Pathological and surgical observations relating to injuries of the spinal cord / [Sir Benjamin C. Brodie].

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OBSERVATIONS

RELATING TO

INJURIES OF THE SPINAL CHORD.

By Sir BENJAMIN C. BRODIE, Bart., F.R.S.,

SERGEANT-SURGEON TO THE KING, AND SURGEON
TO ST. GEORGE'S HOSPITAL.

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SECTION I.

As the spinal chord is an appendage of the brain; as the functions of the one are intimately connected with those of the other; as they are constructed alike of medullary fibres and cineritious substance, enclosed by similar membranes, and protected, each of them, by a strong bony case; it seems reasonable to expect that they should suffer, nearly in the same manner, from the effects of mechanical injury. Pathological and surgical writers (with very few exceptions) seem to have taken nearly this view of the subject, and hence probably it is, that while their works contain abundant information respecting the consequences of wounds and contusions of the head, so little can be learned from them as to the not less important

consequences of the same accidents, where they affect the column of the vertebræ.

It is with a view to contribute my share towards remedying this defect in surgical literature, that I venture to offer the following observations to the Royal Medical and Chirurgical Society. Those who have been much engaged in the practice of large civil and military hospitals will, I trust, discover in them no inaccurate representation of what they themselves have witnessed; while to the younger members of our profession, and to those whose opportunities are less extensive, it may be neither useless nor uninteresting to have placed before them a connected history of a class of accidents, which they must occasionally meet with; which are always attended with danger, and which at the same time lead the mind of the scientific enquirer to a variety of curious physiological and pathological speculations.

It is my intention not to occupy the time of the Society by giving a detailed account of individual cases, but rather to explain the general results of my experience; it being understood, that except where I expressly refer to the observations of others, I make no statements for which I do not find an authority in the written notes of cases, which I have been enabled to collect in the course of the last few years.

Wounds, which penetrate through the external parts into the spinal chord, are almost invariably fatal at a very early period; the examples of recovery from them, which have been recorded by writers

being very few in number, and leading to no important rules of surgical practice. On this part of the subject I have nothing new to offer from my own experience. Those who will take the trouble of referring to M. Ollivier's treatise on diseases of the spinal chord, will find in it a notice of some interesting experiments illustrating the effects of these injuries in animals, as well as the histories of some cases, chiefly collected from other authors, in which they occurred in the human subject.

In considering the other and more common varieties of injury of the spinal chord, I shall in the first instance, as the best foundation of our knowledge, endeavour to describe the effects of these accidents, as they are disclosed to us by dissection, where the patient has died at an early period after the infliction of the injury. Of course it is necessary to include in the description not only the effects produced on the chord itself, but also those on the parts which are in immediate connection with it. The whole of these may be classed under one or another of the following heads.

First. Fractures of the vertebræ without displacement of the fractured surfaces.

Secondly. Fractures with depression or displacement of bone, diminishing the diameter of the spinal canal, and occasioning pressure on the spinal chord.

Thirdly. Fractures complicated with dislocation.

Fourthly. Dislocations not complicated with fracture:

The existence of such dislocations has been doubted by some very distinguished surgeons, but Mr. Lawrence, in a paper on the subject published in the thirteenth volume of the Transactions of this Society, has not only recorded several cases in which they had taken place in the cervical vertebræ, but has also adduced satisfactory evidence of their existence even in the dorsal and lumbar portions of the spine. In a case, which came under my own observation, the fourth and fifth cervical vertebræ had been completely separated from each other, so as to expose the *theca vertebralis* for the extent of half an inch. Similar cases of diastasis have been described by Sir Charles Bell and Mr. Lawrence.

Dislocations of the odontoid process of the second cervical vertebra in consequence of disease, are not very uncommon, so that probably there are few surgeons of much experience, who have not had the opportunity of witnessing cases of this kind *.

Fifthly. Extravasations of blood on the surface of the membranes of the spinal chord. Such extravasations, however, rarely take place to any considerable extent, and bear no comparison to those which occur within the cavity of the cranium in consequence of a rupture of the substance of the brain, or a laceration of the middle meningeal artery.

Sixthly. A narrow clot of extravasated blood is sometimes discovered within the substance of the spinal chord. It is always of a very small size,

* See Rust, in Arthrokakologia: Lawrence, op. cit.; and my own Treatise on the Diseases of Joints.

but from its peculiar situation may be productive of the most dangerous symptoms.

Seventhly. Laceration of the spinal chord and its membranes. Of course it is more easy to conceive than to describe all the varieties of this kind of injury which are met with in practice. The spinal chord may be separated through its whole substance; or it may be torn in one part and not in another. M. Ollivier describes a case in which the attachments of the nerves on one side were destroyed, while those on the other side were entire.

Eighthly. The minute organization of the spinal chord may suffer from a blow inflicted on the spine, even where there is neither fracture nor dislocation, and where the investing membranes do not appear to participate in any way in the effects of the injury. In such cases, if there be an opportunity of examining the spinal chord at a very early period after the accident has occurred, the central part of it is found to be softer than natural, its fibrous appearance being lost in that of a semifluid substance. If the patient survives for a longer period, the alteration of structure is perceptible in the whole diameter of the chord, and occupies from one to two inches, or even more, of its length; and at a still later period it has often proceeded so far as to terminate in its complete dissolution.

This disorganization, softening, and final dissolution, of the spinal chord is the most common consequence of injuries of the spine, and the dangerous symptoms which follow these accidents, are, in the

majority of cases, to be attributed to it. It bears no distant resemblance to the effects of a contusion of those soft parts which are more superficially situated, and it is easy to understand that it may be produced by a severe concussion operating on the delicate medullary fibres and cineritious substance, of which the spinal chord is composed.

In a paper which I communicated to this Society in the year 1828, and which has been published in the fourteenth volume of the Medico-Chirurgical Transactions, I have observed that in what are commonly called cases of concussion of the brain, we are not justified in the conclusion, that because no changes are to be detected after death, "there is, therefore, in reality no organic injury." And I have added, "It is difficult to conceive in what other manner concussion of the brain can operate, so as to produce the effects which it is known to produce: and if we consider that the ultimate structure of the brain is on so minute a scale that our senses are incapable of detecting it, it is evident that there may be changes and alterations in it, which our senses are incapable of detecting also. The speedy subsiding of the symptoms in some cases of concussion does not contradict this opinion. A deep incised wound in other parts may, under certain circumstances, be completely and firmly united in the space of twenty-four hours, and it is easy to suppose that the effects of a much slighter injury may be repaired in a much shorter space of time." These remarks are not less applicable to cases of concussion of the spinal chord

than they are to those of concussion of the brain. We cannot doubt that the nature of the injury is the same in both of them. It is true that much worse consequences usually arise from concussion of the spinal chord than from concussion of the brain; that is, if the patient recovers, his recovery is more tedious: that if he dies, greater changes in the condition of the injured part are detected on dissection. But these differences in the effects of the injury are easily explained. The brain and its membranes completely occupy the cavity of the cranium, while the spinal chord and its membranes occupy only a part of the vertebral canal: and this being the case, it requires no great knowledge of mechanics to enable us to understand why the same degree of violence applied to the head, and spine, should occasion different degrees of mischief to the organs which they contain.

The effect of a violent concussion is at once to impair, and even to destroy the functions of the spinal chord, sometimes even causing the patient's death in the course of a few hours; and the question here presents itself, What is the nature of the injury thus inflicted on the spinal chord, so trifling in appearance, so great in reality, which is capable of producing such important and dangerous consequences? It would be an interesting experiment, but it is one which I have hitherto neglected to institute, where a patient has died at an early period after an accident of this kind, to prepare the spinal chord by maceration in alcohol, and to endeavour by tracing its fibres to ascertain in what respects they are altered

from their natural condition. The process of softening and dissolution of the chord which takes place afterwards has, I know, been regarded by some pathologists as the consequence of inflammation, but a consideration of the following circumstances leads me to doubt the accuracy of this conclusion. 1st. A minute examination of the injured part of the spinal chord will often enable us to detect the commencement of the softening process at a very early period, before sufficient time had elapsed for inflammation to become established, and before any symptoms of inflammation had shewn themselves. 2dly. The softened part of the chord, in the first instance, exhibits no appearance of increased vascularity. 3dly. Even where the softening process is so far advanced as to occasion complete disorganization of the spinal chord, the investing membranes, for the most part, exhibit their natural appearance, there being neither increased vascularity, nor the slightest effusion of lymph, or serum, or pus on their surface. 4thly. The symptoms, which mark the progress of these changes, are (as I shall shew hereafter) merely a continuation of those which the concussion of the spinal chord has occasioned in the first instance, and which of course must have been wholly unconnected with inflammation.

It is true that the disorganization of the spinal chord never proceeds to any considerable extent without an enlargement of the small vessels being perceptible, such as may be supposed to indicate the existence of inflammation: but this is no more than

what happens in the progress of any other disease. As far as I know there is no exception to this general rule. A scirrhous or fatty tumour is not the result of inflammation, but inflammation nevertheless takes place sooner or later as the disease makes progress. Nothing can be more remote from inflammation than neuralgia is in its origin; yet a slight degree of inflammation frequently takes place where neuralgia has been constant and of long continuance. In these and in a number of other cases, which might be enumerated, the inflammation is not the cause, but the effect or concomitant of the disease, whatever it may be.

In further confirmation of the opinions which are now expressed, it may be observed that there is a manifest resemblance between the softening of the spinal chord, which follows mechanical injury, and that softening of the brain and spinal chord which takes place from internal causes, and which was first particularly described by M. Rostan, under the name of *Rammollissement du cerveau.* M. Andral properly rejects the notion that this change is the mere result of inflammation, and every practical pathologist must have had ample opportunities of determining the justice of the argument which he uses, that "We often meet with cases (of *rammollissement*) where there is no appearance of sanguineous congestion, nor of purulent effusion, nor of any morbid secretion; a simple diminution of consistence being all that is to be seen." *

* A treatise on Pathological Anatomy by G. Andral, translated by Dr. Townsend and Dr. West, Vol. II. page 748. 1831.

Although the softening of the spinal chord is not the consequence of inflammation, we must not overlook the circumstance, that inflammation of the investing membranes sometimes exists in combination with it, or that such inflammation may take place where the chord is little or not at all affected in this manner. Inflammation however is to be regarded as one of the secondary effects of the injury, and the consideration of it belongs more properly to another part of the present investigation.

SECTION II.

The peculiar symptoms, which arise as an immediate consequence of injury of the spine, may be referred 1st, to concussion of the spinal chord; 2dly, to laceration or division of its substance; 3dly, to pressure made on it either by displacement of bone or extravasated blood. Afterwards, inflammation of the membrane of the chord may take place, and other organs may be secondarily affected, giving rise to another order of symptoms, which did not exist in the first instance.

Taking a general view of the symptoms, we may observe that they vary; 1st, according to the part of the spinal chord on which the injury has been inflicted: 2dly, according to the kind and degree of injury which the chord has sustained; 3dly, accordingly, as from accidental circumstances, that is from circumstances of which we cannot take cognizance, the life of the patient is prolonged for a shorter or longer period, or ultimately preserved.

Such is the diversity of the symptoms which we meet with in practice, that it would be vain to attempt to give a single connected history of them, which would be applicable to all, or even the majority of the cases: and, on the other hand, a needless repetition in many respects would be the result, if we were to endeavour to distribute the cases under different heads, accordingly as the symptoms arise from different degrees and kinds of injury, or from injuries occurring in different situations. The best consideration which I have been able to give the subject, leads me to believe that the following method of analysis will (on this occasion) be less liable to objection than any other. I propose, in the first instance, to give an account of the several symptoms, which are the consequence of injuries of the spinal chord, in succession, endeavouring to point out (as far as it is in my power to do so) under what circumstances each of them presents itself; and afterwards to offer some general observations, with a view to connect the whole together, and complete the history, which might otherwise be deficient. I hope thus to be enabled to avoid the omission of any facts which are really important, without sacrificing that brevity and conciseness, which it is so important to preserve in all scientific investigations.

Symptoms of Injuries of the Spinal Chord.

Paralysis of the voluntary Muscles.—The most obvious effect of a severe injury of the spinal chord, is a paralytic state of the voluntary muscles below the seat of the injury.

If the spinal chord be divided through its whole substance, or extensively lacerated, or subjected to any considerable degree of pressure, the paralysis is immediate and complete. If the injury be partial, certain muscles may be paralysed, while others retain their power of voluntary motion.

Concussion of the spinal chord often produces complete paralysis also; but more frequently the paralysis arising from it is partial. One limb may be paralytic and another not so; or in the same limb certain muscles may be thus affected, while others are still obedient to the will. In some cases the patient has the power of using his limbs while he is in the horizontal posture, yet he is unable to stand erect. Or the degree of paralysis may vary at different periods. Thus it may be complete at first; then, after three or four days, the power of motion may be in some degree restored; then it may be lost again. Sometimes, although the paralysis is complete, or nearly complete, in the first instance, so speedy a recovery takes place, that the patient is able to walk in the course of three or four weeks, or even sooner; or the converse of this may happen, so that, although there is no more than a weakness of the muscles immediately after the

accident, complete paralysis may take place, sometimes gradually, at other times almost suddenly, after the lapse of several weeks.

Paralysis of the lower limbs is more common than that of the upper. In some cases, in which the injury has affected the spinal chord in the lower part of the neck, the lower limbs are rendered paralytic, while there is either no paralysis, or a less degree of paralysis in the upper limbs. The reason of this is sufficiently obvious to any one who considers what are the origins of the nerves which form the axillary plexus, some of them being probably above the part which is injured: but the circumstance is still remarkable in this respect; that it is contrary to what happens when the functions of the spinal chord are interrupted in consequence of caries of the cervical vertebræ. In these last mentioned cases the paralysis is often complete in the upper limbs for many weeks, or even for months, before it extends to the lower. I have met with only a single case, in which, after an injury of the cervical portion of the spine, there was almost complete paralysis of the muscles of the upper extremities, and none whatever of those of the lower.

A case is recorded by Mr. Stafford, in which there was paralysis of both the upper and the lower limbs, consequent on an injury of the loins, with fracture and displacement of the lumbar vertebræ; and another case fell under my own observation, in which paralysis of the upper limbs followed a contusion of the middle dorsal vertebræ. I conclude that such cases are no more than apparent exceptions to the

general rule, of the paralysis being confined to the parts which are below the injured portion of the spinal chord. It is easy to suppose that the bones may be fractured or displaced in the loins or back, or that blood may be extravasated within the theca vertebralis in one or the other of these situations, while another part of the spinal chord, as high as the origin of the nerves which form the axillary plexus, suffers from the effects of concussion.

Paralysis, after an injury of the spine, is always a dangerous symptom; but many persons thus affected recover nevertheless. For example: a gentleman was thrown from his horse, and received a severe blow on his back. Five weeks afterwards he became paralytic in his lower limbs; but at the expiration of fifteen or sixteen weeks more, he began to recover the use of them, and he was able to walk with the assistance of a stick, when I was consulted about a year afterwards. I have known many cases very nearly resembling this in all essential circumstances. A patient in St. George's hospital, whose lower limbs were paralytic after a severe blow on his spine, regained the use of them in the course of three or four weeks. I shall have occasion to revert to this subject hereafter: in the mean time I may observe, that it is easy to understand that, where paralysis is produced by the pressure of extravasated blood, it may be relieved by the absorption of the coagulum; or that the injury inflicted by concussion on the structure of the spinal chord, may be gradually repaired.

A case is related, by Morgagni, of a young man

who was wounded by a dagger in the neck, and immediately became paralytic in all the parts below the injury. Nevertheless, in less than six weeks he began to re-acquire the use of his muscles, and he was able to walk slowly and cautiously at the end of four months. The records of surgery contain histories which are still more remarkable, in which the spinal chord is said to have been completely divided, without the production of paralysis either at the time or afterwards. Such histories, however, are rare*, and until they are confirmed by further observations, it must remain as a question, whether it be more probable that there should have been so remarkable a deviation from the ordinary course of events, or that the state of the spinal chord in those cases should have been carelessly or insufficiently examined. Undoubtedly our judgment respecting them is not assisted by the analogy of those other cases, which have been described by Magendie, Velpeau, and others, in which the circumstance of a portion of the spinal chord having been reduced to an apparently semi-fluid state without consequent paralysis, may be explained by supposing that there were nevertheless sufficient remains of the medullary fibres to answer the purpose of transmitting the nervous influence.

Muscular Spasms.—A gentleman, in October 1827, was thrown from his horse, which afterwards

* I refer especially to two cases quoted by Velpeau from the Mémoires de l'Academie des Sciences and Desault's Journal.

rolled over him. His head was not struck, and the principal injury seemed to have fallen on the lower part of the spine. Soon after the fall, and while he was yet lying on the ground, his thighs were raised spasmodically towards the trunk, and this was followed by an involuntary tremulous motion of the lower limbs. Afterwards the lower limbs became paralytic, and continued in that state for a period of two months. At the end of that time he began to recover, and when I was consulted, about a year after the accident, he was able to walk without even the assistance of a stick.

In the observations on injuries of the brain which I formerly communicated to this Society *, I mentioned some circumstances which seem to show that the convulsions which occasionally occur at an early period after a severe blow on the head, are the consequence of a slight extravasation of blood, which is sufficient to operate as a cause of irritation, without actually destroying the functions of the brain. Whether the convulsions which took place in this instance had a similar origin, or arose from that disorganization of the spinal chord which is the most usual cause of paralysis after concussion, must be left to future observations to determine. The same symptoms sometimes occur at a later period. For example: a man forty-five years of age, in January 1825, fell from a scaffold, and received a blow on his back. All the parts below the epigastrium became immediately paralysed. At the end of nine days it was

* Medico-Chirurgical Transactions, Vol. XIV., p. 370.

observed, for the first time, that a slight involuntary action of the muscles of the thighs was induced when pressure was made accidentally on these parts. Afterwards severe cramps and painful convulsions took place, whenever pressure was made on any part of the body, or even by lifting up the bed-clothes. At last they were almost constant, so as continually to awaken him from his sleep. When he died, nine weeks after the accident, it was ascertained that there had been a fracture of the fourth dorsal vertebra, with such a degree of displacement as to produce a slight degree of pressure on the spinal chord. There was an abscess, containing from four to six ounces of pus, communicating with the fracture, and extending into the posterior mediastinum. The membranes of the spinal chord, and the spinal chord itself, presented a natural appearance externally, but on the latter being divided longitudinally, the central part of it was found to be in a softened state, so that on being macerated for a short time in water, it almost completely disappeared.

A boy was admitted into the Hospital, in September, 1827, with a fracture and considerable displacement of the third and fourth lumbar vertebræ, so as to cause a manifest alteration in the figure of the spine. He was paralytic in his lower limbs. An attempt was made to restore the displaced vertebræ to their natural position, and was attended with some, but not complete, success. At the end of a month he became affected with slight involuntary motions of the lower limbs, and at the same time he began to

recover the power of moving them voluntarily. Early in the following January he quitted the hospital, and I have had no opportunity of seeing him or hearing of him since.

In each of the two last mentioned cases there was some degree of pressure on the spinal chord; and I am the more inclined to believe that this was the cause of the spasmodic affection of the muscles, as I have not met with any case in which it was proved by dissection, that this symptom existed in combination with disorganization of the chord, and independently of pressure on it.

Affections of the Nerves of Sensation.—If the spinal chord be lacerated, or subjected to any considerable degree of pressure, the sensibility of the parts below the seat of the injury is totally destroyed. If the injury be in the situation of the sixth or seventh cervical vertebra, the destruction of sensibility is frequently partial in the upper extremities, while it is complete in the trunk and lower extremities; but if it correspond with the two vertebræ immediately above these, the patient, during the short remaining period of his life, presents the extraordinary phænomenon of a living head, with its sensibility and muscular powers unimpaired, attached to a trunk and extremities of the existence of which he is totally unconscious.

In cases of concussion of the spinal chord, there are the same varieties with respect to the destruction of sensibility, as there are with respect to that of the power of voluntary motion. Sometimes it is every

where complete; at other times it is complete in one part and not in another, or the sensations may be dull in every part of the body, although not totally destroyed. Sometimes the skin appears to be insensible, the patient being nevertheless conscious of pressure made on the more deeply-seated parts.

Not unfrequently, unusual sensations are referred to parts, the nerves of which are actually incapable of conveying to the sensorium the impressions made by mechanical pressure, or the application of heat. Sometimes the patient complains that he feels as if he had been everywhere severely bruised; or he has a sense of burning, or of tightness and constriction. In many instances, the destruction of sensibility is incomplete at first, but becomes complete afterwards, as the process of softening makes progress in the injured portion of the spinal chord. Where recovery takes place, the restoration of sensibility usually precedes that of the power of voluntary motion; so that the patient may be quite sensible of external impressions, while he is still incapable of employing his muscles for any useful purpose. The last observations apply equally to all cases, whether the spinal chord has suffered from concussion, or from the pressure of displaced vertebræ.

Affection of the Respiration.—It is well known, that if the spinal chord be divided or lacerated above the origin of the phrenic nerves, that is, above the situation of the third cervical vertebra, immediate death is the consequence. Under these circumstances the nervous influence is no longer transmitted either

to the diaphragm or to the other muscles of respiration, and the animal perishes in the same manner as from strangulation. If respiration be performed artificially, by inflating the lungs, the action of the heart may be maintained, so as to cause life to be prolonged for several hours.

Pressure made on the superior portion of the spinal chord, in consequence of dislocation or fracture, is attended with a similar result. A case of sudden death from dislocation of the second vertebra is recorded by Petit, and other similar cases are described by Sir Charles Bell and Mr. Stafford. The latter author mentions two cases of death taking place immediately, from fracture of the second and third cervical vertebræ. I attended a young gentleman who laboured under symptoms of caries of the superior cervical vertebræ, and who, after having eaten a hearty dinner, suddenly expired while altering his position in bed. The body was not examined, but there was good reason to believe that the spinal chord was compressed in consequence of a dislocation of the odontoid process of the second vertebra.

Dislocations of the first and second vertebræ do not, however, prove fatal in this manner in every instance. A most remarkable example of this fact has lately been communicated to the Society by Mr. Phillips. In this case, the dislocation was the result of accidental violence. A child, four or five years of age, was admitted into St. George's hospital, labouring under well marked symptoms of caries of the cervical vertebræ. The function of respiration was unimpaired.

Soon after her admission other symptoms supervened, similar to those which arise from hydrocephalus, and she died as if from pressure on the brain. On examining the body, the ventricles of the brain were found to be much distended with fluid. The transverse ligament of the second cervical vertebra had given way, and the odontoid process formed a considerable projection into the spinal canal. The dura mater however was entire, and prevented the dislocation being so complete as it would have been otherwise. The pressure on the spinal chord was not sufficient to destroy its functions, although it might well be supposed to have operated as a cause of irritation, so as to produce the effusion into the ventricles of the brain. Another patient, a lad about sixteen years of age, who had been admitted into St. George's hospital, labouring under a caries of the cervical vertebræ, died under similar circumstances.

When the spinal chord is seriously injured in the lower part of the neck, (that is below the origin of the phrenic nerves,) or in the upper part of the back, there is nothing to interfere with the due action of the diaphragm, while the intercostal muscles, as well as the muscles of expiration, are rendered paralytic. The patient therefore breathes by the diaphragm only. The ribs are motionless, and the air is expelled from the lungs, not by the contraction of the abdominal muscles, but simply by the elasticity of the abdominal parietes, and the pressure of the abdominal viscera operating on the lower surface of the diaphragm, where that muscle is relaxed. It may be presumed

that under such circumstances expiration is never so complete as where it is the result of muscular action. At all events, we may observe that the patient is incapable of expectorating mucus if it be collected in the trachea: that, if he coughs, the cough is peculiar, being effected by a forcible inspiration, followed by a sudden relaxation of the diaphragm; and that if he be placed in the sitting posture, so that the pressure of the abdominal viscera is removed from the diaphragm, he breathes with much greater difficulty than when he is lying down. All these are to be regarded as very formidable symptoms. Such imperfect respiration seems to be insufficient for the maintenance of life: the patient seldom survives so long as the sixth day, and he more frequently dies in less than forty-eight hours after the occurrence of the accident. Recoveries under these circumstances are very rare.

Injuries of the spinal chord in the lower part of the neck are not, however, necessarily followed by these results. The pressure on the spinal chord may be so small, or the disorganization of it from concussion may be so trifling, that the muscles of respiration are not, at any period, affected by it: or they may not be so in the first instance, and yet become affected afterwards. In one case which fell under my observation, and in which there was a fracture of the seventh cervical vertebra, followed by a softening and dissolution of the spinal chord, the difficulty of respiration did not take place until the twelfth day; but death occurred in less than three days afterwards.

In proportion as the injury affects the spinal chord lower down in the back, so the respiratory function is in a less degree impaired. In a case of fracture of the sixth dorsal vertebra, I observed (what indeed we might well expect to happen) that although inspiration was well enough performed, the abdominal muscles did not act in expiration. Wherever the injury is situated, a disposition to cough, with a copious expectoration, is likely to occur some time after the accident. In one case, in which there was a fracture of the eleventh dorsal vertebra, with softening of the spinal chord in the same situation, these symptoms began as early as the third day; and such was the disposition to cough, that it was induced by any slight change of position. Nevertheless this patient survived until the end of the fifth week.

Priapism.—This is a very common symptom of injury of the spinal chord, and it is remarkable that, although under ordinary circumstances the erection of the penis is the result of an impression communicated from the sensorium, I have never known it to occur, in these cases, except in combination with paralysis. Priapism may take place whether the patient suffers from the effects of simple concussion of the spinal chord, or from those of pressure. It seems to be connected with injuries of the upper, rather than with those of the lower portion of the chord: at least, I am not aware that I have met with it where the seat of the injury has been below the sixth dorsal vertebra. It is for the most part an early symptom, shewing itself in the course of the second

or third day, and it seldom continues after the first fortnight. It occurs even where the sensibility of the parts is totally destroyed, and may be induced by the mechanical irritation caused by the introduction of the catheter, where the patient is entirely unconscious of the operation. This circumstance was pointed out to me many years ago by Professor Macartney, of Trinity College, Dublin; and I have had many opportunities of verifying the correctness of the observation.

Affections of the urinary organs.—Paralysis of the lower half of the body is, as might be expected, attended with an inability to void the urine: so that the patient requires the aid of the catheter. In the great majority of cases he is not sensible of any inconvenience; and indeed is totally unconscious of the bladder being distended: but there are exceptions to this rule, and occasionally he suffers as he would from an ordinary retention of urine, but in a less degree. The incapability of voiding the urine is usually an early symptom, and in fatal cases it continues to the last. When a complete or partial recovery takes place, the power of emptying the bladder is restored sooner than that of using the muscles of the lower limbs. In cases in which the catheter is not employed, the urine flows involuntarily, as in most other cases of over-distended bladder. At other times there is a constant dribbling of urine, although the bladder is in a contracted state, so that on the introduction of the catheter no urine flows.

None of the consequences of injuries of the spinal

chord are more remarkable than the changes which are produced in the secretions of the kidneys and bladder. My attention was first called to this subject as long ago as the year 1807; and my subsequent experience has enabled me to make the following observations on the subject.

The first effect of a severe injury of the spinal chord is not unfrequently to occasion a marked diminution in the quantity of urine secreted. This is most observable where the injury is in the lower part of the neck, and where, in consequence, the function of respiration is very much impaired. Thus, in a patient in St. George's Hospital, in whom there was a forcible separation of the fifth and sixth cervical vertebræ, complicated with fracture and depression of bone, and laceration of the spinal chord, four ounces of urine were drawn off by the catheter at the end of twenty-four hours after the occurrence of the accident, and when he died at the end of twenty-six hours more, the same quantity was found in the bladder, none having been voided in the intermediate time. The same thing, however, may occur when the injury is in the lower part of the spine. For example: a gentleman received a blow on the loins, which occasioned, in the first instance, a partial paralysis of the muscles of the lower extremities. He never experienced any difficulty in voiding the urine, but the secretion was almost entirely, if not entirely, suspended during the first twenty-four hours. I did not see this patient at the time, but I cannot doubt the ac-

curacy of the report which he made when I was consulted some time afterwards.

In some cases, the urine which is first secreted after the occurrence of the accident, although of an acid quality, and free from mucus, has a peculiarly offensive and disgusting odour. In other cases the urine is highly acid, having an opaque yellow appearance, and it deposits a yellow amorphous sediment. In one case this colouring matter was in such abundance that it was found after death to have imparted a yellow tint to the mucous membrane of the bladder, which at the same time bore no marks of inflammation, even exhibiting less appearance of vascularity than under ordinary circumstances.

But the most common change produced in the urine by an injury of the spinal chord is the following. It is voided of an ammoniacal odour, and turbid; when allowed to cool and remain at rest, it deposits a large quantity of adhesive mucus, and when tested with reddened litmus or turmeric paper, it is found to be highly alkaline. After some time a quantity of white matter (phosphate of lime) may be detected in the mucus, and it is tinged with blood. At a still later period a considerable quantity of coagulum of blood is blended with the mucus and urine. These appearances very commonly shew themselves as early as the second or third day after the occurrence of the accident; sometimes not before the end of a week, or even eight or nine days. I have not observed that injury of one part of the spine is more

liable to produce them than injury of another. There is a great variety as to the period of their duration. In fatal cases they sometimes continue to the last, even though the patient should survive for several weeks, or even months; at other times they continue for two or three weeks, then subside, and the urine remains transparent, and of an acid quality afterwards. In other cases the quality of the urine varies almost from day to day, without any manifest reason for the change. It may be alkaline, depositing adhesive mucus; then clear and acid; then alkaline again; and these alterations may take place several times in the progress of the same case.

It is well known to pathologists that such adhesive mucus as is here described is never a constituent part of the urine as it is secreted by the kidneys, but that it is furnished by the mucous membrane of the bladder and ureters, especially of the former, when in a state of inflammation. The effect therefore of an injury of the spine is, in many instances, to occasion inflammation of the mucous membrane lining the urinary organs; and the consequences of such inflammation, where the urine has continued alkaline and loaded with mucus up to the time of the patient's death, are very manifest on dissection. The mucous membranes of the bladder, ureters, pelves, and infundibula of the kidneys is highly vascular; and in some cases the bladder is lined with phosphate of lime, which the mucus has deposited on its surface. Occasionally spots of extravasated blood are found in the

glandular substance of the kidneys, and loose masses of coagulum in the pelves of the kidneys and in the bladder.

An interesting question here presents itself, whether the inflammation of the mucous membrane of the bladder be a primary or a secondary disease? Whether the injury of the spinal chord operates directly on the mucous membrane, or whether its first effect is to alter the quality of the urine, as it is formed by the kidneys, the mucous membrane becoming affected afterwards, in consequence of the irritation excited in it by the contact of an unhealthy and stimulating secretion? These points remain to be determined by future observations.

Affections of the digestive organs.—In the first instance whatever be the seat of the injury in the spinal chord, the bowels are torpid, so that they cannot be made to act except under the influence of the most powerful purgatives. Then the abdomen becomes tympanitic; and in fatal cases, however protracted, these symptoms generally continue in a greater or less degree to the last.

The same state of the nervous system which produces costiveness, occasions incontinence of the fæces which have already reached the rectum, so that the evacuations take place involuntarily, without the consciousness of the patient. In many cases in which the injury is in the cervical portion of the spinal chord, and death takes place in the course of two or three days, there is a disposition to vomit. In one case

which fell under my observation, there was incessant vomiting of a large quantity of dark-coloured fluid: in another case, in which the patient died on the fifth day, during the two days which preceded his dissolution there was a perpetual gulping, and ejection of a similar diseased secretion.

In more protracted cases the alvine evacuations are of a black colour; semi-fluid, somewhat resembling tar or treacle in their appearance, and of a peculiar and offensive odour.

It has not been ascertained, as far as I know, what is the nature of the substance on which this dark colour depends. It certainly is not mere extravasated blood. Probably it is furnished by the secreting vessels of the stomach and intestines, and corresponds to the dark-coloured matter which is sometimes vomited at the termination of typhus fever, or to the black sordes which, under the same circumstances, are attached to the gums and teeth. It is only within the last two or three years that my attention has been directed to the subject, and further observations are required for its elucidation.

Alteration of the vital temperature. — M. Chossat has published an account of some experiments on animals, in which he found that the division of the superior portion of the spinal chord produced a remarkable evolution of animal heat, so that it was raised much above the natural standard. I have made experiments similar to those of M. Chossat, and have met with similar results. I have

also seen several cases in which an accidental injury of the spinal chord has produced the same effect. The most remarkable of them was that of a man who was admitted into St. George's hospital, in whom there was a forcible separation of the fifth and sixth cervical vertebræ, attended with an effusion of blood within the *theca vertebralis*, and laceration of the lower part of the cervical portion of the spinal chord. Respiration was performed by the diaphragm only, and, of course, in a very imperfect manner. The patient died at the end of twenty-two hours; and, for some time previously to his death, he breathed at very long intervals, the pulse being weak and the countenance livid. At last there were not more than five or six inspirations in a minute. Nevertheless, when the ball of a thermometer was placed between the scrotum and the thigh, the quicksilver rose to 111° of Fahrenheit's scale. Immediately after death the temperature was examined in the same manner, and found to be still the same.

In the year 1812 I published an account of some experiments made on rabbits, in which it was found that when these animals were stupified by the action of the Woorara poison, although the same quantity of oxygen gas was consumed in respiration as under ordinary circumstances, little or no animal heat was generated. In the case to which I have just referred, the effect was exactly the converse of that which was produced in these experiments; the respiration being so imperfect that the consumption of

oxygen must have been very much diminished, yet the production of animal heat was much greater than under ordinary circumstances.

Gangrene.—One result of an injury of the spinal chord is a diminution of the vital powers of the external parts, so that gangrene takes place, and sloughs are formed, on even the slightest pressure.

This disposition to gangrene is evidently a direct consequence of the injury of the chord, since it occurs equally whether the action of the heart be strong or feeble, and is limited to those parts which are below the seat of the injury.

In many cases in which the injury has affected the cervical portion of the spinal chord, sloughs begin to be formed, not only on the sacrum and nates, but even on the ankles, as early as the second day. In the last-mentioned parts we have the opportunity of watching the gradual formation of the sloughs. There is first a purple appearance of the skin; then a vesication containing a dark-coloured fluid; and this is for the most part immediately followed by the loss of vitality in the subjacent textures. When the injury has affected the dorsal portion of the spinal chord, the sloughs are generally, but not always, confined to those parts on which the pressure is greatest; that is, to the integuments of the nates and sacrum; and the formation of them begins at a later period. It is remarkable that in these last-mentioned cases the separation of the sloughs begins at an unusually early period, fresh sloughs being formed immediately afterwards.

Affection of the Sensorium.—I refer in this place merely to the effect produced on the sensorium immediately after the accident has occurred.

I have seldom observed the sensorium to be materially affected, except where the injury was in the cervical portion of the spinal chord, and here the results are very different in different cases.

Thus, in one patient, in whom there was a fracture of the fifth and sixth cervical vertebræ, with displacement of bone and laceration of the spinal chord, the functions of the sensorium were in no degree disturbed, the patient being perfectly conscious and talking rationally. Another patient, in whom the same part of the chord was bruised and lacerated, became comatose soon after the accident. On some blood being taken from the arm, the coma subsided; but at the end of twelve hours he became again comatose, and continued so until he died, ten hours afterwards. A third patient, in whom there was a fracture of the fourth and fifth cervical vertebræ, with softening of the spinal chord, was at first perfectly conscious and sensible. In less than twenty-four hours he fell into a state approaching to that of complete stupor; then became delirious, and continued so until he died, thirty-six hours after the accident. A fourth patient, in whom there was a small extravasation of blood in the centre of the spinal chord, opposite the fifth and sixth cervical vertebræ, died in less than forty-eight hours, having been sensible and conscious nearly to the last, but the pupils of his eyes being contracted.

Symptoms not included under the foregoing heads.

The first effect which a severe injury of the spinal chord (whatever may be the exact nature and seat of the injury) produces on the circulation, is to lessen the force of the heart's action, and to cause a state of general depression and collapse; the pulse being very feeble, contracted, and sometimes scarcely perceptible. Occasionally a rigor takes place soon after the accident has occurred.

When the injury is in the lower part of the neck, the patient not unfrequently dies before complete re-action is established, the pulse remaining feeble to the last; or it may beat distinctly, but not oftener than fifty or sixty times in a minute. In the majority of cases, however, after the first twenty-four hours, the pulse rises to ninety-six or a hundred in a minute; but still it is feeble and contracted, indicating a state of great general debility rather than the existence of an active inflammatory disease. The appearance of the tongue corresponds to the character of the pulse; and it is not unusual at the end of twenty-four hours to find it dry and parched, covered with a brown fur, which is soon converted into a black crust, resembling what we observe in the last stage of a continued fever.

When the injury is in the lower part of the neck, but not of such a nature as to occasion death within the first three or four days, or where it has affected the dorsal or lumbar portion of the spinal chord,

and the patient does not die at an early period, or ultimately recovers, the pulse usually remains for a considerable time more frequent than natural, varying from ninety to one hundred and twenty beats in a minute, but feeble and contracted, the tongue at the same time becoming more clean and moist than it was in the first instance. If blood be drawn under these circumstances, the coagulum is of a large size and loose texture; often never exhibiting any inflammatory appearances whatever; sometimes having a slight buffy coat on its surface in the first instance, but none afterwards. As far as I have seen, these observations apply to all those cases in which the effect of the injury is to induce that softening of the medullary substance of the spinal chord, which may or may not terminate in its complete dissolution, without exciting inflammation of the membranes in which it is enveloped; and these facts go far towards confirming the opinion which I have already ventured to express, that this change in the organization of the chord is to be regarded as the result of a peculiar process, which may exist independently of inflammatory action.

Inflammation of the membranes of the spinal chord is undoubtedly a much more rare consequence of injuries of the spine, than inflammation of the membranes of the brain is of injuries of the head. In the cases of this kind which have fallen under my observation, the process of softening and dissolution of the spinal chord had gone on simultaneously with the inflammation of the membranes, and there were during life

all those symptoms by which the existence of the former of these affections is indicated in other instances. But superadded to these, there were profuse perspirations, and severe and repeated rigors marking the occurrence of suppuration: there were also spasmodic twitches of the voluntary muscles, but not until it might reasonably be supposed that pus was collected in sufficient quantity to make pressure on the spinal chord. I have already mentioned cases in which pressure arising from other causes produced a similar effect.

Sir Charles Bell has described two cases, in which inflammation and suppuration of the membranes of the spinal chord followed injuries of the spine, unconnected with softening of the chord itself, and producing symptoms a good deal similar to those which are described as taking place where these membranes are inflamed from other accidental causes. In the first of these was a fracture of the eleventh dorsal vertebra. The patient was affected with delirium, attended with a rapid pulse. The most remarkable circumstance was, that there was no loss either of sensation or of the power of voluntary motion. Death, preceded by typhoid symptoms, took place on the fifth day.

In the other case recorded by Sir Charles Bell, the injury was in the lower cervical and first dorsal vertebræ, and the whole of the spinal chord, from this part to the lower part of the loins, was found after death to be bathed in pus. There were no severe or urgent symptoms for the first eight days; then the

patient was seized with violent convulsions, followed by fever and delirium. There were no paralytic symptoms until the tenth day, when there was a difficulty in raising one arm, and this was followed by complete paralysis of the lower limbs two days afterwards. Death, preceded by typhoid symptoms, took place nearly three weeks after the occurrence of the accident.

These cases are of great interest, and among those, of which I have preserved notes, I can find none precisely similar to them.

I have met with one case in which inflammation of the membranes of the spinal chord took place under peculiar circumstances, being apparently not a primary but a secondary effect of the injury. A man was admitted into the hospital, in whom there was a fracture of the sixth dorsal vertebra; the consequence of a fall from a high scaffold. He died at the end of six weeks, with softening of the spinal chord in the situation of the fracture for the extent of two inches, and having laboured under the usual symptoms. On the tenth day after he met with the accident, there were vesications containing a dark coloured serum on one foot, and a slough had begun to form on the integuments over the *os sacrum*. The sloughing process rapidly extended, and about a week before he died, a large slough came away, including the greater part of one *glutæus maximus* muscle.

On examining the body after death, besides the softening of the spinal chord already mentioned in the middle of the back, the following appearances were

observed. The sloughing process had extended so as to destroy the soft parts covering the *os sacrum* and the parts in its vicinity, including the ligaments at the posterior part of the pelvis and those of the lumbar vertebræ. The spinal canal was in consequence exposed, and a considerable quantity of pus had been deposited between the vertebræ and the *dura mater*. On the *dura mater* being divided, a layer of coagulated lymph of a yellow colour was found adhering to the inner surface of that membrane, and to the external surface of the arachnoid. The lymph was most abundant in the situation of the *cauda equina*, but traces of it were perceptible as high as the lowest dorsal vertebra. From this part to the middle of the back, in which the spinal chord was in a half-dissolved state, the spinal chord and its membranes bore no marks of disease. Unless it were the existence of profuse perspirations, there were no peculiar symptoms which could reasonably be attributed to the extension of the sloughing, and the effects produced by it on the deep-seated parts within the spinal canal.

In reviewing the various consequences of injuries of the spinal chord, we find nothing more remarkable than the following circumstance: that whether the chord be lacerated or compressed, or has undergone that kind of disorganization which is induced by a severe concussion, there is no material difference in the symptoms which arise, or in the results to which they lead.

There is another circumstance not much less worthy of notice than those which I have just mentioned.

The great majority of the symptoms are the same, whatever part of the spinal chord has suffered from the injury. This observation applies to the state of collapse, which immediately follows the accident; paralysis of the voluntary muscles, loss of sensibility, priapism, the disposition to gangrene, the altered secretions of the kidneys, inflammation of the mucous membrane of the bladder, and consequent deposition of adhesive mucus by the urine, and the derangement of the functions of the digestive organs, as indicated by tympanitis, and the discharge of black and offensive evacuations from the bowels.

There is only one order of symptoms with respect to which a great difference exists accordingly as the seat of the injury is in one or another part of the spinal chord. If the functions of the chord be interrupted above the origin of the phrenic nerves, respiration is immediately suspended, and instantaneous death ensues. If the same thing happens in the lower part of the neck, or in the upper part of the back, respiration is performed by the unassisted action of the diaphragm: if in the middle or lower part of the back, the muscles of inspiration are unaffected, but those of expiration are paralysed. It is only in those cases in which the injury is trifling, or confined to the lowest portion of the spinal chord, that the respiration is altogether unaffected. These facts have been already stated, but they deserve our attention in this place, as they explain why the danger to the patient's life is greater and more imminent in proportion as the injury is nearer to the brain. According to my ex-

perience, where a considerable injury has been inflicted on the spinal chord in the lower part of the neck, or in the neighbouring part of the back, of such a nature as to paralyse all the muscles of respiration, with the exception of the diaphragm, the patient rarely survives to the end of the fourth or fifth day, while in the majority of cases he dies at a still earlier period. The following case (to which I have already had occasion to refer) can scarcely be regarded as forming an exception to this general rule. In the patient to whom I allude, there was a fracture of the seventh cervical vertebra. The respiration was not affected in the first instance. On the twelfth day he suddenly began to breathe with difficulty, and by the diaphragm only : on the following day he died. On dissection it was ascertained that there was some displacement of the fractured bone, but not sufficient to occasion pressure on the spinal chord. An inch and a half of the chord was in a softened state, but the softening process had not proceeded so far towards dissolution, as in many other cases at the same period. I conclude that the chord had, in the first instance, undergone a very trifling degree of disorganization, and that it was only as the effects of the concussion became more completely developed that the difficulty of respiration commenced *.

* In a case under the care of Mr. Green, in St. Thomas's hospital, reported in the Medical Gazette, (Vol. I. page 224,) in which there was a fracture and dislocation of the seventh cervical vertebra, the patient survived until the seventeenth day; but it was stated that the respiration was difficult, performed by

Cases of recovery even after what may be regarded as a severe injury of the spinal chord, are by no means uncommon. If it suffers from the effects of concussion, the recovery may be complete; the period of recovery varying from three weeks to twelve months or more. If the chord be lacerated, or much compressed by displaced bone, he may live, but without recovering from the paralysis. Under these circumstances, life may be prolonged for an indefinite period. A man was admitted into St. George's hospital in January, 1823, who had met with an injury in the preceding August, in consequence of a mass of chalk having fallen upon him while working in a chalk-pit. Mr. Hardwicke, of Epsom, being sent for, found the first lumbar projecting over the last dorsal. With some difficulty he reduced the displaced vertebra to its natural position, the reduction (as I was informed) taking place with a jerk or snap. At the time of his being received into the hospital, he had

the action of the diaphragm, with a trifling action of the intercostal muscles. The respiration became more difficult afterwards, but the exact period at which this change took place is not noticed. In another patient, also under the care of Mr. Green, (Medical Gazette, Vol. VI. page 190,) in whom the third dorsal vertebra was the seat of the injury, there was in the first instance paralysis of the lower limbs, and it is represented that he breathed by the action of the diaphragm only: this last observation however was evidently erroneous, as he *breathed easily*, and as there was a slight motion of the ribs, attributed by the reporter to the expansion of the lungs. *Respiration by the diaphragm only is always difficult*, and the expansion of the lungs following the descent of the diaphragm is quite insufficient to account for the motion of the ribs. This patient recovered.

some power of using his lower limbs while in bed, but he could neither walk nor stand, and he was unable to empty his bladder without the aid of the catheter. He remained nearly in the same state when he quitted the hospital, two months afterwards. When I last heard of him, after the lapse of two or three years more, he was still alive, but no material alteration had taken place in his symptoms.

SECTION III.

Treatment of Injuries of the Spine.

In making this communication to the Society, my principal object has been to analyse and arrange the pathological changes, and the symptoms to which injuries of the spine give rise. But I am unwilling to leave the enquiry so incomplete as it would be if I were to omit altogether the consideration of the surgical treatment which these accidents require, and I shall therefore in conclusion offer some brief observations in illustration of the last mentioned subject.

When a bone is dislocated, or when it is fractured and displaced, the first question which presents itself to the surgeon is, whether it ought to be restored to its natural situation? and if so, how is that to be accomplished?

Dislocations and fractures, with displacement of the cervical vertebræ, are not always immediately fatal; and I cannot say that no circumstances can exist which would justify the attempt to effect reduction

in such cases: but it is evident, that if the attempt be made at all, it must be with the greatest caution, and Boyer describes a case in which a child died under it.

There can however be no doubt, that when the injury is in the lower part of the spine, the attempt to effect reduction may be not only made with impunity, but that it may be successful. In proof of this assertion, I may refer to a case which I have already described, which occurred in the practice of Mr. Hardwicke, of Epsom; the patient being afterwards admitted into St. George's hospital, labouring under paralysis of the lower limbs. In another case, to which also some allusion has been already made, and which occurred under my care in St. George's hospital, there was a fracture with great displacement of the third and fourth lumbar vertebræ. When the patient had recovered from the state of collapse which had followed the first shock of the accident, I endeavoured, by fixing the thorax and cautiously extending the pelvis, to restore the vertebræ to their proper place. The attempt was in some degree successful, and no ill effects of any kind resulted from it.

Some discussion has of late years been excited, in consequence of a proposal, which I believe originated with the late Mr. Henry Cline, to apply the trephine in cases of fracture of the spine attended with depression of the bony ring of the vertebræ, with a view to the removal of the depression.

The question respecting such an operation seems to me to lie in a very small compass. If the whole

or nearly the whole of a vertebra be driven forwards, the depression of the posterior part of it will of course occasion a diminution of the size of the spinal canal; but the removal of any portion of the vertebra which is accessible to an operation, will be of little avail, as the irregularity in the anterior part of the canal, made by the displacement of the body of the vertebra, must be the same after, as it was before, the operation.

If there be simply a fracture on each side of the spinous process, with a depression of the loose or intermediate portion of bone, of course there must be a corresponding diminution of the size of the vertebral canal; but as that canal is much larger than the spinal chord, which it contains, it does not follow that the spinal chord is really compressed, or that any material diminution of the symptoms would follow the elevation of the depression.

But let it be supposed that the spinal chord is really suffering from pressure: it has been already shewn, that a much less degree of violence than that which is necessary to occasion a fracture of the spine, may produce concussion, softening, and ultimately dissolution of the spinal chord, with a train of symptoms much worse than those which arise from simple pressure. Now no operation can be of the smallest advantage in this respect: but, on the contrary, if it be necessary to apply the saw in the performance of it, the jar and disturbance of the parts which this must occasion is even likely to aggravate the mischief.

If these views be correct, it is evident that the cases, in which there are any reasonable grounds for the performance of the operation, must be of very rare occurrence, and that even under the most auspicious circumstances it must be doubtful whether it may not be productive of harm rather than of good to the patient.

Nor, as far as I am acquainted with the results, do the experiments, which have been hitherto made on the subject, lead to any more satisfactory conclusion. I am not aware that in any of the cases, in which it has been hitherto performed, the operation has proved the means of preserving the patient's life, or even of relieving any of the more important symptoms.

In the treatment of mechanical injuries generally, nothing is of so much importance as the maintenance of the injured parts in a state of complete repose, and it is not less indispensable for us to observe this rule in cases of injury of the spine, than it is on other occasions. With this view we lay the patient in a supine and horizontal posture on a mattress. We can attain what is wanted in this respect by no other means: otherwise as good a reason might be offered for placing him on his face, with his spine uppermost, as for placing the head on a high pillow in a case of apoplexy or concussion of the brain.

I have shewn that, in some cases, an injury of the spine is followed by inflammation of the membranes of the spinal chord, and there can be no doubt that it is then necessary to take blood from the arm,

and even to repeat the blood-letting several times. The state of the pulse forms a sufficient indication to the practical surgeon of the necessity of such active treatment, and the appearances of the blood after it is drawn will assist his judgment in determining to what extent it should be carried. It is, however, if my experience has not much misled me, a great mistake to suppose that blood-letting is always proper. In the majority of cases the state of the pulse is such as actually to contra-indicate the abstraction of blood, and as I have already stated, the blood when drawn does not in general present those appearances which are supposed to mark the existence of inflammation. I have no reason to believe that blood-letting arrests the process of softening and dissolution of the spinal chord, and indeed I have usually found that the symptoms which mark the existence of these changes make a more rapid progress, in proportion as a larger quantity of blood is taken away. The weak and contracted pulse, the disposition to gangrene, the alkaline quality of the urine, the black and offensive alvine evacuations, and the brown or black fur on the surface of the tongue, would, under other circumstances, be regarded as proofs of depression and debility, indicating the use of stimulants rather than of what are called antiphlogistic remedies. From all that I have seen, I cannot doubt that much harm has arisen from the indiscriminate application of the practice, which is usually proper and necessary after injuries of the head, to cases of injury of the spine.

I have stated that a torpid state of the bowels is almost a constant result of these accidents, such as cannot, be overcome except by the exhibition of powerful purgatives. I have generally found that the combination of ammonia facilitates their action, and that it will often enable them to produce the desired effect, when they would not have produced it otherwise. Attention to this part of the treatment is especially required when the evacuations are black and offensive. The retention of the unhealthy secretions, on which these qualities depend, cannot be otherwise than injurious to the general system.

The use of the catheter is necessary from the beginning, in all cases in which the lower part of the body is paralytic. It does not, however, prevent the urine becoming alkaline, nor the secretion of adhesive mucus from the lining membrane of the bladder. When these changes have taken place, the bladder should be emptied several times daily; and it may be advisable in some instances to inject tepid water into it, so as to prevent any portion of the mucus being retained in its cavity. The mucus is itself the product of inflammation; but, on this, as on other occasions, it forms an irritating application to the parts with which it comes in contact, and thus tends to aggravate and increase the inflammation, on which the formation of it originated.

In the treatment of those cases of injury of the spinal chord, in which gangrene takes place from pressure, we labour under greater difficulties than in ordinary cases of gangrene, owing to the very

slight degree of pressure which is sufficient to produce these frightful consequences. All that it lies in our power to do is to cause the pressure to be diffused over as large a surface as possible, and to endeavour to increase the force of the heart's action by the prudent exhibition of stimulants.

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