EARLY TREATMENT OF PARAPLEGIA FROM FRACKTURES OF THE THORACO-LUMBAR SPINE

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This paper concerns only the immediate treatment of paraplegia from fracture-dislocations of the spine at the thoraco-lumbar level. It is based on experience gained in the treatment of sixty-eight patients of whom forty-seven were treated by us from the beginning and twenty-one were admitted to the paraplegic centre several weeks or months after injury. From this experience we have reached certain conclusions about the immediate treatment of thoraco-lumbar injuries, developing as evidence accumulated, so that some patients seen in earlier years were not treated as they would be now. In this series there are so many varied factors that we have made no attempt to present our observations statistically.

Most paraplegic patients die as a result of large bed sores and urinary tract infection, many of them as the result of inefficient treatment. Moreover, bad initial treatment results in a host of other complications such as gross angulation of the spine, stiffness of joints, contractures and deformities, which seriously delay or even prevent late rehabilitation. Early treatment must be designed to prevent these complications, to assist the establishment of compensatory mechanisms, and to promote every possible recovery of nerve function.

ANATOMY OF THE SPINAL CORD AND NERVE ROOTS

In this study, the relationship of the vertebral column to the spinal cord and nerve roots at the thoraco-lumbar level is fundamental (Fig. 1). The tip of the spinal cord lies opposite the lower border of the first lumbar vertebra. Opposite the junction of the twelfth thoracic and first lumbar vertebrae lie the first and second sacral segments of the cord; while all the lumbar cord segments are situated at a higher level, probably extending as high as the ninth thoracic vertebra. Thus all the lumbar roots arise from the cord above the thoraco-lumbar junction, at which level they lie side by side with the upper sacral segments of the cord. Thus at the thoraco-lumbar junction there are two types of nerve tissue supplying the lower trunk and legs, namely the cord which is very susceptible to injury and incapable of regeneration, and the lumbar nerve roots which are more tolerant of injury and in certain circumstances may be capable of regeneration.

In most patients in this series the injury was severe enough to cause irrecoverable damage to the spinal cord but insufficient to cause irreparable damage to the nerve roots at that level, so that neurological examination of many patients showed that at least some lumbar roots had escaped injury. This finding has been confirmed at operation, by post-mortem examination, and by subsequent histological section of the cord and nerve roots. We refer to it as "root escape."

Classification of thoraco-lumbar nerve injuries—Nerve injuries at the thoraco-lumbar junction may therefore be divided into three main groups: 1) complete division of the sacral cord and all lumbar roots; 2) complete division of the sacral cord with escape of nerve roots on one or both sides; 3) incomplete division of the sacral cord with escape of nerve roots.

Effects of cord section—If the spinal cord is divided at the first sacral segment or immediately above it, there will be complete loss of voluntary power and loss of sensation in all parts supplied by the sacral segments, together with isolated reflex activity of these segments as indicated by reflex bladder and bowel action, presence of the bulbo-cavernosus and anal skin reflexes, and sometimes of extensor plantar responses. Full reflex activity is not established.
until some weeks after injury but, in many cases, the bulbo-cavernous and anal skin reflexes return within a few hours and this, together with complete paralysis and anaesthesia of the sacral segmental supply, indicates transection of the cord.

**Significance of lumbar root escape**—The lumbar roots control flexion and adduction of the hips and extension of the knees; they contribute to the control of extension and abduction of the hips, flexion of the knees, and dorsiflexion of the foot; and they are responsible for much of the sensation of the leg (Figs. 1 and 2). Division of the roots causes loss of these movements and of this sensation. Thus, the clinical picture of complete cord and root division at the thoraco-lumbar junction is that of complete paralysis and anaesthesia below the L.1 segment, together with the return of isolated sacral reflexes but not of the lumbar reflexes.

Full root escape on either side is shown by the presence of reasonably good flexion and adduction movement of the hips with weak extension and abduction movement, good extension and weak flexion of the knees, and weak dorsiflexion of the ankles, but with no plantar flexion of the foot or movement of the toes. Cutaneous sensation to pinprick and cotton wool are present in the lumbar dermatomes, and the knee jerks are present.

Many variations of this clinical picture may occur, depending on the number of nerve roots that have escaped damage and on the degree of injury to the spinal cord; but it cannot be emphasised too strongly that in injuries at this level the presence of voluntary activity in the lumbar segments is evidence not of an incomplete cord lesion but of root escape. Only the presence of voluntary activity in the sacral segments is evidence of an incomplete cord lesion.

Of the sixty-eight patients in this series with paraplegia sustained at the thoraco-lumbar level, thirty-three had complete cord and root lesions, and thirty-five had cord lesions with root escape on one or both sides. Of the thirty-five patients with root escape, twenty had...
complete physiological isolation of the sacral cord with some bilateral root escape, seven had similar cord injury with unilateral root escape, and eight had incomplete cord damage with complete root escape.

The function of the lumbar roots is of the very greatest importance. Without the function provided by lumbar roots, the balance and stability of the lower limbs and trunk are seriously impaired and walking in caliper splints is far from easy. With such function there is much better muscle control, and mobility is greatly increased. If the lumbar nerve roots are undamaged many patients do not require full-length calipers. Even the escape of one or two roots on either side can determine the possibility of the patient taking steps by using the hip flexors instead of merely swinging the legs by pelvic tilting. It is therefore essential
that a careful neurological examination be made to correlate the neurological level with the fracture level and thus to differentiate between cord and root injury, for even with initial complete paraplegia it is our experience that whereas the cord never recovers the roots sometimes do.

**Mechanics of injury to the vertebral column** — Fracture-dislocations of the spine with severe cord and root damage are sustained only as the result of considerable violence; and yet many patients with complete paraplegia have shown only slight vertebral displacement whereas others, with gross shift, have shown no neurological damage. This was puzzling until it was realised that displacements seen on radiographic examination were not necessarily an accurate indication of the actual displacement at the time of injury.

**Classification** — Clinical examination, surgical exploration, and examination of post-mortem specimens showed that fractures and fracture-dislocations of the spine at this level could be divided into stable and unstable types. Instability of the spine after fracture depends upon the degree of damage to the posterior ligaments and articular processes (Figs. 3 to 5). If the posterior ligaments remained intact they acted as a fulcrum; the violence was expended upon the vertebral body and a compression fracture resulted (Fig. 3). These fractures were stable and impacted, and further violence, unless it was greater than the original force, could not displace the fragments more. The displacement was essentially one of angulation; the spinal canal was not seriously deformed and paraplegia was rare; and when paraplegia occurred the cord lesion was often incomplete and the lumbar roots escaped injury. In this series of cases there were only two examples of such fractures, and both patients had incomplete lesions of the cord with complete root escape. (It is theoretically possible in such fractures for a fragment of the vertebral body to be driven back into the spinal canal with severe damage to the cord—but we have not seen such a case. Furthermore, if the posterior ligaments

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**Fig. 6**

Torsional fracture-dislocation between T.12 and L.1. In the antero-posterior view fracture of the right articular process of L.1 and the lateral shift of the articular and spinous processes of T.12 are shown. In the lateral view the typical "slice" fracture is shown. The torsional nature of the injury is illustrated by the dislocation of the right twelfth rib.
are ruptured as a result of flexion strain the vertebrae may separate behind without fracture of the body and an uncomplicated dislocation with locked articular facets is then sustained, the displacement being limited by interlocking of the articular processes—a stable injury in which paraplegia is uncommon; but again there was no such injury in this particular series of patients.

Torsional violence with rupture of the posterior ligaments and fracture of one or both articular processes allows the upper vertebra to swing round upon the lower, taking with it the intervertebral disc and a "slice" of the lower vertebra (Fig. 5). This fracture-dislocation is unstable; the displacement can be reduced quite easily by laying the patient on his back. Consequently, radiographs taken with the patient supine, or in the lateral position with the shoulders and pelvis held in line, often show little displacement whereas if the original torsional strain is reproduced gross displacement can be demonstrated. This has been confirmed on many occasions at operation. In this type of fracture-dislocation lateral shift of the spinous processes with fracture of the articular processes can be seen in the antero-posterior radiographs and the typical "slice" fracture of the body is seen in the lateral projection (Fig. 6). A further important indication of instability is the presence of a palpable gap between the affected spinous processes from rupture of the supraspinous and interspinous ligaments. This torsional dislocation is the most common cause of paraplegia at this level, the cord being crushed between the lamina above and the vertebral body below.

Lumbar puncture—Lumbar puncture has not proved to be of assistance in diagnosis. Complete obstruction to the flow of cerebrospinal fluid has been found in both complete and incomplete cord injuries, whereas a free flow has been observed in several cases of complete lesions of the cord. Tapping the thecal space shows the presence or absence of obstruction to the flow of cerebrospinal fluid but gives no information as to the presence or absence of spinal cord compression, or of the nature of the block—whether extra-dural or intra-dural, from blood clot or bone displacement, or simply from oedema of the cord. Lumbar puncture records no more than the anatomical state during the resting phase of an injury when neurological damage has already been sustained. It is true that demonstration of intrathecal block by lumbar puncture provides yet another indication for exploration when it is associated with progression of abnormal neurological signs, but this occurred in only one case out of sixty-eight and in this case laminectomy proved useless. In seven patients a complete spinal block disclosed within a few hours of the injury had disappeared by the end of the second month without manipulation or operation.

TREATMENT

Management of the vertebral injury—Treatment of the vertebral injury should be designed to prevent the complications of paraplegia by making nursing easy. It should restore and maintain alignment of the spine in preparation for future weight bearing, and it should free the cord and particularly the nerve roots from compression, placing them in a position of safety so that there will be no impairment of such spontaneous recovery as may occur. Thus the deformity should be reduced if it is severe, or if it encroaches upon the neural canal.

Restoration of alignment can be achieved by manipulation or by open operation. The safety of manipulative methods depends upon accurate foreknowledge of the bone damage to the whole vertebra—but despite careful radiographic examination of our sixty-eight patients we found it difficult to be certain of the extent of the bone damage. Repeated mistakes were made in the interpretation of the position of the articular processes, and this rather dangerous hit-and-miss interpretation of the exact displacement made it obvious that manipulative reduction was usually unsafe. Thus all patients in this series in whom there was severe displacement encroaching upon the neural canal were treated by open operative reduction. The operation is simple and safe, and it affords an opportunity of judging the
stability of the spine by examination of the posterior ligaments. It must be added, however, that reduction alone is not enough. If the fracture-dislocation is unstable the spine must be immobilised otherwise displacement will recur. Our experience of external fixation by prolonged immobilisation in plaster has been quite disastrous. Of sixteen patients who had been treated in plaster beds, all had severe pressure sores which took not less than two years to heal (Fig. 7). The alternative is internal fixation, and this we have found simple, safe and effective.

*Technique of operative fixation*—The most satisfactory method is to fix the fractured segments by two plates bolted through one or more spinous processes above and below the level of the dislocation (Figs. 8 and 9). When the spinous processes are damaged this may not always be possible and the surgeon may have to exercise ingenuity in fixing plates to the laminae. Such fixation by plates is effective for eight to twelve weeks, by which time the spine is sufficiently stable through spontaneous fusion of the vertebral bodies.

*Selection of cases for operative fixation*—The decision to operate and plate the spine depends upon the displacement and the stability of the fracture, which is not always easy to assess. There is no difficulty in making such a decision in unstable fracture-dislocations with gross displacement (Figs. 10 and 11). But if there is crushing of the body with intact articular processes, and no palpable gap between the spinous processes, the fracture is stable and no matter how severe the degree of paralysis there is no indication for operative treatment (Fig. 12). But if radiographs show the typical "slice" fracture with minimal crushing of the vertebral body, accompanied by fracture of the articular processes and lateral shift of the spinous processes together with a palpable gap from tears of the supraspinous and interspinous ligaments, the spine is unstable and operative reduction with internal fixation should be performed as an emergency procedure (Figs. 13 and 14).

*Nursing*—All our patients were nursed on ordinary mattresses. With the spine firmly fixed their ease of handling was quite remarkable (Fig. 15). The lumbar thoracic curve was supported by a pillow and the patient was rolled from the supine position to each side alternately at two-hourly intervals throughout the day and night. The buttocks and shoulders were supported by extra pillows when the patient was in the semi-lateral position. When he was supine the
Unstable fracture-dislocation (Fig. 8) reduced by open operation and fixed by plates bolted to the spinous processes (Fig. 9).

Figure 10—Fracture-dislocation of T.12 on L.1 with gross displacement and clearly unstable. Figure 11—The displacement has been reduced by open operation and the spine fixed by plates.
legs were slightly raised so that the heels did not lie on the bed; in the lateral position the knees and ankles were separated by small pads or pillows. All pressure areas could be seen and inspected at each turn and the only local treatment to the skin was washing with soap and water and occasional powdering. Early active and passive physiotherapy was applied to the upper and lower limbs as soon as the general condition permitted.

In the normal person, constant change of position is a reflex action and in this way prolonged pressure on any one area of the skin is avoided. In the paraplegic patient this mechanism is lost, so that areas of skin are subjected to pressure for just so long as the patient is left in one position. Continuous pressure for no more than a few hours causes necrosis of the subcutaneous tissue, although the full extent of such damage may not always be apparent as a superficial sore for some time. Pressure sores can always be prevented by the regime of regular turning. During the past seven years we have not had one single serious pressure sore in patients so treated.

**Care of the bladder and bowel**—The aim of early management is to protect the bladder from infection, and to prevent over-distension or persistent contraction during the long phases of inactivity and subsequent recovery. Treatment must be continued until compensatory mechanisms have been established, whether by manual compression, abdominal straining, reflex activity, or a combination of all three. Therefore the treatment employed must be the one that is most suitable for prolonged use. The emphasis should primarily be on the prevention of complications, and secondarily on the encouragement and reinforcement of reflex activity. These objects can be achieved only by effective bladder drainage and lavage. Opinions differ widely on the technique that is most appropriate. Our method of choice was by bladder drainage with an indwelling urethral catheter. By this method the bladder capacity was controlled and distension avoided. The bladder was exercised regularly and the cavity
Fig. 13

Fig. 14
Same case as Figure 13. The spine has been fixed by two plates.
kept clear of debris by intermittent washouts. Strict aseptic technique reduced or even removed the risk of infection of the lower urinary and genital tracts, and the state of efficiency of the bladder could be observed quite easily.

The indwelling urethral catheter we have used is of the Foley type, not larger than 18 French gauge; the catheter was changed every week; drainage was free into a bottle beneath the bed. Twice a day the bladder was irrigated with fluid alternately filled and emptied. Care was taken to empty it completely by suction after every irrigation. Suction was discontinued when the tone of the bladder sufficed to clear its own cavity of debris during the washout. The solutions used were Suby's solution M, boric acid, or flavasole according to the circumstances. Antibiotics were used occasionally but not as a routine. All patients were encouraged to drink not less than six pints of fluid each day. This method of treatment was successful in avoiding phosphatic incrustation. Rigid aseptic precautions were always taken.

Bowel function is always disturbed and too often it has been neglected. Dirty beds and soiled linen should not be accepted as inevitable sequels: the judicious use of aperients, laxatives, enemas and manual evacuation, singly or in combination, reduces inopportune bowel actions to a minimum. No patient should be allowed to remain constipated for longer than three days and the regime should be continued until a habit reflex or control by straining is achieved.

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RESULTS

The results of this routine of management have been good. Patients whose spines were stabilised by internal fixation were moved freely and easily in bed with comfort and confidence. The reduction was well maintained and there were no redisplacements. Wounds healed by first intention and all patients were able to sit up quite safely in a chair by the end of the third month when bone union was well advanced.

No pressure sores occurred in our own group of cases and the absence of sores has been responsible for a great reduction in the period of in-patient treatment. The average stay in hospital in an uncomplicated case has been a little over nine months, compared with an average period of over two years for a similar group of patients with pressure sores.

No muscle or joint contractures have occurred and the return of any voluntary movement has been recognised at an early stage and encouraged.

The periods of catheter drainage varied from two to thirty-four weeks, with an average of nineteen weeks for complete lesions and seven weeks for incomplete lesions. Catheter complications developed in seven cases but did not interfere with treatment; all of them resolved quite rapidly. There were five cases of epididymo-orchitis, two cases of peri-urethral abscess, and five cases of small vesical calculi. The calculi were easily removed at the end of the period of catheter drainage.

Of the sixty-eight patients in the whole series, forty-seven were treated by us throughout, operative exploration being undertaken in thirty and internal fixation in nineteen. Of the early cases, twenty-four had complete initial paraplegia below the L1 segment—that is, complete cord and root lesion. Of these, four later developed root recovery. Nineteen had partial root and complete cord lesion. In all these the function of the roots improved but that of the cord did not. Four had incomplete cord lesions and these remained unchanged.

Of the twenty-one late cases admitted weeks or months after the injury twelve had complete paraplegia when first examined and there was no subsequent change. Nine had root escape and in these the cord function remained unchanged but the function of the roots improved. There was not one patient in the whole series in whom the function of the cord improved.

There were three deaths from operation, one from a ruptured lung, one from a ruptured stomach lying in the thorax, and one from pulmonary embolus on the third day.

It thus appears that this method of immediate treatment has advantages in the avoidance of complications and possibly in the encouragement of recovery of function of the lumbar roots.

SUMMARY

1. Paraplegia from fracture-dislocation at the thoraco-lumbar junction is a mixed cord and root injury. The root damage can be distinguished from cord damage by neurological examination and by comparison of the neurological level with the fracture level.
2. Even though the cord injury is complete, as it usually is, the roots often escape or recover.
3. Fracture-dislocations can be divided into stable and unstable types. Because of the possibility of root recovery care must be taken to prevent further damage to the roots by manipulation of the spine or during treatment. For this reason unstable fracture-dislocations are fixed internally by plates.
4. Internal fixation also assists in the nursing of the patient. The nursing technique and the care of the bladder are described.