Section of Orthopædics.

President—Mr. W. Rowley Bristow, F.R.C.S.

[*December* 6, 1927.]

DISCUSSION ON SPINAL INJURIES.

Mr. Geoffrey Jefferson, F.R.C.S.

Abstract (1).—Varieties of spinal injuries, the three groups of common usage: fractures, dislocations, fracture-dislocations. Shall not refer in detail to fractures of the spinous or transverse processes.

(2) Mechanics of injury to vertebræ. Two variables: (1) the nature of the bones; (2) the qualities of the force. Spinal injury usually caused by indirect violence.

(3) The different results of injuries applied to the head; may break skull, failing that, the neck. Atlas fracture. Difference in qualities of the force causing atlas fracture and low cervical dislocation.

(4) The compound nature of the vertebral body. The two columns, anterior, spongy; posterior, compact. The nature of wedge-compression of the vertebral body. Variations in the shape of the wedge. Reasons. Occur at all levels, including cervical spine.

(5) Frequency of injury at different levels of vertebral column. "Localization" of injury. The two places of the graph of injury. The cervical at C. 5. Reason. The thoracic-lumbar peak at T. 12, L. 1 industrial. Is there a third peak at C. 2?

(6) The effects of violent flexion of the spine: cervical flexion causes luxation at C. 5 or so. Extension causes fracture of odontoid. Violent flexion and extension therefore cause injury at very different levels. Thoracic region, why is there no "peak" of injury at T.6, 7? Lumbar region.

(7) Displacement of fragments. Continuation of violence after the essential injury has been effected. Kümmell's disease, no inflammatory process involved.

(8) Injury to the intervertebral discs, essential for displacement. Imperfect rupture a cause for difficulty in reducing luxations. The worst cases those in which it is most easily done, but most of these have cord damage.

(9) Spinal injury from minimal violence. Examples of trivial cases, diving, brushing hair and so forth. Vertebral displacement in disease a much more serious thing.

(10) Curious stability of many cervical luxations. Reasons. Locking of the inferior zygaphophyses.

(11) Injury to nervous elements left principally to other speakers. Cord compression very rare. Immediate and irremediable damage. Root injuries. Falling mortality of modern statistics due to better diagnosis.

(12) Primary operation for fractures of spine relegated to oblivion. Rarity of indications for open operation. Reduction the best treatment.

Prologue.

Civilization in its erratic onward march has offered us as its crowning gift the adornment of the mind and the advancement of learning. The chief function of such an academy as we constitute seems to me to be the philosophical contemplation of some large subject in the light of such special knowledge as we may happen to possess. At the same time, we know full well that it is only intensive study of small corners of our vast field that we can to-day hope to make any lasting contribution to the world's literature on any subject. And in doing so we must refrain at all costs from the temptation of attaching too much importance to one or other striking example in our experience, save in so far as it may have stirred our imagination to see more than the bare outlines of a case history, to see displayed instead the very vitals and principles concerned. We must try to see the subject as

22 Jefferson: *Discussion on Spinal Injuries*

a whole, and so to use our individual experience that it may light one section of a long and fascinating but continuous road. I know of no other subject in which the continuity of the fundamental principles can be traced so clearly through the kaleidoscopic patterning of injury as is the case with the spine. And it is to those little varying principles rather than to the minute description of any one particular fracture that I wish to devote myself now.

It is fitting, perhaps, that one from Manchester should have the honour of opening this discussion, for it was a young man, William Thorburn by name, who published from that city a small monograph: "A Contribution to the Surgery of the Spinal Cord," about forty years ago. This calls for more than passing comment because it was the first book devoted primarily to spinal injury, and particularly because it was the most important contribution to the subject of localization in the anterior horn cells, that is to say segmental localization, which had yet seen the light in any country.

The localization of muscle function was at that day one which had profoundly stirred our profession; only a few years before Thorburn's book appeared the world had been thrilled to hear the results of cortical stimulation, and here seemed to be a further enlargement of an enthralling subject. Within the next ten years two other monographs of the utmost importance came from the press. The first was Theodor Kocher's "Die Verletzungen der Wirbelsaule zugleich als Beitrag zur Physiologie des menschlichen Ruckenmarks" (1896), the second, Wagner and Stolper on "Die Verletzungen der Wirbelsaule und des Ruckenmarks" (1898), both being similar in scope and aim to Thorburn's book. In the intervening thirty years only one other book on spinal fracture calls for special comment, that from Rotterdam by Loos "Over Wervelfracturen" (1921). I have omitted mention of a standard author whose name no one interested in fractures can well pass by unnoticed—Gurlt, whose "Lehre des Knockenbruche" is still a rich quarry for the inquirer. But apart from these standard authors, our subject has been constantly enlarged and embroidered as years have passed, by short and long papers in periodical literature, each illustrating some special phase—first the advantage of X-rays, then the characteristics of some special injury, or some phase of cord damage. The most important of these in my view are Kümmell's paper on spondylitis traumatica (1891), and Head's and Riddoch's splendid work on the physiology of cord injury.

Varieties of Spinal Injury.

Setting aside cases of muscle and tendon rupture and confining ourselves to the bony skeleton of the spine, we must at the outset have a simple classification—and we might do worse than employ that of common usage, dividing injuries into three groups: pure fractures, pure dislocations, and fracture dislocations, each category finding its best exemplars at some particular point of the spinal column, decided largely by the architecture of the bones. Omitting for the moment the simple fractures of the transverse processes, spinous processes, and laminæ, we find that all three categories are produced by a similar mechanism, generally a longitudinal vertical compression to which flexion is almost immediately added for a simple anatomical reason—the compound nature of the vertebral body.

There are two variables in the mechanics of vertebral injury, one, the nature of the bones, the other, the qualities of the force, which may differ in strength, direction, and point of impact between one case and another. Thus a force applied vertically or obliquely to the head may first injure the skull, or if that escapes, may fall on to the cervical spine at some point, whilst if that escapes also, it is unlikely that any injury will arise elsewhere, as the column becomes stronger below.

I have insisted on the importance of head injury as a cause of cervical fracture or cervical dislocation. Direct violence is always an uncommon cause of vertebral disruption; the majority of spinal injuries are caused by force applied at a distance. I remember the first case in which this was forcibly demonstrated to me. A young man was struck on the top and right side of the head by a falling cotton bale at the docks and was admitted to hospital unconscious, with a scalp wound on the right parietal bone. When he recovered he complained of pain in the neck and of paralysis of the right arm. Those attending him believed him to have had a contrecoup contusion of the left motor cortex, until we were able to demonstrate a dislocation of the fifth cervical vertebra with injury to the upper cord of the brachial plexus. Similar cases were the first two fractures of the atlas that I saw, an experience sufficient to make me suspicious of any complaint of pain in the neck after a head injury.

If the injuring body is hard, and particularly if its velocity is high, a fracture of the skull will result, and that elastic structure will absorb the full force of the injury. If, however, the wounding body is soft and yet very heavy the spine, and, particularly its cervical portion, will be the part injured. That is to say, that a force may be so adjusted that it will be unable to overcome the resistance of the skull, and yet will break the spine. We know that the ordinary mechanism of fractures of the cranial base, as we call them (though we have long known that they are rarely limited to the anatomical base), is compression between the injured point and the resistance of the vertebral column at the occipital condyles. We know that in rare instances, the head may be "mushroomed" down on to the spine, which drives a ring of bone around the foramen magnum up into the skull. But, as a rule, the bone of this area resists and if the skull fails to break elsewhere, the force acts on the spine. It will still be at its greatest immediately below the occiput and then will fade as it travels downwards. Perhaps the atlas will be broken, perhaps some lower vertebra, but we can best get a picture of the anatomy and mechanics of injury to the individual vertebræ if we remember the exact parallel between cranial injury on the one hand, and vertebral injury on the other—compression between a force above and a resistance below, acting equally in opposite directions. In order to take in displacement, as in dislocations to which the neck is notoriously liable, we must add to the element of force another, namely, that of movement. This may be supplied by the force itself, that is, it may have a strong horizontal or oblique direction. But this necessary movement may sometimes be supplied by the spine itself, which tends to move, to flex, as soon as it is compressed.

I may illustrate these points further by considering the common effects of a violent force applied to the head by means, say, of a heavy sack falling on it from above, or by the patient falling on to something soft but resistant, like sand or earth. We will presume that the skull escapes damage. If the head is erect and the violence is short and sharp, suddenly applied and almost immediately removed, the atlas is apt to be broken, for the bone is weak and the violence relatively at its maximum, there being no intervertebral discs to damp the shock. But if the force is not quite so rapidly removed, and if it contains a strong element of movement the head will be compressed down on the spine and moved quickly in the appropriate direction. Here the quality of movement has dominated the picture and an entirely different injury follows, i.e., dislocation of the lower cervical spine. Movement, plus violence, constitute the essential for dislocation. We will now consider the anatomy of the vertebræ.

The Compound Nature of the Vertebral Body.

When we examine the vertebral column we see that it consists of two parallel fused cylinders of different structure and with different purposes. The anterior consists of the vertebral bodies and intervertebral discs whose general purpose is the

support of weight, the posterior of an interrupted articulated column of neural arches giving protection to the spinal cord. From the neural arches are thrown out a number of transverse and spinous processes whose chief purpose is to allow of muscular attachment, and this essential function is made clearer by the general mechanism of fracture of these struts—by muscular violence—though fractures of these accessories are common incidentals to graver injury. Of the two columns which comprise the spine, the anterior column is much more compressible than the posterior in which the cancellous tissue is enclosed in a thick compact covering. If the spine is violently compressed from above, the anterior pillar gives way more rapidly than the posterior, because of its spongy bone and the intervertebral fibro-cartilages. Thus flexion follows immediately on compression. This point is well illustrated in the wedge-shape of the bodies in the so-styled Kümmell's disease, and again in actual bone disease—tuberculosis. The bony shell of the vertebral centrum is slightly stronger behind where the neural arch is fused on to it. This in itself would produce a slightly eccentric collapse, but the dominant factor is the resistance

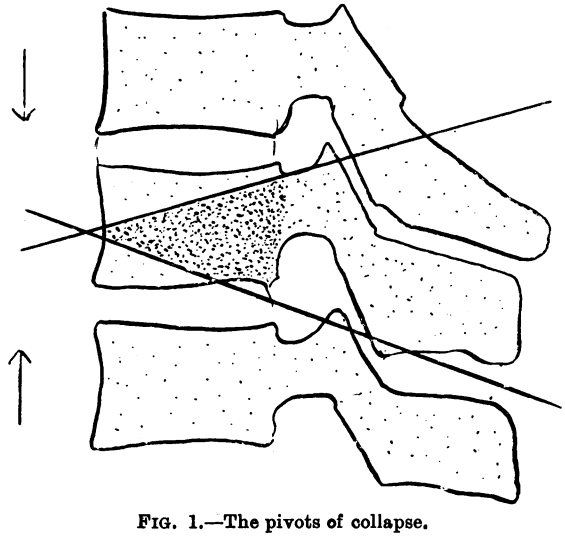

FIG. 1.—The pivots of collapse.

of the posterior bony pillar of articulated arches. The posterior part is held up by these relatively incompressible elements whilst the forepart sinks.

Figure 1 illustrates this point, the bones above and below swinging towards one another and causing the intervening bone to collapse. No doubt these factors are the explanation of the gibbus of Pott's disease, although a common theory has been that the angular curvature is due to tuberculosis affecting principally the anterior part of the vertebral body. The explanation now suggested seems to me more reasonable.

The vertebral body assumes many shapes under compression, but only one calls for special comment, that in which the posterior height is notably decreased. This is to some extent made possible by flattening of the contiguous intervertebral discs which may allow of a considerable loss of height in the centrum. Pulverization of the pedicles by force, or dissolution of their substance by disease, are more potent factors, and then the vertebral body may be greatly deformed, concertina-wise.

I have spoken of the neural arch as a compact structure, but it actually contains a considerable cancellous element; the X-ray rather exaggerates it in the dry specimen, the pedicles might be compressed towards one another to some extent, although I have no pathological material to prove it.

On these grounds we should logically expect that this "wedging" of the vertebral bodies would best be seen in that part of the column where the bodies are high and spongy and well held apart by thick discs and high zygapophyses. All will agree, I think, that this is indeed the case and that it is best seen in the lower thoracic and lumbar regions. That it is also most often seen there, as well as most

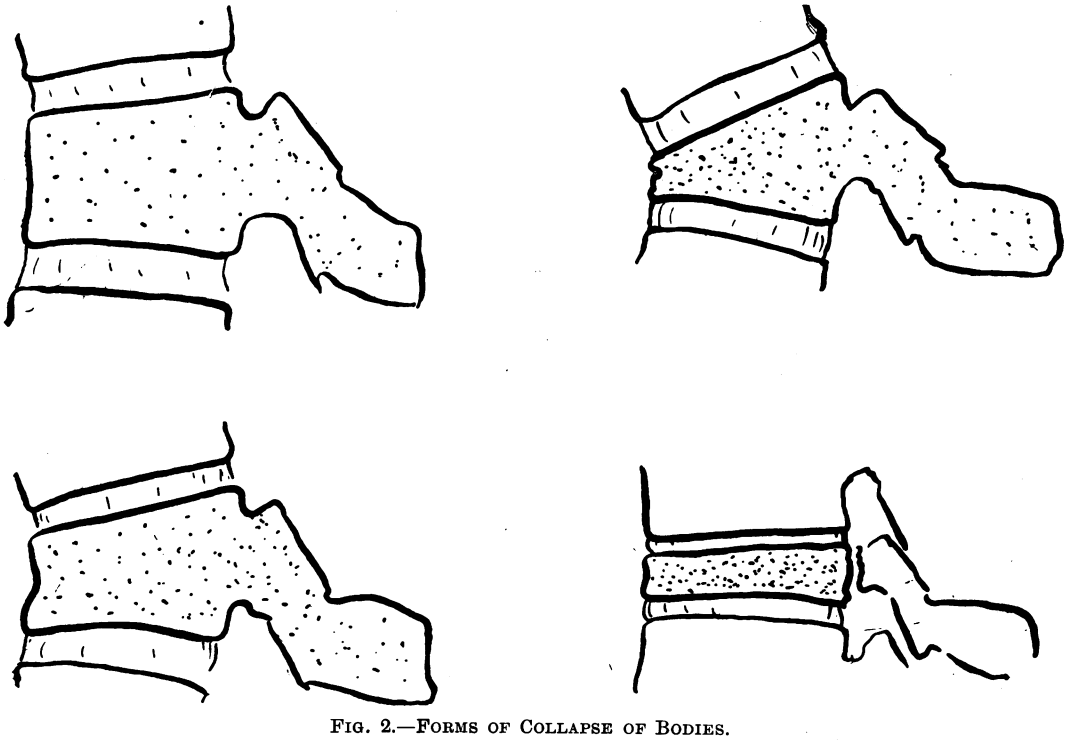

FIG. 2.—FORMS OF COLLAPSE OF BODIES.

Various forms assumed by the centrum in collapse. In the fourth type, general loss of height of the centrum, pedicular and zygapophyseal damage is necessary.

typically, depends on another point to which I shall shortly refer. The wedging may at times be seen in the cervical region, but it is never complete there, probably because sufficient violence is never applicable to the neck without some movement occurring, usually flexion, of course, which destroys the direct axial nature of the compression and a dislocation results instead.

The tendency of the vertebral column to flex when it is compressed is aided by the protective reflex described by Magnus, by which any unexpected touch on the head causes the person to bend forward instantaneously and involuntarily.

26 Jefferson: *Discussion on Spinal Injuries*

Frequency of Injury in Different Regions of the Spine. "Localization" of Injury.

The relative liability of the different sections of the spine to injury is best studied by means of a graph (fig. 3).

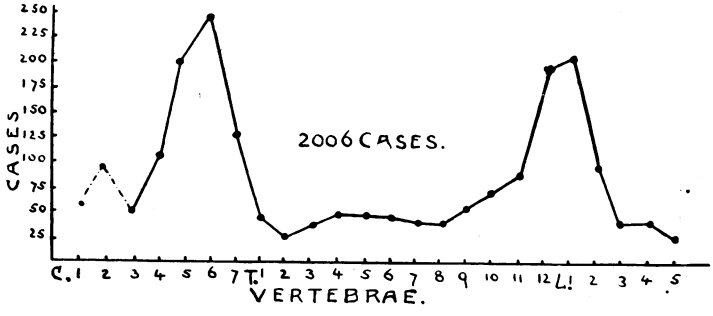

Fig. 3.—Graph of the localization of spinal injury from 2,006 cases in the literature. Note the "critical points."

This has been compiled from a large number of cases in the literature and immediately presents an interesting fact—that there are two peaks of frequency, one cervical, the other thoraco-lumbar.

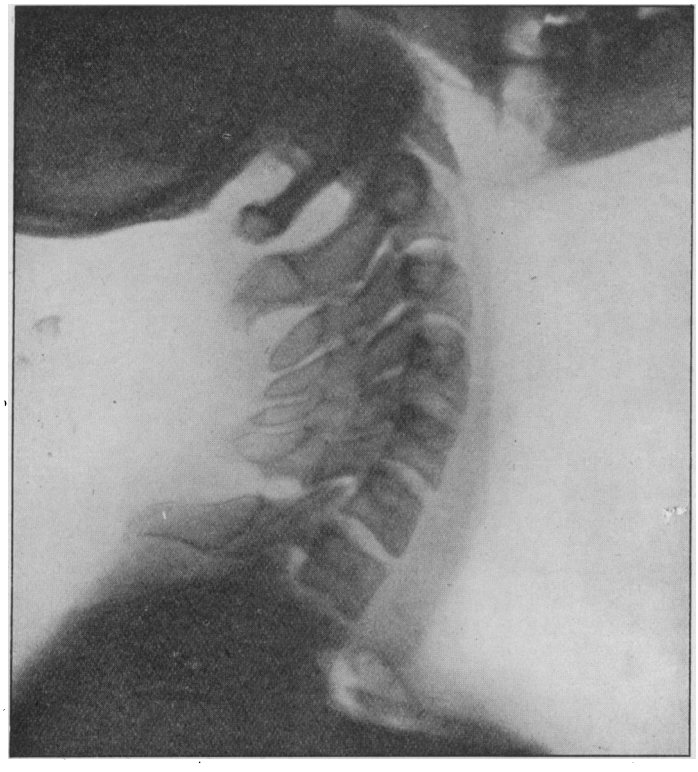

Fig. 5.—A normal neck in full extension. Note how the atlas rides like a skate below the skull, keeping its distance in all movements. The chief movement occurs in C.2—6.
[*Author and Dr. Morris.*

The cervical peak consists almost entirely of dislocations, the other of vertebral compressions and fracture-dislocations, but since the mechanism of both types is essentially the same the fact that the injury is technically different matters not at all. The existence of two peaks is traditional and common knowledge, their precise situation is, I believe, new. It will be noted that the cervical peak is not at the cervico-thoracic junction, as so commonly stated, but at a higher level. The reasons for the peaks are clear enough—a change in the mobility of the spine under the influence of compression and flexion, one portion travelling faster than its lagging neighbour, and disruption at the point of change results. The point of change in the neck is not at the junction of C.7 with T.1, but one or two vertebræ higher. The

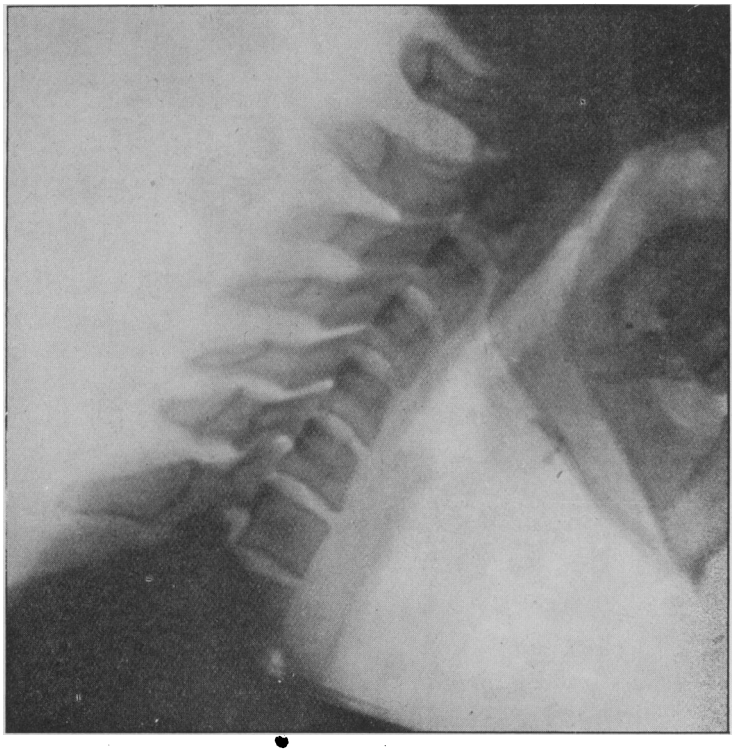

FIG. 6.—A normal neck in full flexion. Compare with fig. 5.
[*Author and Dr. Morris.*

seventh cervical vertebra is really thoracic in type, less mobile, and, as we know, apt at times to present additional thoracic characteristics. The mobility of the cervical spine indeed increases as we pass upward to the head, being far greater in the upper four vertebræ than in the lower three. Figs. 5 and 6 illustrate this fact.

Another fact of great importance is brought out by an inquiry into the mechanism of the two groups. The cervical group is due to the application of force to the head particularly and is the common result of everyday accidents in the home and street, e.g., falls with the flexed head and so forth.

The thoraco-lumbar peak is almost entirely composed of industrial accidents when the spine has been bent by a great force usually applied about the shoulders

or the nape of the neck, a form seen particularly in coal mining, and heavy labouring accidents. I have ventured, therefore, to label these two groups (1) the civilian or universal, and (2) industrial; they will vary in height from one hospital to another according to the type of accident principally dealt with. Thus in colliery and dock areas the lumbar peak will soar high. Fig. 3 represents the general incidence drawn from 2,000 cases in the literature. The figures for the upper two cervical vertebræ may be out, as I have sifted the literature for these more thoroughly than for any other fracture. On the other hand, fractures of the atlas, axis, and odontoid are more often missed than injuries elsewhere. With this chart in mind, I will turn to my own hospital figures. During the years 1919-1927 85 examples of proved vertebral damage—major fractures of the spine—were admitted to the Salford Royal Hospital. Of these, 18 patients died, 12 within the first 48 hours (often from coincident damage elsewhere), and four more during the first week. As in head injuries, the first three days is the critical period, and the majority of those patients who live longer will survive for months or years. In four cases with central cord hæmorrhage the patients are still alive three or four years later and usefully ambulant.

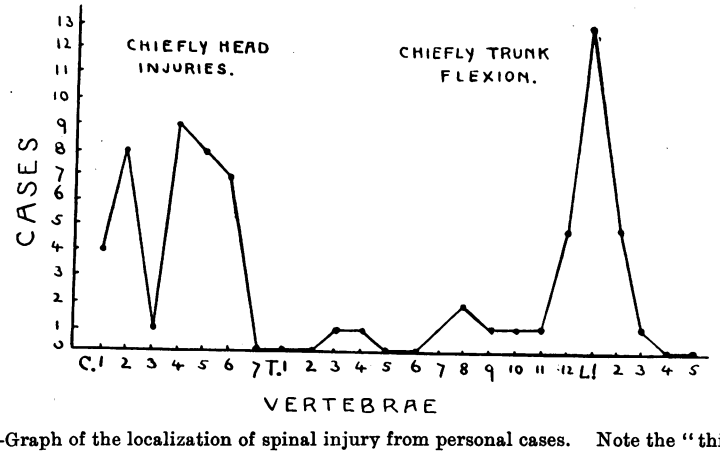

FIG. 4.—Graph of the localization of spinal injury from personal cases. Note the "third peak."

There were four cases of injury to the issuing roots: all did well.

In fig. 4 I have set out my own hospital figures in another graph. It shows the same cervical and lumbar peaks as the other: the cervical reaches a maximum opposite a different vertebra. I do not attach any particular importance to this; it happens to represent an experience which will vary a little. The essential fact remains unchanged, that all statistics show a peak here with its base on the fourth, fifth and sixth cervical. This chart shows another peak for the neck opposite the second cervical.

Are there three peaks of incidence for vertebral injury?

This, the most cephalad peak, has already been hinted at in the previous graph (fig. 3), but in the second it is higher, more obvious. It is just possible that it may represent an unusual experience, but I have purposely kept down its height by not including several cases which I have seen but have not treated. I am for my own part quite convinced on anatomical grounds that there is a third peak. There are indeed three places in the vertebral column where mobility is profoundly altered: at C. 2 where the compound movements of the head turn into the simpler character

of general spinal movement; at C. 4, 5 or 6, where the mobile neck goes over into a more limited type of mobility; and at T. 12 and L. 1, where flexion of the trunk especially hinges. And I believe that we are able to localize by our fracture cases the centres of the changing types of spinal movement, and vice versa. And these I propose to call the three "critical points" in the spine.

THE EFFECTS OF VIOLENT FLEXION OF THE SPINE.

The results of violent flexion of the spine may be summarized thus:—

Cervical Region:

Flexion of the neck alone by a strong moving force applied to the head will result in a dislocation, roughly at the juncture of the middle and lower thirds. This is the common result of this type of violence and accounts for a large group of spinal injuries in all walks of life, in all conditions of men and women. The mobility of the head oftentimes no doubt serves the person in good stead and he may escape the injuring force by its means. But the more the head is depressed the more difficult it becomes to elude the pressure, for the bones lock and lateral movement of the neck is curtailed.

We are at the moment admittedly speaking of flexion of the neck, but should the head remain upright under the influence of a blow, the force, as far as the neck is concerned, will fall chiefly on its upper part, on the first two cervical vertebræ, for the violence gradually expends itself by irradiation and loss in the elasticity of bones and discs as it presses downwards.

Let us suppose now that although the neck remains upright the head itself is violently extended or flexed, as would be occasioned by a force moving in a horizontal direction as well as pressing from above. In this case a common result is a fracture of the odontoid process which is pulled off by the ligaments attaching it to the occiput.

I strongly suspect that whilst the common effect of violent flexion of the neck by a blow on the head is a low dislocation about C. 5, violent extension, leading to rapid locking of the zygapophyses constitutes of the cervical spine a rigid column and the continuation of the force acts on the still mobile skull and exerts itself on the odontoid process. The only posterior displacements of the upper fragment (as it were) that I have met with personally, in the neck, and indeed, in the whole spine, have been cases of fracture of the odontoid process as if the full brunt of over-severe extension fell on it and it alone.

Thoracic Region.

Flexion of the thoracic region should lead to disruption at its most bent part, the summit of the arc, T.6 and T.7. The graph of fractures shows no peak here and we are left with the conclusion that flexion of the thoracic spine alone must be very difficult to accomplish, and this I am certain is the case. For if we apply force to the root of the neck and shoulders we are applying it not to the thoracic region alone, but to the lumbar spine as well. It is indeed difficult to see how the thoracic spine can be easily broken, especially at its centre and in its upper reaches, except by extension, or by some peculiar type of flexion.

Fractures of the lower thoracic vertebræ are more easily understood, for the hazards of flexion and of posture at the moment of impact may cause the lower thoracic bone segments to form, at the moment, the summit of the forced curve.

THORACO-LUMBAR JUNCTION.

We have already spoken of that most important group of cases, the heavy industrial category, and particularly of changes in relative mobility as a factor in localization of injury. While it is true that this gives us the clue to the site of injury we have still the mechanics of the actual break to consider. This is fortunately

simple enough. If an arc is bent beyond its limits of cohesion, it gives at the top of the curve. The back bending under pressure does not, when it has passed a certain point, actually form an arc, but a parabola, for the lumbar spine has little power of flexion and soon locks. The still travelling upper segment swings on downward and forward and an angled arc or parabola results; the fracture occurs at the site of maximum bend. This point is usually somewhere between T.11 and L.2, but circumstances may increase its range two or three vertebræ higher but rarely more than a vertebra lower.

Two cases recently seen may be taken as typical examples of the mechanisms just described.

I.—A man, aged 47, was injured in a motor-car collision and was admitted to a neighbouring hospital as a head injury. Concussion soon passed off, an X-ray was taken and disclosed no fracture of the skull, so that he was sent home. He complained of severe pain in the neck radiating down on to the shoulders, always a most suggestive thing. His doctor observing this and noting limitation of movement advised further examination by X-rays. A dislocation of the fifth cervical vertebra forward on the sixth was clearly seen. This illustrates the common failure to diagnose vertebral injury early in persons who have sustained no damage to the spinal cord, and in whom the picture of recent head injury has overshadowed all else.

II.—The second case illustrates very well the effects of full flexion of the thoraco-lumbar spine. A young man was lying on the top of a taxi-cab inside its luggage guard-rail repairing the roof, and whilst he was still engaged on this the car was driven into a garage. Clearance was not sufficient and he caught his left foot (he was lying on his right side, feet towards the front of the car) on the lintel of the door. As the car passed slowly in he was pushed back until his shoulder jammed against the guard-rail at the back of the roof, and then, further slipping being impossible, his back was forcibly flexed by the leg against the fulcrum of the shoulder. The clinical picture suggested abdominal injury (and this, indeed, sometimes does occur from violent flexion of the trunk—I have seen rupture of the diaphragm for example), but on laparotomy retroperitoneal hæmorrhage alone was found. A skiagram taken later showed that he had a fracture of the first lumbar vertebra, a compression fracture, with traction injuries of the transverse processes of several lumbar vertebræ. An area of anæsthesia in the distribution of T. 12 – L. 2 on the left side only was subsequently discovered. He made a good recovery and walks with the aid of a stick. Here, in brief, we have much of the story of one of the common groups of spinal injury.

Violent Extension of the Spine.

Violent extension is a much more uncommon mechanism of spinal injury than is flexion, and introduces the question of torque fractures of the pedicles, with which I do not propose to deal. I have already mentioned the importance of extension as a means of fracture of the odontoid process, and will for the time leave the matter there.

The Displacement of the Fragments.

Since the common mechanism of fracture or dislocation is downward compression, with its natural concomitant, flexion, it follows that the upper fragment is usually displaced forwards. The amount of displacement depends largely on whether the violence is continued after disruption has occurred. If we wished to produce a Kümmell compression of a vertebral body experimentally we should remove the force as soon as the bone collapsed. If, however, the force continues, and especially if some impetus in a horizontal direction is added, then the inter-vertebral disc will be torn, pedicles broken and displacement induced. Indeed, the so-called fracture-dislocation of the spine is nothing more than the true counterpart of a broken long bone with displacement, a multi-articulate composite bone being substituted for the simple osseous column of the limb. Similarly, a Kümmell compression is the homologue of a greenstick fracture, for only one element of the

vertebræ is damaged. The importance of the continuation of the force, that is the time element no less than the energy and its direction, is not to be under-rated as a cause of complicated injury, though I fear that it is often not appreciated.

KÜMMELL'S DISEASE.

Kümmell, in 1891, described the wedge compressions, the pathological anatomy of which I have already treated. He gave it, as is well known, the name "spondylitis traumatica." The title implies an inflammatory process, a factor which most people would to-day deny to it. Kümmell's work was done before X-rays were employed, and he had no opportunity of observing the immediate effects of crushing, nor of observing, as many of us must have done, that the vertebral deformity does not notably increase as time passes and weight is borne. This statement needs some slight qualification, for it is clear that if the centrum is badly damaged and weight is immediately put upon it, a slight collapse may occur further than would have been the case if time had been given for bone repair in recumbency. But no inflammatory agent is involved.

INJURY TO THE INTERVERTEBRAL DISCS.

It is evident that no actual displacement of one vertebra upon another can occur unless the intervertebral disc is torn. This point is of more importance in dislocations of the neck than in the grosser types of injury elsewhere. There is no doubt that after dislocation recoil is the rule; possibly the voluntary extension of the head again, which is still possible in a patient whose cord has been badly damaged at the point of injury, may help the process of replacement. But the fact is that from a study of the X-ray images of different cases one would be rarely able to say correctly which had had cord injury and which had not, as the appearances are so similar. In the worst cases the intervertebral disc has been badly damaged and this makes reposition easy. In the milder cases in which there is greater indication for reduction of displacement the manœuvre is often of the greatest difficulty. The incomplete tear of the disc has a good deal to do with this, because the vertebræ cannot easily be separated and coaxed into place. A considerable lift is needed to disengage the articular processes, and this is only possible when the vertebral connexions have been badly damaged. I must confess that my own essays to reduce dislocations in precisely the cases in which one would most wish a good reduction, have not been fully successful even after several attempts, whilst the hopelessly paralysed cases are easy.

I have spoken as if the tear always runs through the disc, but this is not the case, as the cohesive power of these cartilages is very high and often a fracture through the juxta-epiphyseal part of the centrum is occasioned. This cannot be made out *in vivo*, and even on the post-mortem specimen the fact may not be easily visible, but X-rays will disclose it. As a rule some part of the disc is actually torn up; the posterior end may project back into the vertebral canal through the torn posterior ligament and may press on the cord.

SPINAL INJURY FROM SLIGHT VIOLENCE.

Some of the most interesting cases of spinal injury are those due to trivial causes. I have seen three examples. In one the lifting of a heavy parcel induced a fracture through the axis in an old man. In another a boy sustained a partial dislocation of the atlas on the axis diving in the baths. He forestalled manual reduction by the bones slipping spontaneously into place whilst he was asleep on the night after admission to hospital. The third case was a young woman with a luxuriant head of hair. Whilst combing it one night and throwing her head back she managed

to displace unilaterally one of her cervical vertebræ. The precise site of the injury was not ascertainable on X-ray, but the extreme pain, the posture, and absolute rigidity of the neck left the observer in no doubt as to the diagnosis. This was easily reduced by manipulation without an anæsthetic. W. H. Davies, in his delightful "Poet's Alphabet," uses a precisely similar mechanism as this to kill his cousin.[1]

The fact remains that injuries induced by little waywardnesses of fortune are not uncommon, but are not likely to be serious if the bones are healthy. There are certain folk-stories in medicine which do not bear close scrutiny.

Many cases of sudden death from displacement of bones affected by disease, usually tuberculosis or syphilis, are well authenticated. I have seen one case of this type.

A young and apparently healthy woman had a giant-celled myeloma of the radius, and in addition a recent deformity of the neck. X-rays revealed considerable loss of substance in the body of the third cervical vertebra, possibly of tumour origin. A plaster cast was applied but she did not tolerate it well, and after a few weeks went home. I heard subsequently that she had collapsed whilst coming downstairs in her own home some months afterwards and was found to be dead. Such happenings are rare after the average cervical luxation; for one of the features which has most impressed me has been its extraordinary stability, for which, of course, there is a sound anatomical reason.

Stability of Cervical Luxation.

That a man may have a cervical luxation, and that of considerable degree, that it may not injure his cord in any way, and that he may walk about while it is unreduced or incompletely reduced, may work and have a normal life, is well known. Fibrous fixation occurs in time, but why, once the articular processes are disengaged, does the upper fragment not slip further forward and impinge on the cord? Fortunately the upper surfaces of the cervical vertebræ have high lips posteriorly, a peculiar feature not seen elsewhere. The result is that the inferior zygapophyses catch against these and are arrested there, and in this stable condition may remain for years. It will be noted that the inferior articular processes of the luxated vertebra catch in the intervertebral notch, and that just as they cannot easily go forward, so they cannot easily go back. This is the explanation of the difficulty of reduction in many cervical dislocations, as considerable traction will be needed to disengage the articular processes. Nor can they be tilted backwards as a help to this end, for further flexion would probably kill the patient or at least jeopardize a cord already in danger.

Injury to Nervous Elements.

I shall not enter into this exceedingly interesting phase of the subject in any detail since there are others here to fill in my omissions. But one thing I must comment upon, and that is the falling percentages of mortality of vertebral injury as a whole. The enormous statistical change is due not to some revolutionary or superb method of treatment, but to a simpler cause—the more frequent recognition

[1] ". . . . . for she
Had heaps of hair, when combed down,
Could be a coat, or half a gown.
Until one day when full of joy
To hear my baby coo so well,
She tossed that hair, and its full weight
Breaking her slender neck—she fell.
Your cousin died. . . . ."

Mr. Davies kindly answered my inquiry as to the authenticity of the story, and informed me that it was a family legend, but he could not vouch for the fact.

of the less lethal grades of vertebral fracture. A change begins to come over the rather melancholy scene with Kümmell's recognition of a fairly common type of serious spinal injury without cord damage. Opportunely the application of X-rays as a means of diagnosis was introduced soon afterwards, and from that time onwards the proportion of non-fatal cases, of cases with no cord contusion, has increased by leaps and bounds.

Injuries to the nervous elements may be classified into two chief subheadings:—

(*a*) Injury to issuing nerve roots.
(*b*) Injury to the cord proper.

These two groups I shall leave to be dealt with by other speakers, but of cord damage I would say this, that it is rare for the cord to be divided, and that in the cervical region it is rare for the cord to be compressed. We hear, I firmly believe, too much of cord compression in fractures of the spine. Experience has taught me that the cord is damaged by instant contusion, and such damage being, of course, irreparable, operations undertaken with the object of relieving pressure are futile procedures. I will not go so far as to say that pressure never occurs, and in rare instances it can be traced in gradually increasing amount. Such cases, of course, cry aloud for operation, but they are exceedingly uncommon. One thing we can be quite certain of, is that immediate operation as a cure for spinal fracture has had its day and passed into the limbo of half-forgotten things. When it comes to the type of operation which we ought to perform, I personally favour reduction rather than the classical laminectomy.

It is exceedingly unfortunate that the common thoraco-lumbar junction fracture should fall so heavily on the conus and epi-conus, an injury which gives a characteristic neurological picture. If this injury fell just one or two vertebræ lower, the results of spinal injury would be infinitely less disastrous.

Dr. George Riddoch.

In all cases of vertebral fracture the question for primary consideration is whether the spinal cord or the roots of the cauda equina have been damaged or not. The presence of disturbance of neural function and its amount must influence our views more than any other factor in regard to prognosis and treatment. Approached from this aspect a practical classification of fractures of the spine is: (1) those without neurological manifestations; (2) those with immediate paralysis, and (3) those with late paralysis or a subsequent aggravation of existing paralysis.

Pathology of Injuries to the Spinal Cord.

The damage is immediate, occurring at the time of the bony injury. Three groups of pathological changes are found:—

(*a*) *Hæmorrhage.*—In the form of minute extravasations, this occurs for a varying distance above and below the main lesion. Large hæmorrhages are often absent and when present are in the grey matter in the form of a fusiform swelling (hæmatomyelia). After a time the blood becomes absorbed or may be replaced by brownish, gelatinous material.

Outside the spinal cord and either intra- or extra-dural or both, there is always some bleeding which may be considerable. But hæmorrhage by itself is probably never a cause of spinal compression.

(*b*) *Neural Changes.*—There are areas of focal necrosis, most extensive under the site of the bony lesion but usually present also in the segments immediately above and below it. Myelin sheaths are degenerated and axis cylinders swollen and irregular.

34 Riddoch: *Discussion on Spinal Injuries*

(*c*) *Œdema.*—Local œdema, which is always found, is probably one of the group of pathological changes that cause "spinal shock," that is, the transient disturbance of function as opposed to the permanent defect due to irremedial structural damage.

Lastly, there often are lesions of the spinal roots at the level of the injury.

Clinical Picture of Severe Paraplegia.

This can be divided into three stages: (1) Muscular flaccidity or "spinal shock"; (2) reflex activity; (3) gradual failure of reflex functions.

(1) *Stage of "Spinal Shock."*—There is immediate and complete flaccid paralysis with loss of sensibility below the level corresponding to the spinal lesion. Urine and fæces are retained and priapism from venous engorgement which may be present immediately after the injury soon disappears. Reflex action is almost entirely suppressed. Thus, with an injury at the level of the fifth cervical segment, the tendon-jerks of the upper and lower limbs, as well as the abdominal and cremasteric reflexes are abolished, the only reflexes that may be preserved being the plantar, bulbo-cavernosus and anal. These are supplied by the lower sacral segments and their preservation illustrates the law that "spinal shock" is greatest near the lesion and diminishes towards the distal extremity of the spinal cord. It may be also recalled that, as originally pointed out by Sherrington, the effects of "spinal shock" are entirely in the direction caudal to the injury. The form of the plantar reflex at this stage is of interest. It is obtained only by stimulation of the sole of the foot, for example, scratching or pricking, and the toes may move either up ("extensor") or down ("flexor"). But the response is unaccompanied, as it is later, by contraction of the hamstrings and other flexors of the limb.

In addition to these motor, sensory and reflex changes, the lower extremities, owing to vasomotor paralysis, rapidly lose heat if uncovered, and swell if allowed to hang down. Sweating also is abolished.

This almost total suppression of reflex function in the affected parts does not necessarily mean that the spinal cord has been divided. What it indicates is a local block in conduction which may be grossly structural and permanent but, on the other hand may, in part, be due to changes of a transient kind such as œdema or intramedullary hæmorrhage. Thus it is clear that until the temporary effects of "spinal shock" have had time to disappear it is impossible to assess the amount of damage and disturbance of function that will persist. The necessary period of waiting has been found from experience to be from two to six weeks.

Up to the time of the recent war, it was generally believed, following the teaching of Bastian, that with complete transection of the spinal cord, practically no return of reflex activity was to be expected. According to this view, reappearance of—for example—the knee- and ankle-jerks indicated incomplete division and some recovery of conduction at the site of the injury. This, however, has proved to be untrue, except under special circumstances, namely when early and severe toxic absorption, as from urinary sepsis or bed-sores, lead to degenerative changes in the isolated portion of the spinal cord.

(2) *Stage of Reflex Activity.*—In uncomplicated cases, however, the effects of "spinal shock" begin to pass off in from a few days to three weeks after the injury, whether the spinal cord is completely divided or not.

The first evidence of return of reflex function usually is contraction of the hamstrings along with upward or downward movement of the toes on plantar stimulation. About the same time involuntary flexor spasms of the lower limbs make their appearance, at first gentle and hardly perceptible but soon increasing in vigor, amplitude and frequency.

About three weeks after the injury the knee- and ankle-jerks return, the latter usually before the former, and retention of urine and fæces is no longer complete. At irregular intervals a small quantity of urine is expelled by active contraction of the detrusor with simultaneous relaxation of the sphincter. Gradually automatic micturition becomes complete and the bladder empties itself about every two or three hours. The capacity of the bladder varies not only in different individuals but in the same individual, tending to diminish the longer the organ is paralysed.

With automatic micturition, reflex defæcation and sweating appear, the sudorific region being more or less extensive than the area of analgesia. This variation depends upon the level of the spinal lesion.

What has been described as a "mass-reflex" is an extensive reaction consisting of bilateral flexor spasm of the lower limbs, and of the trunk if the lesion is high enough, along with reflex micturition and sweating. It occurs when the transected spinal cord is in a state of considerable reflex activity and can be evoked by stimuli so diverse as pinching or scratching of any part of the paralysed trunk and lower limbs, distention of the bladder or rectum or even movement of the body in bed.

(3) *Stage of Gradual Failure of Reflex Function.*—Even in cases of complete spinal transection the isolated portion of the cord may remain in a state of reflex activity for many years if the patient is properly cared for. There is no time to deal with this part of the problem, but the management of paraplegic patients is perhaps given insufficient attention. With the development of pulmonary or septic complications, as from severe urinary infection or extensive bed-sores, reflex activity in the paralysed region diminishes and the clinical picture seen during the early period of "spinal shock" may reappear.

Clinical Picture of Less Severe Paraplegia.

The stage of suppression of function or "spinal shock" tends to be shorter or incomplete, and the spastic paralysis is more often of the extensor than of the flexor type. By this is meant that the increased muscle-tone is greater in the extensor muscles, the glutei, quadriceps, extensors and calves, than in the corresponding opponents. The mass-reflex is absent, and stimulation of the thighs tends to evoke extension rather than flexion of the lower limb. Voluntary power and sensibility, if lost, may begin to return with reflex functions and the bladder and rectum become, although imperfectly, under the patient's control.

In the slighter cases of spinal injury, which are perhaps more common at the level of the cervical and lumbar enlargements than elsewhere, voluntary power and sensibility, although impaired, are not abolished even at the moment of the accident. The Brown-Séquard syndrome may be present, and rapid improvement in the clinical state indicates that the loss of function is due rather to pathological changes of a transient kind than to gross structural damage.

The cervical and lumbar enlargements are the usual sites of hæmatomyelia, in which internal compression from the central bleeding may play a prominent part in causing the disturbance of function. The causal injury may be trivial and unassociated with recognizable vertebral fracture. More often than not a considerable amount of recovery occurs, especially in regard to the disorders due to interference with the long tracts (remote effects). But local disturbances, motor, sensory and reflex, almost always remain to some extent.

Meningitis Circumscripta Serosa.

This condition, to which various names have been applied, is the chief cause of late paralysis or aggravation of pre-existing paralysis after spinal injuries. Pathologically it consists of thickening of the arachnoidal trabeculæ with loculation of the spinal

36 Riddoch: *Discussion on Spinal Injuries*

fluid, which have a tendency to progress and involve the spinal roots as well as compress the spinal cord. Clinical manifestations may be delayed for months or a year or more after the injury; the earliest of these, as a rule, are pain and cutaneous tenderness of root distribution. The area of hyperalgesia, even from the onset, indicates an affection of more than one posterior root, and it invariably spreads upwards and downwards as well as to the opposite side. Sooner or later signs of spinal compression appear, and the spastic paralysis and sensory loss is more or less progressive, although at the beginning the remote signs may vary from day to day. These, as with spinal compression from extramedullary tumour, from which the clinical picture is in striking contrast in regard to the local effects, are often more motor and reflex than sensory. Disorders of bladder and rectal function, unless the lesion is in the neighbourhood of the lumbo-sacral enlargement or the cauda equina, usually appear relatively late. If unrelieved by surgical interference, the condition will go on to complete paraplegia.

A fairly characteristic story is as follows. A woman, aged 53, fell down two flights of stairs in April, 1925, and apparently escaped with a fractured wrist. There was no evidence of spinal fracture. About four weeks later her right lower limb became noticeably weak, and by the end of the summer her left lower limb began to fail. (The early appearance of this remote motor sign without preceding root pains is unusual.) It was not until the end of the year that her left hand and arm became weak and numb, so that she was apt to "drop things" without knowing that she had done so. A little later her left shoulder and side of her neck began to be tender, this tenderness being soon followed by sharp pains in her right wrist on moving it.

The weakness of her lower limbs had progressed so far that at the time of examination in January, 1926, she had great difficulty in walking. There was slight frequency of micturition. At that time the positive signs present were as follows: There was cutaneous tenderness to dragged pin in an area corresponding to the distribution of C.2 to C.6 roots on the left side and C.2 to C.5 on the right side. Her upper limbs were weak and ataxic with marked loss of postural sensibility and defective tactile discrimination (compass test). Recognition of the vibrations of a large tuning-fork was not grossly impaired. All four limbs were spastic and weak with increased tendon-jerks, diminished abdominal reflexes and extensor plantar responses.

Sensibility in the trunk and lower limbs was little impaired, except that there was relative cutaneous analgesia on the right side from about the fifth rib downwards. The cerebro-spinal fluid showed no abnormality.

Meningitis circumscripta serosa was suspected, and spinal blockage was confirmed by lipiodol injection into the cisterna magna and subsequent X-ray examination. None of the lipiodol left the posterior basal cistern.

On January, 28, 1926, Mr. Sargent operated and found great distension of the dura from loculation of cerebro-spinal fluid in the cervical region of the spinal canal. On breaking down the arachnoidal adhesions the cord immediately began to pulsate.

After the operation the patient improved steadily, and within five weeks could use her arms freely and could sew and write. Her upper and lower limbs became progressively stronger, and when I last heard of her six months ago she could walk for a considerable distance. Her arms were almost perfect.

If the condition had been allowed to progress, not only would the paraplegia have increased, but bulbar signs would soon have developed. A case of this kind, with periodic attacks of severe vomiting, fainting and clouding of consciousness, was under my care in the recent war and was successfully operated upon by Mr. Wilfred Trotter.

Section of Orthopædics 37

Diagnosis of the Level of the Lesion.

When bony deformity or X-ray evidence of fracture is absent, the diagnosis of the site of the cord lesion must be made on neurological grounds alone. An injury of the spinal cord, as a rule, gives rise to two groups of phenomena of different localizing significance. The one in which the symptoms and signs are due to interference with the long tracts (remote signs) are of less value than are those which are to be attributed to impairment of the motor, sensory and reflex paths entering and leaving the spinal cord at the level of the injured segments (local signs). The local paralysis is atrophic and usually hypotonic, and is associated with diminution or abolition of the corresponding tendon reflexes. These motor and reflex abnormalities are more easily detected in the limbs than in the trunk, and so are of more value when one or other of the spinal enlargements is damaged.

With regard to sensory changes as a localizing aid, positive signs such as pain and cutaneous tenderness of root distribution, are much more valuable than negative signs alone (sensory loss), even when these, too, are due to root lesions. The difficulty is all the greater when the loss of sensibility is entirely segmental in origin, as is sometimes the case with vertebral fractures. Here the important upper level is not that of complete analgesia, but of sensory impairment, there being an intermediate zone of diminished sensibility between the region of most severe change to that of normal sensation. Again, having demarcated the upper boundary of reduced sensibility, one must still take into consideration the fact that because sensory impulses underlying pain and temperature entering the cord do not cross in the posterior commissure at once the main lesion is at least two segments higher.

Fortunately, from the clinician's point of view, if not from the patient's, the three common situations of traumatic spinal injury are associated with a more sharply defined upper boundary of sensory change than occurs with lesions elsewhere. Thus, with spinal cord lesions from fracture-dislocation of the fifth or sixth cervical and twelfth thoracic or first lumbar vertebræ, the local effects fall on the upper or lower limbs. Here segmental and root sensory areas not in anatomical sequence are in juxtaposition. This gives rise to an abrupt change from normal to abnormal sensory regions in the upper arm and upper part of the chest, and in the outer and inner aspects of the thighs and in the buttocks (figs. 1 and 2). So also with a lesion from fracture of the axis—if the patient survives, a similar sharp boundary is found between the distribution of the second cervical spinal root and that of the fifth cranial nerve.

For the purposes of localization, sensibility to pain is of more importance than sensibility to touch. Testing for the recognition of the vibrations of a tuning fork (C = 128) is also of great help, especially on the trunk, if the posterior columns have been damaged.

Flaccid, atrophic palsy, along with the diminution or abolition of the corresponding reflexes, especially when situated in the limbs, is of at least equal localizing value to sensory changes. For example, with a lesion of the fifth cervical segment, the spinati, deltoid, biceps and supinator longus are weak and wasted, and the supinator- and biceps-jerks are reduced or absent whilst the triceps-jerk is preserved. So also when the lesion falls on the twelfth thoracic and first lumbar segments, the lower part of the internal oblique and transverse abdominal muscles are paralysed, with the result that when the head is flexed there is bulging in the iliac fossa. In addition, the lower abdominal reflex is abolished. But in the third common situation of spinal injury from fracture-dislocation, namely, the upper cervical region, local muscular wasting may, in cases of survival, be of less value because of the difficulty of its detection unless the third and fourth cervical segments are damaged, when affection of the sterno-mastoids, trapezii and diaphragm provides an important clue. With

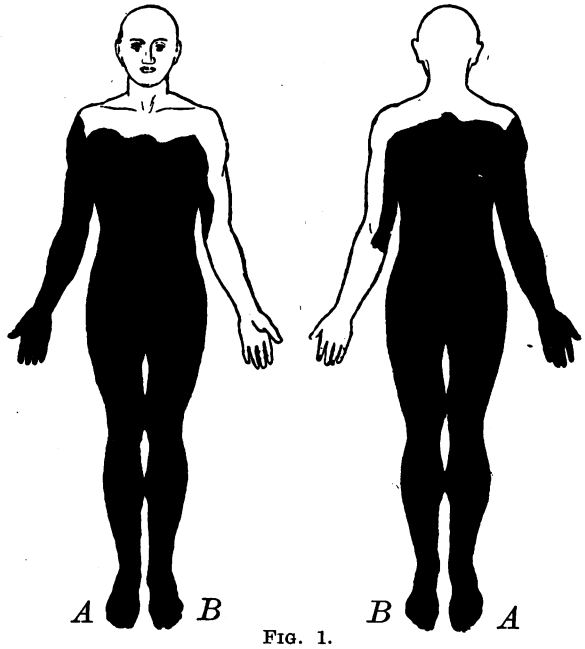

FIG. 1.

A.—Shows the border between parts of normal and abnormal sensibility to pin-prick when the lowest intact segmental areas correspond to cervical 3 and 4.

B.—Shows the border when the lowest intact segmental areas correspond to cervical 8 and thoracic 1.

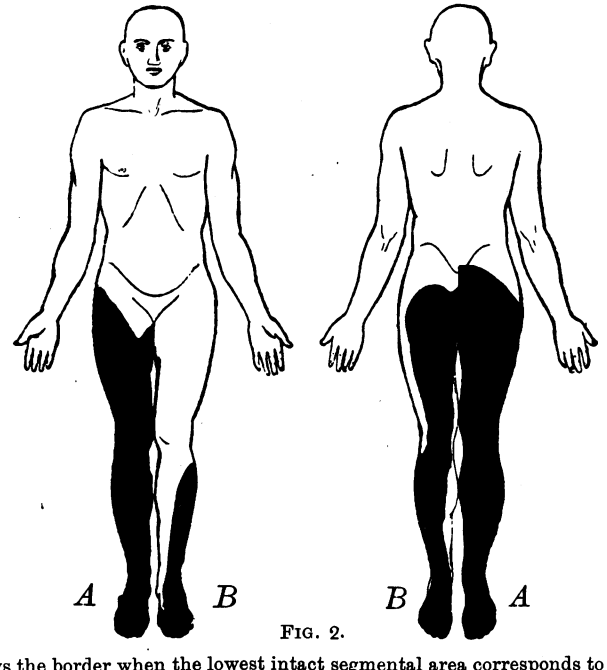

FIG. 2.

A.—Shows the border when the lowest intact segmental area corresponds to lumbar 1.

B.—Shows the border when the lowest intact segmental area corresponds to lumbar 4.

(Figs. 1 and 2.—From "Reports upon Injuries of the Spinal Cord to the Medical Research Council," Special Report Series No. 88.)

spastic quadriplegia following high cervical lesions, one or other of two reflex reactions in the upper limb may be evoked by potentially painful stimuli. These were described as the extension and flexion reflexes of the upper limb, reactions which in many ways are comparable to those found in the lower limbs. In brief, the extension reflex consists of adduction and retraction at the shoulder, extension at the elbow, higher pronation of the fore-arm and flexion at the wrist, in response to scratching or pinching of the tissues on the inner aspect of the limb or on the chest from about the second to the sixth ribs. The flexion reflex, in which the limb becomes bent at the elbow and wrist, is evoked from the same receptive field by similar stimuli, but it is most easily obtained from the hand whilst the extension reflex is excited, best from the axilla.

Differential Diagnosis between Lesions of the Conus and Cauda Equina.

The lower end of the spinal cord terminates at the level of the lower border of the first lumbar vertebral body or the space between the twelfth thoracic and the first lumbar spinous processes. The conus medullaris is therefore liable to be damaged with severe fracture-dislocation of these vertebræ. But if the bony injury is lower a nervous lesion, if present, is confined to the roots of the cauda equina.

Differentiation of these neural injuries is of practical importance, for whilst spinal roots, if not divided, are capable of some regeneration, gross structural damage to the spinal cord is permanent. In the recent war, experience showed that a considerable amount of recovery was in general to be expected with injuries confined to the cauda equina. At the same time, pain was often prominent and lasting, and if the second, third and fourth sacral roots were badly damaged, retention of urine was often prolonged with the consequently greater risk of severe urinary sepsis.

On the other hand, with high conus lesions, although conduction in the cerebro-spinal tracts remained permanently abolished, the vesical reflexes may recover within three or four weeks and so diminish the risk of grave cystitis and pyelitis. In such cases the bulbo-cavernosus and anal reflexes return fairly easily and are of considerable diagnostic aid.

When should Laminectomy be Performed in Spinal Injuries?

This question has probably, for the present, been settled by the experience of clinicians in the recent war. In a report on injuries of the spinal cord drawn up for the Medical Research Council by a representative committee, certain definite conclusions were arrived at to which, I imagine, there will be general agreement. In it is emphasized the fact that the full extent of damage to the spinal cord is immediate. Extra-medullary hæmorrhage, although it may from organization impair the functions of the cauda equina, is not a cause of spinal cord compression. Further, in-driven fragments of bone, which press on the spinal cord, are passive agents and are not vital and growing like a tumour. Increasing disturbance of function as a result of their presence can only be secondary from fibrosis or loculation of cerebro-spinal fluid. Thus their immediate removal is not necessary.

Further, the danger, as found from experience, of operation during the period of spinal shock, especially with cervical or upper thoracic injuries, is stressed, and it is insisted that laminectomy should not be undertaken earlier than from two to six weeks after the injury. After this time it is justified if there is gross bony deformity, when (1) there is reason to believe that the cord has not been transected, (2) recovery is arrested, and (3) there is severe and persistent root pain.

To these views I would still subscribe, except that since root pains may tend to diminish, and even to disappear, it might be better to consider rhizotomy as a question for later consideration.

40 Riddoch—Shires: *Discussion on Spinal Injuries*

Contra-indications are: (1) "The certainty that the cord has been divided, as shown by gross displacement of the vertebræ and absence of signs of conduction; (2) progressive recovery of function along with no radiographic evidence of marked bony encroachment; and (3) the presence of sepsis." The consideration, of course, has not, as a rule, to be taken into account with fracture-dislocation in civilian practice.

Two conditions call for operations on the spine at the late stage, namely, intractable and severe root pains and meningitis circumscripta serosa. Rhizotomy is usually successful in relieving pain in such cases, provided that a sufficient number of posterior roots are divided. The operation should include at least two posterior roots on one or both sides above and below those that are injured.

In meningitis circumscripta serosa the results of operation are, as a rule, most gratifying. As with removal of compression from any other cause, the amount of recovery that follows it is often considerable, even when paraplegia has been severe. But the best results are of course to be expected when the condition is dealt with before the functions of the cord are much impaired.

Dr. Bertram Shires

said that, as orthopædic surgeons were well able to diagnose fracture of the spine, he would be content to discuss pitfalls in diagnosis, and say something about his experience of fractures.

Every year members of the profession were circularized by the Medical Defence Union about the desirability of having cases of injury radiographed, and he suggested that radiography should be more frequently resorted to. Already this year he had seen three cases of fractured spine which were undiagnosed and not radiographed for several weeks. Radiography was important, not only from the point of view of diagnosis, but also from the standpoint of the insurance companies. He constantly saw, for insurance companies, cases of spinal injury in which the question arose whether the arthritis was traumatic or originally medical. It was important to take radiograms of the spine, not only immediately after the accident, but, if the symptoms continued, some weeks later, because one constantly saw evidence of deposits of bone in the ligaments.

He considered that subluxation of vertebræ did occur, and that with perfect stereoscopic skiagrams it was possible to discover it.

He would mention a few points of technique. For instance, an X-ray picture of the upper cervical spine could only be taken through the mouth, and by means of a stereoscopic view. That sounded easy, but it was not so, as one did not necessarily obtain a view of the upper joints by that method. Occiputs differed in shape, and the only way to take a skiagram of the upper cervical spine was to do it through the mouth, first by screening and then fixing the patient in position, so that one knew that the vertebræ looked for—occiput and atlas, or atlas and axis—came into the picture.

In the examination of the lower cervical spine, one must have an antero-posterior and a lateral position, but it was not possible to take a lateral view of the seventh cervical vertebra with the patient lying down, because the shoulders came into the view; the patient must stand up and extend the neck. Similarly, if the patient was standing, and one moved the scapulæ out of the way, it was possible to get a lateral view of every vertebral body.

Diagnosis of fractures of the transverse processes was difficult, particularly in the lumbar region, because various shadows were cast by the gas-filled bowel, by muscles, and by collections of fæces, and these shadows being cast across the transverse processes suggested a fracture. It was only by careful stereoscopic radiography that one could feel sure about these fractures.

In fractures or fracture-dislocations of the coccyx, the lateral X-ray view was the important one; it was also difficult, but not impossible to obtain. It was simply a question of technique, and a sufficient exposure to overcome the buttock shadows.

It had been suggested that lipiodol might be helpful in the diagnosis of spinal lesions. In his own experience, the fractures which caused encroachment on the spinal column already showed themselves, and no more information was gained by the fact that lipiodol was found to be arrested at that site.

Mr. G. F. Stebbing.

The number of patients treated at Lambeth Hospital for fracture of the spine has been rapidly increasing.

In the three years	1919 to 1921	there were	5	cases
,, ,, ,,	1922 to 1924	,, ,,	12	,,
,, ,, ,,	1925 to 1927	,, ,,	32	,,

This increase, which is not accounted for to any large extent by more accurate diagnosis, is much greater than the increase in cases of major injuries to the head, pelvis and limbs. The explanation is, I think, to be found in the increase of serious street accidents, many of which find their way to the Poor Law Hospital, especially if they are such as to demand prolonged institutional care.

Of the thirty-two cases treated during the last three years, fourteen had gross injury to the spinal cord; five of the fourteen died, one fifty years after the injury, one 122 days after the injury, and the others eight days, two days and one day respectively. The man who died fifty years after the injury had had a fracture of the lower dorsal spine when 11 years old, and had had a decompression operation some twenty years ago. He had a spastic paraplegia, but had been able to get about on crutches until shortly before his death from pyelonephritis. On post-mortem examination there was found considerable meningitis above and below the old injury.

The patient who died 122 days after injury was a man, aged 69, who had had a fracture between the second and third cervical vertebræ, with complete paraplegia from the day of the injury. Post mortem, the cord did not appear to be compressed, but was softened at the site of the fracture. There was severe pyelonephritis. The other three were injuries to the cervical spine, two of them having other injuries as well.

Of the nine patients who have survived the injury, six recovered sufficiently to go home after being treated for periods varying from seven months to two and a half years, three of the six being able to return to work; one had permanent paraplegia, and was transferred to another institution, and two are still in the hospital, one with complete, apparently permanent, paraplegia; the other making satisfactory progress towards recovery. Decompression operations were performed on two of these patients, but in neither case did the operation reveal any pressure on the cord.

It is to be noted that only two of these fourteen cases had been sent to Lambeth after being treated in other hospitals.

The eighteen cases without serious nervous complications present examples of injuries to all regions of the spine, including one of the axis and one of the sacrum. Two of these patients died, one a man, aged 82, with a fracture of the sixth dorsal vertebra, the other a man, aged 86, with a fracture of the fifth cervical.

Six of these eighteen cases were patients with fracture of the cervical spine, four of whom had been treated at other hospitals. In each case the only complaint was of stiffness and pain on movement of the neck, and none of them was admitted to any hospital immediately after accident. Five of the six were treated by

42 Stebbing—Openshaw: *Discussion on Spinal Injuries*

immobilization in a plaster jacket for a prolonged period, and left the hospital free from pain, but with more or less limitation of movement. The sixth patient was a man, aged 78, admitted two years after a compression fracture of the fifth cervical vertebra. He was treated for two months by massage and radiant heat, and left hospital in much the same condition as he entered.

Nine patients were admitted with compression or chip fractures of the lumbar vertebra, six having received treatment, without prolonged immobilization, at other hospitals before admission. In each case admission was because of pain and stiffness of the back, and more or less relief was obtained by prolonged rest followed by massage and radiant heat.

One patient was admitted some weeks after a fracture of the sacrum, without paralysis but with troublesome sciatic pain; he left the hospital eighteen days after admission without any improvement.

Consideration of the above cases leads to the following suggestions:—

That only a minority of fractures of the spine are associated with gross nervous lesions, and those without nervous symptoms are still commonly not diagnosed early, or if diagnosed are not treated by prolonged immobilization, which is the treatment that offers the best chance of complete recovery. That fractures with paraplegia are best treated by reduction of the displacement and prolonged immobilization; that more or less recovery can be expected in more than half the patients so treated, and that decompression operations have not proved of any value in this series.

In cases with nervous injuries the common cause of death is pyelonephritis. We have tried many methods of preventing cystitis, but have never succeeded. By careful intermittent catheterization and administration of urinary disinfectants, the urinary infection can generally be controlled in cases in which recovery is taking place, but in those in which paraplegia has been permanent, pyelonephritis has been the cause of death in each of our cases.

Neither bed-sores nor pneumonia have occurred in any of our cases, and, with careful nursing I do not think they should be common complications of fracture of the spine.

Mr. Openshaw

said his experience, extending over forty-five years, agreed with Mr. Stebbing's, that in most of these cases the patients died from pyelonephritis. He would also emphasize, as Mr. Stebbing had done, the fact that prolonged immobilization of the spine was an essential for recovery in many cases.

He agreed as to the importance of skiagrams, especially stereoscopic.

There were many cases of injury to the spine in which there were no nervous symptoms, and those cases were particularly important to the orthopædic surgeon. With a definitely tender vertebra, or with slightly displaced and prominent vertebræ —especially about the fifth to the eighth dorsal vertebræ—one should be suspicious. If there was tenderness over one vertebra and hyperæsthesia of the dorsal branches of the corresponding intercostal nerves, with or without definite deformity, there had probably been a wrenching of the spine, and referred nervous symptoms were likely to ensue.

He had only seen about two cases of odontoid process fracture; so, from the practical point of view, this fracture was so rare, so fatal, and so difficult to diagnose, as to be unimportant. In one case the nurse, while washing the patient's back so as to prevent the formation of bed-sores, turned the body and left the head where it was, the result being sudden death.

Section of Orthopædics 43

Dr. J. F. BRAILSFORD

showed a series of lantern slides illustrating fractures of the spine.

Mr. ST. J. D. BUXTON

said he had to report the investigation of twenty-nine cases, considered in detail in the tables.

TABLE I.

Five-year period		Per cent.
Serious accidents, about	1,200	
Fractured spines „	16	or 1·3
Cases investigated, 29		
Of these:—		
Died within 48 hours	7	24
„ later	10	34·5
Survived and well	11	38
Unlikely to survive	1	3·5
	29	

TABLE II.

Site of injury	Number of cases	Cord crushed	Paraplegia	Slight cord or nerve root signs	Reduced	Died within 48 hours	Later	Living and well
Occ. atlant.	1	1	—	—	—	1	—	—
Cerv. 3	1	—	—	1	spontaneous	—	—	1
Cerv. 5 and 6	9	—	5	4	2	2	3	4
Dorsal 1	1	—	—	—	—	—	—	1
„ 6	2	—	2	—	—	—	1	1[1]
„ 8	1	—	—	1	—	—	—	1
„ 9	1	1	1	—	—	1	—	—
„ 10 to 12	7	1	7	—	—	3	3	1[2]
Lumbar	3	—	3	—	—	1	2	—
„ trans. processes	3	—	—	—	—	—	—	3
Total	29		18			8	9	12

[1] Operation at Glasgow.
[2] This patient is alive, but not likely to survive.

In cases of paraplegia complicating fracture of the spine, the surgeon was faced with: (1) Respiratory complications; (2) abdominal complications, such as distension of the bowel and incontinence of urine; (3) trophic sores.

With regard to the first, when the lesion was cervical, pulmonary collapse occurred, but was liable to be followed by a rapid septic pneumonia. He would be interested to know how long a patient could live when all respiratory muscles were paralysed, except the diaphragm.

Urinary complications were responsible for a large number of deaths, but trophic sores often led to a fatal septicæmia.

He showed a specimen of a cervical spine, in which there had been a fracture-dislocation of the fifth cervical vertebra. The dislocation had been reduced three hours after the injury. The patient died of a septic condition of the lungs on the fifth day, but had no pyrexia. The paraplegia was little improved, which was to be expected, as the specimen shows the dura full of blood and the central canal greatly distended with blood.

He considered that reduction by traction should be used in cervical cases, and that it was likely to improve cases with partial cord or root symptoms. After reduction fixation should be used, if possible.

44 Everidge: *Discussion on Spinal Injuries*

Mr. JOHN EVERIDGE.

Enough has already been said this evening to make it unnecessary for me to dilate upon the gravity of urinary complications in fractures of the spine. I may remind you of the figures given by Sir John Thomson-Walker in his address to the Hunterian Society in February, 1917. Of 111 gunshot wounds of the spine admitted to the Star and Garter Hospital to the end of 1916, nineteen died of urinary infection. Of 339 admitted to the King George Hospital to the same date, 160 died.

The factors governing ascending infection are: (1) Over-distension of the bladder interfering with such protection of the upper urinary tract as is afforded by the valve mechanism at the lower end of the ureter. The result is an increased tension in the kidney. (2) A lower resistance from trophic disturbance associated with the nerve lesion. (3) Infection introduced by the catheter.

Dr. Riddoch has alluded to the two well-recognized stages of disturbance to the normal act of micturition following cord injuries. The first stage, the stage of urinary retention, lasts usually about fifty-five days, but may persist as long as eighteen months, depending upon the level of cord injury. During this period some form of relief must be given, and the catheter is usually resorted to. The second stage, the stage of periodic reflex micturition, then follows, and a condition is established resembling the normal state obtaining in a child up to the age of two or thereabouts, in which the bladder is reflexly emptied when the afferent impulses stimulate the centre controlling micturition in the lumbar cord.

In the desire to prevent the initial infection introduced by the catheter, and to eliminate such increased intravesical tension as would aggravate the tendency to an upward spread of infection, Sir John Thomson-Walker expressed his opinion that suprapubic drainage, established at the earliest possible moment, might reduce the high mortality due to pyelonephritis and pyonephrosis. Such an initial treatment might tide over the danger period until reflex micturition was automatically established.