54 the evidence of real improvement is slight. The only instances, therefore, in which the locality of the injury is known, and in which there would appear to have been a *bona fide* improvement, are Cases 12, 18, 27, 45, 46, 48, and 56, in which the injury affected respectively one of the lumbar vertebræ, the sacrum, the twelfth dorsal or first lumbar, the twelfth dorsal, the junction of the twelfth dorsal and first lumbar, the eleventh dorsal, and the junction of the two last dorsal vertebræ. Of these seven, the two first almost certainly affected the cauda only; in the third the termination of the cord was probably injured, and clearly the terminal region (supplying the bladder and rectum) did not, as regards the latter at any rate, share in the recovery; to the fourth (45) the same remark applies; in the sixth (48) the partial recovery is probably due entirely to the nerve-roots, and not to the cord; in the seventh (56) the improvement was almost trivial; and in one only (46) is there anything like satisfactory evidence of recovery of any portion of the spinal cord itself.

It would appear, then, that we may sum up as follows: That the operation of trephining the spine for traumatic lesions, as compared with the condition which it is intended to relieve, does not present any very great dangers, and appears unlikely to increase the gravity of the prognosis, but that as both *à priori* argument and the results of published cases show that it is unlikely to be of service, it should be abandoned, except in cases of injury to the cauda equina, and that in the latter, on the other hand, it will probably prove to be an eminently justifiable and serviceable procedure.

But even in injuries of the cauda equina we are not called upon to operate in every case. Many of these will progress most favourably or recover completely without any interference; and if there seems to be a fair prospect of such recovery, our treatment should be expectant. Both from the evidence of the cases given above

and from that supplied by the results of injuries to nerve-trunks elsewhere, it would appear that the chances of recovery are not seriously diminished by postponing operation for a reasonable time. Before we interfere, we should therefore be assured that nature will not effect a cure. Experience, however, shows that if spontaneous recovery is about to take place, it will not be very long in commencing, and will follow a fairly continuous course. Under these circumstances, I should be inclined to lay down the rough rule, that if at the end of six weeks there is no recovery, or if recovery is at a standstill, then, and then only, should we operate for crushes of the cauda equina.

Another and very different class of exceptions to the doctrine of non-intervention in injuries to the spinal cord is furnished by those cases in which the injury has affected not the bodies, but the arches of the vertebræ. In the latter the pathological conditions differ entirely from those found in the former. The crush of the cord is obviously not liable to be so severe where the laminæ only are depressed, as it is when the entire vertebra is displaced and the cord is subjected to the weight of a considerable portion of the body. In pure fractures of the laminæ, also, the consideration that the bones have probably at once regained their normal position, and that the cord has thus been placed in the most favourable position for recovery, has less weight, for these structures are frequently tightly wedged after injury, and are not subject to the natural extending forces of elasticity, of muscular action, and of the body weight. Thus the cord, having once been jammed, the pressure is more liable to be maintained. Again, a tightly wedged lamina will be subject to movement with every movement of the body, and will then be continually engaged in further ploughing up the cord. We may therefore hope to improve the patient's chances of recovery by the removal of a depressed arch, and the above considerations regarding the risks of the operation must lead us to the conclusion that such a proceeding is here justifiable. In such cases, also, we should act without delay, as we cannot, as in the case of the cauda equina and the peripheral nerves, trust to the long retention of any capacity for regeneration which may be present in the structures involved, and as there is the constant danger of the infliction of further damage upon movement.

A successful result in a case of this nature was obtained by Péan. A man received a bite from a horse in the mid-dorsal region, which was at first supposed to be only a "pinch of the skin." After some days nervous symptoms began to come on

gradually, and culminated in complete paraplegia, retention of urine, and severe local pain. After an interval, of which the duration is not recorded, Péan found, in addition to the above symptoms, a depression of the seventh and eighth dorsal spinous processes. Cutting down upon these, he removed about ten fragments which had entered the spinal cord, and, without any complication, the patient was "restored to almost his ordinary condition." The course of events in this case is not very clear, as, had the fragments been at once driven into the cord, which seems to be assumed in the report, the nervous symptoms would have been immediately produced. Probably, therefore, the broken arches were secondarily depressed by movement or pressure; but however this may have been, the case illustrates the advantages which may result from the excision of bony spiculæ actually in contact with or penetrating the spinal cord, when the latter is not crushed beyond repair.

Section II.—Caries of the Vertebræ.

Ashhurst[1] states incidentally that portions of the vertebræ were removed "for disease" by Heine, Roux, Holscher, and Dupuytren, but I have been unable to find the records of these cases, and the first operation of this nature with which I am acquainted is that performed by Jackson in 1882, since which time several similar cases have been subjected to the same procedure. All of these have been collected in the following table:—

[1] *Loc. cit.*, p. 56.

TABLE II.

No.	Operator and Date.	Reference.	Symptoms before Operation.	Nature of Operation.	Symptoms after Operation.	Result.
1	Jackson (Sheffield). 1882.	Atkin, *Brit. Med. Jour.*, 1883. Vol. i. p. 812.	Boy, aged 12: at third month after onset paralysis and wasting of lower limbs: exaggerated deep reflexes: straining on micturition: no sensory troubles: at sixth month angular curvature: tonic spasm of limbs: anæsthesia: incontinence of urine.	Removal of spine and laminæ of ninth dorsal vertebra: dura exposed, but not opened: "spinal cord rose to the opening made in the bone." "Full antiseptic precautions."	Wound healed in fifteen days: in a week could micturate properly: painful tonic contractions had disappeared: could draw knees up to abdomen, move toes and feel throughout the limbs.	Partial (?) recovery.
2	Macewen (Glasgow). 1883.	*Brit. Med. Jour.*, 1888. Vol. ii. p. 308. Case i. (*Ibid.*, 1886. Vol. i. p. 40.)	Boy, aged 9: complete motor and sensory paraplegia: incontinence of urine and fæces (18–24 months): ankylosis: treatment for three years by Sayre's jacket: limbs wasted and spastic.	Removal of laminæ of fifth, sixth, and seventh dorsal vertebræ: no pulsation in cord: thick connective tissue dissected off back of dura: cord then began to pulsate.	In twenty-four hours limbs warmer and less rigid, returning sensation: in eight days movements of limbs and control over sphincters: in six months could walk without support: in five years could walk five miles, play at football, &c.	Recovery.
3	Macewen. 1884.	*Ibid.* Case ii.	Girl.	A dense connective tissue between the bone and the theca removed with part of adherent theca: cord shrunken without pulsation: removal of laminæ until pulsatile cord exposed.	In ten hours limbs warmer, less livid, and with subjective sensations: on fourth day continence of urine and fæces: sensation returned quickly, motion slowly: in eight months could walk a quarter mile: in four years remained well.	Recovery.
4	Macewen.	*Ibid.* Case iii.	.....	.....	.....	"Also successful."

5	Macewen.	*Ibid.* Case iv.	Pyrexia due to tuberculosis.	.....	Operation possibly hastened death.	Death in a week.
6	Macewen.	*Ibid.* Case v.	Pyrexia due to tuberculosis.	.....	Death from tuberculosis: wound healed.	Unrelieved.
7	Southam (Manchester). 1885.	Author, *Brit. Med. Jour.*, 1888. Vol. ii. p. 665.	Boy, aged 6: angular curvature: absolute motor and sensory paralysis: respiratory troubles: fever: apparently dying.	Removal of third dorsal lamina, giving exit to pus: spray and carbolised gauze dressings.	Improvement in respiration temporary only: broncho-pneumonia.	Death in twenty-four hours.
8	Horsley (London). 1888.	*Med. Chir. Trans.*, Vol. lxxi., 1888, p. 402.	Complete paralysis of all four limbs: "severe caries of the second and third cervical vertebræ."	.....	Wound healed without complication: movement of legs on eighth day: of arms later: rapidly regaining power.	Recovery.
9	Wright (Manchester). 1888.	*Lancet*, July 14, 1888.	Boy, aged 7 years: seven months ill: angular curvature in mid-dorsal region: paresis, &c.: under treatment for six months: later, spastic paralysis of lower limbs: anæsthesia as high as eleventh ribs: incontinence of urine and fæces: no abscess.	Removal of three prominent arches: lower part of theca thus exposed covered with "leathery substance," which was cut away with scissors: cord did not pulsate, but no point of constriction found: careful antisepsis.	Wound healed in a few days: on twelfth day returning sensation, which spread down limbs: on twenty-seventh day could feel pin-pricks as low as left foot and right knee: on fifteenth day, flexion of thighs possible: on fifty-first day began to get worse, and was in a few days as bad as before operation: after six months *in statu quo*. (See also 13.)	Unrelieved.
10	Duncan (Edinburgh). 1888.	*Edin. Med. Jour.*, March 1889, p. 829.	Boy, aged 11: duration of disease about twenty-one months: angular curvature in mid-dorsal region: spastic paralysis, almost absolute, as high as the groin: anæsthesia as high as the abdomen (?): bladder and rectum not affected.	Removal of fourth, fifth, sixth, and seventh dorsal arches: membranes of cord adherent to bone by "granulation texture:" the latter being scraped away, the dura appeared "tolerably white and smooth," and faint pulsation was then observed: plaster jacket applied.	On third day could move ankles and recognise a touch: on seventh day could move knee: on fourteenth could move legs throughout and localise sensation: at end of 3½ months could walk a little with spastic gait, and could feel well: wound healed on seventh day.	Recovery.

TABLE II.—*continued.*

No.	Operator and Date.	Reference.	Symptoms before Operation.	Nature of Operation.	Symptoms after Operation.	Result.
11	Abbe. 1888.	*New York Med. Jour.*, Nov. 24, 1888.	Man, aged 21: duration of disease five months: pain and swelling over tenth dorsal vertebra: temperature hectic: swelling contained pus: partial loss of motor and sensory power in lower limbs: difficulty in retaining urine and fæces: exaggeration of deep reflexes.	Evacuation of pus: removal of eighth, ninth, and tenth dorsal arches, which were carious, and scraping away from posterior aspect of dura a dense mass of connective tissue and detritus.	Sensation began to return in a week, motor power in a month: at end of four months general health good: patient could walk with assistance of a chair, and was steadily improving.	Recovery.
12	Deaver. 1888.	*Inter. Jour. Med. Sc.*, Dec. 1888.	Woman, aged 45: duration of disease four months: paralysis of left leg, followed by arm: exaggerated deep reflexes on both sides: no anæsthesia: deep and painful swelling on left side of neck.	Removal of third and fourth cervical arches, which were carious: the dura was adherent to the bone and thickened: an exploring needle was introduced into it with negative results.	Respiration became much embarrassed towards end of operation, and this trouble continuing, patient died in three days: death was attributed to injury done to the phrenic nerve by the exploring needle. *Post-mortem.* — Compression, hæmorrhage, and degeneration of left side of cord, due to inflammatory growth.	Death.
13	Wright. 1889.	Personal communication.	Same case as No. 9.	Removal of some more arches: bony fragments reimplanted.	Nervous symptoms practically unaltered, although general health is better: wound healed by primary union.	Unrelieved.

The results of these thirteen operations are as follows. In two only (5 and 12) does the operation appear to have done harm; in three (6, 7, and 13) no relief was afforded; in one (9) marked improvement resulted, but a relapse occurred, probably from recurrence of the inflammatory compression; and in the remaining seven we have most obvious relief. The clinical history of the latter group demonstrates clearly that this relief was a direct result of the operation, and was not due to a chance connection. From these figures then we deduce at once the conclusion that in certain of these cases surgical interference is of undoubted value, and it remains only to ask what are the indications for the operation.

It is generally recognised that the nervous phenomena resulting from spinal caries are not due to the mere curvature of the spine; that the latter leaves the vertebral canal little, if at all, diminished in size; and that the implication of the cord arises from some other cause. It is equally certain that the lesion is not in most, if in any, cases an acute myelitis, but rather a result of pressure, to which the changes in the cord structure itself are secondary. This pressure may be exercised by solid fungating masses springing from the bodies of the vertebræ, or by acute inflammatory swelling or hæmorrhage in connection with the meninges, but by far most frequently it is the result of a chronic thickening of the latter. Hence, then, although other causes may be at work, much the most common is chronic localised pachymeningitis compressing the implicated section of the cord. This conclusion is adopted by most writers upon the subject,[1] and is in accordance with the writer's own experience of a considerable number of post-mortem examinations.

It follows, therefore, that we may best hope to relieve these nervous phenomena in those cases in which they are of comparatively slow onset, although it may be possible, as was attempted in Case 7, to extend the operation to more acute cases of compression by suppuration or by hæmorrhage. The chances of success in such an operation must be regarded as very doubtful, but we cannot yet say that it may not have its uses. Up to the present time, however, benefit has ensued only in cases of chronic pachymeningitis, a limitation of the scope of the operation implied also in Mr. Macewen's rejection of cases in which there is rise of temperature. Having thus a clear idea of the condition which we hope to relieve, two other considerations only are necessary. Of these, the most obvious is that we must

[1] Elliott, *New York Med. Jour.*, June 2, 1888.

freely remove the thickened perimeningeal connective tissue, and that only when this has been done can we hope for any good result. The other is that paralysis secondary to spinal caries has, even when of long duration, a remarkable tendency to recovery, if the recumbent position be rigorously maintained, and that we must therefore not operate too early, but must first be convinced that no improvement will result without such intervention, the more so as the frequent occurrence of late recovery itself indicates that we are not seriously diminishing our chances of success by such delay.

Section III.—Other Pressure Lesions.

It having once been proved, as it has been, that the operation of trephining the spine falls within the range of practical surgery, and that chronic pressure lesions of the cord are, even after long duration, susceptible of very great, if not, in some instances, perfect recovery, it follows that the operation is practicable and advisable in any such disease in which the source of pressure is accessible for removal, and is not amenable to other methods of treatment.

In the case of tumours of the membranes or nerve-roots, this has been demonstrated in the most practical manner possible by Mr. Horsley's brilliant operation, and obviously that which can be done for intravertebral tumours can be equally well done in the case of tumours of the vertebræ themselves, and tumours growing into the spinal canal from other regions, provided that the anatomical connections of these growths are not such as to preclude removal. An interesting case of this nature has recently been operated upon in the Manchester Infirmary by Mr. Wright, who is reserving a full report until after the lapse of a longer period, but who has kindly permitted me to use the following notes:—

Case 49.—*Fibro-sarcoma of neck involving brachial plexus and invading spinal canal—Removal—Cure of spinal symptoms.*

A. H., aged thirty-eight, was admitted on August 6, 1888, under the care successively of Drs. Morgan and Ross. For some twenty years he had noticed a slowly-growing swelling on the left side of his neck. Fifteen months before admission he first observed numbness and weakness, of progressive character, in

the left arm; three months later the left leg began to fail, and recently the right arm and leg had been losing power. There was a history of alcoholism, but not of syphilis or any hereditary disease. On admission, the tumour was about the size of an orange, seated in the posterior triangle of the neck, well defined in outline, slightly mobile, firm and elastic; pressure upon it caused pain in the distribution of the ulnar nerve: no other growths were discovered. The left arm was weak and the muscles wasted, the flexors of the wrist and fingers and intrinsic muscles of the hand being mainly affected; "claw-hand" was well marked; partial anæsthesia affected the ulnar side of the forearm and hand. The right arm was also weak, but without atrophy or impairment of sensation: here also the paresis was rather more marked in the flexors of the wrist and fingers, and in the intrinsic muscles of the hand. The deep reflexes at the wrist and elbow were increased. The left lower limb presented the usual evidences of spastic paralysis; the right was but slightly weakened. The left eye projected a little. Pupils normal. General health good. Anti-syphilitic and other treatment proved of no avail, and all the above symptoms became gradually intensified. The spastic symptoms extended to the right lower extremity, the muscles of both lower limbs becoming tonically rigid; paralysis increased, and, on the left side, extended to the upper arm muscles.

On August 21st, 1888, the tumour in the neck was removed by an ordinary dissection; it was about the size and shape of a lemon, and distinctly encapsuled, and was afterwards found to consist chiefly of fibrous tissue, with portions which were clearly sarcomatous, and with areas of myxomatous degeneration. A projection penetrated one of the intervertebral foramina, apparently that for the third cervical nerve, and the base of this process having been ligatured, the chief mass of the growth was torn away, the appendage being temporarily left *in situ*. A second smaller growth, about the size of an egg, was now found lying below the first, and this, which resembled the latter in character, was also removed. Both growths were connected with the cords of the brachial plexus. Attention was next turned to the projection which invaded the vertebral canal. The implicated foramen was large enough to admit the tip of the little finger, and a Volkmann's spoon being thus introduced into the canal, the growth was carefully and gently scraped away. There was no hæmorrhage or other trouble, and the spray, with other antiseptic precautions, was used throughout the operation.

The wound was healed on the twentieth day. Nervous symptoms

were almost immediately relieved. On the day after the operation the contractions of the lower limb muscles were much slighter, and thereafter they ceased entirely. At the same time the lower limbs began to regain power. The right arm also increased markedly in power, and the grasp, which had been almost entirely lost, became quite strong again. The left arm improved to a less extent, but the forearm muscles regained some power, whereas those of the upper arm did not. The improvement thus noted occupied about three weeks, after which the patient was discharged. Some time later, when last seen by Mr. Wright, he could walk, and the right upper limb was almost well, the left *in statu quo*.

There can be little doubt that the growth had here penetrated the vertebral canal along the course of the left third cervical nerve-root, that the latter had been comparatively little injured at first, but that on entering the canal, the growth had more seriously implicated the less resistant tissue of the cord itself, and had grown across the anterior aspect of the latter. In this way only can we explain the comparatively trivial sensory troubles, the spastic symptoms in the upper and lower limbs, and various other minor points. The chief damage was no doubt done to the cords of the left brachial plexus. The operation greatly relieved the pressure upon the cord, but the damage done to the roots of the plexus outside the spinal canal appears to have been irreparable. Although the case is not one of "trephining the spine," in the ordinary sense of the term, it falls within the category of intravertebral operations, and illustrates the benefits to be derived therefrom.

It remains only to add that similar procedures may clearly be adopted for cysts, for otherwise incurable pachymeningitis, for chronic rheumatic arthritis of the vertebræ with compression of the cord, and possibly for certain meningeal hæmorrhages, either at an early stage, when life is directly threatened, or later, should absorption be unsatisfactory.[1]

[1] As the above is passing through the press there has appeared a report by Drs. Dercum and White (*Annals of Surgery*, June 1889) of two cases in which the latter opened the spinal canal. In the first the diagnosis is obscure, but severe nervous symptoms recovered shortly after the operation, in which the dura mater was opened. The second was a case of tubercular pneumonia, caries of the vertebræ, and acute myelitis: death ensued within thirty hours of the operation. Dr. Abbe (*New York Med. Rec.*, February 1889) has also opened the spinal canal and divided several of the cervical nerve-roots close to the dura mater, in a case of intractable neuralgia: the patient survived and manifested some improvement in his symptoms.

CHAPTER VII.

OPHTHALMOSCOPIC CHANGES IN INJURIES OF THE SPINAL CORD AND IN TRAUMATIC NEUROSES.

Few subjects have been less investigated, and on few is the information which we possess more conflicting, than on that of the changes seen in the fundus oculi after injuries to the spinal cord, the original observations upon the point being remarkably limited in number, while the references found in medical literature are mainly more or less accurate expositions of the work of but very few observers. Under these circumstances, I have thought it worth while to make a few fresh investigations, and to compare the results with the conclusions arrived at by others.

A double source of confusion has been introduced into the consideration of this subject—a confusion of which we must in the first instance endeavour to divest ourselves. It is exceedingly common to find after severe shocks to the nervous system certain eye-symptoms—retinal irritability, photophobia, retinal weakness, muscæ volitantes and other subjective phenomena, disturbances of accommodation (especially if there be previous refractive error), weakness of the internal recti, and last, but not least, more or less complete loss of vision, with marked restriction of the visual field. These conditions are recognised as retinal, accommodative, or muscular asthenopia and as "hysterical" amblyopia, of the last of which affections several instances will be mentioned in considering traumatic hysteria. They are all purely functional troubles, and bear no relation to any organic changes in the fundus oculi, nor, so far as I can find, is there a single instance on record in which such symptoms were followed by optic atrophy, although many writers certainly convey the impression that in nearly all such cases ophthalmoscopic changes eventually supervene.[1] Hence, then,

[1] *Cf.* Erichsen, Science and Art of Surgery, 8th edit., London, 1884, vol. i. p. 777.

at the outset, superfluous as it may seem, we must insist upon the truism, that the existence of changes in the optic nerve or disc cannot be established unless objective evidence of such change be forthcoming, as the result of either an ophthalmoscopic or a post-mortem examination, and that the presence of subjective visual troubles is not necessarily any indication of organic disease.

The second source of confusion to which I have referred is that until recently it has been customary to describe as "concussion of the spine" a large number of cases which are now recognised as neurasthenic or hysterical, which may collectively be denominated traumatic neuroses or traumatic neuro-psychoses, and which are in no way dependent upon lesions of the spinal cord. Here again, then, we must reiterate a second truism, that those cases only should be regarded as injuries of the spinal cord in which there is definite evidence of some lesion of that structure.

In order to obviate as far as possible these two initial difficulties, which appear to have insensibly crept into and complicated the descriptions of many writers, we must therefore confine our attention strictly to cases in which changes in the fundus are proved, and not merely inferred to exist; and we must carefully distinguish between *bona fide* injuries of the spinal cord on the one hand, and the large class of traumatic neuroses on the other. To keep clear this latter important distinction, it will be well to discuss separately the visible optical changes: *first*, in definite organic lesions of the spinal cord; *second*, in slighter injuries to the back, not directly implicating the spinal cord, and unaccompanied by such circumstances as cause severe shock to the nervous system; and *third*, in injuries of which the local conditions are similar to the last, but which are complicated by more or less severe general shock—*i.e.*, practically, railway injuries.

I.—Injuries of the Spinal Cord.

In the above pages there will be found thirty-eight personal observations of severe injuries to the spinal cord, the records of which cases, including fractures, dislocations, and hæmorrhages, constitute the basis from which my own conclusions have been drawn. Of these thirty-eight cases, seventeen were injuries below the level of the third dorsal nerve-roots. In none of the seventeen were there ever any subjective eye-symptoms,[1] and, in nine at least, I failed, on examining the discs,

[1] There was one doubtful case, in which, however, repeated investigations failed to show any changes in the fundus (p. 123).

to find anything abnormal. Hence, although the evidence is purely negative, my own experience would appear to indicate that, in severe injuries below this level, ophthalmoscopic changes do not arise, even at long intervals after the receipt of the injury. The majority of the injuries have been considerably below the third dorsal nerve, but the considerations which follow lead us to assign to the upper dorsal region the dividing-line between cases which do, and those which do not, give rise to changes in the disc.

There is, however, one recorded case which apparently points in an opposite direction. Mr. Bruce Clarke [1] reports the case of a man who, having been struck by a falling weight, sustained a fracture of the fourth, fifth, and sixth dorsal vertebræ, with complete division of the cord at the level of the fifth and sixth, dying on the tenth day. On the third day it is stated that "there is well-marked hyperæmia, with considerable œdema of both discs; a good deal of effusion obscures the vessels in many places." But here it was noted on the second day that breathing was "entirely diaphragmatic," and on the third that there was well-marked hyperæsthesia of the chest; so that it appears highly probable that myelitis had rapidly extended for a considerable distance above the injured region, and had reached, at least, to the extreme upper limit of the dorsal portion, before any optical changes were found; from which it would follow that the exception is apparent rather than real, and that the eye-troubles may be traced to an extension of the cord mischief above the level of the dorsal region.

Very different results are obtained from a study of cases of injury above the second dorsal nerve, *i.e.*, above the level of the "cilio-spinal centre." The twenty-one cases of injury in the cervical region above described include fifteen of fracture or dislocation, with one recovery, and six of intraspinal hæmorrhage, four of which recovered, and in one of which (Case 21) the patient lived for eighteen months after the accident. In no case, either of recovery or of early or tardy death, did any subjective eye-symptoms present themselves, and we may therefore assume that in none were there any very serious papillary changes.

In seven cases, however, we have definite ophthalmoscopic observations, of which the results are as follows:—

1. (Case 8.) A man, aged thirty-three, was struck upon the back of the neck by a weight, receiving a fracture of the fifth and sixth cervical vertebræ, with dislocation forwards of the fifth, and suffering from total paralysis, anæsthesia, &c., below the level of

[1] St. Barth. Hosp. Rep., vol. xvi., 1880, p. 171, Case 4.

the lesion. He died on the seventh day, the diagnosis being confirmed by post-mortem examination. I examined the discs on the sixth day, finding no abnormality. The pupils and palpebral fissures were small, and the former did not dilate upon irritating the skin of the back of the neck.

2. (Case 13.) A woman died in forty hours from fracture-dislocation between the sixth and seventh cervical vertebræ, with the usual symptoms of a crush of the spinal cord, the consequent paralysis extending rapidly to the phrenic roots. The lesion was confirmed by post-mortem examination. I examined the eyes within twelve hours of the accident, finding the right disc normal; the left could not be seen owing to an incipient cataract. The only mobile pupil was reduced in size.

3. (Case 14.) A man died in thirty-one days from a dislocation of the last cervical vertebræ. There were the usual symptoms of a crush of the spinal cord, and the post-mortem examination established the diagnosis. On the seventeenth day I found both discs normal and identical. The pupils and palpebral fissures were contracted on both sides, but especially on the right, where there were other evidences that the cervical sympathetic was more severely injured.

4. (Case 15.) In a case of unilateral dislocation of the fifth cervical vertebra, with incomplete crushing of the cord, causing paralysis, anæsthesia, &c., below the injured region, the dislocation was reduced, and the man gradually recovered almost completely. I examined his discs on several occasions, within the first few weeks after the accident, without finding any changes. The pupils and palpebral fissures were, as usual, diminished in size.

In these four cases, then, there was no evidence of changes in the disc, but, as we shall shortly see, the examination in Case 13 (and perhaps also in Case 8) was too early, and that in Case 14 too late, for us to affirm that no such change had or might have arisen. Case 15, in which the cord injury was not very complete, is the only one in which we may safely assume that the optic discs were unaffected. There remain three other cases.

5. (Case 10.) A man, aged thirty-three, sustained a fracture of the sixth cervical vertebra, with dislocation forwards of the fifth. He died on the twenty-ninth day, and the post-mortem examination confirmed the diagnosis. The symptoms and appearances were those of a crush of the cord in the region named, with myelitis ascending for some little distance, but with no evidence of basic meningitis. The palpebral fissures and pupils were small, and the latter did not dilate on pinching the skin of the neck.

On the third day the optic discs were perfectly normal. On the fifth day their margins were less well defined than before, and there was slight congestion of the retinal veins. On the sixth day the discs were still more hazy, but there was no obscuring of the vessels by effusion. Thereafter they were not examined.

6. (Case 12.) A young man sustained a fracture of the first dorsal vertebra, with dislocation forwards of the seventh cervical. He died on the tenth day, and presented the symptoms and post-mortem appearances of a crush of the cord at the region referred to, with some ascending myelitis, but with no evidence of basic meningitis. The palpebral fissures and pupils were contracted, and the latter did not dilate on pinching the skin of the back of the neck. On the third day the optic discs were a little hazy and ill-defined, there being also slight venous congestion of the retina. On the fifth day the same symptoms were present, but there was no evidence of effusion. On the ninth day the discs were more indistinct than before, and the smaller vessels were quite obscured by exudation.

7. (Case 11.) After an injury to the spine this patient presented the symptoms of a crush of the cord above the level of the sixth cervical root, followed by myelitis, which slowly extended upwards for some ten days and then ceased. Improvement now commenced, and for another fortnight there was gradual return of power in some of the muscles of the upper limbs, after which the condition was unchanged. On the fifty-sixth day the laminæ of the affected vertebræ were removed; the myelitis at once began to reascend, and eight days later the patient died. He had no symptoms of basic meningitis. The autopsy confirmed the diagnosis. Both pupils and palpebral fissures were contracted throughout. On the second and third days after the accident, he had profuse lachrymal secretion, with congestion of the conjunctivæ and flushing of the face. On the morning of the third day the left hand was warmer and redder than the right, and in the evening the condition was reversed; but on the fourth day the left was again redder and somewhat congested. On the sixteenth day I examined the discs for the first time, and found them both hazy, with ill-defined outlines and doubtful engorgement of the retinal veins. Two days later I could find no abnormality in the right disc, but the left was still hazy as before, the difference between the two being very obvious. On the following day Dr. Little kindly examined the eyes, and found the right disc perfectly healthy, whereas "the left was hazy, with some distension of the vessels and haziness along their course." Dr. Little had no doubt

that there was at this time a pathological change on the left side, especially in view of the difference between the two eyes. On the thirty-third day I again found both discs slightly hazy, the right being less well defined than at the last examination, but the left less obscured, so that their condition was now practically the same. On the thirty-ninth day both discs were quite clear and healthy. On the forty-fourth day Dr. Little again reported, "Both optic nerves quite healthy and alike, well defined, and no haziness whatever." Hereafter I made no examination until the day before death, when I was unable to detect any departure from the normal, but when, owing to the patient's condition and restlessness, it was difficult to make a satisfactory examination.

From the above facts it will appear that in four cases of crush of the upper portion of the spinal cord (third cervical to second dorsal), where frequent examinations were made, ophthalmoscopic changes were found in three, being absent in one only; that in three other cases such changes were absent on the first, sixth, and seventeenth days respectively; and that in six cases which survived the accident for long periods no subjective symptoms arose, so that optic atrophy probably never ensued.

In the three cases known to be affected the changes consisted in haziness, with want of definition of the disc, accompanied by slight distension of the retinal veins. In the first case, the changes ensued on the fourth or fifth day after the accident; they increased until the sixth day, but were not investigated at a later period. In the second case, they had commenced on the third day, increased on the fifth, and been followed by effusion, obscuring the smaller vessels, before the ninth, after which death prevented further change. In the third case, the haziness and congestion were found on the sixteenth day, but may have been present previously; the right eye almost immediately afterwards returned to the normal condition, the left getting worse; then the left improved, and the right again presented congestive changes; and finally, on the thirty-ninth day, both were normal. In all the cases there was evidence of paralysis of the cervical sympathetic; in the last, remarkable vascular and secretory changes occurred both in the face and upper limbs, and consecutive myelitis first got worse, and then again improved. In none was there any evidence of basic cerebral meningitis.

So far as I can ascertain, the occurrence of similar changes in the optic disc in cases of spinal injury has not hitherto been described, but on the other hand there are no complete observations which would indicate a negative view. True, Dr. Clifford

Allbutt [1] states that in seventeen "severe injuries, which proved fatal within a few weeks," no changes appeared in the eye, and that such "changes do not become established in the cases which run a short course, but they slowly supervene in the course of weeks or months in more chronic cases." We are, however, not told how often or at what intervals these fatal cases were examined, and enough has been said to show that, without frequent observations, the changes might readily be overlooked. On the other hand, the description given by Dr. Allbutt of certain effects which he observed in "chronic" cases of spinal injury coincides almost exactly with the appearances above referred to; and in similar accord with his statement, that (always in chronic cases) these changes are the more readily produced the higher is the lesion, is my observation of three (acute) cases in the cervical region and of none at a lower level. These coincidences are the more remarkable because, as will shortly appear, Dr. Allbutt has found these appearances only in chronic cases, whereas I have failed to detect them except in severe or "acute" spinal injuries.

II.—Slight Spinal Injuries Unaccompanied by Direct Lesion of the Cord or by Functional Neuroses.

Slight blows, bruises, and sprains of the back are exceedingly common. They may present only local symptoms (pain, &c.), or they may be accompanied by a sort of "pseudo-paralysis," in which, owing to the fear of pain, the patient avoids free movements of the limbs or spine, holds the back and other joints rigid, and perhaps does not even defæcate or urinate with his normal force. Cases of the latter description are fully discussed in the third chapter of Mr. Page's work on "Injuries of the Spine," [2] and it is unnecessary to explain more fully the kind of injury to which reference is now made. But in spite of the large number of such minor injuries to the back that come under observation annually in hospital practice, I have found none in which there were subjective eye-symptoms, nor have a considerable number of ophthalmoscopic observations revealed a single instance of any affection of the optic discs. Moreover, I find only one reported case of the kind in which such changes were said to have ensued, viz., that of Dr. Thorowgood.[3] The patient was a girl twelve years

[1] The Ophthalmoscope in Diseases of the Nervous System, &c., London, 1871, also Lancet, January 15, 1870.

[2] Second edit., London, 1885, p. 120.

[3] Transactions of the Clinical Society of London, vol. viii., 1875, p. 80.

of age, who received a blow—apparently not a severe one—on the lower part of the back. The pain which was thereby caused soon disappeared, but shortly afterwards she had pains at the back of the neck, with tenderness, slight swelling, and muscular stiffness; this also got better in a few days. Then, a month after the accident, she rapidly lost the sight of both eyes and was found to have the condition of "choked discs." The latter again recovered in about a month, leaving the girl in perfect health. These changes are attributed to "slowly progressing basic meningitis" involving the optic nerves; but I fail to appreciate the grounds for such a diagnosis, especially as the ophthalmoscopic appearances are quite different from those found by any other observer after spinal injury, and I can only regard as a pure accident the supervention of uncomplicated acute optic neuritis a month after a blow on the lower part of the back.

In certain cases, however, slight injuries of the spine may be followed by a subacute or chronic spinal meningitis, but such cases are unquestionably uncommon, only two having come under my own observation among some four hundred railway accidents and spinal injuries due to various causes. Again, chronic degeneration of the cord is said occasionally to follow the slighter spinal injuries, but this also must be a rare condition, and it is one which I have not personally met with.

If, however, there be produced, as the result of an injury, either chronic meningitis or chronic degeneration of the spinal cord, may we meet with ophthalmoscopic changes? Dr. Clifford Allbutt states that he found such changes in eight out of thirteen cases which he examined; but unfortunately he does not describe the cases, and it is perhaps permissible to doubt whether they were all genuine spinal injuries. His paper appeared in 1870, at which time "traumatic hysteria" was hardly known and traumatic neurasthenia hardly recognised, all obscure effects of injury to the nervous system being called injuries of the spine. Verriest[1] also records a case, which appears to have been an instance of chronic traumatic myelitis, and in which optic neuritis resulted. But, with these exceptions, we have no reported cases of secondary traumatic spinal disease giving rise to optic neuritis, the observations of Mr. Wharton Jones being, as we shall shortly see, described too vaguely to constitute reliable data.

Hence, then, we may perhaps sum up this section of the subject thus:—Slight spinal injuries are very common, but there is no evidence that they tend to be followed by changes in the

[1] Page, Brain, 1886, vol. ix. p. 262.

optic disc. Such injuries are, however, in rare cases followed by chronic meningitis or myelitis, and in the latter condition there is an *à priori* probability that optic neuritis may supervene. Both of these affections are, however, very rare, and with the exception of Dr. Allbutt's eight cases, in which we have not the materials for an accurate diagnosis, there is but one recorded instance of this conjunction.

III.—Traumatic Neuroses, with or without Slight Injury to the Spine.

Under the above heading are included those cases, best illustrated by the results of railway collisions, in which, although there may have been some slight sprain of the spine, the resulting symptoms are due mainly to a traumatic neurosis. The cases differ from those of the last section in the presence of this latter most important factor, and the distinction between the two groups is of the greater consequence, as it is not impossible that it is to the neurosis, rather than to the spinal injury, that we owe such changes in the fundus as are sometimes met with. Here also, however, changes of the optic disc are so rare, that, among the numerous railway injuries which have come under my own observation, and which include many severe cases of traumatic neurosis, I have seen but one doubtful case of lesion of the optic disc—a case which will be more fully referred to below. The *functional* eye-symptoms, to which reference was made at the beginning of this chapter, are more often present than absent, but in no instance have I seen them followed or accompanied by organic changes. For obvious reasons, I do not always make an ophthalmoscopic examination in such cases, unless there is some suggestion of eye-mischief; but we may safely assume that had many of those which were not thus examined presented any pathological change, the attention of the railway company concerned would probably have been attracted to the matter in at least one instance.

My experience is therefore directly opposed to the teaching of most writers, who appear to regard optic neuritis as a frequent result of "concussion of the spine;" but the discrepancy is susceptible of explanation. In 1869 Mr. Wharton Jones[1] first stated that he found ophthalmoscopic changes in certain traumatic cases, but he gave no details, and no account of the cases in which the changes were found, nor of the frequency with which

[1] Failure of Sight from Railway and other Injuries. London, 1869.

he had observed them. One year later Dr. Clifford Allbutt[1] published the observations already referred to. In 1875 appeared the second edition of Mr. Erichsen's work on "Concussion of the Spine." Having enumerated the various subjective symptoms already referred to, he gives an excellent account of their pathology, and then passes on to quote largely from Mr. Jones and Dr. Allbutt. After a long extract from the latter, he says: "One or other of these conditions occur in the majority of cases of spinal injury, such as we are describing in this work," leaving on the mind of the reader the impression that the "one or other of these conditions" refers to the different ophthalmoscopic changes observed by Dr. Allbutt. This extraordinary verbal confusion has since been repeated, so that even in the 1884 edition of his text-book (p. 778), almost the same words are used, and the reader is led to expect optic neuritis in almost every case of "spinal injury;" and yet Mr. Erichsen has not mentioned a single case in which he has himself seen ophthalmoscopic changes. In their respective articles on spinal injuries, Messrs. Jacobson[2] and Liddell[3] merely quote the above writers without adding any evidence of their own. Dr. Gowers[4] also quotes Dr. Clifford Allbutt, without bringing forward any fresh material. And thus we may trace back to the same source the opinions expressed by the majority of writers upon this point.

Mr. Page,[5] on the other hand, who has investigated the subject for himself, arrives at conclusions entirely opposed to the above, but similar to mine, saying that, in this class of cases, he has "never been able to discover any lesion or pathological change in the fundus of the eye." Similarly, in the discussion by the Ophthalmological Society on "Eye-Symptoms in Diseases of the Spinal Cord,"[6] there is but one reference to injuries, that of Dr. Hughlings Jackson (p. 229), who says "he knew of none [*i.e.*, of no eye-symptoms] from lesion of it [the cord], excepting when that lesion was in the cilio-spinal region . . . (contraction of the pupil . . . narrowing of the ocular aperture)."

There are, however, a few reported cases, of which I believe the following to be a complete list, in which optic neuritis has

[1] *Loc. cit.*

[2] Holmes' System of Surgery, 3rd edit., London, 1883, vol. i. pp. 656 and 703.

[3] Ashhurst's Encyclopædia of Surgery, London, 1884, vol. iv. p. 886.

[4] Medical Ophthalmoscopy, 2nd edit., London, 1882, p. 169.

[5] *Loc. sup. cit.* Also Heath's Dictionary of Surgery, article, "Disorders of Vision from Injuries of the Head and Spine."

[6] Trans. Ophth. Society, vol. iii., 1883, p. 190. See also Gowers, Lancet, 1883, vol. i. pp. 869 and 1031, and Medical Times and Gazette, 1883, vol. i. p. 661.

supervened upon so-called spinal injuries, but in which probably the spinal cord played no part in the production of the symptoms. Mr. Bruce Clarke [1] records two cases. The first is that of a man who, having fallen upon some bottles, sustained one or two scalp wounds, and suffered from mental confusion, followed by general weakness of his muscles, most marked in the right arm, with tenderness over the lower cervical region. This patient presented "intense hyperæmia of both optic discs," but no swelling or affection of the retinal vessels, and no interference with sight. In this case the man would appear to have been suffering from hysteria, and certainly there is no sufficient evidence of injury to the spinal cord: he "evidently endeavoured to make himself out as bad as he could," and hence "the dynamometric test was fallacious." The visual fields were apparently not tested. The second case was one of a fall upon the back of the head, followed by certain psychical symptoms, loss of power and sensation in the left leg, retention of urine, and slight priapism. On the third day both discs were hyperæmic. This, again, is not obviously the result of injury to the spinal cord, there being in the psychical symptoms a suspicious indication of some cerebral lesion.

Oppenheim [2] also gives two cases, the first apparently purely functional, and certainly due to blows upon the head, without any sign of cord-lesion; the second presenting symptoms resembling those of general paralysis or sclerosis in patches, and due to blows inflicted in a railway collision, both on the back of the head and on the lower part of the back. In the first, the left disc was found, fourteen months after the accident, to be pale and slightly atrophic, the visual field being restricted for colours. In the second, there was atrophy of the right disc with contracted colour-field. In the paper from which these cases are quoted, Oppenheim lays much stress upon them as indicating an organic origin of the symptoms of "traumatic neuroses;" but in a later article [3] he says he has not since seen such appearances —a statement of the more importance in view of his extensive experience and careful research. In any case, as has been said, the presence of cord-mischief is not proved, and the unilateral character of the symptoms points rather to a cerebral origin.

[1] *Loc. cit.*, Cases I. and III.

[2] *Archiv für Psychiatrie*, vol. xvi., 1885, p. 760. See also Schöler and Uhthoff, *Beiträge zur Pathologie des Sehnerven und der Netzhaut bei Allgemeinerkrankungen.* Berlin, 1884, p. 46.

[3] *Berliner klinische Wochenschrift*, 1888, February 27, p. 170

Finally, Plüger[1] quotes cases from Mooren,[2] whose original article I have been unable to obtain, but quotes so vaguely that it is impossible to be sure to what conditions the latter is referring. The passage runs: Optic neuritis is found "further in concussion of the brain, and even of the spinal cord, of which Mooren adduces several cases" (des weiteren bei Erschütterung des Gehirns und sogar des Rückenmarks, wofür Mooren mehrere Fälle aufführt).

From the above summary we are led to the conclusion that the occurrence of optic neuritis is extremely rare in the cases formerly described as concussion of the spine, and that even when present, there is no indication whatever that it bears any relationship to a lesion of the spinal cord.

The final question remains, When such changes do supervene, may they not be the result of the functional neurosis rather than of the usually trivial bruise or sprain of the back, which is generally also present?

On page 195 is reported a typical instance of hysterical hemianæsthesia in a woman—the result of a railway accident. Not long before one of my visits to this patient, Dr. Dyson, of Sheffield, and Dr. Jones, of Wath, examined her eyes, and, in the words of the former, found, on the opposite side to the anæsthesia, "intense hyperæmia of retina and disc, the lower part of the disc especially being swollen (choked) and its margin ill-defined." A few days later I was unable to satisfy myself that there was any abnormality, and Dr. Jones stated that the changes which he had seen had vanished. Fifteen months later Dr. Jones writes me that "the disc is paler than the other, and in the lower border (inverted image) a large artery is distinctly lessened in calibre." Although I was thus unable to verify the observation, there can be no doubt but that vascular changes had been manifested in a case in which there was never any suggestion of spinal injury, but in which the whole course was that usually seen in traumatic hysteria; but unfortunately the case is rendered of little value, as illustrating any connection between the general condition and the optic change, by the fact that a very severe bruise had been received on the same side of the face as the affected eye, and that it is thus impossible to deny the existence of a peripheral injury.

Vascular changes in the disc and retina are, however, certainly not incompatible with the recognised results of hysteria, in which we frequently find vascular changes elsewhere, and we have also other evidence that ophthalmoscopic changes may occur apart

[1] *Archiv für Ophthalmologie*, 1878, Bd. xxiv. Abth. ii. p. 178.
[2] *Ophthalmolog. Mittheilungen aus dem Jahre* 1873.

from organic disease of the nervous system. In the discussion by the Ophthalmological Society, already referred to, the late Dr. Mahomed,[1] remarking "how much can we rely on such symptoms as localising symptoms, or even symptoms of organic, as distinguished from functional, disease," refers to several cases of optic atrophy or neuritis "in association with various conditions of deteriorated health," and "in association with catamenial irregularities;" and finally, reviewing the evidence, he says, "It appears to me that they may be produced by conditions of nervous exhaustion, of sympathetic excitation, by reflex trophic disorders, and other remote or diffused conditions. If this be so, it is clear that we should never pronounce a grave diagnosis on the evidence afforded by such symptoms as these alone. . . . They may mean functional disorder," &c. Other writers have frequently described optic neuritis in hysteria and other conditions of general debility (*cf.* Gowers, "Medical Ophthalmoscopy," p. 175). And in a very complete paper on "Functional Eye-Symptoms in Hysteria and Allied Conditions," Dr. Hill Griffith [2] records, among four cases of "hysterical blindness," one of "marked hyperæmia of discs," and one, in which "the retinal vessels are tortuous to a very marked extent."

On these grounds, then, it would appear that there is an *à priori* probability that the functional traumatic neuroses may give rise to changes in the optic discs; that there is some evidence that such changes have—although very rarely—been observed; and that in this way we may perhaps explain some of the cases in which the appearances were—in the absence of satisfactory evidence—attributed to a lesion of the spinal cord.

[1] *Loc. cit.*, p. 246.

[2] Trans. Oph. Soc., vol. viii., 1888.

CHAPTER VIII.

TRAUMATIC HYSTERIA, ESPECIALLY IN RELATION TO RAILWAY ACCIDENTS.

It is but a few years since "concussion" was regarded as one of the commonest injuries of the spinal cord, and the exact nature, and especially the prognosis of that disease, has perhaps been productive of as wide differences of opinion and of as much discussion as any question in pathology. And although recent writers are now practically unanimous in agreeing that concussion of the spinal cord is at least an extremely rare lesion, there is still much dispute as to the significance of the nervous symptoms commonly observed after severe physical, or physical and psychical, shocks. Under these circumstances it will perhaps not be out of place to collect here a number of cases which have come under my own observation, comparing with current doctrines the lessons which they teach, and thus presenting a *résumé* of our present knowledge of a pathological condition which, although not very common, is by no means rare, as the result of railway collisions and other severe accidents. In thus sketching the clinical history of traumatic hysteria, I do not claim to be bringing forward any strictly original matter, but rather to be presenting certain facts which are as yet but imperfectly familiar to many of the profession, but upon which we may at any time be required to express a very definite judgment.

1. Definition.

A satisfactory definition of the term "traumatic hysteria" is hardly possible, but a fairly clear conception of the meaning in which it is here used may be obtained by a series of negations. An injury may act upon the nervous system in one of several ways. We may have a direct mechanical solution of continuity,

a hæmorrhage, inflammatory changes (acute or chronic), or other organic (degenerative) processes. There are also certain traumatic effects of which the pathology is as yet obscure—probably ichoræmic—as hydrophobia and tetanus. In other cases, injury merely calls forth manifestations of a more or less latent pathological condition, as in post-traumatic delirium tremens. All of these can be at once excluded from consideration. Again, local injury to a nerve may give rise to phenomena known as *reflex*, a term including another obscure group of cases, susceptible probably of a more refined division. Where there is a distinct reflex effect, or where the injured nerve is certainly the source of a progressive organic change, we can again exclude the cases from consideration, but some instances described as "reflex paralysis" fall, I believe, within the category of traumatic hysteria.

There remain a large number of nervous affections, of traumatic origin, not known to possess any organic basis, and with somewhat ill-defined outlines, among which we must seek for the cases now under consideration,—affections described as "shock," "concussion," "neurasthenia," and "hysteria." "Shock" is an expression of a comparatively definite and well-recognised meaning, which it is not necessary now to discuss at length, but which does not include hysteria. "Concussion," on the other hand, is used in the vaguest possible manner, in the nosology of some writers apparently covering nearly all, if not all, the functional as well as some of the organic traumatic nervous lesions. The classical "concussion of the brain" is a well-understood affection, representing almost certainly a definite organic pathology, viz., intracerebral hæmorrhages. To such cases it should, I believe, be restricted for the present, as its otherwise vague signification only obscures our views of many affections capable of much more accurate description.

"Neurasthenia" is constantly spoken of by English writers as almost synonymous with hysteria, from which, however, it can and should be clearly distinguished. The symptoms of neurasthenia arise from a general defect in the nutrition and action of the nervous system, and, when they follow an injury, are characterised chiefly by general debility, confusion of thought, loss of memory, mental irritability, disturbed sleep, dreaming, headache (usually posterior), interference with visual accommodation, photophobia, palpitation, frequency of the pulse, dyspeptic troubles (furred tongue, foul breath, constipation, and nausea or epigastric pain), sweating, a concentrated condition of the urine, &c. This is a clinical picture which, with slight variations, constantly presents

itself after injuries, especially after railway injuries. The symptoms follow those of "shock," and are the expression of an exhausted nervous system. They are generally transient, and will pass away under conditions and a line of treatment which may be briefly described as "tonic."

That such neurasthenia may be, and, indeed, frequently is, combined with true traumatic hysteria, cannot be denied; but the two conditions are nevertheless essentially distinct, and, even when they are present together, the symptoms pertaining to each can generally be clearly separated. Neurasthenia is far more common than hysteria (out of some three hundred cases of railway accident, of which I have notes, I find only about twenty-five of hysteria, whereas more or less neurasthenia is almost invariable); its effects are much more diffused throughout the system, and less well defined; and its duration is usually comparatively brief. It may be said that the one is merely a minor degree of the other, but I doubt if this be pathologically true,[1] and for practical purposes we can certainly draw a rough distinction.

Granting, then, that sharp divisions are at present impossible, I, nevertheless, think that we may tentatively classify the post-traumatic functional neuroses somewhat as follows:—

1. *Acute effects.*
   - (*a.*) General nervous depression—"shock" or "collapse."
   - (*b.*) A more localised and defined disturbance of cerebral (cortical) origin—"acute hysteria" or "hysterics."

2. *Chronic after-effects.*
   - (*a.*) General nervous depression—"neurasthenia."
   - (*b.*) A more localised and defined disturbance of cerebral (cortical) origin—"chronic hysteria."

Such an arrangement, even if it be somewhat arbitrary, is at least convenient for purposes of reference and of description, and it has the advantage of avoiding the coining of new terms. I would, then, endeavour to define "traumatic hysteria" as a functional affection of the nervous system, resulting from an injury, due probably to a change localised in some portion of the cerebral cortex, and manifested by correspondingly well-defined and localised

[1] If the pathogeny of hysteria be "suggestion" or "auto-suggestion," and that of neurasthenia merely exhaustion, there is a clear theoretical as well as a practical distinction.

symptoms. Or we may say that it has no known organic basis, that it is not reflex in origin, and that it is neither shock nor neurasthenia.[1]

2. History and Nomenclature.

Traumatic hysteria has been studied chiefly from two points of view; two series of observations having originated apart and gradually converged. Thus we have, on the one hand, the recent growth of our knowledge concerning hysteria; on the other, we have the writings of those who have been interested in the real or supposed peculiarities presented by railway accidents.

Hysteria has, of course, been recognised for ages, but has, until comparatively recently, been regarded as an affection peculiar to the female sex and connected with the generative organs. The latter idea is now entirely abandoned, and of late years it has been amply demonstrated, especially by Charcot and his pupils, that the male sex is liable to neuroses which, owing to the similarity of their manifestations to those of female hysteria, have naturally received the same name. It is hence universally accepted that, although much commoner in the female sex, and perhaps not unfrequently finding their origin in diseased conditions of the genital organs, the symptoms thus designated are essentially of nervous origin, and may be induced by very various causes, the action of which is not limited to the female. Hence we are now all perfectly familiar with "hysteria in the male," and have ceased to feel surprise at the paradox implied in the use of this etymologically meaningless term.

Another line of investigation has familiarised us with important local manifestations of hysteria, which have received prominence only within the last half-century. Brodie ([2]) * first drew attention to certain joint-affections, dependent apparently on a functional change in the nervous system, and so closely allied to the before-known manifestations of hysteria as to have been placed within the same category. Coulson,([3]) Skey,([4]) and others

[1] It may be well here to point out that, in addition to the troubles above referred to, accidents may be followed by other symptoms, which, regarded superficially, would appear to indicate a lesion (organic or functional) of the nervous system, but which are really due solely to an endeavour to prevent pain, as from a sprain, &c. Mr. Page has described at length how many cases of so-called "concussion" are but sprains of the spine, with concomitant muscular rigidity or feebleness, arising from purely local causes.

* The numbers refer to the Bibliography appended to this chapter.

insisted upon and extended Brodie's conclusions. It is, however, mainly to Russell Reynolds,(6) followed by the French school, with Charcot, (67, &c.) at its head, that we owe our present detailed knowledge of the phenomena of this pathological state.

The knowledge, or, at any rate, the due recognition of injury as a cause of hysteria, would appear to have arisen entirely within this same half-century. Suggested, but without emphasis, by the earlier writers above quoted, the connection has been mainly insisted upon by the French school, by Wilks (16) and Page (34) in this country, and by Walton (17, 19) and Putnam (18) in America. That, in either sex, symptoms resembling those of hysteria may arise from injury is now placed beyond all doubt, and it is equally certain that many cases formerly differently described belong to the same group. Such cases may be found in the writings of Larrey,(1) Weir Mitchell,(8) Erichsen,(15) Brown-Séquard,(21) Oppenheim,(26, 33) &c. Such is a brief outline of the history of our knowledge of traumatic hysteria, as observed in military surgery and in the ordinary accidents of civil life.

Running side by side with the gradual growth of the conclusions thus referred to, there has been a controversy which frequently trenches upon the same ground—the discussion of the significance of the symptoms observed mainly in the victims of railway collisions.

Mr. Erichsen,(15) in a work which, for careful observation and graphic description, is probably unsurpassed in our language, has enumerated the majority of these symptoms, attributing them to a change in or about the spinal cord, frequently to a meningo-myelitis, and classifying them as "concussion of the spine." As the result of the views so ably expressed by him, we have the term "railway spine" now imported into various European languages. The most obvious difficulty which arose in the way of this theory was the fact that many, if not all, of the symptoms would appear to be of cerebral rather than of spinal origin, and Mr. Erichsen's own view of an extension of meningo-myelitis to the cranial contents has appeared to many authors to be unnecessary, arbitrary, and unsupported by any evidence. Hence Putnam,(18) Walton,(17) Westphal,(10) Moeli,(13) Oppenheim,(69) and many others, have looked rather to the brain than to the spinal cord as the source of the evil, and we have the term "railway spine" replaced by the undoubtedly preferable "railway brain." Such a change is, however, obviously but one step towards the truth. "Railway brain" connotes no definite pathology, and, like its predecessor, includes many diverse conditions.

Hence others, as Oppenheim in his later works, have endeavoured to express the facts in more definite and more intelligible terms. Mr. Page ([34]) has done more than any other surgeon to render our ideas upon this point somewhat less obscure, and he classifies the majority of *bonâ fide* neuroses as "neurasthenia," as almost synonymous with which he uses also the term "hysteria." Modifying this view very slightly, I should be inclined, as above stated, merely to limit the term "neurasthenia" rather more than he does, and to distinguish more sharply between that affection and hysteria. The American writers already quoted distinctly admit the "hysterical" aspect of many cases. Oppenheim,([69]) clearly recognising the cerebral source of these various troubles, and describing the symptoms together, calls them "traumatic neuroses" or "traumatic neuropsychoses." Strümpell ([76]) also speaks of traumatic neuroses, which he divides into "general traumatic neuroses" and "local traumatic neuroses," the former subdivision including roughly those symptoms to which I have referred as neurasthenic, together with some of the hysterical affections, the latter those of hysteria solely. Bernhardt ([75]) recognises three classes of cases, viz.: (1.) those in which there are fairly definite symptoms, probably of organic origin; (2.) those of hysteria or hystero-epilepsy; and (3.) those in which, without any definite symptoms, there is a feeling of weakness, malaise, and inability to work. Cénas ([79]) clearly describes as the possible results of a railway accident (1.) meningo-myelitis and meningo-encephalitis, which are rare; (2.) hysteria; and (3.) neurasthenia. Hence, then, there would now seem to be a fairly general acceptance of the classification which has been used above, and the term "traumatic hysteria" is very widely adopted as a description of many cases of functional nerve-disease arising from railway accidents. I would only repeat, that, in my opinion, neurasthenia and hysteria are distinct, and that, often as they are found in combination, neurasthenia is common without hysteria, and hysteria is at least not unknown without neurasthenic symptoms.

A few words are required with reference to the use of the term "traumatic hysteria." I employ it because it appears to me highly inadvisable to replace old names by newly-coined ones, unless the former be distinctly objectionable. Hysteria is, by some, regarded as inadmissible, on account of its etymology, its original significance, and the erroneous theory which it implied. But we have now finally escaped from all danger of being misled by the older views. Hysteria no longer connotes any theory, and,

in the present imperfect state of pathological science, it is often better to use meaningless words rather than such as imply a theory which may turn out to be wrong. Extremes here meet, and a word which means nothing, or a word which refers to an utterly dead theory, are equally useful. Typhoid is no longer confused with typhus, smallpox conveys no suggestion of a relationship to syphilis, rachitis does not for us mean inflammation of the spine, and hysteria does not mean a reflex utero-ovarian neurosis. Why uproot a term whose significance is intelligible to all, and which can never again mislead, as possibly some of its proposed substitutes may do?

3. Etiology.

Certain *predisposing* elements in the causation of traumatic hysteria have to be considered:—

(1.) *Age.*—Like all hysteria, the traumatic form is an affection chiefly of middle life. Berbez ([58]) found the average age of twenty-one cases to be twenty-five years; the youngest being 19, and the oldest 56. Of seventeen cases which have come under my own notice, the average age was 31; being in the female $28\frac{1}{2}$, and in the male 35; the youngest was a girl aged 18, the oldest a man aged 42.

(2.) *Sex.*—It is hardly necessary to repeat that the male sex is by no means exempt. Indeed, Berbez concluded that traumatic hysteria was commoner in men than in women, having seen fourteen cases in the former and seven in the latter. His statistics, however, take no account of the fact that accidents are much commoner among men. I find that of 228 persons injured in railway accidents, 157 were males and 71 females, and that among the former there were ten, and among the latter thirteen cases of distinct "chronic" hysteria. This comparison yields a percentage of 6.37 for men and of 18.31 for women; or roughly, the probabilities of a railway accident being followed by hysteria is three times as great in the female as in the male.

(3.) *Marriage* appears to have no influence.

(4.) *Heredity.*—The evidence is here most conflicting. Some writers—mostly those of the French school[1]—maintain that there is always, or nearly always, a hereditary taint; others, chiefly among the German writers, find no grounds to suppose that heredity has any influence—a view more in accord with my own expe-

[1] *Cf.* Berbez (p. 15), who found a hereditary taint in nine out of twenty-one cases.

rience, which appears to show that the effect of hereditary neurotic antecedents has been much exaggerated.

(5.) *Race.*—The evidence of the *Salpétrière Clinique* is that race has no effect, but the experience of British observers tends to show that hysteria is a more serious affection in France than it is with us. (*Cf.* British Medical Journal ([12]).)

(6.) *Occupation* and *social circumstances* would appear to be without influence.

(7.) A "*neurotic temperament*" almost certainly plays some part in the production of traumatic hysteria, although it has here nothing like the importance which it possesses in relation to ordinary hysteria.

(8.) *Chronic alcoholism* probably predisposes to traumatic hysteria, as to hysteria in general.

The *exciting* cause is of course an accident, but the varying conditions of the accident are of etiological importance. There can be no question but that mental impressions are of far greater effect in the production of traumatic hysteria than is physical injury. Hence horrible surroundings, as where several people are injured at the same time, will increase the risk of its production. Two somewhat opposed conditions will also do so, viz., extreme suddenness, on the one hand, or a period of terror immediately preceding the accident, on the other. The effect of terrible surroundings and suddenness is one cause of the disproportionately large number of hysterical cases after railway collisions, and perhaps in military surgery.[1] Case 53 is a good instance of previous terror. The subjective element in the etiology is well illustrated by Case 56. This woman was in a railway accident, in which, owing to the breaking of an axle, a carriage was overturned and cut to pieces by a train on the opposite line. Everybody in the damaged carriage was hurt, and four persons were killed, but the shock was hardly felt at all by the passengers in the rest of the train, of whom our patient was one, and, with the exception referred to, none of whom complained of the slightest injury. *Per contra*, it is a frequent observation that children or persons who have been asleep or drunk at the time of a railway accident suffer less than others from the effects of "nervous shock."

Direct injury to a nerve would also seem to be a potent cause of hysteria, and many cases described as "reflex" undoubtedly belong to this category.[2] In Case 62, in which the hysterical symptoms came on much later than usual, the previous nerve-lesion

[1] Larrey ([1]). Weir Mitchell ([8]).

[2] Brown-Séquard ([21]). Weir Mitchell ([8]).

may have supplied the requisite stimulus, and I have recently seen a case in which, in a very slight railway collision, the patient received a contusion of the right ulnar nerve, followed by total anæsthesia in its distribution, with partial hemi-anæsthesia, retraction of the field of vision, and dragging of the foot upon the same side.

It is to be remembered that the severity of the injury—that is, the *mechanical* severity—bears no relation whatever to the liability to hysteria. On the other hand, the region injured certainly appears to affect the result. Numerous reported cases show clearly that head-injuries are liable to cause complete hemi-anæsthesia or double monoplegia, the symptoms arising on the *same* side as the lesion. (*Cf.* Case 53.) Also injuries in the region of joints appear to have some special tendency to produce localised functional neuroses—the shoulder being especially exposed to such effects. (Case 54.)

Lastly, it must not be forgotten that surgical operations are injuries, and that hysterical symptoms after operations are by no means rare. To this cause are probably to be attributed some of the nervous troubles which are often ascribed to the anæsthetic, but which are thus more likely to be diminished than increased by its use.

4. Symptoms.

The symptoms of traumatic hysteria are readily divisible into two groups, owning a possibly quite different pathology. We have, firstly, certain manifestations which come on immediately after the accident, and last for a very short period; and, secondly, those which, whether they come on at once or not, are of much more persistent duration. To the first group I propose now to devote but a passing attention.

(1.) *Acute Hysteria.*—It is a matter of almost daily observation that injuries may give rise to passing "hysterical" manifestations—loud screaming, crying, laughter, or even convulsions. These nervous symptoms are explosive in nature, and generally soon pass away, leaving either no trace of their presence or a merely temporary nervous lassitude—a slight form of neurasthenia. As suggested, they are very different from the more defined and stable forms of hysteria, are merely a manifestation of a passing excitement, and have little, if any, connection with the more serious symptoms. We need not now refer to them further.

There is, however, another aspect of "acute" hysteria. It is

commonly found that the victims of railway accidents have passed through a more or less brief stage of what they call unconsciousness. This is not the ordinary unconsciousness of "concussion of the brain;" and it is unaccompanied by any of the usual symptoms of the latter condition—vomiting, relaxation of the sphincters, &c. The condition is rather one of general obliquity to external impressions, in which many voluntary acts are performed almost automatically, the higher mental faculties alone being in abeyance. Such a state resembles much more closely the hypnotic condition. The injured person may get up and walk away, taking little or no notice of his surroundings, acting as in a dream, and perhaps only "coming to himself" after a considerable interval, and at some distance from the scene of his accident. Many of the persons injured in the Hexthorpe collision, on September 16, 1887, told me that they "found themselves across the field" adjoining the line where the collision occurred; others that they walked to Doncaster, but had no recollection of so doing. Vibert ([68]) mentions a man who thus proceeded from Charenton to Paris, passing many people on the line, but totally ignoring them; and another man, injured in a collision, who, mechanically as it were, travelled by rail and coach for an entire day to reach his home. Such persons have a remarkable dazed look, which is admirably represented in the young man occupying the foreground of Mrs. Butler's picture "Balaclava." The whole aspect and manner are strikingly similar to those of a state of somnambulism. Further, such persons often have extraordinary after-impressions of the accident. They describe something very large overwhelming them, or they think they remember episodes which could not have occurred. Many passengers in the trains which collided at Hexthorpe gave circumstantial accounts of the actions of the railway servants or of themselves, of screams, waving of hands, seeing signals moved, attempting to get out of the carriages, &c., details totally incompatible with the time allowed by a train coming suddenly round a corner at a rate of twenty miles an hour. Here, doubtless, we have to do with "auto-suggestion," during a condition resembling that of hypnotism. One of the most remarkable accounts thus given me was that of a man shaken in a very slight collision. He was travelling with his wife, and, after describing how he himself was hurt, he told me that the latter fell forwards with her left eye on to the point of an umbrella, held by a person opposite to her; that this umbrella struck her just above the eye and knocked it out on to her cheek; and that he then placed the hollow of his hand over her eye and pushed it

back! This statement was at least not contradicted by the wife, in whose presence it was made to me. When I saw the woman, the eye was in its normal position, the sight was perfect, there had never been any cut or wound, but there was some ecchymosis. That the man believed his tale I have little doubt, as it was too ridiculous for a fraud, and the most rational explanation seems to be that this was a hysterical dream.

I may refer also to the case of a gentleman well known in Manchester, who, while travelling with me, allowed the train, in which he should have proceeded, to leave a side station without him. Seeing the train already started, he ran after it, attempted to get on, and fell on to the line, sustaining fortunately no serious injury. He afterwards described minutely how he had tried to get on to the third carriage from the rear of the train, but failing, had fallen behind it, and how the remaining coaches had then passed over him. To this account he always adhered, although several railway servants, who saw the occurrence, noticed that he jumped at and missed the *last* carriage, and fell *behind* the whole train, nothing passing over him. As in this case there was no question of compensation, we may safely assume that the gentleman believed his own dream.

Like the explosive manifestations above mentioned, these symptoms are seldom of long duration, nor are they necessarily followed by anything more severe. The patient doubtless believes his visions to his dying day, but they do him no harm. These conditions, however, appear to me to be of the greatest interest in connection with the pathology of traumatic hysteria, to which we shall refer later, as indicating the identity, so strongly insisted upon by Charcot,[67] of the "chronic" results of traumatic hysteria and of hypnotic hysteria—this stage corresponding as accurately as possible to that of the minor degrees of hypnotism.

(2.) *Chronic Hysteria.*—Having thus cleared the ground by noting the early hysterical symptoms, we turn to those which are much more persistent in their nature, and which we may call "chronic" or "stable" hysteria. It is not my intention to enumerate all the possible manifestations of the disease—this has frequently been done by others—and I shall refer mainly to my own cases, merely calling attention, in passing, to their chief points of interest. Let it be premised only that the symptoms may be (1) psychical, including epileptiform attacks and hysterical insanity; (2) motor, including paralysis and contractures of the

limbs, and special effects upon such organs as the larynx and the bladder; (3) sensory symptoms—anæsthesia, hyperæsthesia, and paræsthesiæ of the general or special sensory nerves; and (4) vaso-motor, secretory, and trophic troubles. In most cases there are also symptoms which are rather to be regarded as the effects of combined neurasthenia.

Psychical Symptoms.—In considering the mental aberrations of traumatic hysteria, we are met by the initial difficulty that our methods of observing mental phenomena are (except, perhaps, in the case of trained alienists) so imperfect that we can hardly distinguish between true insanity, hysteria, and mere neurasthenia. The following is, however, I believe, a case in point. When I first saw the patient, I regarded it as a case of hysterical dementia, but my friend Dr. E. S. Reynolds, after hearing my description, classifies it as melancholia attonita (melancholia with stupor). It seems further to be an exaggeration and prolongation of the state of acute hysteria which has already been referred to as resembling that of hypnotism.

CASE 50.—*Hysterical melancholia—Hemianæsthesia.*

A woman, aged twenty-nine, of the lower classes, was hurt in the collision at Hexthorpe on September 16, 1887. When I saw her on October 12, she was confined to bed, and had been so since the accident. Owing to her mental condition, I found it almost impossible to obtain any definite information from the patient, and was obliged to depend mainly upon the statements of her friends. She had had severe bruises of the right side of the face, of the left hand and wrist, and of both ankles. For several days she passed only a small quantity of urine of very high colour, and she had been troubled by constipation, with melæna, on several occasions. She suffered from a good deal of pain in the lumbar region, as well as from that due to the bruises. Both feet and legs were almost, but not quite, absolutely anæsthetic. The voice was peculiar, being very high-pitched, apparently "jerked out" with great difficulty, and very weak, besides which there was bad stammering. The result was that speech was almost unintelligible. Before the accident I was told that she had a powerful voice, and made her living as a hawker,

and after recovery the speech presented no abnormality. She had frequently had "fits" since the accident, consisting, so far as I could learn, of convulsive seizures, followed by coma. Her mental condition was remarkable. She had an intensely frightened "scared" look, like that of a wild animal. She paid little or no attention to her surroundings, and it was with the greatest difficulty that she could be got to answer even simple questions. She was quite incapable of connected speech, but there were none of the emotional manifestations usually regarded as hysterical. Six weeks later I saw her again. Her mental condition had improved; she was able to be up, and took notice of her surroundings, but still had a very "startled" appearance and demeanour, and did not volunteer any remarks. In answer to questions she was fairly clear. Anæsthesia was now localised on the left side of the body, and was complete as regarded the skin. The field of vision in the left eye (tested by the finger) was diminished in size, that of the right was apparently normal. The stammering and laryngeal symptoms were unaltered. Without entering upon details, I may say that there were no signs of organic disease, and that her own medical adviser and a distinguished consulting physician who saw her agreed with the diagnosis of hysteria. Shortly afterwards the question of compensation was settled. By the kindness of Dr. Jones of Wath-upon-Dearne, I was enabled to see this woman again on October 13, 1888, more than a year after the accident. She suffered no special inconvenience, but said she did not feel quite so strong as formerly. The voice had regained its normal character, and the mind was quite clear. On examining her, however, we found sensation less perfect on the left than on the right side throughout the body. The senses of smell and taste were also weaker on the left side; indeed that of smell was almost entirely lost. Hearing was unaffected. The field of vision of the left eye was distinctly contracted in all directions, that of the right was diminished above and below, but not laterally. (These tests were made by the finger only.) There was no paralysis, and both superficial and deep reflexes were normal. The woman herself appeared to be quite unaware of any deficiency, and was capable of attending to her business. The condition of this patient's optic discs was one of some interest, but the facts have been sufficiently related above (p. 182).

This case illustrates very clearly the condition of hysterical hemi-anæsthesia, as also a laryngeal affection, to both of which we shall refer later. But beyond this I am convinced that there

was for a time a profound mental change, also of hysterical origin.

CASE 51.—*Hysterical melancholia—Suicidal impulses—Anæsthesia.*

Another case was that of a man, aged about forty, injured in the same accident, who besides bruises sustained a fracture of some ribs. He was detained at Doncaster for six weeks, and then sent home, stated by his attendants to be quite well. I saw him at his house six months after the accident. He complained of pain about the chest, giddiness, bad sleep, and other neurasthenic symptoms, which did not appear to be very severe. He also complained of numbness in the right arm, and I found distinct relative feebleness of sensation on the inner side of the right arm and forearm, but not elsewhere. His demeanour was that usually observed in melancholia, the peculiar listless expression and manner which is better recognised than described, and which contrasted markedly with the joviality of disposition which he had manifested soon after the accident. His wife said that he would often get up in the night and talk of suicide, and on questioning him, he admitted, although not readily, occasional suicidal impulses. He had, however, never attempted to carry them out. When I saw him, he was already improving, and as not long afterwards his solicitors settled his claim, we may assume that, as predicted, recovery was satisfactory.

Interesting points in this case are—the onset of mental symptoms after returning home, a usual result in melancholia; the abortive suicidal ideas generally resulting from hysterical insanity; and the patient's own reticence on the subject. In other cases I have seen slight symptoms of melancholia, and sometimes the patients speak of suicidal impulses. Whether these are, however, genuine cases of hysteria, I am not quite sure, but in the two above mentioned, and especially in the first, the concurrence of well-recognised hysterical symptoms would appear to be highly significant.

Other symptoms of chronic traumatic hysteria, affecting the higher cerebral functions, are coma, convulsions, and emotional manifestations, but these are so well known as to require no present remark. I may, however, mention one case, which, though slight, is typical, and was very well described by the patient.

CASE 52.—*Slight hysteria—Epilepsy.*

A married woman, aged twenty-eight, was injured in a slight railway collision, receiving a cut over the nose, which soon healed. She had some not very marked digestive and neurasthenic troubles. But from time to time there came on "fits," which she thus described:—A pain would suddenly commence, "sometimes in the feet, sometimes in the head, or other part of the body." She would then go cold, and had to sit down, feeling much "confused," but not actually losing consciousness. In a few minutes the "fit" would pass off again. At first the attacks came on frequently, but a month after the accident they were much fewer, occurring only every two or three days. During this time she had been taking bromide of potassium. No other symptoms were present. These seizures would seem to be clearly of an epileptiform nature, and of hysterical origin.

As these sheets are passing through the press two other cases have come under my notice—one in which a man, with well-marked and very obstinate hemi-anæsthesia and a painful zone in the right groin, presented a most typical hystero-epileptic seizure after manipulation of the latter region; the other that of a boy who, after a blow from a cricket-ball in the right groin, had several epileptic seizures, accompanied by anæsthesia of the same side.

Motor Symptoms.—Motor changes in the limbs occur in one of two forms. There may be either flaccid paralysis or spasmodic contracture. This paralysis or contracture may affect the whole, or less often a segment, of one or more limbs. It is always limited, not by the anatomical distribution of nerves, but by the physiological arrangement of the muscles supplying the various joints or segments. When it takes a hemiplegic or paraplegic form, we find rather a double monoplegia than a genuine hemi- or paraplegia, the muscles of the trunk and face escaping the paralysis. At times the mouth is drawn to one (the anæsthetic) side, as if there were facial paralysis, but in such cases there is really spasm and not paralysis. Case 53 is an instance. The paralysed muscles often undergo a good deal of atrophy. Their electric reactions remain normal, a point which is of value in distinguishing these cases from peripheral nerve-lesions, but the resistance to the electric current is increased in presence of the accompanying anæsthesia (Vigoureux). The muscles often contract very readily on mechanical irritation by tapping, or

after the application of a bandage (Charcot). The condition of the tendon reactions varies, but they appear to be most frequently diminished in the affected region (Charcot). On the other hand, in hemi-anæsthesia *without* paralysis I have usually found the knee-jerk increased—a result which may be due to the coincident neurasthenia. Anæsthesia is apparently always present in the paralysed regions (*infra*), but when there are contractures there is usually great pain in the region of one of the larger joints (*arthralgie*).

CASE 53.—*Hysterical paralysis and hemi-anæsthesia.*

Dr. Dreschfeld has kindly allowed me to refer to the following case:—G. S., aged thirty, a farm labourer, was admitted to Dr. Dreschfeld's wards on October 30, 1888. He is a total abstainer, but a heavy smoker. No hereditary neurotic taint can be traced. His work has always been heavy and in the open air. Hitherto he has been very healthy.

A year ago he was covering a haystack with a sheet, when a strong wind blew both him and the sheet from the top of the stack to the ground; he did not fall immediately, but found himself going, and struggled vigorously to save himself, being at the time much frightened. He fell upon his head and was unconscious for from half to three-quarters of an hour, during which time he was conveyed home without his knowledge. On regaining consciousness, he found a large swelling on the left side of the head, but no cut, and there was bleeding from the nose. During the day he felt weak but had little pain. On the following morning he had headache and nausea, and vomited about half a pint of dark clotted blood, but he went to work. Since then, however, he has done scarcely any work, and has suffered from headache, dizziness, and almost daily vomiting of food, containing a little blood. He has also noticed failure of sight and hearing, with numbness and weakness of the left side of the body.

On admission, the man presented the usual "facies hysterica." The upper and lower limbs on the left side were both very weak, but they presented no rigidity, nor was there any inequality in the paresis of the various muscles. At first sight he appeared to have facial paralysis, but careful observation showed, as is usual in hysterical cases, that there was really *spasm* of the facial muscles on the left side. The mouth did not open properly, the left side being the worse. The tongue was protruded to the

right, and that with difficulty only, owing to spasm, mainly of the muscles of the *left* side (glosso-labial hemispasm of Charcot). There was no dysphagia, but mastication caused pain in the maxillary articulation of the left side. The muscles presented no fibrillar tremblings. They reacted to the faradic current.

Sensibility, both superficial and deep, was completely lost over the left side of the body, except at the following points, viz.: (1) The region of the bruise, immediately behind the left parietal eminence; (2) the costal margin; and (3) the groin. In these regions there was hyperæsthesia, and deep pressure on the left

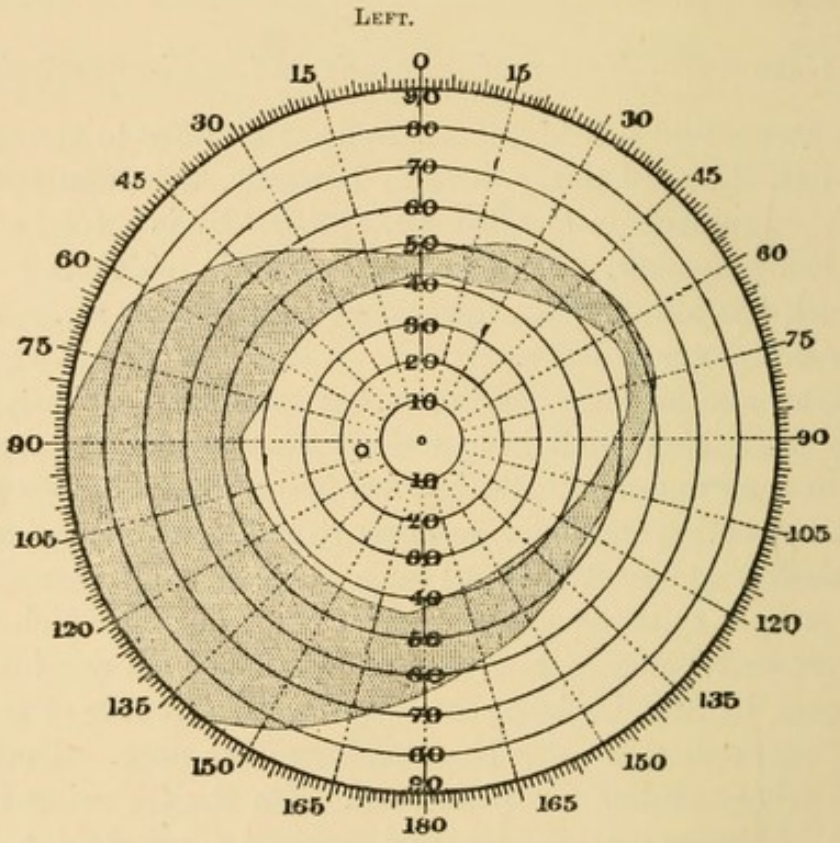


Fig. 33.—Case 53.—The outer line indicates the normal, the inner line the actual boundary of the field of vision.

groin caused a distinct hysterical crisis, with flushing of the face, fixity of gaze, and rigidity of the body. Pains were complained of "all over the body," especially in the left arm and leg, and in the head, where the frontal and sub-occipital regions were most painful. The spine was tender throughout, especially in the cervical and lumbar regions. The fauces were anæsthetic.

The special senses were also affected. Thus he complained of a constant bad taste in his mouth, and a week after admission, I found the left side of the tongue hyperæsthetic (a condition which was also noticed in Case 57). Hearing was impaired on the left side, a watch being audible at a distance of five

inches from the right ear, and half-an-inch from the left. The pupils were normal. Movements of the eyeballs caused pain. Eyesight was impaired, and the field of vision was found to be peripherally contracted in both eyes, but especially in the left, in which it was reduced almost to fixation point. The accompanying perimetric tracings were taken a week after admission, when the man was rapidly recovering, and are no guide to the extent of the contraction of the field when first seen, but indicate the differences between the eyes. A most remarkable point is, that the field of vision of the right eye is abnormally large, a

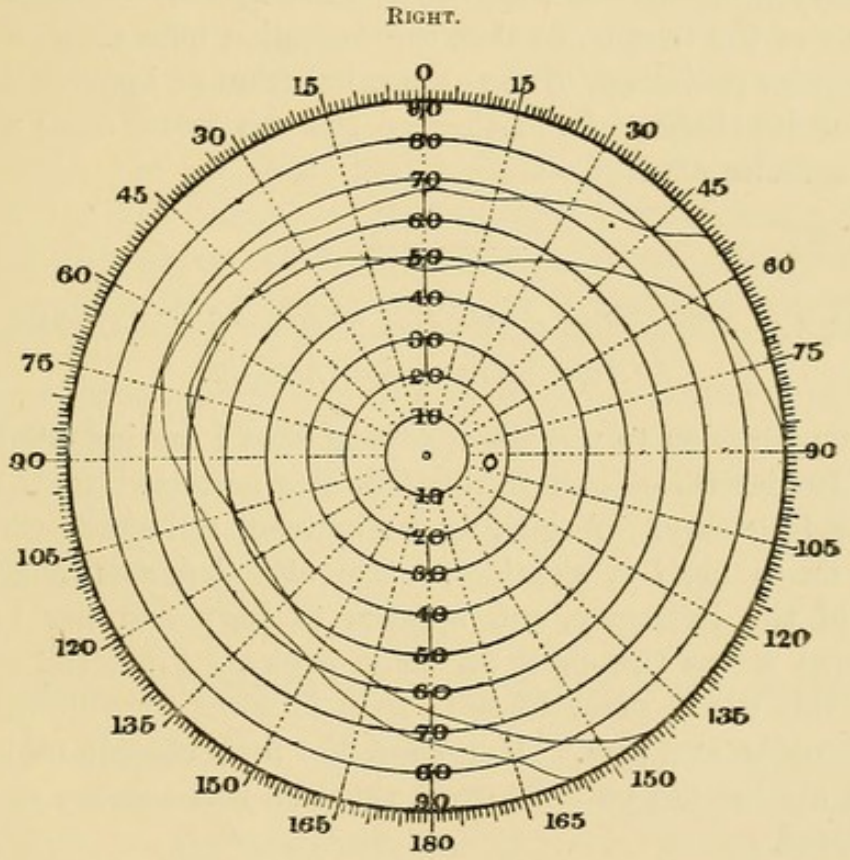


FIG. 34.—CASE 53.—The inner line represents the normal, the outer the actual boundary of the field of vision.

condition which I have since seen very well developed in another and most typical case. In this connection it is interesting to note that in hysterical paralysis the healthy side has been found to present an *increase* of power (Féré), and possibly we may here have an increased sensory activity, enabling the extreme anterior portion of the retina, which is usually without function, to acquire some perceptive power.

The reflexes were normal throughout, except that the right knee-jerk was somewhat exaggerated and the left plantar reflex was lost.

There was frequent vomiting, sometimes of blood.

The treatment was solely expectant, with confinement to bed, and after an interval of less than three weeks from the date of his admission, the patient was so far recovered that he had but little remnant of either paralysis or anæsthesia.

In the above case the tongue was deflected to the right, *i.e.*, *away from* the paralysed side, owing, apparently, to spasm of the genio-hyoglossus muscle of the left side; but in two cases which I have since seen, the tongue has been deflected *towards* the anæsthetic side. In one of these there was on the anæsthetic side very well-marked hardening from spasm of the intrinsic muscles of the tongue, so that the deflection here arose, not from an irregular projection of the organ, but from an internal derangement of its shape. In neither of the two latter cases were the facial muscles affected.

CASE 54.—*Hysterical contraction of upper limb—Paralysis—Anæsthesia and arthralgia.*

For permission to use the following case I am indebted to Dr. Leech, under whose care the patient was admitted to the Manchester Infirmary. A girl, aged eighteen, fell about Christmas 1885 on to her left shoulder. She attended at the accident-room of the Infirmary, and appears to have had her left arm bandaged across the chest for some weeks. From the accounts given, this would seem to have been followed by cellulitis about the shoulder and arm. Hereafter, the limb became useless and caused her intense pain, so great that she was anxious to have it amputated.

On June 13, 1888, she was admitted to Dr. Leech's wards. The left upper limb was held rigidly to the side, with the elbow and wrist flexed, and the fingers bent in upon the palm. It was much wasted, and the muscles were rigid. The various joints could be moved only by the use of considerable force, and active resistance to such movements could be felt. The girl complained of intense pain on movement, especially of the shoulder, and of great tenderness about the latter joint. So great was her pain, that sleep was almost entirely lost, and she was being rapidly worn out. She had absolute superficial and deep anæsthesia of the forearm and lower part of the arm, but great hyperæsthesia of the upper part of the latter, and there was some diminution of sensation of the whole of the left side of

the body, with distinct contraction of the field of vision on that side. The muscles of the left upper limb reacted normally to the faradic current.

Besides these symptoms, she had "hæmatemesis," which was found to be due to sucking a small abrasion inside the mouth. Her general appearance was markedly hysterical.

Careful observation showed that, when unaware that any of the medical staff or nurses were watching her, she made very fair use of her left arm, having much greater power in it than she professed to have.

Under these circumstances she was treated by massage, faradism of the limb, internal administration of tinc. valerian. ammon., and careful moral supervision and instruction; the result being that when she left the hospital a month after admission, she had lost the pain, and acquired a very considerable amount of power in the limb, the nutrition of which was rapidly improving. This is a case of contracture, involving mainly the most usual seat—the shoulder-joint. Many similar cases are recorded by Charcot and others.

Besides these paralyses of limbs, it is not uncommon to find motor troubles in connection with the larynx and the bladder. In two cases I have seen affections of the larynx, one being Case 50, already quoted as an illustration of mental defect; the other is as follows:—

CASE 55.—*Hysterical paralysis of adductors of glottis.*

A girl, aged nineteen, was injured in a slight railway collision. I saw her on the following day, and learned that in the morning she had gone to her work, but, feeling too ill to continue it, had returned home and gone to bed. She had since slept a good deal. She said that she had been senseless for a short time after the accident, and since then she had had a good deal of pain from bruises of both knees and arms and of the side of the neck. One symptom, which I was told by her medical attendant had come on since the morning, was a marked hoarseness and aphonia, sometimes passing into a mere whisper, just as in a laryngitis. She had no cold, but under the circumstances it did not seem advisable, nor was it practicable, to make any examination of the throat or larynx. Here, as in Case 50, there appears to have been a temporary paralysis of the adductors of the vocal cords. Six weeks later I saw the girl again, and learnt that the vocal trouble had passed away in a few days. She then presented

only vague neurasthenic symptoms, with well-marked neurotic dyspnœa, which were gradually subsiding.

Retention of urine, again, is a very frequent result. I refer to it in several of my cases, but will here give one where it was the chief symptom, and in which the amount of the secretion appeared to be considerably diminished.

CASE 56.—*Hysterical retention of urine.*

A charwoman, aged thirty-eight, was in a railway collision under the peculiar circumstances already mentioned, as illustrative of the effect of fear, apart from physical injury. She certainly sustained no bruises, but was frightened, and may have been slightly shaken. Almost immediately after the accident severe "flooding" came on. I saw her two days afterwards, when she complained of great pain in her head and abdomen: the flooding still continued, but was diminishing: the bowels had not been moved since the accident, and she had only passed urine once: the pulse was feeble, 76. There was no sign of organic injury. A week later I saw her again. She was feeling much better, and the flooding had ceased, but she still felt very weak and "all of a tremble," and she had only passed urine five times in nine days. From this time she made a rapid recovery, and a few weeks later I learned that she was well. Owing to legal reasons, no compensation could be claimed, a point which was decided within a few days of the accident, and which generally expedites recovery.

Temporary retention of urine is a very common result of shock, seen constantly after railway and other accidents; but such retention usually passes off within at most forty-eight hours. Here the condition was so prolonged as to merit in my opinion the designation of hysterical. In the above case the catheter was not used, and this is undoubtedly the true principle of treatment. If once operative relief be given, the condition may be indefinitely prolonged; whereas, if the patient be left alone, micturition will almost always, if not always, be shortly accomplished. It is of course necessary before deciding to leave the case untouched to make sure that there is no organic injury, either to the urinary or the nervous system; but having made the diagnosis, we should follow the invariable rule of ignoring as far as possible the

hysterical symptoms. I shall refer later to another case of retention of urine with other hysterical symptoms, which terminated in death (Case 66).

Sensory symptoms.—Before summarising the various sensory phenomena met with in traumatic hysteria, it will be convenient to refer to certain illustrative cases.

CASE 57.—*Hysterical hemi-anæsthesia—Paresis and torticollis.*

On August 1, 1888, there presented herself, among Mr. Wright's out-patients at the Manchester Infirmary, a woman, aged thirty-eight, seven years a widow, and with one child. She gave the following account of herself. About nine weeks previously, she had fallen down a narrow staircase of some thirteen steps, striking her head at the bottom in such a way as to bend the neck forwards and force the head between the knees. Her sister ran to her, and says she found her black in the face; she seized the head and threw it back. The patient was then put to bed, and could not walk for five weeks. A medical man, who saw her, told her that the head had been "put out" and "put in again." While confined to bed she had a succession of "fits," and her head became drawn to one side; for some days she seems to have been comatose, and to have had unconscious evacuations; for more than a week she could not move her right arm, but the left was "all right."

When I saw her, she complained of pain on the left side, chiefly in the region of the mastoid process, but affecting the whole of that side of the head and neck, as well as of pain behind the right shoulder. The head was firmly drawn over to the right side, and both sterno-mastoid muscles were very tense. She complained also of difficulty in swallowing, with well-marked globus, and of imperfect vision.

The demeanour was distinctly hysterical. She had no paralysis, but would not move her right arm freely, owing to the pain caused thereby, nor was there any muscular atrophy. The knee-jerks were a little exaggerated. The right arm was partially anæsthetic, and the visual fields, tested by the finger, were both much diminished in extent.

The patient was sent into the Infirmary, and I re-examined her two days later. The anæsthesia of the right upper limb was now much more marked, and was bounded by a line running right

round the limb at its junction with the trunk, *i.e.*, over the tip of the acromion and across the axilla. She was unable to localise the position of the limb when her eyes were closed. The sensation of the legs was not affected. She had hyperæsthesia of the right mamma and of the cervical and mid-dorsal regions of the spine. The right ovarian region was also markedly hyperæsthetic, pressure over it causing flushing of the face, screaming, and clonic facial spasm, followed by exhaustion, which lasted for some minutes.

The patient was now removed to the medical wards, and placed under the care of Dr. Dreschfeld, where I believe she

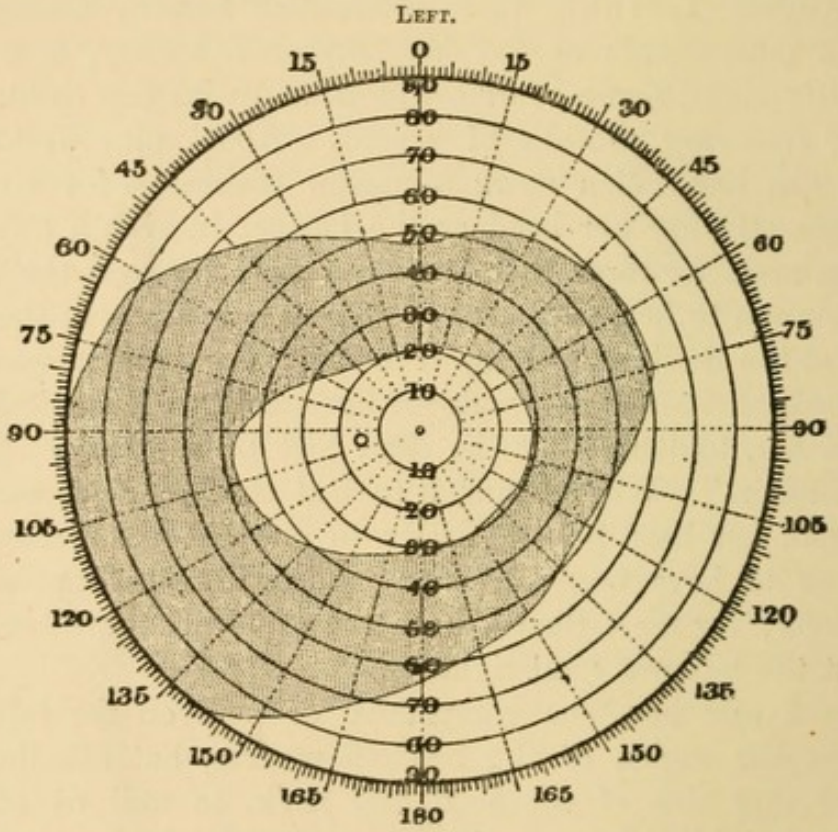


Fig. 35.—Case 57.—The outer line indicates the normal, the inner line the actual boundary of the field of vision.

improved considerably, and whence she was shortly afterwards discharged.

On September 8th she came to me again, saying she was as bad as ever, and was getting weaker. She had now the same deflection of her neck as before. Anæsthesia affected the whole of the right side of the body, including the tongue and fauces on the same side. She was unable to swallow solids. Otherwise her condition was as when first seen. The perimetric tracings (figs. 35 and 36) show a field of vision considerably and almost equally contracted in both eyes. The knee-jerks were normal on both sides.

She was again made an in-patient under Dr. Dreschfeld, and three weeks later she professed herself much better. There was no pain, except a little in the neck, when she had been sitting up for some time, and she had slight tenderness of the cervical and mid-dorsal regions of the spine. Sensation was very slightly duller on the right than on the left side, no difference being observed in the palate and throat, but the right side of the tongue was *hyperæsthetic*, as in Case 53. The head was almost straight, vision was good, and the globus had vanished. The

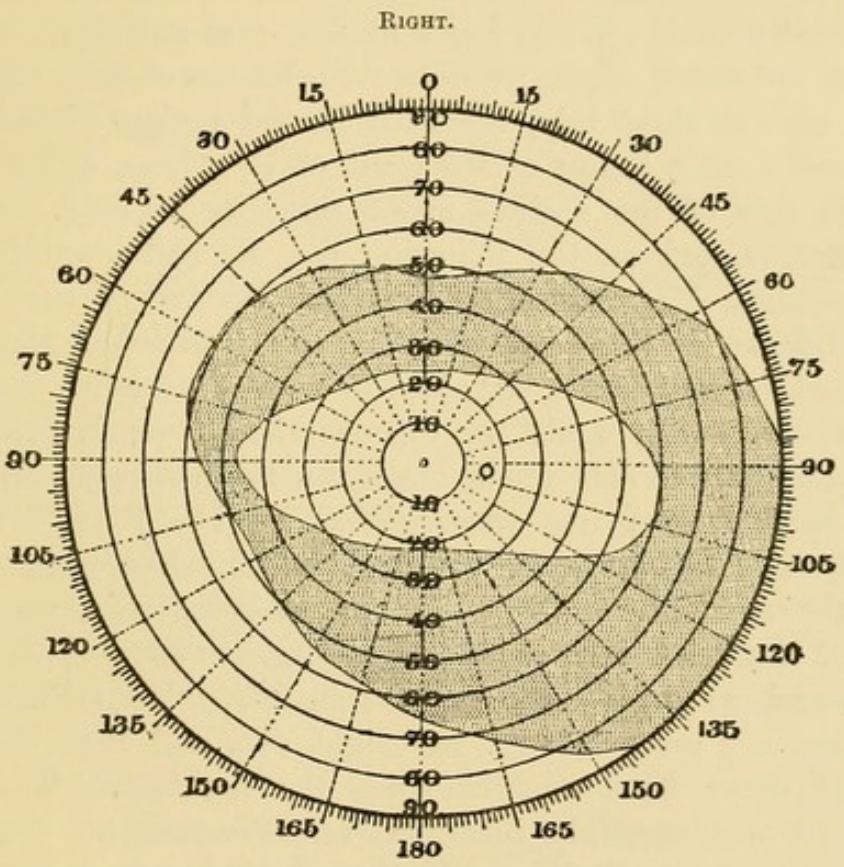


Fig. 36.—Case 57.—The outer line indicates the normal, the inner line the actual boundary of the field of vision.

treatment consisted in daily faradisation of the back of the neck, with internal administration of bromide of potassium.

This case illustrates very clearly the condition of unilateral anæsthesia with associated hyperæsthetic regions and hysterogenic points. The contraction of the visual field of both eyes, which was here seen, is not very usual, the common condition being for this change to occur either solely, or far more markedly, on the anæsthetic side.

CASE 58.—*Hysterical hemi-anæsthesia.*

A man, aged thirty-five, was injured in the railway accident at Hexthorpe on September 16, 1887, being in a carriage which was smashed to pieces. He told me that at the time of the accident he lost his eyesight, and then became unconscious, from which description I assume that he fainted. In this condition he was removed to the Doncaster Infirmary, and, recovering consciousness on the road thither, he says that he found his right "knee-cap" displaced outwards, and that he replaced it with his hands. When I saw him, he was suffering from the usual symptoms of shock, together with bruises of both legs, most severe on the right side, especially in the region of the knee-joint, and from a bruise of the front of the chest, and a cut on the left side of the occiput about three inches long. He was very nervous, and on the following day we had great difficulty in persuading him that there was no fracture of the ribs or "breast-bone." For some weeks he was retained in Doncaster, and was then sent home, supposed to be convalescent.

I saw this man again, at his own house, on November 7, 1887, and on two subsequent occasions, the last being on March 10, 1888, when I was accompanied by Dr. Ross. On the first-named date he was in bed, and said he had been so ever since the accident. He complained of great pain across the back of the head, difficulty of breathing, anxiety—especially at night—and constant coldness of the feet. He said that he could not see properly with the right eye, and that the right leg had never been straight since the accident. The latter statement was certainly incorrect, as there was no change in the shape of the limb, except that due to old genu valgum, which was slight, and equally marked on both sides. I found no anæsthesia in the lower limbs, but did not then test the upper extremities or the fields of vision.

Later, when he began to walk, he found that the right leg would often "give way under him," and he thought he had to raise it higher than he used to do. He also had to watch the ground to see where he put it, and had twice fallen. He now had distinct right-sided hemi-anæsthesia, not absolute, but very well marked, and sharply bounded by the middle line of the body. This anæsthesia affected the senses of taste and smell. On the left side he could hear a watch at the distance of five inches, on the right side at a distance of one inch only. The visual field, tested by the finger, was slightly retracted on the

left side, but very markedly so on the right. Objects looked at with the right eye he described as if seen through gauze.

Shortly after my last visit, in March, his claim was settled by the railway company, and in May I heard that he was much better, but that the right leg still occasionally gave way, and that the sight of the right eye remained a little dim—symptoms which were passing off.

This is another typical case of right hemi-anæsthesia affecting all the sense organs. The difficulty in walking and the description given by the patient of the attention which he had to bestow upon the right leg in doing so are characteristic of the loss of muscular sense or localising power in that limb, and there was not a trace of real paralysis, and no atrophy.

CASE 59.—*Hysterical hemi-anæsthesia.*

Another similar case is that of a man, aged forty-two, who was hurt in a slight railway collision on August 29, 1888. On the following day I found him in bed in a semi-stupid condition. He was unable to give any clear account of his accident, but I learnt that he had had three fits in the short journey which he had to take to reach home, and that on getting there he was insensible. He complained of pain in the head, back, and abdomen, and there were bruises of the back and head. The pulse was slow (56) and full. Beyond this he presented no sign of injury.

A fortnight later, when I saw him again, he was feeling much better, and was up out of bed. He now complained of pain in the head, chest, and left arm, and of feeling dazed when walking. He said also that sometimes he could not move his left arm at night, but could do so in the daytime. Sensation was very deficient on the whole of the left side. In the right eye, the field of vision, as tested by the finger, was equal to my own; but in the left it was reduced almost to the fixation point. He had also achromatopsia on the left side, but none on the right. There was no paralysis, and the superficial and deep reflexes were normal. He complained somewhat of restless sleep and a poor appetite.

Six months later, on January 29, 1889, he was suffering from pain in the back of the head, and from some pain and weakness in the lower part of the back, but the anæsthesia and visual affection had disappeared. About a fortnight after this

date, and immediately before a legal inquiry into the amount of compensation to be awarded, the man was again examined by Dr. Ross, who found slight left-sided hemi-anæsthesia. The progress of the case after the settlement of compensation is unknown to me.

Here we have a note of a condition which is usually found, namely, achromatopsia, on the same side as the diminished field of vision, the two symptoms generally, though not always, occurring together. The supposed inability to move the left arm in the dark was, doubtless, due to the impossibility of localising its position, there being no muscular weakness. An interesting and not very unusual condition is the disappearance and subsequent return of hysterical symptoms. (See p. 223.)

The next two cases are examples of less extensive anæsthesia.

Case 60.—*Hysterical anæsthesia.*

A man, thirty-one years of age, was injured in a railway collision, thirteen days after which I saw him for the company concerned. He stated that for a short time he was stunned, that he afterwards vomited, and that he had been confined to bed for about ten days. He had a bruise on the left elbow, and another over the base of the second right metacarpal bone. In addition to these troubles, he complained of pain in the epigastrium and lower lumbar spine and in the back of his head. For the first few days he was said to have passed blood both with his fæces and his urine, but this had ceased when I saw him. There were then no signs of organic injury. He had, however, the following clearly hysterical symptoms:—He complained of a noise in the left maxillary articulation on movement of the jaw, which was due to his partially slipping the condyle off its articulating surface. He had "numbness," not always constant, together with a sense of pricking in the right upper limb. Here I found a patch of anæsthesia on the palm of the hand, and another small patch in front of the fore-arm, a short distance below the elbow-joint. He said he could not see as well as formerly, the letters running together when he tried to read. I did not at that time examine his visual fields, but this was done a few days afterwards by Dr. Hill Griffith, who has kindly given me the annexed perimetric tracings, and who tells me that he found no achromatopsia. A fortnight later I heard from his medical attendant that he was much better, and that

another consultation was not required, and a few days thereafter he accepted compensation for his injuries and resumed his work.

Case 61.—*Hysterical anæsthesia.*

A man, aged twenty-seven, was injured in the same collision as the patient last mentioned, and I saw him for the company concerned three weeks later. He said he had vomited blood almost immediately after the collision, but had only done so once.

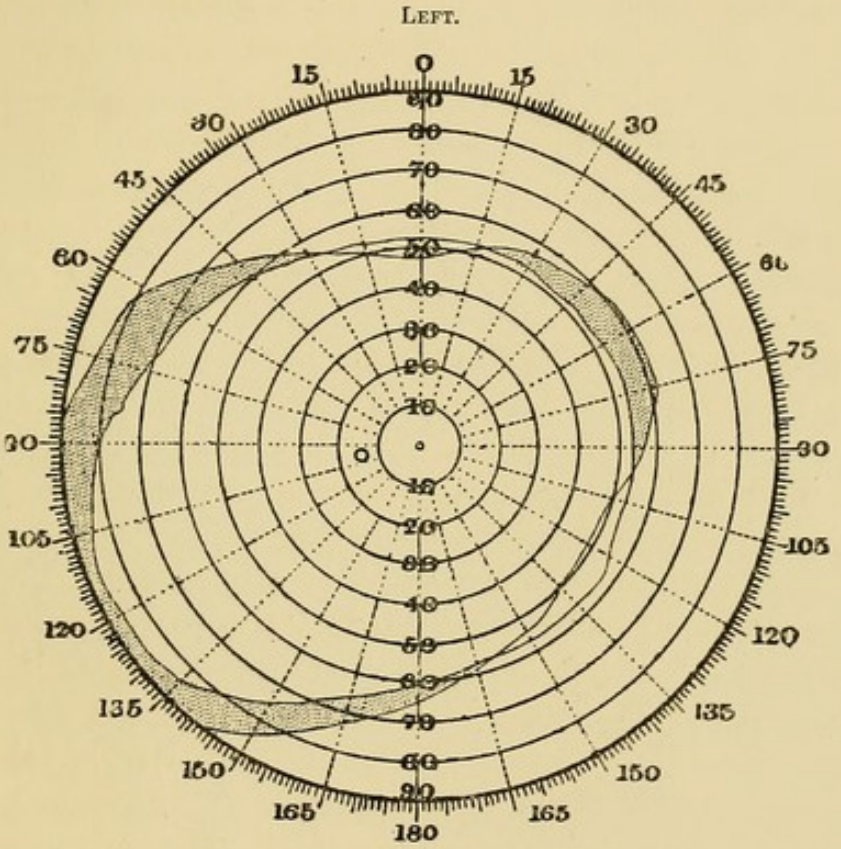


Fig. 37.—Case 60.—The outer line indicates the normal, the inner line the actual boundary of the field of vision.

He had since had pain in the head, back, and abdomen, with shooting pains in the left lower limb running from the hip to the foot. There was tenderness about the umbilicus and the second lumbar vertebra, and on either side of the latter, but no deformity. The tongue was furred; the pupils rather insensitive. In the left groin there was some hyperæsthesia, and the left thigh and leg were less sensitive than the right. The cremasteric reflex was normal and equal on both sides, the knee-jerks lively, especially on the left side. There was no trace of paralysis. Both visual fields (tested by the finger) were markedly and equally contracted. Three weeks later the anæsthesia was not sufficiently marked to

be registrable by the æsthesiometer; the hyperæsthesia had disappeared, as had the eye symptoms, and the chief complaint was of pain in the back. The left knee-jerk was still the more lively. Here the combined anæsthetic and hyperæsthetic areas might have led to a suspicion of organic affection, probably a sprain of the spinal column with some pressure on the nerve-roots, but the clue to the diagnosis is given by the visual changes, as well as by the absence of all motor symptoms.

Nearly a year after the accident I saw this patient again with Mr. Jessop of Leeds. He was then suffering from various neur-

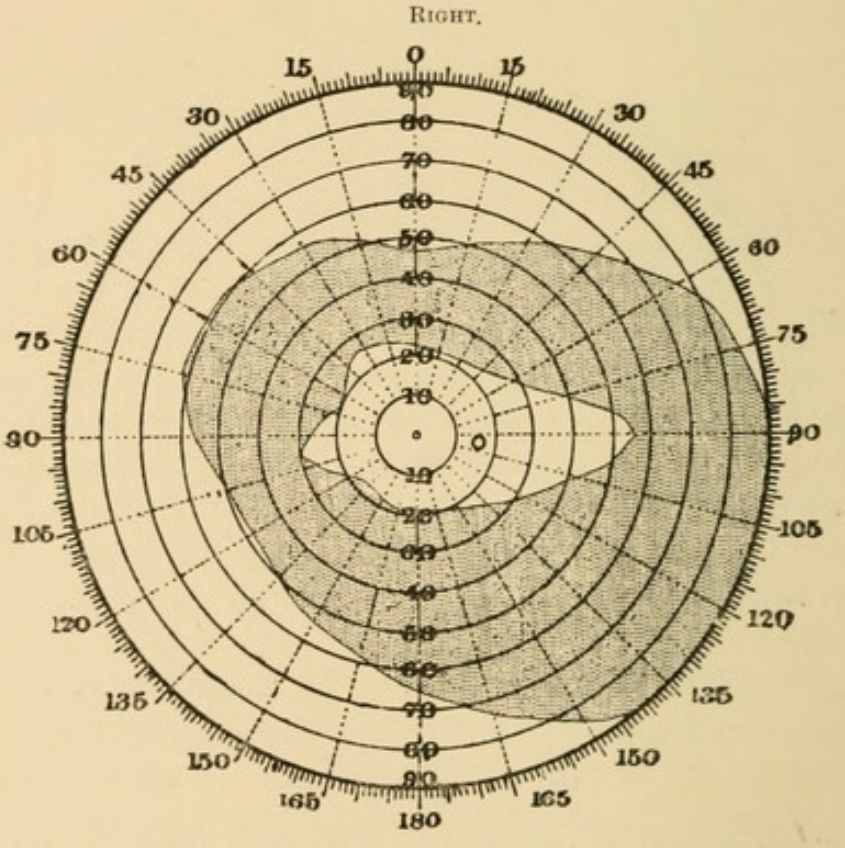


FIG. 38.—CASE 60.—The outer line indicates the normal, the inner line the actual boundary of the field of vision.

asthenic symptoms—pain and intense hyperæsthesia of the back, dyspepsia, &c.—but he had no anæsthesia or affection of the fields of vision. Shortly afterwards he received compensation, and a month after the settlement of his claim his solicitor informed me that he was quite well and had returned to his occupation as a bookmaker's assistant.

The following case illustrates in a remarkable manner the difficulties which may arise in diagnosis, owing to the fact, to which reference has already been made, that an organic lesion of one or more peripheral nerves may give rise to hysterical symptoms.

CASE 62.—*Injury to left crural plexus—Subsequent hysterical hemi-anæsthesia.*

A woman, thirty-two years of age, who was in the Hexthorpe railway collision, was jerked violently forwards, and then fell back, with her left side on the arm of the carriage-seat. She gave the following account of herself:—After the accident she was able to walk some little distance, but in an hour or so there came on intense pain of the left thigh and leg, shooting down the back of the limb. In the course of the evening this pain disappeared completely, and was followed by loss of sensation and paralysis of the limb. The latter symptoms continued for some three weeks, and at the end of that period anæsthesia was beginning to pass off and to be again replaced by pain. When I saw the woman, she had pain in the lumbar spine, with loss of sensation of the left lower limb and diminution of the knee-jerk on that side. I made a more complete examination six weeks later. The patient then complained of tenderness over the first and second lumbar vertebræ. She had anæsthesia of the whole of the left lower limb, except over a strip of skin extending from the inguinal canal towards the inner side of the knee, and thence down the inner side of the leg to about the middle of the tibia. This band was broader above than below, and here sensation, although not absolutely lost, was feeble. Anæsthesia extended over the gluteal region, and was limited by a line corresponding accurately to the lower margin of the distribution of the ilio-inguinal and ilio-hypogastric nerves, which had escaped. There was no paralysis. The plantar reflex was absent, the patellar less marked than on the right side, but still quite distinct. She had had no urinary or bowel trouble.

Here I diagnosed a sprain of the lumbar spine, or a bruise from falling back on to the seat of the carriage, with injury to the nerves of the lumbar and sacral plexuses on the left side, there being anæsthesia in the distribution of all the roots below the third lumbar (*cf.* chap. v.); resting the opinion upon the grounds that the anæsthesia followed the anatomical distribution of the nerves rather than the segmental arrangement which obtains in hysteria; that the condition of the reflexes was in accordance with it; and that the history of the mechanism of the injury was also in agreement. The disappearance of paralysis before that of the anæsthesia does not militate against this view, as, after injuries to nerve-trunks, the sensory may persist long after the motor symptoms.

A year later I saw this woman again, with her medical adviser, Dr. Jones, of Wath. I then learned that after my last visit she had developed anæsthesia of the whole of the left side of the body, and that the anæsthesia was not of uniform intensity, but came and went from time to time. The compensation was settled, and rapid recovery ensued. When I saw the woman, after so long an interval, there were, however, certain persistent symptoms. She said she had occasional pricking sensations of the left buttock and of the back of the left thigh; she frequently felt as if there were something in her left boot, and she could not stand on the left leg alone, as she could do on the right. I found some diminution of sensation of the whole of the left side of the body, including the senses of hearing, taste, and smell. The left field of vision was distinctly contracted, the right normal. In the case of the left lower limb, sensation was much less acute on the buttock and back of the thigh than on the front of the latter, and less also on the outer than on the inner side of the leg, *i.e.*, there was greater disturbance of the sciatic and its branches than of the anterior crural. The plantar reflex was absent on the left side, normal on the right; the knee-jerks were equal. The patient said most distinctly that none of her symptoms interfered with her comfort or usefulness.

Here, then, I believe that to the original organic injury we had superadded, at a much later date, a typical hysterical hemi-anæsthesia, both of which could be traced at the last examination.

It is unnecessary to multiply instances of traumatic hysterical anæsthesia. But I may add that in some cases which I believe to have been *bonâ fide*, I have found affection of the special senses only. Thus I have notes of four cases of marked deafness, one of which was combined with feebleness of the grasp and "numbness" in the hands, but not with actual loss of tactile sensibility. In two cases the field of vision was contracted in both eyes, but there was no other symptom. In these cases there has, however, usually been some previous weakness of the affected organ. Thus of the four cases of deafness, three admitted having previously been slightly deaf, but stated that they were rendered much worse by the accident, while one gentleman who had contracted field of vision had always been short-sighted. It is difficult under such circumstances to exclude fraud, unless the patient be previously well known, and it is doubtful whether, if genuine, they should not be regarded as instances of neurasthenia acting on a weak part, rather than as examples of hysteria proper.

Reviewing all these cases, together with other numerous published examples, we arrive at the following general conclusions. The most common symptom is anæsthesia. This is usually on the left side. Of eleven of my cases, in seven it was on the left, in four only on the right. The anæsthesia does not follow the distribution of nerve-trunks, but, like the paralysis, is bounded by straight lines, usually either dividing the limbs into segments, each of which corresponds to a joint, or more often marking off a whole limb from the body. It is both superficial and deep, the muscular sense being also lost. The fauces are usually anæsthetic on both sides (Charcot, ([67]) Dreschfeld ([43])), or sometimes on one only (Case 57).

When this sensory paralysis takes the form of hemi-anæsthesia (and very frequently also in cases in which it is limited to a segment only), there is combined with it anæsthesia of the sensory organs on the same side—deafness, loss of taste and smell, and diminution of the field of vision, never hemianopsia. The diminution of the visual field may affect the opposite eye, to a less extent than that of the anæsthetic side, and in two cases I have found enlargement of the field in the opposite eye. The diminution is usually uniform and peripheral, but there may be scotomata. Achromatopsia is usually, but certainly not always, also present.

Hyperæsthesia, superficial or deep, is usually found at some part of the body, especially in the neighbourhood of contracted joints. It is frequently found also at parts of the non-anæsthetic side of the body. The relative arrangement of anæsthesia and hyperæsthesia bears no resemblance to anything seen in organic disease, the latter, like the former, being bounded by straight lines running round the limbs. Very frequently there is hyperæsthesia about the costal margin, in the groin, or in the testicle, and pressure on such a hyperæsthetic region (hysterogenic point) may induce a hystero-epileptiform crisis, a condition which does not, however, appear to be very common in traumatic hysteria.

Paræsthesiæ are various and inconstant phenomena.

Vaso-Motor, Trophic, and Secretory Symptoms.—These are much less common than are the sensory or motor phenomena of traumatic hysteria, but I believe, nevertheless, that we do meet with such symptoms, due to hysteria, and to hysteria alone, and that the following cases are to be regarded as examples. It is quite usual to find the regions affected with hysterical anæsthesia very pale, and in one case I have seen marked œdema. Again, although

they preserve their normal electric reactions, the paralysed muscles often undergo a good deal of atrophy. Hence, there can be no question but that well-marked vascular changes may result from hysteria, and if so, we must not be surprised that in some instances more distinctly trophic and secretory symptoms ensue.

Case 63.—*Hysteria—Urticaria.*

A married woman, aged thirty-four, was injured in a slight railway collision, receiving a blow on the right side of the head, and slight bruises on the left arm and thigh. For a short time she was unconscious, and during the journey home she said she was very hysterical all the way—the term is her own. I saw her five days later, when her chief symptoms were an excited manner, a quick jerky pulse, palpitation, and premature menstruation. But about a week after the accident she began to be troubled with a rash, of the nature of urticaria. This came out every evening about 8 or 9 P.M., and remained until 11 A.M. or noon of the following day. It consisted of large bullæ, scattered all over the body, and very itchy, followed by patches of redness. When I saw her on the afternoon of the twentieth day, she had numerous red raised patches over the lower limbs, due to these bullæ. Here I can find no satisfactory explanation of the rash beyond a "functional" vaso-motor or neuro-trophic change. The patient was certainly taking bromide of potassium, but this had none of the characters of a bromide rash. It continued for about three weeks, and then passed off, the woman recovering entirely.

Case 64.—*Hysteria—Anæsthesia and hyperæsthesia—Herpes.*

In another railway case, the patient, a married woman, aged twenty-six, received bruises of the left leg, right side, and head. She was still confined to bed a week after the accident, when I saw her, and she then complained of pain about the second lumbar vertebra. Sensation was deficient in the left lower limb, exaggerated in the right. She had no paralysis, but the left leg "seemed to go from under her" when she stood up. The knee-jerks were very lively on both sides, the plantar reflex more marked on the right. The night before my visit she had a "fit," in which severe pain in the head was followed by unconsciousness. But the most interesting point is that she had developed a well-

marked herpetic eruption on the right side of the body, accurately limited by the middle line before and behind, and occupying the buttock, groin, and upper and outer part of the thigh. The region thus affected was very painful, and in the right groin was an inflamed gland. I never saw the patient again, but am credibly informed that two months later she was well. Here, then, there would appear to have been no organic spinal injury, but merely a functional change, a view which is supported by the absence of paralysis, of bladder or rectal troubles, or of marked changes in the reflexes, by the co-existence of an apparently hystero-epileptic seizure, and by the rapid recovery.

In the following case, also, I think that we must look to a profound functional derangement for an explanation of the symptoms.

CASE 65.—*Shock—Pyrexia.*

A gentleman, thirty-nine years of age, was shaken in the Hexthorpe railway collision. Five days afterwards he complained of pain in his "inside," back, and head, and of startings at night. He had no bruises, nor any objective signs except rather free perspiration, and, although intensely nervous, he was able to be out of bed. On the eleventh day he felt much more unwell, and was very restless all day; in the evening the temperature, which had previously been normal, rose to 102° (pulse, 100). On the following morning the temperature was 101°, pulse 100; he could scarcely be roused, would take no food, and passed urine of very low specific gravity (1005). This condition continued for two days more, the temperature rising to 101.4°, and he was very restless and slept badly, groaning constantly, and refusing food. He also became almost aphasic, using wrong words, and being unable to fix his attention upon any point, or even to finish his sentences. At no time were there any indications of thoracic, abdominal, or other organic mischief. Then, on the evening of the fourteenth day after the accident, the temperature fell to 99°, on the following morning to 98°, and in some two days more he was as well as before the attack. A perfect recovery ensued, and six or eight weeks after the accident he was as well as he had ever been.

In this same category of hysterical vaso-motor troubles, also, we must probably place a not very infrequent symptom—the passage of very dilute urine. This is, I am inclined to think, a

distinctly hysterical manifestation. It is very common in ordinary traumatic neurasthenia to find the urine concentrated, with a deposit of urates, but the reverse condition I have never noticed without other hysterical symptoms.

Ovarian hyperæsthesia, again, is extremely likely to be due to ovarian hyperæmia, and a general hyperæmia of the genital organs (in the female, at any rate) would explain the "flooding" referred to in Case 56, as well as premature menstruation, which is frequently observed after railway accidents. In several of the above cases will be found references to hæmatemesis and melæna, as in Case 53, in which there appears to have been frequent hæmatemesis for a year. Melæna generally, and hæmatemesis often, cannot be traced to fraud, and they might also be explained by vaso-motor changes. I would, however, wish it to be clearly understood that on these vaso-motor symptoms I now speak with great reserve. The facts of the above cases are correctly recorded, the explanation is most obscure.

5. Pathology.

The classical researches of Charcot have established beyond question the practical identity of the symptoms of traumatic hysteria with those which can be produced by suggestion during the hypnotic sleep. In patients hypnotised, not too deeply, it is possible to produce, either by manipulation of the limbs, or by authoritative assertions to the subject of experiment, paralysis and anæsthesia absolutely similar in character to those which have been described above. Hence we are naturally led to seek for an explanation of the traumatic results by a comparison with the fairly well explained manifestations of the hypnotised. For this purpose we require the analogues of the hypnotic state and of the suggestion.

As regards the latter, Charcot has shown that in hypnotised persons, light blows may often produce paralysis and anæsthesia, apart from verbal description to the subject of the results which are to ensue. Hence he postulates the theory of *auto-suggestion*. A blow causes a sense of congestion or weight in the implicated region, and this would appear to be capable of inducing the idea of paralysis, which is forthwith translated by a disordered cortex into the fact. It is clear, then, that in the hypnotic condition a slight trauma is capable of evoking by auto-suggestion manifestations identical with those of hysteria. But further, Charcot

has found that in one case, at any rate, previous hypnotism was not essential to the production of this result, and hence he is led to believe that conditions other than those produced by the ordinary methods of hypnotism may predispose an individual to these hysterical manifestations. Such a condition he believes to be supplied by "nervous shock," and he thus arrives at the conclusion that the two elements necessary for the connection of traumatic with hypnotic hysteria are provided. "Nervous shock" replaces hypnotism, "auto-suggestion"—a result of abnormal sensations provoked by the injury—replaces suggestion by the operator. This theory has, like most other theories, been attacked, but it certainly appears better suited than any other yet advanced to explain the facts which present themselves.

In an early portion of this paper I have referred, under the name of "acute hysteria," to certain common conditions resulting from nervous shock, which correspond very closely indeed to those of the slighter degrees of hypnotism. The peculiar inattentive condition there described, accompanied as it is by disordered imaginations, thus presents one factor in our pathological nexus, and we may regard the inhibition of cerebral action, thus evoked by the shock of an accident, as being very closely allied to that produced by the efforts of the mesmeriser.

The suggestive element is even more easy of explanation. In most cases of traumatic hysteria we find that the paralysed region bears a close relation to the region injured, and here the subjective effects of a blow suffice to explain the origin of the idea of paralysis. Every one must be familiar with the numb, dead sensation following a blow, especially a blow upon a nerve-trunk; and can anything be more likely to suggest the idea of paralysis? The suggestion naturally becomes most pressing in such instances as Case 62, in which a local organic paralysis and anæsthesia are already vividly presenting themselves to the patient's consciousness. Then, again, it must be remembered that, in the case of railway accidents at any rate, the general public of this country has been educated to *expect* "concussion of the spine" with paralysis, and that, in the minds of the laity, the very mention of a railway accident calls up the required idea. Other elements may also be present, as, for instance, powerful emotions, which, especially in the case of fear, frequently cause a passing inhibition of muscular force, manifested by staggering, trembling, or even falling, and which are obviously supplied by the accident. Thus there are various obvious channels by which the idea of paralysis may readily be suggested.

On these grounds, then, there appears to be the closest possible connection between traumatic hysteria and the paralysis of hypnotic suggestion, and on these grounds we must, I think, accept the theory of Charcot.

If we attempt to go further, and to inquire into the material basis of hysteria, we find ourselves almost hopelessly without the guidance of facts, and we pass, moreover, to the consideration of questions, which, as they relate to all varieties of hysteria, and by no means to the traumatic form only, I do not intend now to discuss. Suffice it to say that the change is almost certainly cortical, and is probably associated with an anæmia of one side of the cortex, possibly with a correlated hyperæmia of the other.

6. Prognosis.

My own experience, relating, as it does, mainly to isolated examinations, hardly furnishes, if taken alone, sufficient grounds for any definite conclusions on this most difficult of questions; nor do we find in current literature any very satisfactory data; but a comparison of experience with previous observations is not altogether without value. Whereas some writers refer to these cases as practically incurable, others speak of them as almost invariably recovering with rapidity, and on both sides we find opinions expressed with a perhaps somewhat unwarrantable dogmatism. The main reason of this discrepancy would appear to be that the question of pecuniary compensation enters in a varying degree into relationship with the cases observed by different authors. Before we can arrive at any definite decision, we must endeavour to divest ourselves of this source of confusion. Looking to our own cases, we find three only in which there was no such question (Cases 53, 54, and 57). These were all treated in hospital, and had all been previously neglected. Before they came into hospital they either manifested no tendency to improvement, or were getting distinctly worse. In hospital, on the other hand, the improvement was rapid and obvious. Unfortunately, the exigencies of public practice do not allow of their being retained sufficiently long for the completion of a cure, but we can hardly doubt that a more prolonged stay would suffice to produce this result, and these cases seem strongly to suggest the probability of a complete cure within, at most, a few months, *provided the conditions be satisfactory.*

Most instructive in this connection are the following cases recorded by Mr. Collier ([70]). Briefly, these are as follows:—

(1.) Fall on head. Epileptiform seizures; almost complete anæsthesia; retraction of field of vision; retention of urine. Recovery in three days.

(2.) Crush of toe. Anæsthesia of limb. Recovery in one month.

(3.) Fall on shoulder. Contracture of limb; retraction of field of vision. Date of recovery not known, but patient ceased to apply for treatment after a fortnight.

(4.) Fall. Mutism; paralysis of adductors of vocal cords; paralysis of tongue; convulsions. Immediate recovery on faradisation; return of symptoms in a few hours; permanent recovery on a second faradisation.

In none of these was there any question of compensation, and all were properly treated from the first.

If, then, there be no pecuniary complication, and if the case be at once placed under proper treatment, we may apparently expect perfect recovery within a few weeks. If, again, the case be neglected, but the financial difficulty be still excluded, the symptoms appear to become more fixed, and a longer period, probably some months, may be required for an absolute cure. That in either case an absolute cure is to be expected appears to me almost certain, both from the above-quoted and from other published cases. I am confirmed in this opinion by the fact that, whereas traumatic hysteria is by no means rare, I am unacquainted with old standing incurable cases such as we should meet if the symptoms were persistent, and at the same time (as is universally admitted) very rarely fatal.

Unfortunately the majority of these cases arise from railway injuries, and here we always have the baneful effects of the compensation question. Now it must be admitted that these cases do not recover so rapidly as those to which we have already referred, and we are led to ask why this should be so? Is it because the results of railway collisions are much more severe, or because the expectation of compensation increases the duration of the symptoms? Connected as I have been with several railway companies, I have been struck by two facts, viz., *first*, that among the large number of railway officials of every social grade whom I have known, many of whom have been passengers at the time of collisions, but none of whom can claim compensation, I have never met with any who have suffered from severe or persistent nervous symptoms; and *second*, that in none of the accidents with which I have been concerned has any railway servant complained of such symptoms. Bruises, fractures, burns,

and deaths we meet with only too frequently, but traumatic hysteria is to me unknown in either of these two classes of persons. As railway officials are similarly constituted to the rest of the population, I presume that they do occasionally suffer from traumatic hysteria, and I can therefore only conclude that they recover from it within a brief period.

We are thus, then, driven to the view that compensation, or rather waiting for compensation, markedly aggravates the hysterical symptoms, a position which we can assume without for one moment impugning the honesty of all the sufferers with whom we meet. The origin of traumatic hysteria being an idea or a suggestion, it is but natural that anything which tends to fix this idea will operate towards retarding convalescence. In a compensation case everything does tend to fix the idea. The repeated examinations by various experts, the frequency with which the patient is called upon to detail his every symptom and sensation, the accounts of his accident which he reads in the press, the almost continuous repetition to himself of his sufferings, all serve but too well to rivet the suggestion on a mind weakened by the worry of legal proceedings and by the fear of the popularly accepted fate of the victim of "railway spine." And thus we find that, in these "compensation cases," the prognosis of traumatic hysteria becomes much more grave than in those to which we have already referred.

It may be objected that if the waiting for compensation be the cause of this additional prolongation of the illness, payment should induce a recovery as rapid as in other cases, but a moment's consideration will show that this is not so. We have already seen how mere neglect or unsuitable treatment renders an ordinary case much more intractable, even when it does at last acquire more satisfactory surroundings, simply because the longer the symptoms have lasted the more rooted has become the idea, and the longer it is likely to last. Hence we must not expect, as a rule, to find an immediate entire recovery after settlement of a claim, but we are certainly justified in saying that recovery will thereby be rendered comparatively very rapid. All of the cases above quoted, in which the subsequent history of the patient has been traced, bear out this view. And it would seem not improbable that the rate of recovery after compensation may bear a direct ratio to the duration of the symptoms before it. Thus, in Case 52, the settlement was made within a fortnight of the accident (before I saw the patient), and within a month the improvement was so great that very little inconvenience was

caused by the symptoms. In Case 56, in which no compensation could be claimed, recovery ensued in a few weeks; and we may note, in passing, that, among the injured in the collision which produced this case, there were no other instances of traumatic hysteria. Case 58 showed little, if any, improvement during the seven months before settlement, but one month after it the patient's medical adviser (whose services had already ceased to be required) writes:—"I was surprised to see him looking so well. In appearance he has certainly improved very much." The patient himself still complained of some disability, but, in the absence of details, we may take the above as a satisfactory report. Case 60 was that of a man who was able within a month of the accident to pursue his occupation of a book-maker. Cases 50 and 62 were only settled many months after the accident, and at the end of a year there was still slight anæsthesia in both, but in neither case did such symptoms as persisted interfere materially with the comfort of the patient. In Case 61 the hysterical symptoms shortly disappeared, but the neurasthenic troubles persisted for a year, and then yielded in a few weeks to the effects of pecuniary compensation.

In order to give the more accurate prognosis, it is necessary to consider certain other conditions which will influence the duration of traumatic hysteria. Thus, in the male, the symptoms, although less readily produced, appear to be more fixed in character than in the female (Charcot). A neurotic tendency, whether hereditary or acquired, is also of bad omen. Chronic alcoholism, again, tends to render the prognosis worse. Marked fluctuation in the symptoms, such as transference of hemi-anæsthesia from one side of the body to the other, or temporary disappearance, as in Case 59, are eminently favourable conditions. The case last referred to illustrates very distinctly the disastrous effect of legal proceedings in aggravating the hysterical troubles.

In the above remarks a possible, although a rare eventuality, has been ignored. Life is but seldom imperilled by traumatic hysteria, but that complications may ensue which may terminate in death is shown by the following remarkable case.

CASE 66.—*Hysterical hemi-anæsthesia and retention of urine—Vomiting—Cystitis—Exhaustion—Death.*

An unmarried girl, twenty-four years of age, was injured in a slight railway collision. She became unconscious, and did not

remember the circumstances of the accident. When I saw her on the following day, she complained of pains all over her body, but especially in the head, left side, and back. She tossed about very restlessly in bed, but said that all movements caused pain. The pulse was quick (108), and she had marked "facies hysterica," but there were no other signs of injury. I did not examine the sensation.

I saw her again a fortnight later, and found her in a very quiet—it might almost be said semi-comatose—condition, from which she had to be roused before she would pay any attention to questions. In spite of this, she started violently on hearing the slightest sudden noise. I was told that she was often quite unconscious for hours at a time. She had anæsthesia of the right side of her face and chest and of the right hand, but for several reasons I made no further examination of her sensation. I was also told that ever since the accident she had had to have her urine withdrawn by the catheter, and that she vomited constantly. The bowels were much constipated, and could be relieved only by enemata. Shortly before this she had been seen by Dr. Ross, who did not then regard the case as a very serious one—an opinion which I certainly shared.

She now appears to have become rapidly worse, and a week or so later was seen by Dr. Dreschfeld, who then found her comatose, with universal anæsthesia, fever, and cystitis. I know little of the termination of the case, except that some weeks after the accident she died exhausted.

There was no post-mortem examination, but, in the absence of any evidence whatever of a gross lesion—a point upon which all who saw her were agreed—it would appear that this was a case of death from exhaustion, due to hysteria, with persistent vomiting, and cystitis from retention of urine.

Such a termination must be extremely rare, but its possibility has to be considered in giving a prognosis.

7. Treatment.

Concerning treatment, I have nothing to add to the results of previous observers. On one point, however, I would strongly insist—the advisability of separation from friends and relatives. The value of such isolation in various other neuroses is generally admitted. Weir Mitchell and Playfair have demonstrated the benefit to be derived from it in the case of hysteria, and the above-quoted hospital cases but confirm their conclusions. Adopt-

ing the pathological views enunciated by Charcot, we must endeavour to exclude, as far as possible, the idea of paralysis, &c., and conversely to suggest a return of power in the affected limbs, while at the same time we attend to the general health of the patient. Hence we must strive to eliminate the often-mentioned factors which tend to fix the idea. At the same time we must as far as possible persuade the patient to use the affected extremities—a convenient method, in the case of the upper limb, being by the frequent use of the dynamometer. Massage and faradism are of undoubted value, both probably acting not only by improving nutrition, but also by evoking the muscular sense, and thus suggesting movement. Good results have occasionally been obtained by hypnotism and by "transference," but of these I have no personal experience. Legal questions should be settled as early as possible.

The general treatment should be tonic. The bromides are frequently largely used, and probably generally do more harm than good, tending as they do to increase the neurasthenic prostration (Page [32]). If there be much cerebral excitement, the bromide of ammonium appears preferable to the potash salt. Cold-bathing and douches are of value, as is also over-feeding. The details of treatment are, however, almost as various as those of the symptoms, and must be adapted to each special case. Much may depend upon the moral influence of the physician, if not of the lawyer.

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