MANIPULATIVE REDUCTION OF CRUSH FRACTURES OF THE SPINE*

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For at least two thousand years it has been recognized that fractures demand immobilization, and for many hundreds of years methods of reducing fractures have become more and more specialized and more and more successful. It is therefore the more inexplicable that crush fractures of the spine have been neglected, and that an apathy which would have been criticized in the treatment of other injuries has been condoned and even commended. It cannot be said that it is the layman alone who has regarded a broken back as irreparable, and until recent years there appears to have been no systematic attempt to reduce these fractures. The object of this paper is to record—it is believed for the first time—a method of reducing crush fractures of the spine, safe enough and simple enough to be capable of universal application, and of giving successful results in the hands of any practitioner who knows the rudiments of plaster work. It has the value of requiring no anaesthetic, no apparatus, and no skilled assistance, and can be applied as effectively in a private house in the country as in a fully equipped hospital.

RESULTS OF INADEQUATE TREATMENT

The growing risks of industrial life and of life on the highways has led to a remarkable increase in the frequency of this injury. During the last two years I have seen no fewer than sixty-five cases of crush fracture of the spine which have been treated elsewhere by the accepted method of simple recumbency in bed for a few weeks. That these patients are still wandering from surgeon to surgeon and from clinic to clinic is itself evidence that a serious disability usually remains.

The angular deformity of the spine which always appears is often progressive, because there is continued absorption of the unprotected wedge-shaped vertebra. In those cases where, in addition to the crushing of a vertebra, there is forward dislocation of the upper segment, the spine is mechanically unstable, and on several occasions it has been observed that the forward slipping has continued several years after the injury, despite the constant use of a posterior spinal support. But the group of cases which is most important, because, although amenable to successful treatment, it is neglected, is that in which the obvious complication of paraplegia has not arisen, and yet there is an angular kyphotic deformity of greater or less degree. The malalignment of the complex system of spinal joints accounts for the complaint of "weakness of the back," early onset of fatigue after exertion, persistent local aching pain, and sharp pain referred to the chest, abdomen, or lower limbs. It also accounts for the development of osteo-arthritis changes at an unusually early age. These problems are not to be solved by attributing the symptoms to hysteria, by labelling the case "industrial back," and having recourse to county court arbitration. Nor can they be solved by operative fusion of the spine in the late stages. The solution is to treat the case from the outset as a fracture or dislocation in any other region of the body would be treated—namely, by manipulative reduction of the displacement and immobilization until the fracture is consolidated.

RATIONALE OF MANIPULATIVE REDUCTION

We know that the vertebra is crushed by forcible flexion of the spine, and that the kyphotic deformity is one of acute flexion at the level of the injury. It follows that reduction can be effected only by moving the spine in the opposite direction of extension. When the normal limits of hyperextension are reached, weight is taken off the front of the vertebral bodies, the intervertebral spaces are opened anteriorly, the anterior common ligament is put on the stretch, and the tension of the ligament is such that a vertebra crushed into a wedge will be restored to its original shape.

During the last eighteen months several articles have appeared in America describing methods of reduction of compression fractures, but although the methods have been successful in the authors' hands, all of them have been based on manœuvres either too difficult or too dangerous to admit of general application. A general anaesthetic has been regarded as essential, and the operators have insisted on prolonged recumbency after reduction in a plaster bed. The most notable contribution was that of Davis of Erie (Pa.), who described the results in thirteen cases where traction and forcible hyperextension were combined by suspending the anaesthetized patient from the roof of the operating theatre by the heels, in such a way that he was lying face downwards on his upper chest, the lower half of the spine and the lower limbs being in mid-air. A plaster bed in which the patient subsequently lay was made in this position. Herzikoff described a case of reduction in which four strong men had combined to exert traction on the patient's spine. According to one method I saw practised in the United States, after suspending the deeply anaesthetized patient by the Davis method, the operator thrust with the whole of his body weight on the patient's spine "until the bones were felt to crunch."

Such a method is based on an entire misconception of the structure of the vertebral body and of the pathological anatomy of a crush fracture. The cancellous bone of the body of a vertebra is a delicate framework, which rapidly collapses as soon as the enveloping layer of compact bone is fractured. Once the compact layer is broken very little force is necessary to make the vertebra collapse, and an equally small force applied in the opposite direction will open up the cancellous tissue again. Moreover, the interlocking of the segments of a fully extended spine is so close that the trunk above and below the level of fracture provides a pair of unusually powerful levers.

We have, in fact, found in practice that if a patient with a crush fracture of the vertebra, within a few days of the injury, lies prone with hyperextended spine, supported only by his arms at the side of his head and by the front of his thighs and legs, leaving the trunk entirely unsupported, *body weight alone* is sufficient to restore the vertebra to its original shape and give perfect anatomical reduction. Completely successful results have been secured by this very simple method, even ten days after the injury, but the ideal time for reduction is the first day. The method involves no manipulation, no trauma, and no anaesthetic, so that there is no danger of increasing the shock. The shock, in fact, begins to disappear as soon as the plaster is applied, because only then is the patient free from pain, and only then can he be moved in comfort. Not until the plaster is applied is the danger of cord injury avoided, and if there is already paraplegia the only hope of recovery lies in immediate relief of pressure. Moreover, it is the recumbency of the first few days which may precipitate pulmonary congestion and pneumonia, and the sooner it is possible to change the patient's position regularly and frequently the more certainly is pulmonary complication avoided.

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METHOD OF REDUCTION

Not only is a general anaesthetic quite unnecessary, but the position required can be maintained much more easily by a conscious than by an anaesthetized patient. Although complaint is made of aching and discomfort in the arms where the weight of the trunk is borne, none of the patients complained of pain in the back, so that we

FIG. 1.—Hyperextension of the spine secured and maintained by two tables of different height.

have not thought it necessary to adopt Böhler's suggestion of injecting novocain locally. One-quarter or one-third of a grain of morphine is given half an hour before.

Two tables are arranged end to end, with a space between slightly greater than the length of the patient's trunk. The front table is raised on blocks or chairs so that it is about two feet higher than the other; although not essential, it is an advantage to use an operating table of adjustable height, so that the hyperextension can be attained gradually by screwing up the table after the patient is in position. Throughout treatment, flexion of the spine must be avoided. The patient is therefore lifted *face downwards* on to the lower table, and a double layer of stockinette pulled over the trunk and stitched over the shoulders and beneath the perineum. The spinous processes and the iliac crests may be further protected by small pads of adhesive felt, but it is essential that the plaster should fit very closely; bulky padding with wool or felt is to be avoided. A closely fitting woollen bathing costume is an excellent substitute.

The patient is now assisted into such a position that he is gripping the edge of the higher table with his abducted arms, the head resting on a small pillow. The lower table supports his lower limbs as high as the upper thigh, but between the groins and the neck there is no support. In this position he is unable to prevent his spine from gently sagging into full hyperextension (Fig. 1). The plaster is applied at once, and is well moulded to the curve of the spine, the sacrum, and iliac crests. The rubbing in of layer after layer of plaster gives just sufficient pressure to ensure that the normal limit of hyperextension has been reached; beyond this no manipulation of any sort is employed. The plaster should extend up to the neck, and although it may be cut out below each axilla to allow free arm movement, none must be removed from the front of the thorax (Fig. 2). It extends well over the sacrum and down to the level of the trochanters and symphysis pubis, with a small area cut out over each groin to allow flexion of the hips. If the plaster is a good, closely fitting one it is not neces-

sary, even in lumbar fractures, to include either hip, and we strongly deprecate the suggestion that these patients should remain recumbent in a plaster bed or frame.

AFTER-TREATMENT

As soon as the plaster is dry the patient is encouraged to move about in bed, and is turned frequently to avoid pulmonary congestion. Wasting and hypotonicity of the spinal musculature must be avoided. From the second or third day in uncomplicated cases definite exercises for the erector spinae are practised at regular intervals. The patient should lie prone and lift the head from the bed against resistance. Each lower limb should be lifted with the knee straight by hyperextending the hip. These exercises involve energetic contraction of the erector spinae, and despite the plaster jacket a patient can maintain a better muscular tone in this way than he could if any amount of massage and electrical treatment were possible.

After ten days the patient may get up and walk for increasing intervals. We regard this as a very necessary part of the treatment, not only because it still further assists in maintaining muscular tone, and establishes the free circulation which is essential for rapid union, but because it restores the patient's mentality to normal. The sooner a man is dispossessed of the notion that "his back is broken" and that he "will never walk again," the more certainly is subsequent functional disturbance avoided.

Protection of the vertebra is necessary for four months. If exercises are being constantly practised the plaster should be retained for the whole of this time. After sixteen weeks movements of the spine itself are practised, and if a normal musculature and a normal circulation have been maintained there will be no difficulty in restoring full movement. Manipulation to break down intermuscular adhesions will not, as a rule, be necessary. Within six months he should be capable of resuming his normal occupation.

RESULTS OF TREATMENT

During a two-year period sixty-five cases of fracture of the vertebral bodies have been seen either privately or in hospital. Manipulative reduction was attempted in seven cases where the injury was of less than one month's duration. In one, of three and a half weeks' duration, paraplegia was present with urinary infection already well established, and the patient died of uraemia four weeks later. The other six men were seen within a few days of the injury, and in each case reduction was completely successful. Anatomical reposition of the compressed vertebra was secured (Figs. 3a and 3b, and 4a and 4b), with a normal range of movement. In two cases there was slight ossification of the anterior common ligament with the formation of a symptomless spur, but no osteo-arthritic changes have supervened.

FIG. 2.—Plaster jacket completed.

FIRST-AID TREATMENT

All first-aid workers should be taught in the future that a patient with an injured spine must be carried face downwards. No first-aid splintage can be perfectly efficient, and if, as is customary, he is carried by the shoulders and the hips, some degree of sagging between

FIG. 3a.

FIG. 3b.

FIG. 3a.—Lateral x-ray of eight-day-old crush fracture of first lumbar vertebra before reduction. (Case P.P. 1486.)

FIG. 3b.—Lateral x-ray of same case as Fig. 3a the day after reduction and plaster.

the points of support is almost inevitable. If he is face upwards the spine is flexed; and, however momentary this may be, the deformity must be exaggerated and the risk of injury to the spinal cord greatly increased. If, on the other hand, he is carried face downwards the spine is hyperextended. Not only is no harm done, but it is more than possible that the displacement will be reduced by the time he reaches hospital.

CONCLUSIONS

The experience of these seven cases has thrown a new light on the condition known as Kümmell's disease of the

the radiologist would certainly have reported either no bone change or a very trivial injury. Yet Figure 3a, taken twenty-four hours earlier, shows very marked collapse. It is clear that the condition described by Kümmell differs in no respect from any other compression fracture of the spine, except that reduction was

FIG. 4a.

FIG. 4b.

FIG. 4a.—Lateral x-ray of nine-day-old crush fracture of second lumbar vertebra before reduction. (Case P.P. 1203.)

FIG. 4b.—Lateral x-ray of same case as Fig. 4a, showing end-result twelve months after reduction.

spontaneously effected before the first radiogram was taken. When the ease with which reduction can be secured is realized, there is no difficulty in recognizing the possibility of spontaneous reduction.

The reading of an x-ray film of the spine is therefore not to be undertaken lightly. Only the most perfect films can be relied upon, and the slightest sign of injury must be regarded with suspicion. Moreover, the surgeon himself must recognize the possibilities of serious collapse which lie behind apparently insignificant degrees of compression of a vertebra, and such "trivial" injuries must be treated with the respect they deserve.

Summary of Cases of Crush Fracture of the Spine Treated by Reduction and Plaster.

Case No.	Sex	Age	Duration	Localization	Complication	Treatment	Result
P.P. 481	M	33	1 day	12th dorsal	—	Reduction; plaster for 10 weeks	Fracture fully reduced, but some absorption occurred later owing to protection for too short a period. Slight pain. Normal occupation and recreations in 5 months.
P.P. 1203	F	45	9 days	2nd lumbar	—	Reduction; plaster for 4 months	Perfect result. Full recovery in 5 months. (Figs. 4a and 4b.)
P.P. 1486	F	50	8 days	1st lumbar	Fractured pelvis	Reduction; plaster	Still in plaster. Anatomical reduction. (Figs. 3a and 3b.)
B.G.H. 1718	M	33	25 days	1st lumbar	Paraplegia; urinary infection	Reduction; plaster	Died 4 weeks later from uraemia
B.G.H. 1744	M	30	5 days	12th dorsal	—	Plaster 3 months; spinal support 6 weeks	Complete recovery. Resumed heavy work in 6 months
L.R.I. 11680	M	23	9 days	1st lumbar	Fracture of tarsus, R. and L.	Plaster and spinal support 6 months	Spine fully recovered. No symptoms
L.R.I. 15146	M	51	1 day	2nd lumbar	Fracture of transverse processes L2 and L3	Plaster 3 months; support 3 months	Perfect result. Drives heavy car all day without symptoms

spine. It has long been recognized that the progressive absorption of the vertebral body which characterizes this disorder is due to trauma, but it has been difficult to explain why the radiogram taken within a short time of the accident has shown no injury, whereas later radiograms have shown very marked absorption. This is now explained, for we have seen that even after a very severe compression simple hyperextension will restore a vertebra so perfectly that in the post-reduction radiogram it is practically impossible to localize the injury. Figure 3b shows a radiogram taken the day after reduction. If in this case there had not been a previous x-ray examination,

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