DISTRACTION FRACTURES OF THE LUMBAR SPINE

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Distraction fractures of the upper lumbar spine are most often associated with the wearing of seat-belts. Twenty patients with this spinal fracture were reviewed and half of them had intra-abdominal injuries. Eight patients required an exploratory laparotomy. Three distinct patterns of distraction fractures have been identified. Open reduction, local spinal fusion and Harrington instrumentation are recommended for unstable fractures and for those with neurological involvement. Four cases of non-union are included in the series. Legislation for the compulsory wearing of seat-belts should encompass improvements in design and stricter criteria for installation.

In 1948 Chance reported three unusual fractures of the lumbar spine where horizontal splitting of the spinous process and neural arch occurred. He stated that he "could not think of any anatomical explanation of the peculiar site and direction of the fracture". The next report of this vertebral injury was in 1965 when Howland, Curry and Buffington reported a patient who was injured while wearing a lap-belt, and they coined the term "Chance fracture". They suggested that the mechanism was similar to the breaking of a stick across the knee, the seat-belt acting as a fulcrum about which hyperflexion occurred. The pathomechanics of the injury were clarified by Smith and Kaufer (1969) who reviewed fractures of the lumbar spine associated with lap-belts including five Chance fractures. They deduced that distraction was an important component of the disruptive force and that injury took place when the subject "submerged" under the lap-belt at impact with hyperflexion of the lumbar spine over the fulcrum of the high-riding restraint, as shown in Figure 1.

Spinal injuries attributed to wearing a seat-belt are uncommon. Garrett and Braunstein (1962) reviewed 944 patients with injuries associated with seat-belts and found only 12 with injuries of the lumbar spine. A review of the literature indicates that 36 Chance fractures have been documented (Chance 1948; Howland *et al.* 1965; Fletcher and Brogden 1967; Haddad and Zickel 1967; Smith and Kaufer 1969; Greenbaum, Harris and Halloran 1970; Marsh and Bailey 1970; Ritchie *et al.* 1970; Dehner 1971; Rogers 1971; Rennie and Mitchell 1973; Yosipovitch, Robin and Makin 1977; Bilo and van

Fig. 1

Mechanism of Chance fracture: forward flexion over a high-riding lap-belt producing vertebral distraction.

Vuuren 1979).

The purpose of this paper is to report 20 cases of distraction fracture of the lumbar spine treated at the Royal North Shore Hospital of Sydney between 1973 and 1981, and to emphasise the high incidence of concomitant intra-abdominal injury which is not surprising in view of the mechanism of vertebral fracture.

CLINICAL MATERIAL

Our experience is that Chance fractures are relatively common. Twenty Chance fractures occurred in the 179 fractures and fracture-dislocations of the thoracolumbar spine admitted to our hospital during the nine years of our study. The hospital is the major regional referral centre for acute spinal cord injuries in New South Wales, which has a population of approximately six million.

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The pertinent clinical details are listed in Table I. There were six men, 12 women and two children. The average age of the adults was 26 years. Three of the patients presented late, having been managed initially elsewhere.

Levels of fracture. The upper lumbar spine was the site of injury in all but one of our patients, Case 18, who had fractured her twelfth thoracic vertebra. Fractures did not occur below the third lumbar vertebra. One case of a double level injury has been reported (Rogers 1971).

Table I. Details of 20 patients with distraction fractures of the lumbar spine

Case	Sex	Age (years)	Level of fracture	Type of fracture	Mechanism of injury and type of restraint	Neurological lesion	Abdominal trauma	Other injury	Management	Result
1	M	31	L2	II	MVA—driver Lap-belt	—	—	Transverse process fractures	Extension cast	United No pain Full function
2	M	18	L3	II	MVA—driver Harness	—	Caecal perforation Duodenal haematoma	—	Extension cast	United No pain Full function
3	M	12	L3	I	MVA—passenger Lap-belt	—	Caecal perforation Mesenteric tears	—	Boston brace	Non-union of posterior element No pain Full function
4	F	23	L3	II	MVA—passenger Lap-belt	—	Transient ileus	Facial lacerations	Extension cast	United Asymptomatic
5	F	20	L1	I	MVA—driver Ejected	—	Transient ileus	—	Compression wiring and bone graft	United Minor lumbar ache Full function
6	F	22	L1	I	MVA—passenger Lap-belt	—	—	Clavicle and rib fractures	Bed rest in extension	United No pain Full function
7	M	20	L1	I	MVA—driver ?	Left S3 hypo-aesthesia	—	Facial lacerations Multiple fractures	Harrington distraction	Solid fusion No pain Full function
8	F	40	L1	I	MVA—driver Lap-belt	—	—	Rib fractures Right VII nerve palsy	Harrington distraction	Solid fusion No pain Full function
9	F	22	L1	III	MVA—passenger Lap-belt	L3 paraparesis	Seat-belt contusion	—	Posterior spinal plates	United Paraparesis persists
10	M	33	L1	I	Fell 5 metres on to railing	T11 paraplegia	Retroperitoneal haematoma	Skull and rib fractures	Bed rest in extension	United Paraplegia
11	F	20	L1	I	MVA—passenger Lap-belt	—	Pancreatitis Pseudocyst Urinoma	Pleural effusion	Bed rest in extension	United No pain L1 kyphos
12	F	36	L2	III	MVA—passenger ?	—	Ruptured duodenum	—	Bed rest Harrington compression	Solid fusion No pain
13	F	23	L3	I	MVA—position unknown Lap-belt	Bilateral L2 hypo-aesthesia	—	—	Posterior plate Posterior fusion	Solid fusion No pain Full function
14	F	23	L2	II	MVA—passenger Lap-belt	—	—	—	Bed rest Four stage fusion for kyphosis	Solid fusion Minor lumbar ache Full function
15	M	18	L1	II	MVA—driver ?	—	—	—	Harrington compression	Solid fusion No pain Full function
16	F	20	L2	II	MVA—passenger Lap-belt	Depressed right knee reflex	Pancreatitis Pseudocyst	Rib and pelvic fractures	Posterior spinal plates	Solid fusion No pain Full function
17	F	18	L3	II	MVA—passenger ?	—	—	Femoral fracture	Bed rest Late anterior fusion	Solid fusion No pain Full function
18	F	21	T12	II	MVA—passenger Lap-belt	—	Pancreatitis Ruptured kidney and diaphragm	Rib fractures	Extension cast	United T12 kyphos Asymptomatic
19	M	11	L3	II	MVA—rear seat passenger Lap-belt	—	Seat-belt contusion (ileum resected)	—	Extension cast	Vertebral body union Vitamin B12 required Full function
20	M	55	L1	II	Fell 1.6 metres on to his back	—	—	—	Extension cast	United No pain Full function

MVA—Motor vehicle accident
?—Restraint type unknown

Fracture patterns. Three distinct patterns of fracture were observed: in Type I fractures (Figs 2 to 4; eight cases), which were originally described by Chance, the fracture line traverses the spinous processes, laminae, apophyseal joints, pedicles and transverse processes with a variable direction through the vertebral body; in Type II fractures (Figs 5 to 7; 10 cases) the fracture line enters the laminae at the base of the spinous process but is otherwise the same as in Type I; Type III fractures (Figs 8 and 9; two cases) appeared to be the result of distraction with a rotatory element, the posterior elements being involved on one side only, with the fracture line passing through the posterior elements and the vertebral body in a manner comparable to Types I and II. We deduce that the rotatory force in Type III fractures arises from the patient spiralling around the lap-belt at impact. We know of one patient, not included in this series, who

sustained a variant of this injury (Figs 10 and 11) and in whom nerve root signs occurred on the side opposite to that of the fracture suggesting a distraction force.

No correlation was observed between the fracture type and either visceral or neurological injury. The latter occurs only with marked vertebral displacement, which is unusual.

A variant of distraction injury which has been described in wearers of seat-belts, though not included in the present series, is one where no fracture occurs but rather a dislocation (Kaufer and Hayes 1966; Huelke and Kaufer 1975).

Abdominal trauma. Varying degrees of contusion of the abdominal wall were observed. There was no constant relationship between the presence or absence of seat-belt "burns" and intra-abdominal injury. Ten patients required treatment for intra-abdominal injury, primarily of

Fig. 2

Fig. 3

Fig. 4

Type I fracture. Figure 2—Anteroposterior radiograph of the lumbar spine showing the transverse fracture of the spinous process, pedicles, transverse processes and laminae. Figures 3 and 4—Anteroposterior and lateral diagrams of the fracture.

Fig. 5

Fig. 6

Fig. 7

Type II fracture. Figure 5—Anteroposterior radiograph showing a transverse fracture entering the laminae at the base of the spinous process, involving pedicles, transverse processes and vertebral body. Figures 6 and 7—Anteroposterior and lateral diagrams of the fracture.

Fig. 8

Fig. 9

Type III fracture. Figure 8—Anteroposterior radiograph showing a transverse fracture of one pedicle and transverse process, involving the laminae with dislocation of the contralateral apophyseal joint. Figure 9—Diagrammatic presentation of Figure 8.

Fig. 10

Fig. 11

Lap-belt fracture. Figure 10—Anteroposterior radiograph of the lumbar spine: rotation about the lap-belt produces ligamentous injury, bony disruption being limited to one side of the midline. Figure 11—Diagrammatic presentation of Figure 10.

the upper abdomen. Eight of these underwent exploratory laparotomy. Rupture of the intestinal tract had occurred in four patients (Cases 2, 3, 12 and 19), and blunt trauma to the pancreas in three others (Cases 11, 16 and 18). Two of the latter developed pseudocysts, one of which required a further operation.

MANAGEMENT AND RESULTS

Thirteen patients were initially managed conservatively and seven were treated by open reduction and internal fixation.

Nearly anatomical reduction of distraction fractures of the lumbar spine can be achieved in a high percentage

of cases by spinal extension over pillows, though early mobilisation in an extension cast may be impracticable because of intra-abdominal injury. Patients were treated with bed rest or immobilised in a cast for six to eight weeks during which an exercise programme was commenced to strengthen the abdominal and paraspinal musculature. One patient (Case 11) had a residual kyphos of 10 degrees; reduction was not attempted because of a protracted period of serious illness due to her visceral injuries. One other patient (Case 18) had a residual kyphos of seven degrees after closed reduction. One child (Case 19) with non-union of the posterior elements is asymptomatic and the fracture of the vertebral body has

Fig. 12

Non-union of a Chance fracture: the fracture was originally plated in distraction. Symptoms warranted posterior fusion.

healed well. His fracture was not diagnosed until three weeks after his accident, and postural reduction at that time was incomplete. No further treatment was considered necessary.

Patients whose fractures were considered to be unstable, including those with significant neurological damage, were managed by open reduction, internal fixation and local spinal fusion. Two patients (Cases 9 and 16) had Williams plates inserted and another (Case 5) had circumferential wiring of the adjacent spinous processes. Since 1975, Harrington instrumentation has been employed in all three cases requiring open reduction and was removed routinely six months after operation. All of these patients were mobilised in closely moulded casts as soon as their wounds had healed. All recovered normal or near normal spinal function with minimal symptoms. Each spinal fusion was shown to be solid at exploration. There were no wound infections.

Three patients who presented with painful non-union of their fractures were managed initially at other hospitals (Cases 12, 13 and 17). Cases 12 and 17 had been treated with bed rest before undergoing open reduction. In Case 13 the spine had been plated in distraction, an error in surgical technique (Fig. 12). All of these patients obtained a solid fusion with a further operation and had minimal symptoms subsequently.

In Case 14, an 80 degree kyphos of several years standing required anterior release, halopelvic distraction, posterior release and then anterior fusion for correction; this patient had initially been treated conservatively.

DISCUSSION

The introduction of compulsory wearing of seat-belts in Australia in 1970 was associated with a 15 to 20 per cent reduction in the deaths of adult occupants of cars but also with the emergence of injuries directly associated with restraints in frontal impact collisions (Trinca and Dooley

1975). These authors reported that 10 per cent of adults admitted to hospital after head-on collisions had various injuries which could be causally linked with seat-belts. They also noted that only 5.5 per cent of children under the age of eight years were restrained and for them, the pattern of injury and mortality remained unchanged. Trinca and Dooley concluded that seat-belt design was inadequate. We concur strongly and have previously drawn attention in this journal to injuries of the cervical spine associated with seat-belts (Taylor, Nade and Bannister 1976). Another factor is that seat-belt anchorages are not adjustable for persons of different height. The need for prompt governmental action is clear. No data are available on the incidence and pattern of spinal and abdominal injuries which occur with the newer inertia reel seat-belts which became compulsory in this country in 1975 for new vehicles. These restraints should, in theory, improve seat-belt positioning across the pelvis and minimise the tendency to "submarine" beneath the lap component. Whilst there are no immediate apparent advantages in our classification of these distraction fractures we suggest that in a much needed prospective study with careful analysis of car crash injuries, the fracture type could well give important clues for improvement in occupant restraints.

Fig. 13

Anteroposterior plain radiograph showing a posterior element "gap" (arrowed). Note the increased apparent interspinous distance at the fracture level.

Distraction fractures of the lumbar spine heal well, as do most cancellous bone fractures, provided they are adequately reduced and immobilised. The long term sequelae are minimal and the functional results are very satisfactory. Non-union has not been reported previously but its occurrence in fractures with wide separation of the posterior elements is not surprising. Close coaptation of the fracture surfaces should be the principal aim of management. We consider that unstable fractures are

best managed by open reduction and internal fixation with Harrington compression or distraction assemblies. The decision as to which type of instrumentation to employ is best made at operation. A one-level fusion only is required and these heal well. The instrumentation which encompasses proximal and distal mobile spinal segments should be removed six months after operation.

The high incidence of intra-abdominal injury in this series emphasises the importance of early diagnosis. Traumatic pancreatitis may not become apparent for 12 to 24 hours after injury and there is no positive correlation between pancreatic injury and elevation of the serum amylase (Jones 1978). Peritoneal tap is of value in detecting intra-abdominal bleeding and lavage provides a sensitive and early guide to the severity of traumatic pancreatitis (McMahon, Playforth and Pickford 1980). The reported mortality for closed pancreatic injury has been as high as 18 per cent (Jones 1978). The rupture of

a hollow viscus is similarly not invariably apparent immediately after injury. One patient in the present series who had a caecal perforation (Case 2) did not lose bowel sounds and develop abdominal distension until five days after injury. We suggest that in patients who present after car accidents the presence of seat-belt burns on the abdominal wall should raise the index of suspicion for intra-abdominal injuries. A lateral decubitus radiograph of the abdomen and a diagnostic peritoneal tap are wise precautions. On the other hand, the intra-abdominal injury may dominate the early clinical picture and a distraction fracture of the lumbar spine may be undetected. The plain anteroposterior radiograph of the abdomen provides the clue with a gap in the posterior elements at the level of injury (Fig. 13). It is easy to appreciate how, in the absence of lateral displacement, such a fracture may not be recognised on cursory examination of the radiograph.

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